THE UNIVERSITY OF ZAMBIA SCHOOL OF NATURAL SCIENCES FINAL EXAMINATION 2015 – 2016

1. **BIO 1401: BIOMOLECULES AND CELLS**
2. **BIO 1412: BIOMOLECULES AND CELLS**
3. **BIO 2002: STATISTICAL ANALYSIS OF BIOLOGICAL DATA**
4. **BIO 2302: BASIC MICROBILOGY**
5. **BIO 2701: BASIC PHYSIOLOGY**
6. **BIO 2801: DIVERSITY OF PLANTS**
7. **BIO 2812: DIVERSITY OF ANIMALS**
8. **BIO 3421: MOLECULAR BIOLOGY**
9. **BIO 3501: MYCOLOGY PRACTICAL PAPER**
10. **BIO 3501: MYCOLOGY THEORY PAPER**
11. **BIO 3612: BIOCHEMISTRY AND PHYSIOLOGY OF PARASITES**
12. **BIO 3712: ANIMAL PHYSIOLOGY**
13. **BIO 3822: FISH BIOLOGY THEORY PAPER**
14. **BIO 3841: EVOLUTIONARY BIOLOGY**
15. **BIO 4161: FRESHWATER ECOLOGY**
16. **BIO 4171: POPULATION ECOLOGY**
17. **BIO 4230: INSECT ECOLOGY AND PEST MANAGEMENT THEORY PAPER**

18. BIO 4325: ECOLOGY AND EPIDEMIOLOGY OF PARASITIC DISEASES PRACTICAL PAPER

19. BIO 4341: INDUSTRIAL MICROBIOLOGY

20. BIO 4452: TECHNIQUES IN RECOMBINANT DNA TECHNOLOGY THEORY PAPER

21. BIO 4632: MOLECULAR PARASITOLOGY

22. BS 4182: WILDLIFE AND RANGELAND AND MANAGEMENT

23. C 2615: BASIC PHYSICAL CHEMISTRY

24. CHE 1000: INTRODUCTION TO CHEMISTRY

25. CHE 2001: AGRICULTURE AND VERTINARY CHEMISTRY

26. CHE 2112: INTRODUCTORY BIOCHEMISTRY

27. CHE 2219: CHEMICAL ANALYSIS

28. CHE 2415: BASIC INORGANIC CHEMISTRY

29. CHE 2511: BASIC ORGANIC CHEMISTRY

30. CHE 3122: ENERGY TRANSACTION SYSTEMS

31. CHE 3211: SPECTROSCOPIC METHODS OF ANALYSIS

32. CHE 3222: SPECTROSCOPIC METHODS OF ANALYSIS

33. CHE 3411: CHEMISTRY OF MAIN GROUP ELEMENTS AND TRANSITION METAL COMPLEXES

34. CHE 3422: ORGANAMETALLICS AND REACTION MECHANISMS

35. CHE 3522: POLYFUNCTIONAL COMPOUNDS, MOLECULAR REARRANGEMENTS AND ORGANIC SYNTHESIS

36. CHE 3622: COLLOIDS AND ELECTROCHEMISTRY

37. CHE 4102: BIOCHEMICAL PROCESSES AND RESEARCH TECHNIQUES

38. CHE 4422: METAL CHEMISTRY AND THEIR APPLICAION TO ORGANOMETALLICS AND CATALYST

39. CHE 4611: QUANTUM CHEMISTRY AND MOLECULAR SPECTROSCOPY

40. CHE 4811: INORGANIC INDUSTRIAL CHEMISTRY

41. CHE 4922: ORGANIC INDUSTRIAL CHEMISTRY II

42. CSC 2000: COMPUTER PROGRAMING

43. CSC 2202: INTRODUCTION TO OPERATING SYSTEMS

44. CSC 2702: DATABASES AND INFORMATION MANAGEMENT

45. CSC 2912: NUMERICAL ANALYSIS

46. CSC 3011: ALGORITHMS AND COMPLEXITY

47. CSC 3120: ANALOGY AND DIGITAL ELECTRONICS

48. CSC 3301: PROGRMMING LANGUAGE DESIGN AND PARADIGMS

49. CSC 3402: FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE

50. CSC 3600: SOFTWARE ENGINEERING

51. CSC 3612: IT PROJECT MANAGEMENT

52. CSC 4130: HARDWARE DESIGN AND IMPLEMENTATION

53. CSC 4505: GRAPHIC AND VIDEO COMPUTING

54. CSC 4630: ADVANCED SOFTEWARE ENGINEERING

55. CSC 4722: DISTRIBUTED SYSTEMS

56. CSC 9135: AGRICULTURE ECONOMICS

57. GES 1310: INTRODUCTION TO GEOGRAPHY

58. GES 2210: FUNDAMENTALS OF PHYSICAL GEOGRAPHY

59. GES 2411: MAPPING AND FIELD TECHNIQUES

60. GES 2422: STATISTIOCAL METHODS IN GEOGRAPHY

61. GES 3330: ENVIRONMENTAL METHODS AND DEVELOPMENT

62. GES 3342: ENVIRONMENTAL PLANNING AND MANAGEMENT

63. GES 4372: TOURISM, ENVIRONMENT AND DEVELOPMENT

64. GES 4451: CARTOGRAPHY

65. MAT 1100: FUNDAMENTAL MATHEMATICS

66. MAT 2100: ANALYTICAL GEOMETRY AND CALCULUS

67. MAT 2110: MATHEMATICS AND STATISTICS

68. MAT 3100: MULTIVARIABLE CALCULUS

69. MAT 3200: ABSTRACT ALGEBRA

70. MAT 3110: ENGINEERING MATHEMATICS II

71. MAT 3300: REAL ANALYSIS

72. MAT 3902: PROBABILITY THEORY

73. MAT 4100: THEORY OF FUNCTION OF A COMPLEX VARIABLE

74. MAT 4212: MODULE AND FIELD THEORY

75. MSE 3060: CHEMISTRY TEACHING METHODS

76. MSE 9040: ADVANCED BIOLOGY TEACHING METHODS

77. PHY 1010: INTRODUCTORY PHYSICS

78. PHY 2112: ATOMIC AND MODERN PHYSICS

79. PHY 2522: ANALYTICAL MECHANICS AND SPECIAL THEORY OF RELATIVITY

80. PHY 2712: OPTICS

81. PHY 4132: THEORETICAL NUCLEAR PHYSICS

82. PHY 4221: SOLID STATE PHYSICS I

83. PHY 4222: SOLID STATE PHYSICS II

84. PHY 4242: PHYSICS

85. PHY 4422: DIGITAL ELECTRONIC 11

86. PHY 4815: PHYSICS OF RENEWABLE ENERGY RESOURCES AND ENVIRONMENT

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 1401: BIOMOLECULES AND CELLS
THEORY EXAMINATION

TIME: THREE HOURS

Instructions:

1. Answer **all** questions.
2. All questions carry equal marks.
3. Use the answer sheet provided to record the answers.
4. A correct answer carries +4 marks.
5. A wrong answer carries –1 mark.
6. The option "I do not know" carries 0 mark.
7. Use ink to record the answers on the answer sheet.
8. Cross out a wrong entry and write the correct one by the side.
9. Handover both the answer sheet and question paper at the end of the examination.
10. Any communication with another candidate will lead to disqualification.
11. Use of cell phones is not allowed.

1. Choose the statement which is true.
    1. The nucleus of a molecule contains two or more atoms.
    2. The orbitals of an atom are found in the nucleus.
    3. The basic parts of an atom are orbitals, electrons and protons.
    4. The mass number of an atom is determined by the nucleus.
    5. The nucleus of an atom contains electrons and protons.
    6. I do not know.

2. A certain atom has 6 protons, 6 electrons and 7 neutrons; its atomic number is ... while its mass number is...
    1. 13, 6
    2. 18,12
    3. 18,6
    4. 6,13
    5. 6,7
    6. I do not know.

3. The number of orbitals in the first shell of an atom is...
    1. one
    2. two
    3. three
    4. four
    5. five
    6. I do not know.

4. Electrons in the ... orbital are at lower energy level than those in the ... orbital of the same shell.
    1. p; s
    2. s; p
    3. 2px; 2py
    4. 1s; 2s
    5. 2p; 2s
    6. I do not know.

5. Choose the statement which is **false** about water.
    1. Water has a high surface tension due to hydrogen bonding.
    2. Ice is solid because its water molecules are held rigidly by ionic bonds.
    3. Water has a maximum density at 4°C.
    4. The water molecule is held together by covalent bonds.
    5. Water is both partially positive and partially negative.
    6. I do not know.

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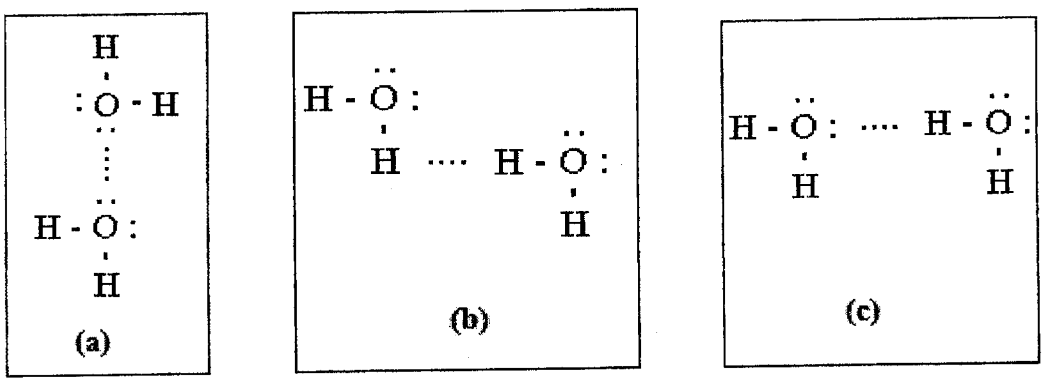
6. What do cohesion, surface tension, and adhesion have in common with reference to water?
    1. All increase when temperature increases.
    2. All are produced by ionic bonding.
    3. All have properties related to hydrogen bonding.
    4. All have to do with nonpolar covalent bonds.
    5. 3 and 4 only.
    6. I do not know.

7. Choose the diagram(s) which indicate(s) how water molecules form hydrogen bonds.



1. (b)
2. (c)
3. (a)
4. (a) and (b).
5. (a) and (c).
6. I do not know.

8. Study Figure 1.

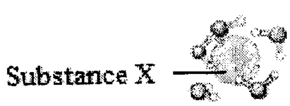


Figure1. Water molecules surrounding substance X.

Substance X should be...

1. positively charged.
2. amphoteric.
3. amphipathic.
4. negatively charged.
5. hydrophobic.
6. I do not know.

TURN OVER

9. Why does ice float in liquid water?
    1. The liquid water molecules have more kinetic energy and thus support the ice.
    2. The ionic bonds between the molecules in ice prevent the ice from sinking.
    3. Ice always has air bubbles that keep it afloat.
    4. Hydrogen bonds keep water molecules farther apart in ice than in liquid water.
    5. The crystalline lattice of ice causes it to be denser than liquid water.
    6. I do not know.

10. Choose the **correct** statement.
    1. Fructose is an optical isomer of galactose.
    2. Glucose is a structural isomer of galactose.
    3. Ribose is a structural isomer of deoxyribose.
    4. Alpha glucose has the OH group on carbon 1 above the ring.
    5. Galactose is an optical isomer of glucose.
    6. I do not know.

11. The bond formed between glucose and fructose is a ... bond and the product is...
    1. $1\rightarrow4$ glycosidic, sucrose.
    2. $1\rightarrow4$ glycosidic, maltose.
    3. $1\rightarrow6$ glycosidic, lactose.
    4. $1\rightarrow2$ glycosidic, sucrose.
    5. $1\rightarrow4$ glycosidic, lactose.
    6. I do not know.

12. Give the functions of amylose, cellulose and glycogen in the order the substances are given.
    1. Storage , Storage, Structure
    2. Structure , Storage, Structure
    3. Structure, Storage, Storage
    4. Storage , Structure, Structure
    5. Storage , Structure, Storage
    6. I do not know.

13. Which of these is a **correct** combination of monosaccharides that form a disaccharide?
    A. Glucose + Glucose = Maltose
    B. Glucose + fructose = Lactose
    C. Glucose + galactose = Sucrose
    D. Glucose + galactose =Lactose
    1. A
    2. B
    3. C
    4. A and D
    5. B and D
    6. I do not know.

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14. The two structures making up starch are...
   1. amylose and cellulose.
   2. amylose and amylopectin.
   3. amylopectin and glucose.
   4. amylase and glucose.
   5. amylase and maltose.
   6. I do not know.

15. Study the characteristics of molecules A, B and C and answer the question that follows.

   A. Ester of long chain fatty acid and a long chain alcohol
   B. Ester of glycerol and two fatty acids
   C. Solid ester at room temperature

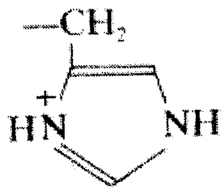
   The three molecules can be identified as:
   1. A = triglyceride, B = oil, C = fat
   2. A = diglyceride, B = oil, C = wax
   3. A = wax, B = monoglyceride, C = oil
   4. A = wax, B = diglyceride, C = fat
   5. A = wax, B = oil, C = fat
   6. I do not know.

16. Phospholipids are suitable in the formation of the cell membrane because of their ... nature.
   1. hydrophobic
   2. amphoteric
   3. hydrophilic
   4. amphipathic
   5. dipolar
   6. I do not know.

17. Choose the **correct** statement(s).
   1. One subunit of haemoglobin represents the tertiary structure of proteins.
   2. The four subunits of haemoglobin represent the tertiary structure of proteins.
   3. Amino acids are held together by hydrogen bonds in the protein primary structure.
   4. Statements 1 and 3 are correct.
   5. Statements 2 and 3 are correct.
   6. I do not know.

TURN OVER

18. Study the R-group of an amino acid at pH7 as given below and answer the question that follows.



The amino acid with this R-group is...

1. basic.
2. non-polar.
3. hydrophobic.
4. acidic.
5. aliphatic.
6. I do not know.

19. Choose the **correct** statement(s).
    1. Collagen is a globular protein consisting of three polypeptide chains.
    2. Myoglobin is a transport protein with one subunit.
    3. Keratin fibre is a structural protein with a tertiary structure.
    4. Statements 1 and 3 are correct.
    5. Statements 2 and 3 are correct.
    6. I do not know.

20. Two of the standard 20 amino acids contain sulphur atoms. These are...
    1. cysteine and threonine.
    2. methionine and serine.
    3. methionine and cysteine.
    4. threonine and serine.
    5. glycine and lysine.
    6. I do not know.

21. The optical activity of an amino acid results from the fact that it's alpha carbon ...
    1. has no net charge.
    2. is a carboxylic acid.
    3. has a double bond with oxygen.
    4. is bonded to four different chemical groups.
    5. is symmetrical.
    6. I do not know.

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22. The negative charge on DNA is mainly due to the presence of …
    1. amino acids.
    2. ribose sugar.
    3. nitrogenous bases.
    4. phosphate groups.
    5. deoxy ribose sugar
    6. I do not know.

23. Purines ... while pyrimidines...
    1. are one ringed structures; are two ringed structures
    2. are one ringed structures; are one ringed structures
    3. are two ringed structures; are two ringed structures
    4. include adenine and thymine; uracil and guanine
    5. include adenine and guanine; uracil and thymine
    6. I do not know.

24. A nucleoside is a ... without a ...
    1. nucleotide; sugar
    2. nucleotide; phosphate
    3. sugar; base
    4. base; nucleotide
    5. phosphate, nucleotide
    6. I do not know.

25. The adjacent nucleotides of DNA are joined together through .. bonds.
    1. ionic
    2. hydrogen
    3. phosphodiester
    4. glycosidic
    5. phosphoester
    6. I do not know.

26. Which of the following is **not** a characteristic of prokaryotes?
    1. DNA
    2. Cell membrane
    3. Cell wall
    4. Endoplasmic reticulum
    5. Cytoplasm
    6. I do not know.

TURN OVER

27. In bacteria, some of the functions of eukaryotic organelles are performed by ..
    1. vesicles.
    2. lysosomes.
    3. ribosomes.
    4. the plasma membrane.
    5. mitochondria.
    6. I do not know.

28. Choose the **correct** statement.
    1. Bacterial cells use cilia to stick to other bacterial cell.
    2. Bacteria use pili for a special kind of sexual reproduction.
    3. Plasmids are organelles which contain their own DNA.
    4. A flagellum is used by some bacteria to stick to other bacterial cells.
    5. Bacteria do not have a true nucleus but have a structure called a nucleolus.
    6. I do not know.

29. Choose the statement which is **false** about the bacterial cell wall.
    1. It is made up of a phospholipids and proteins.
    2. Protects the cell from the outside environment.
    3. Maintains the shape of the cell.
    4. Has pathogenic properties.
    5. It is permeable to water and other small molecules.
    6. I do not know.

30. Given that the sedimentation coefficient of a prokaryotic ribosome is 70S, it's two subunits are ...
    1. 50S and 20S.
    2. 40S and 30S.
    3. 60S and 10S.
    4. 50S and 30S.
    5. 35S and 35S.
    6. I do not know.

31. The position where ribosomal RNA is produced, in eukaryotes, is called …
    1. nuclei.
    2. cisternae.
    3. nucleolus.
    4. Golgi complex.
    5. centrioles.
    6. I do not know.

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32. Ribosomes are found in the following structures:
   1. Bacterial cells, mitochondria and chloroplasts.
   2. Eukaryotic cells, bacterial cells and golgi bodies.
   3. Chloroplasts, golgi bodies and nucleus.
   4. Endoplasmic reticulum, nucleus and lysosomes.
   5. Mitochondria, cell membrane and vesicles.
   6. I do not know.

33. Plant cells discharge their waste materials into …
   1. rough endoplasmic reticulum.
   2. mitochondria.
   3. cytoplasm.
   4. Chloroplast.
   5. vacuoles.
   6. I do not know.

34. The following characteristics are distinct to bacterial, plant and animal cells respectively:
   1. Mitochondria, cell membrane, and ribosomes.
   2. Circular DNA, chloroplasts and lysosomes.
   3. Ribosomes, vacuoles, and chloroplasts.
   4. Golgi bodies, endoplasmic reticulum and cytoplasm.
   5. Cytoplasm, vacuoles and mesosomes.
   6. I do not know.

35. Respiration in bacterial cells takes place…
   1. in the cytoplasm.
   2. on the cell membrane.
   3. in the nucleoid.
   4. in the cell wall.
   5. in the ribosome.
   6. I do not know.

36. Identify the **correct** statement(s).
   1. The nucleoid is the location of DNA in bacteria.
   2. DNA is present in all types of living cells.
   3. Plasmids are made of DNA material.
   4. 1 and 2 above.
   5. All the above.
   6. I do not know.

TURN OVER

37. An atom has a mass number of 23 and atomic number 11. The number of protons are ...
   1. 11
   2. 12
   3. 22
   4. 23
   5. 46
   6. I do not know.

38. An atom with two shells has all its orbitals full. Its atomic number is …
   1. 4
   2. 5
   3. 6
   4. 8
   5. 10
   6. I do not know.

39. Atoms have no electric charge because they have …
   1. an equal number of charged and non-charged particles.
   2. neutrons in their nuclei.
   3. an equal number of electrons and protons.
   4. an equal number of neutrons and protons.
   5. more neutrons than electrons.
   6. I do not know.

40. Which one of the following statements is **false** about positive ions?
   1. They are also known as cations.
   2. They are formed when electrons are removed from atoms.
   3. They have the same mass as the atom from which they were formed.
   4. They have fewer orbitals than the atom from which they were formed.
   5. They attract negative ions.
   6. I do not know.

41. Which of the following statements is **false** about sodium chloride?
   1. It has strong covalent bonds.
   2. It is soluble in water.
   3. It melts at a high temperature.
   4. It has ionic bonds.
   5. It is a solid at room temperature.
   6. I do not know.

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42. Which one of the following is **false** about water?
    1. In ice each water molecule is bonded to four others.
    2. Water molecules have a high melting point due to intermolecular hydrogen bonding.
    3. Water has a maximum density at 1 ^{O}C.
    4. It is dipolar.
    5. Water is a liquid at room temperature.
    6. I do not know.

43. Which kinds of bonding can be found in a sample of water?
    1. Nonpolar covalent bonds only.
    2. Hydrogen bonds only.
    3. Both polar covalent and hydrogen bonds.
    4. Ionic and nonpolar covalent bonds.
    5. Hydrophobic interactions.
    6. I do not know.

44. The volume of water in a pond in high temperature conditions, does not change significantly over a long time because …
    1. the latent heat capacity of water is low.
    2. wind speed doesn't affect evaporation of water.
    3. water has a very low specific heat capacity.
    4. water has high latent heat of vapourisation.
    5. water has many covalent bonds in it.
    6. I do not know.

45. A needle can be made to float on water because water has …
    1. very strong capillary forces.
    2. higher density than the material the needle is made of.
    3. a high surface tension due to hydrogen bonding.
    4. weak adhesive forces.
    5. a low surface tension.
    6. I do not know.

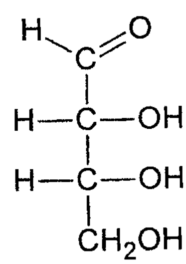
46. A polysaccharide formed by a β1-4 linkage is …
    1. lactose.
    2. glycogen.
    3. amylopectin.
    4. amylose.
    5. cellulose.
    6. I do not know.

TURN OVER

47. Which of the following molecules is a carbohydrate?
   1. $C_3H_7O_2N$
   2. $C_3H_8O_3$
   3. $C_{12}H_{24}O_{12}$
   4. $C_{13}H_{26}O_2$
   5. $C_{20}H_{40}O_2$
   6. I do not know.

48. Which of the following molecules is a ketose?
   1. Ribose
   2. Glucose
   3. Fructose
   4. Glyceraldehyde
   5. Galactose
   6. I do not know.

49. Classify the molecule shown according to the location of its carbonyl group and the number of carbon atoms.



   1. Ketotriose
   2. Ketotetrose
   3. Aldotetrose
   4. Aldopentose
   5. Aldotriose
   6. I do not know

50. Starch is composed of two polymers… which is … chain, and …., which is …
   1. amylose; unbranched; amylopectin; branched.
   2. Amylopectin; branched; amylose; branched.
   3. amylose; branched; amylopectin; unbranched.
   4. amylopectin; branched; glycogen; branched.
   5. 1 and 4 above are correct.
   6. I do not know.

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51. Which of the following is an accurate description of the phospholipid bilayer in cell membranes?
   1. It is made up of two layers of phospholipid polymers.
   2. It is made up of two layers of phospholipid molecules with the tails pointing away from each other.
   3. It is made up of two layers of phospholipid molecules with the tails lying parallel to each other.
   4. It is made up of two layers of phospholipid molecules with the tails interacting with each other.
   5. It is made up of one layer of phospholipid molecules with the tails interacting with each other.
   6. I do not know.

52. Which of the following statements is **true** regarding the movement of substances across the phospholipid bilayer?
   1. Water and ions are unable to cross the bilayer due to the charges present in the head groups.
   2. Water and ions are unable to cross the bilayer due the hydrophobic tails of the phospholipid molecules.
   3. Water and ions are encouraged to cross the bilayer by interacting with the charges present in the head groups.
   4. The molecules in the bilayer are fluid, and so the cell membrane is porous allowing free passage of ions and water across the cell membrane.
   5. Water and ions are able to cross the bilayer due to the charges present in the head groups.
   6. I do not know.

53. Which of the following statements is **correct**?
   1. Three fatty acids combine with 3 glycerol molecules to release 3 water molecules.
   2. Three fatty acids combine with 1 glycerol molecule to release 3 water molecules.
   3. One fatty acid combines with 2 glycerol molecules to release 2 water molecules.
   4. One fatty acid combines with 3 glycerol molecules to release 3 water molecules.
   5. Three fatty acids combine with 1 glycerol molecule to release 1 water molecule.
   6. I do not know.

54. Which of the following functions are associated with lipids?
   1. Cell membrane structural formation.
   2. Vitamin production.
   3. High energy production.
   4. Food reservation.
   5. All the above
   6. I do not know.

TURN OVER

55. Bubbling hydrogen gas through polyunsaturated vegetable oil will cause the oil to become more …
    1. unsaturated and more liquid.
    2. unsaturated and more solid.
    3. saturated and more liquid.
    4. saturated and more solid.
    5. saturated and have more double bonds.
    6. I do not know.

56. Identify the term which refers to the arrangement of different protein subunits in a protein complex.
    1. Primary structure
    2. Secondary structure
    3. Tertiary structure
    4. Quaternary structure
    5. All 1, 2, 3 and 4.
    6. I do not know.

57. Serine contains a hydroxyl functional group on its side chain and so its strongest possible interaction will be a(n) …
    1. ionic bond.
    2. hydrogen bond.
    3. van der Waals interactions.
    4. hydrophobic interactions.
    5. covalent.
    6. I do not know.

58. Which of the following statements is **false** regarding transport proteins?
    1. They are present in cell membranes.
    2. They serve to carry polar molecules across the hydrophobic cell membranes.
    3. They are required to transport amino acids across cell membranes.
    4. They are required to transport hydrophobic substances across cell membranes.
    5. They help to transport ionic molecules across the cell membrane.
    6. I do not know.

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59. The repeating units of proteins are ...
   1. glucose.
   2. amino acids.
   3. fatty acids.
   4. glycerol.
   5. peptides.
   6. I do not know.

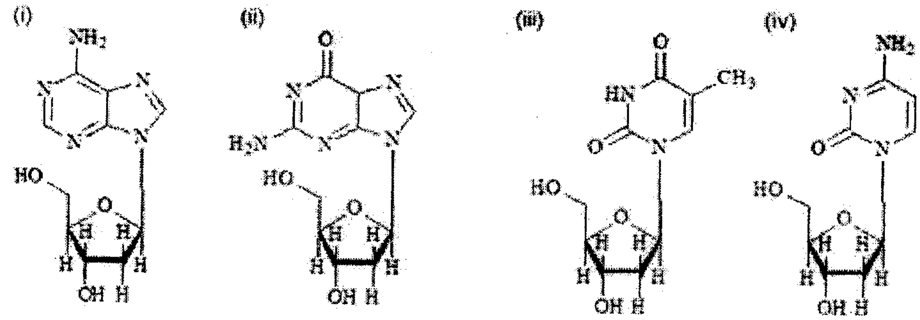
60. Tertiary structure is maintained by ...
   1. peptide bonds.
   2. hydrogen bonds.
   3. di-sulphide bonds.
   4. hydrophobic interactions.
   5. All the above bonds.
   6. I do not know.

61. Complementarity of nitrogenous bases plays a major role in the structure of...
   1. nucleosides.
   2. carbohydrates.
   3. DNA.
   4. RNA.
   5. Both 3 and 4 above.
   6. I do not know.

62. To which of the following does adenine form hydrogen bonds in tRNA?
   1. Guanine
   2. Cytosine
   3. Uracil
   4. Thymine
   5. Adenine
   6. I do not know.

TURN OVER

63. What type of structures are the compounds (i) – (iv)?



1. Nucleic acids
2. Nucleosides
3. Nucleotides
4. Deoxyriboses
5. Riboses
6. I do not know.

64. Eukaryotic DNA is present in …
1. the nucleus only.
2. nucleus, mitochondria and smooth endoplasmic reticulum.
3. mitochondria, rough endoplasmic reticulum and chloroplast.
4. the nucleus, chloroplast and mitochondria.
5. nucleus and cytoplasm.
6. I do not know.

65. DNA is the genetic material in …
1. prokaryotes, eukaryotes and viruses.
2. prokaryotes and eukaryotes only.
3. prokaryotes only.
4. cellular organisms only.
5. eukaryotes only.
6. I do not know.

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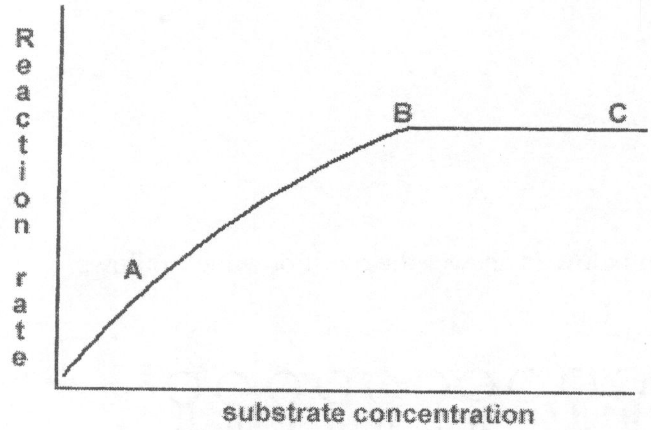
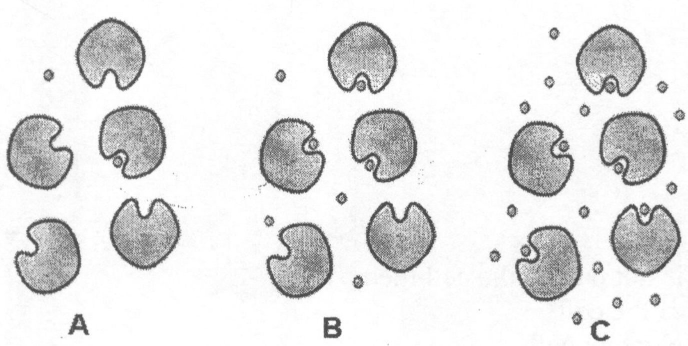
66. Based on the graph below, which of the following could increase the reaction rate?



1. Increase the amount of substrate keeping enzyme concentration constant.
2. Reduce the temperature.
3. Increase the temperature to its optimum.
4. Reduce enzyme concentration, keeping substrate concentration constant.
5. Reduce substrate concentration, keeping enzyme concentration constant.
6. I do not know.

67. In what way could you increase the rate of reaction as it is taking place in image **C**?

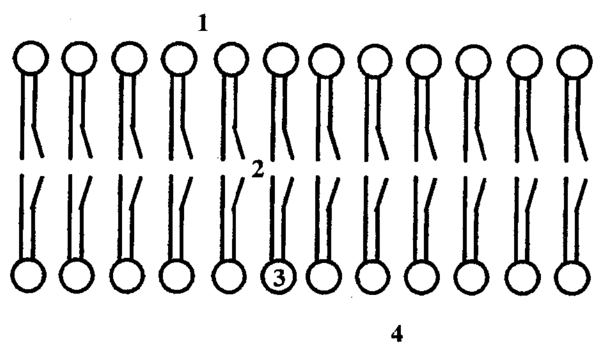


1. Add more substrate.
2. Add more enzyme.
3. Reduce enzyme concentration.
4. Reduce substrate concentration.
5. Add more water.
6. I do not know.

TURN OVER

68. Which substances are used by prokaryotes for movement?
   1. Cilia
   2. Pilli
   3. Flagella
   4. Contractile vacuoles
   5. Cell wall
   6. I do not know.

69. Use the illustration below to answer the question which follows.



Which part in the illustration represents the location where you would expect to find water insoluble substances?

   1. 1
   2. 2
   3. 3
   4. 4
   5. 2 and 3
   6. I do not know.

70. Which of the following is not part of the cell theory?
   1. The basic unit of life is the cell.
   2. Cells came from pre-existing cells.
   3. All living organisms are composed of cells.
   4. All cells contain membrane bound organelles.
   5. All metabolic reactions take place in cells.
   6. I do not know.

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71. Which of the following statements is **false**?
   1. Flagellum is for movement.
   2. DNA can replicate.
   3. Cytoskeleton suspends organelles.
   4. Lysosomes are for digestion of organic waste in a cell.
   5. Animal cells do not have vacuoles.
   6. I do not know.

72. Which of the following terms are **not correctly** matched?
   1. A pilus is for reproduction.
   2. A cell wall is for protection.
   3. A plant vacuole is for storage of waste cell substances.
   4. Liver cells have mitochondria.
   5. Palisade cells have lysosomes.
   6. I do not know.

73. Which process changes a chlorine atom into a chloride ion?
   1. Electron loss.
   2. Electron gain.
   3. Proton gain.
   4. Proton loss.
   5. Neutron gain.
   6. I do not know.

74. How many electrons should a carbon atom gain or lose in order for it to be stable?
   1. Gain 4 or lose 4.
   2. Gain 4 or lose none.
   3. Gain 2 or lose 4.
   4. Gain 2 or lose 2.
   5. Gain four and lose 1.
   6. I do not know.

75. What is the maximum number of electrons that can be accommodated in the first, second and third electron shells of an atom?
   1. 2, 8, 8
   2. 2, 6, 8
   3. 2, 6, 6
   4. 2, 8, 6
   5. 2, 2, 2
   6. I do not know

TURN OVER

76. Non covalent bonds differ from covalent bonds in that ...
   1. They are individually very weak.
   2. They can add up to create a strong attraction force between two very close molecules.
   3. They stabilise associations between two different macromolecules.
   4. They hold together two atoms of different charges.
   5. All 1, 2, 3 and 4 above.
   6. I do not know.

77. Ionic bonds arise from...
   1. sharing electrons between two atoms.
   2. transferring electrons from one atom to another.
   3. glycosidic bonds between two molecules.
   4. dehydration reactions.
   5. polymerization reactions.
   6. I do not know.

78 Which statement is **false** about a pure water sample?
   1. It has a pH of 7.0.
   2. It is composed of polar molecules.
   3. It is composed of ionic bonds.
   4. It is composed of covalent bonds.
   5. It is a good solvent.
   6. I do not know.

79. Which of the following statements is **correct**?
   1. The specific heat capacity of water is very low.
   2. Water freezes at 5 degrees centigrade.
   3. Water expands as the temperature increases.
   4. A lot of energy is required to separate water molecules.
   5. Energy is not required to raise the temperature of water.
   6. I do not know.

80. When water is consumed in a biochemical reaction the process is called ...
   1. melting.
   2. evaporation.
   3. condensation.
   4. frosting.
   5. hydrolysis.
   6. I do not know.

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81. Choose the **correct** statement about the properties of water...
   1. Its specific heat capacity helps keep the temperature of living cells constant.
   2. Its latent heat of vaporization helps in the cooling of living organisms.
   3. Its hydrophobic properties make it a universal solvent.
   4. 1 and 2 are correct.
   5. Solid water sinks at 6 °C.
   6. I do not know.

82. When a water body develops solid ice at the surface, life forms at the bottom of the water body...
   1. suffocate to death.
   2. become hyperactive.
   3. become inactive.
   4. freeze to death.
   5. continue with normal life.
   6. I do not know.

83. The great strength and resistance to hydrolysis of cellulose are due to ...
   1. its branched chains.
   2. the straight chain portion that is associated with 1, 2-glycosidic bonds.
   3. long chains of glucose attached to nitrogen.
   4. parallel arrangement of cellulose fibers.
   5. the straight chain portion that is associated with 1,6-glyosidic bonds.
   6. I do not know.

84. Which one of the following substances has the highest molecular weight?
   1. Glucose
   2. Pentose
   3. Sucrose
   4. Amylopectin
   5. Triose
   6. I do not know

85. What is the difference between a monosaccharide, disaccharide and a polysaccharide?
   1. The number of atoms in a molecule.
   2. The number of hydrogen atoms in a molecule.
   3. The number of monomer units in a molecule.
   4. The type of glyosidic bond between monomer units.
   5. The arrangement of hydroxyl groups in a molecule.
   6. I do not know.

TURN OVER

86. Identify the oligosaccharide from the following substances.
   1. A chain of fifteen monomer units.
   2. Tetrose.
   3. A chain of four monomer units.
   4. A chain with one thousand monomer units.
   5. A branched carbohydrate.
   6. I do not know.

87. One property of condensation reactions is that ...
   1. they are reversible.
   2. they are irreversible.
   3. they cause a breakdown of macromolecules.
   4. they use a lot of water in a cell.
   5. None of the above.
   6. I do not know.

88. Which of the following statements is **correct**?
   1. The melting points of unsaturated fats are lower than those of saturated fats.
   2. The melting points of unsaturated fats are higher than those of saturated fats.
   3. The melting points of both are the same.
   4. All of the above.
   5. None of the above.
   6. I do not know.

89. Phospholipids form a micelle in a water solution because of ...
   1. hydrophilic interactions between water and hydrophobic parts of phospholipids.
   2. hydrophobic interactions between water and phospholipids.
   3. hydrophobic repulsions between hydrocarbon chains.
   4. hydrophilic interactions between heads of phospholipids and water.
   5. hydrophilic interactions between hydrocarbon chains in water.
   6. I do not know.

90. The general formula of a fatty acid is ...
   1. $(CH)_nCH_2\,{}_nCOOH$
   2. $CH_3(CH_2)_nCOOH$
   3. $(CH_2)_nCOOH$
   4. $(COOH)_nCOOH$
   5. $C_3H_8O_3$
   6. I do not know

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91. Which bonds join amino acids together?
    1. Hydrogen bonds.
    2. Hydrophobic forces.
    3. van der Waals forces.
    4. Peptide bonds
    5. Ionic bonds.
    6. I do not know.

92. Globular proteins …
    1. are insoluble in water.
    2. serve as structural materials.
    3. are involved in physiological processes.
    4. are made up of three polypeptide chains in form of fibres.
    5. contain hydrogen bonds only.
    6. I do not know.

93. Which of the following is a functional group of a protein?
    1. An –OH group.
    2. An amino group.
    3. A carboxylic group.
    4. A hydrogen atom.
    5. 1, 2 and 3 are correct.
    6. I do not know.

94. In what form would an amino acid exist at a pH 8?
    1. Zwitterion ion.
    2. The amino acid will have a net charge of zero.
    3. It will become positively charged.
    4. The amino acid will become an anion.
    5. It will become dipolar.
    6. I do not know.

95. Which statement is **true** about the polarity of a polypeptide chain?
    1. It has an amino-terminus and a carboxylic terminus.
    2. The polarity in a peptide chain allows for pH control.
    3. This kind of polarity allows hydrogen bonding.
    4. It refers to hydrophilic properties.
    5. All the above mentioned statements
    6. I do not know

TURN OVER

96. What are the forces that determine the folding of a protein molecule into a unique shape?
   1. Hydrogen bonds.
   2. Ionic interactions.
   3. van der Waals interactions.
   4. Hydrophilic interactions.
   5. All the above.
   6. I do not know.

97. Which one of the following statements about mRNA is **false**?
   1. It carries the genetic information from DNA.
   2. It codes for the synthesis of specific proteins.
   3. It forms associations with ribosomes.
   4. It is made in the nucleus.
   5. Its base triplets are called anticodon.
   6. I do not know.

98. The polarity of a DNA strand is determined by...
   1. the nitrogenous bases containing hydrophilic amino groups.
   2. the presence of uracil in the molecule.
   3. sugar molecules.
   4. hydrogen bonds between the nitrogenous bases.
   5. its sugar-phosphate back-bone.
   6. I do not know.

99. Which statement is true about the following reaction?

$$\text{Substrate (S)} \xrightarrow{\text{Enzyme (E)}} \text{Product (P)}$$

   1. If the concentration of S is high and the concentration of P is low, then enzyme activity is high.
   2. When the concentration of P is high and the concentration of S is low, then enzyme activity is high.
   3. This reaction is irreversible.
   4. When the concentration of E drops, the reaction stops completely.
   5. When the concentration of E is increased, the concentration of S increases as well.
   6. I do not know.

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100. Which of the following is a substance that lowers the activation energy?
   1. An ion
   2. A reactant
   3. A catalyst
   4. A substrate
   5. A product
   6. I do not know.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 1412: MOLECULAR BIOLOGY AND GENETICS
THEORY PAPER **(100 MULTIPLE CHOICE)**

TIME: THREE HOURS

INSTRUCTIONS:

1. **You are not allowed to communicate with any other candidate (Cell phones are not allowed in the examination hall).**
2. If you have any question, raise your hand and wait for the invigilator to attend to you
3. Use the answer sheet provided to answer the questions.
4. Answer **ALL** questions.
5. Use ink to record your answers on the answer sheet.
6. Cross out the wrong and the write the correct one by the side.
7. Choose the best answer from the five options given for each question.
8. The option 'I do not know 'carries 0 marks.
9. Each correct answer carries 4 marks.
10. Each wrong answer carries negative one (-1) mark.
11. A blank space carries negative one (-1) mark.
12. Handover the question paper and answer sheet to the invigilator at the end of examination.
13. Tables required for some questions are given on the last page of the examination paper.

1. Choose the relationship which is true regarding the central dogma of molecular biology.
   1. translation --> replication --> protein.
   2. transcription --> translation-->protein.
   3. translation-->protein--> replication
   4. transcription --> protein -->. translation
   5. transcription --> translation --> replication.
   6. I do not know.

2. Semi-conservative replication of DNA was first demonstrated in...
   1. human beings.
   2. *Escherichia coli.*
   3. onion root tips.
   4. *Drosophila.*
   5. pea plants.
   6. I do not know.

3. The correct sequence of stages of prokaryotic DNA replication is...
   1. initiation --> activation --> termination.
   2. initiation --> polymerisation --> termination.
   3. modification --> activation --> termination.
   4. initiation --> termination --> modification
   5. initiation -->replication --> transcription.
   6. I do not know.

4. The process of removing the ... from pre-mRNA and joining the remaining ... together to form a mature mRNA molecule is called ...
   1. exons, introns, splicing
   2. exons, introns, transcription
   3. introns, exons, post-transcriptional modification,
   4. introns, exons, poly A tail addition.
   5. introns, exons, posttranslational modification.
   6. I do not know.

5. The presence of a methylated guanine head on an RNA molecule indicates...
   1. exons which must be removed.
   2. a newly synthesised tRNA molecule.
   3. the initiation of transcription.
   4. a mature tRNA molecule.
   5. a mature mRNA molecule.
   6. I do not know

6. Ribosomal RNA ...
   1. is synthesised in the prokaryotic nucleolus.
   2. combines with tRNA to form ribosomes.
   3. is synthesised in the eukaryotic cytoplasm.
   4. is synthesised in the eukaryotic nucleolus.
   5. carries the genetic code.
   6. I do not know

7. Which of the following does not code for an amino acid?
   1. AUG
   2. UGA
   3. UUU.
   4. CCG.
   5. UGG
   6. I do not know.

8. Choose the statement which represents the Wobble hypothesis.
   1. The genetic code is universal.
   2. Two amino acids may have one codon.
   3. The tRNA molecule has a complex shape
   4. There are more than one stop codons.
   5. The codon CUG may pair with the anticodon GAU
   6. I do not know.

9. The codon, anticodon and DNA sequence for tryptophan are ... and ... respectively
   1. UGG, ACC, TGG
   2. UGG, ACC, ACC
   3. UGA, ACU, ACT
   4. AUG, AUC, ATC
   5. AUG, UAC, TAC
   6. I do not know

10. During the process of translation...
    1. the growing polypeptide is passed from the P-site to the outside.
    2. all incoming tRNAs must first bind to the P-site.
    3. initiation begins with the binding of the ribosome to the start anticodon.
    4. the message on tRNA is translated into a polypeptide.
    5. termination is achieved by the binding of tRNA to the stop codon.
    6. I do not know.

11. The role of mRNA is to...
    1. speed up the process of protein synthesis.
    2. translate the genetic code into a specific amino acid.
    3. transmit genetic information for protein synthesis.
    4. modify newly synthesised proteins.
    5. provide information needed for DNA synthesis.
    6. I do not know.

12. The enzyme amino acyl-tRNA synthetase....
    1. synthesises tRNA.
    2. activates the target amino acid.
    3. attaches an amino acid to tRNA.
    4. synthesises mRNA.
    5. activates the target tRNA.
    6. I do not know.

13. The term gene expression is the ...
    1. production of a protein from information on DNA.
    2. production of gametes from the male or female gonads.
    3. fertilization of the female gamete by the male gamete.
    4. conversion of an enzyme from its inactive form into its active form.
    5. removal of introns from pre-mRNA.
    6. I do not know.

14. Choose the item which is not part of the *Lac* operon.
    1. Repressor
    2. Regulator
    3. Inducer
    4. Promoter.
    5. 1 and 3 above
    6. I do not know.

15. A bivalent is made up of ...
    1. two chromatids.
    2. sister chromatids.
    3. Four homologous chromatids.
    4. 1 and 2 above are correct.
    5. 1 and 3 above are correct.
    6. I do not know

16. Explain what happens during the G2 phase.
    1. Chromosomes replicate.
    2. DNA duplicates.
    3. Enzymes and proteins are synthesised.
    4. A cell experiences growth.
    5. 2 and 4 above.
    6. I do not know

17. In mitosis chromatids are held together by ...
    1. centromere.
    2. spindle fibre
    3. centrosome
    4. centrioles
    5. microtubules
    6. I do not know.

18. Choose the event which corresponds to prophase.
    1. Formation of a wall plate
    2. Formation of four haploid chromosomes
    3. Formation of spindle fibres
    4. Alignment of chromosomes along the equatorial plate.
    5. Separation of sister chromatids.
    6. I do not know.

19. Cell plate formation is a feature of ...
    1. bacterial cell division.
    2. plant and animal cell division.
    3. animal cell division.
    4. plant cell division.
    5. plant and bacterial cell division.
    6. I do not know

20. Separation of bivalents takes place during ...
    1. telophase.
    2. anaphase I.
    3. metaphase II.
    4. prophase I.
    5. anaphase II.
    6. I do not know.

21. Choose the stage when the diploid cell becomes haploid.
    1. Prophase I.
    2. Metaphase II.
    3. Anaphase II.
    4. Anaphase I.
    5. Telophase I.
    6. I do not know.

22. In a monohybrid cross the ...
    1. recessive phenotype disappears in the F_1 generation.
    2. dominant phenotype disappears in the F_2 generation.
    3. recessive phenotype re-appears in the F_1 generation.
    4. recessive phenotype appears in the F_1 generation..
    5. co-dominant phenotype disappears in the F_1 generation.
    6. I do not know.

23. In a monohybrid testcross ...
    1. all the progeny have the recessive phenotype.
    2. the progeny phenotypic ratio is 3:1
    3. the progeny phenotypic ratio is 1:1.
    4. the progeny phenotypic ratio is 1:2:1
    5. the progeny have three phenotypes.
    6. I do not know.

24. A monohybrid test cross is used to ...
    1. test the phenotype condition of a dominant parent.
    2. test the genotype condition of a dominant phenotype.
    3. test the genotype condition of a homozygous recessive parent.
    4. test the phenotype condition of a heterozygous recessive parent.
    5. test for both genotype and phenotype of heterozygous parents.
    6. I do not know.

25. One pure variety of peas has yellow seeds which have a smooth shape while another variety has green seeds which have a wrinkled shape. The F_2 generation of these two varieties has some plants with yellow seeds which are wrinkled. The observation in the F_2 generation is because of...
   1. multiple alleles.
   2. parents who are dihybrid.
   3. the events of prophase I
   4. incomplete dominance
   5. co-dominance.
   6. I do not know.

26. The F_2 generation of a dihybrid cross will have ... genotypes and.... phenotypes.
   1. 4, 9
   2. 4, 16
   3. 9, 4
   4. 16:4
   5. 8, 8
   6. I do not know.

27. The dihybrid cross YyRr x yyRR will produce:
   1. 4 genotypes and 9 phenotypes
   2. 2 phenotypes and 4 genotypes
   3. 2 genotypes and 2 phenotypes
   4. 4 genotypes and 2 phenotypes
   5. 9 genotypes and 4 phenotypes
   6. I do not know.

Q28- 30. Use the information below to answer these questions.

A cross was carried out between two plants; YyRr (yellow, round seeds) x yyrr (green, wrinkled seeds). Out of 96 progeny, the following results were obtained:

Yellow round	58
Yellow wrinkled	11
Green round	12
Green wrinkled	35

A chi-squared test was carried out to test the results of the progeny using Table 1 and probability value of 0.05.

Table 1. Tabulated (critical) chi-squared values for up to four degrees of freedom

		Probability							
		0.01	0.05	0.10	0.20	0.5	0.7	0.8	0.9
Degrees of freedom	1	6.6	3.8	2.7	1.6	0.5	0.2	0.06	0.02
	2	9.2	6.0	4.6	3.2	1.4	0.7	0.5	0.2
	3	16.3	7.8	6.3	4.6	2.4	1.4	1.0	0.6
	4	13.3	9.5	9.2	7.3	4.4	3.0	2.3	1.6

28. The calculated chi-squared value is...
   1. 150.
   2. 36.
   3. 5%.
   4. 95%.
   5. 65.
   6. I do not know.

29. The degrees of freedom are...
   1. 2.
   2. 3.
   3. 4.
   4. 9.
   5. 16.
   6. I do not know.

30. Use the results of the test in question 28 to make your conclusion at probability value of 0.05.
   1. The results agree with the Mendelian F_2 dihybrid ratio.
   2. The results do not agree with the Mendelian F_2 dihybrid ratio.
   3. The results agree with the Mendelian F_1 dihybrid ratio.
   4. The results do not agree with the Mendelian F_2 monohybrid ratio.
   5. The results agree with the principle of multiple alleles.
   6. I do not know.

31. Which of the following is (are) involved in a the replication fork?
   1. DNA helicase
   2. RNA primer
   3. DNA polymerase III
   4. Single stranded binding proteins.
   5. All of the above components
   6. I do not know

32. DNA replication is semi-conservative because the … strand will be complemented by a new strand in the … helix.
   1. RNA; DNA
   2. Primer; DNA
   3. template; double
   4. new; double
   5. lagging; RNA
   6. I do not know

33. Why must the lagging strand of DNA be replicated in short pieces?
   1. Because of limited space between the forks.
   2. To avoid the helix getting distorted.
   3. Ligase can synthesise a short length of nucleic acid.
   4. DNA polymerase III can synthesize a strand of DNA 5^{I} to 3^{I} direction.
   5. It helps with proof reading during the polymerisation process.
   6. I do not know

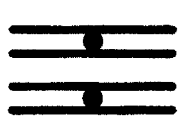
34. Which one of the following is false about mRNA processing in eukaryotes?
   1. Exons are not affected by post-transcription of mRNA.
   2. The primary mRNA transcript is longer than mature mRNA.
   3. Exons are excised and hydrolyzed before mRNA moves out of the nucleus.
   4. Introns are removed before mRNA leaves the nucleus.
   5. Primary mRNA transcript is modified by 5' capping and 3' polyadenylation.
   6. I do not know

35. Which one of the following statements is correct about RNA polymerase?
   1. It facilitates replication in DNA duplication.
   2. It establishes hydrogen bonds between nucleotides in DNA.
   3. It polymerises both introns and exons.
   4. It is involved in polymerisation of DNA strands.
   5. It recognizes promoter sequences on DNA for replication to take place.
   6. I do not know

36. Using the genetic code provided, identify the 5'to 3' nucleotide sequence for the tripeptide Phe-Gly – Lys.
   1. UUU GGG AAA
   2. GAA CCC CTT
   3. AAA ACC TTT
   4. CTT CGG GAA
   5. AAA CCC UUU
   6. I do not know.

37. Choose the statement which is false.
   1. An allele is responsible for many visible traits.
   2. Every trait is potentially affected by many genes.
   3. The sequence of nucleotides in a gene specifies the sequence of amino acids.
   4. Every amino acid is coded for by one codon.
   5. Many traits are affected by both the environment and genes.
   6. I do not know.

38. Study the homologous chromosomes given below.



A
B
C
D

Cross over can take place between the following pairs of chromatids;
   1. A and D
   2. B and C
   3. C and D
   4. B and D
   5. 1, 2 and 4 are possible.
   6. I do not know.

39. Choose the correct statement.
 1. The cells from which gametes are produced are haploid.
 2. Sexual reproduction provides for genetic variation.
 3. The male reproductive organs are called gametes.
 4. Mitosis produces a tetrad of cells.
 5. Meiosis is important because it is responsible for repair of broken tissue.
 6. I do not know.

40. Choose the false statement.
 1. Synapsis is a regular occurrence in meiosis.
 2. Mitosis is a reductional division.
 3. The male reproductive organs produce gametes.
 4. The genetic content of tissue cells are identical.
 5. All of the above statements are false.
 6. I do not know.

41. Chromosomes are best observed at the stage of …
 1. Interphase
 2. Prophase
 3. Metaphase
 4. Anaphase
 5. Telophase
 6. I do not know.

42. Which one of the following is not part of a eukaryotic chromosome in any phase?
 1. Centriole
 2. Histone
 3. Nucleosome
 4. Chromatin
 5. Centromere
 6. I do not know

43. In anaphase I, the …
 1. chromatids are pulled apart.
 2. centromeres are replicated.
 3. chromosomes exchange segments of DNA.
 4. non-sister chromatids are separated.
 5. centrioles replicate.
 6. I do not know.

44. Ribosomal RNA, …
 1. is a site for polypeptide synthesis.
 2. is a transport molecule for amino acids to the ribosome.
 3. travels to the ribosome to direct the assembly of polypeptides.
 4. transcribes DNA.
 5. translates DNA codes into proteins.
 6. I do not know.

45. A somatic cell has 24 chromosomes aligned at metaphase. How many chromosomes are present at anaphase?
    1. 12
    2. 24
    3. 36
    4. 48
    5. 96
    6. I do not know.

46. Interphase is the part of a cell cycle when...
    1. a cell ceases to function.
    2. a germ cell forms its spindle apparatus.
    3. a cell grows and duplicates its DNA.
    4. mitosis proceeds.
    5. meiosis takes place.
    6. I do not know

47. Which of the following components of DNA replication involves multiple RNA primers?
    1. Unwinding DNA double helix.
    2. Leading-strand DNA synthesis.
    3. Lagging-strand DNA synthesis.
    4. Telomere synthesis.
    5. Repair of damaged DNA.
    6. I do not know.

48. Which of the following statements is true about Mendel?
    1. His discoveries concerning genetic inheritance were generally accepted by scientific community in the mid-19th Centaury.
    2. His discoveries concerning genetic inheritance were generally rejected by scientific community in the mid-19th Century.
    3. He believed that genetic traits of parents would usually blend in their children.
    4. He carried out experiments about gene linkage.
    5. 2 and 4 are correct.
    6. I do not know

49. The idea that different pairs of alleles are passed to offspring independently is Mendel's principle of ...
    1. unit inheritance.
    2. segregation.
    3. independent assortment.
    4. linkage.
    5. incomplete dominance.
    6. I do not know.

50. A lethal condition arises when …
    1. one allele is dominant to the other.
    2. both alleles independently express themselves equally.
    3. alleles are tightly linked on the same chromosome.
    4. both alleles fail to express themselves.
    5. the allele is in a homozygous condition.
    6. I do not know.

51. Which of the following is not a property of the genetic code? It is …
    1. non overlapping
    2. almost universal
    3. ambiguous
    4. commaless
    5. redundant
    6. I do not know

52. The expression of a given gene in a cell depends on …
    1. the type of cell and its function.
    2. its biochemical conditions.
    3. its cellular signals.
    4. presence of appropriate enzymes in the cell.
    5. All of the above
    6. I do not know

53. In prokaryotic cells the … precedes the structural operon gene.
    1. lactose molecule
    2. repressor
    3. promoter
    4. operator
    5. Both 3 and 4
    6. I do not know

54. Phenylketon uria (PKU) is an inherited disease caused by a recessive allele p. If a woman and her husband are normal but carry the recessive allele, which one of the following statements would be correct?
    1. All their children will be of normal phenotype.
    2. All their children will have the disease
    3. At least one child will have the disease
    4. Half of their children will have the disease
    5. Three-quarters of the children will have the disease.
    6. I do not know.

55. Crossing over occur during…
    1. laptotene.
    2. pachytene.
    3. diplotene.
    4. zygotene.
    5. diakinesis.
    6. I do not know.

56. Linkage prevents …
    1. homozygous condition.
    2. heterozygous condition.
    3. recombination.
    4. segregation of alleles.
    5. coupling and repulsion phenomenon.
    6. I do not know.

57. Elongation of the leading strand during DNA replication …
    1. progresses away from the replication fork.
    2. occurs in the 3' to 5' direction.
    3. produces Okazaki fragments.
    4. depends on the action of DNA polymerase III.
    5. does not require a primer.
    6. I do not know.

58. Multiple replication forks along the DNA …
    1. correct replication errors.
    2. reduce DNA replication time.
    3. increase DNA replication time.
    4. ensure that the new and old DNA strands are complementary.
    5. signal DNA polymerase to stop.
    6. I do not know.

59. In the ABO blood system, alleles I^A and I^B are co-dominant to each other and they are both dominant to allele I^O. Predict the parental phenotypes whose mating produces the following offspring blood genotypes: I^AI^B; I^AI^O; I^BI^O and I^OI^O
    1. O and O
    2. B and O
    3. A and O
    4. A and A
    5. A and B
    6. I do not know

65. Which of the following enzymes are used to join bits of DNA?
    1. Endonuclease
    2. RNA primase
    3. DNA polymerase
    4. RNA ligase
    5. DNA ligase
    6. I do not know.

66. When DNA replication starts …
    1. the leading strand produces Okazaki fragments.
    2. hydrogen bonds between nucleotides of two strands break.
    3. bonds between the nitrogenous bases and the deoxyribose sugars break.
    4. the phosphodiester bonds between two adjacent nucleotides break.
    5. hydrogen bonds between nucleotides in the phosphate backbone of DNA break.
    6. I do not know

67. The process involved in the formation of RNA from a DNA template is called …
    1. transcription.
    2. translation.
    3. replication.
    4. transformation.
    5. protein synthesis.
    6. I do not know.

68. Which part of tRNA forms hydrogen bonds with mRNA?
    1. Terminal $3'$end of molecule.
    2. Terminal $5'$ end of the molecule.
    3. Codon.
    4. Anticodon
    5. Acceptor arm
    6. I do not know.

69. The DNA template for protein synthesis has the following base sequence: AGCTTCGA. Determine the order of complementary bases in mRNA.
    1. TCGAAGCT
    2. UGCUAGCT
    3. TCGAUCGU
    4. UCGAAGCU
    5. UGCAAGCA
    6. I do not know.

70. Which of the following statements is correct?
    1. A charged tRNA is one that has an amino acid attached to it.
    2. A source of energy is required for an amino acid to get activated.
    3. The acceptor arm of tRNA ends in the nitrogenous bases CCA.
    4. The bond between tRNA and amino acid breaks in the P site.
    5. All the above statements are correct.
    6. I do not know.

71. Which of the following is not directly involved in translation?
   1. mRNA
   2. tRNA
   3. Ribosomes
   4. translocase enzyme
   5. RNA polymerase
   6. I do not know.

72. If a codon on a DNA non-template strand is ATC, the corresponding tRNA anticodon will be …
   1. ATC.
   2. AUC.
   3. UAG.
   4. TAG.
   5. TAG.
   6. I do not know.

73. Which of the following is the most appropriate definition of an operator?
   1. A series of genes that are controlled by one promoter site on DNA.
   2. A set of coding regulatory sequence of bases on DNA.
   3. A DNA binding protein that helps to transcribe a cluster of genes.
   4. A protein that is transcribed by nonstructural genes.
   5. A non-coding regulatory DNA sequence to which a repressor protein binds.
   6. I do not know.

74. Which of the following is true of the lac operon in *E. coli*?
   1. The operon is only switched on in the absence of lactose.
   2. The lac operon is polycistronic mRNA.
   3. β-galactosidase is only produced in large quantities when the lac repressor is bound to the operator.
   4. The promoter is the binding site for the lac repressor.
   5. The operon enzyme transcribes the structural genes when the lac repressor is bound to the operator site.
   6. I do not know.

75. There are … possible combinations, of … sequences that can be made from …
   1. 60; four-letter nucleotide; four nucleotides.
   2. 64; three-letter nucleotide; three nitrogenous bases.
   3. 61; three-letter nucleotide; three nitrogenous bases.
   4. 64; three-letter nucleotide; four nitrogenous bases.
   5. 58; two-letter nucleotide; four nucleotides.
   6. I do not know.

76. The first mRNA codon to specify an amino acid is always
    1. TAC.
    2. UAA.
    3. UAG.
    4. AUG.
    5. UUA
    6. I do not know.

77. Transcription occurs along a DNA template in the direction … forming mRNA in the … direction.
    1. 5' to 3'; 5' to 3'
    2. 5' to 3'; 3' to 5'
    3. 3' to 5'; 5' to 3'
    4. 3' to 5'; 3' to 5'
    5. 3 and 4 above are correct
    6. I do not know

78. Chromosomes that are of the same size, shape and banding pattern are called …
    1. sister chromatids.
    2. duplicates.
    3. homologues.
    4. non-sister chromatids.
    5. bivalents.
    6. I do not know

79. The process of matching chromosomes becoming zipped together occurs during …
    1. prophase I.
    2. prophase II.
    3. metaphase I
    4. metaphase II.
    5. Anaphase II.
    6. I do not know

80. Chromosome theory of inheritance states that …
    1. genes occupy specific positions on chromosomes.
    2. homologous chromosomes segregate from each other during meiosis.
    3. non homologous chromosomes assort independently during meiosis.
    4. 1, 2 and 3 above are correct.
    5. Only 1 above is correct.
    6. I do not know.

81. The three base sequence of DNA codes for one …
    1. protein.
    2. strand of mRNA.
    3. amino acid.
    4. polypeptide.
    5. strand of tRNA.
    6. I do not know

82. Someone who is homozygous has ...
1. only one dominant allele for a gene.
2. only one recessive allele for a gene.
3. two different alleles for a gene.
4. neither dominant nor recessive alleles for a gene.
5. two copies of the same allele for a gene.
6. I do not know

83. From a cross of heterozygotes, which of the following ratios indicates presence of a lethal gene?
1. 1:1
2. 1:2:1
3. 2:1
4. 3:1
5. 4:1
6. I do not know

84. There are three possible alleles of the blood group gene: I^A, I^B and I^O. However, in an individual, there can be only two alleles; one contributed by the father and another by the mother. Considered together in a population there can be … genotypes and … distinct phenotypes.
1. four; six
2. three; two
3. six; four
4. five; two.
5. four; two
6. I do not know

85. An animal somatic cell nucleus contains 12 chromosomes while a nucleus of a sperm cell contain only 6 chromosomes. What does "n" equal to for this species?
1. 3
2. 6
3. 12
4. 24
5. 48
6. I do not know

86. During which of the following stages of a cell cycle would a chromosome consist of only a single chromatid?
1. Karyokinesis
2. mitotic metaphase
3. Mitotic prophase
4. G1.
5. G2.
6. I do not know.

87. Which of the following events occurs in meiosis but not in mitosis?
    1. Segregation of sister chromatids.
    2. Pairing of homologous chromosomes.
    3. Crossing-over between homologous chromosomes.
    4. Alignment of chromosomes on the metaphase plate.
    5. 2 and 3 are both correct.
    6. I do not know.

88. In the life cycle of a human cell, each chromosome contains two chromatids by the end of the ... phase.
    1. G1
    2. G2
    3. metaphase
    4. synthesis
    5. cytokinesis
    6. I do not know.

89. Unattached earlobes is dominant to attached earlobes. Two parents, both with unattached earlobes, had a child with attached earlobes. What are the chances that their next child will have attached earlobes?
    1. 100%
    2. 75%
    3. 50%
    4. 25%
    5. 0%
    6. I do not know.

A cross between plants with red flowers (C^R) were crossed with plants which bear white flowers (C^W). The offspring had pink flowers. (Use this information to answer questions 90 and 91).

90. Identify the parental cross which gave rise to the results above.
    1. $C^R C^R$ x $C^R C^R$
    2. $C^W C^R$ x $C^W C^R$
    3. $C^R C^R$ x $C^W C^W$
    4. $C^W C^W$ x $C^W C^W$
    5. $C^R C^R$ x $C^W C^R$
    6. I do not know.

91. Identify the kind of inheritance shown in the cross above.
    1. Complete dominance
    2. Incomplete dominance
    3. Codominance
    4. Inheritance involving lethal genes.
    5. Multiple allele inheritance.
    6. I do not know.

92. Vanica noticed that there was a lot of variation in height among her classmates. From this observation what do you know about the inheritance pattern of height?
    1. Tallness is dominant to shortness.
    2. Several of the children are taking growth hormones.
    3. It is continuous variation.
    4. It is dependent on the environment each one comes from.
    5. It is controlled by a few genes.
    6. I do not know.

93. From a cross of heterozygotes, which of the following ratios show co-dominance?
    1. 4:1
    2. 1:1
    3. 1:2:1
    4. 3:1
    5. 2:1
    6. I do not know.

94. What type of blood group will the offspring of the following parents have?
    Mother with blood group AB x Father with blood group O.
    1. O
    2. A or B
    3. AB
    4. A or O
    5. O or B
    6. I do not know.

95. What amino acid is coded by the triplet of bases UAU?
    1. Phenylalanine
    2. Serine
    3. Tyrosine
    4. Cysteine
    5. Glycine
    6. I do not know.

96. In the F2 generation, the 3:1 ratio is really a disguised …
    1. 1:2:1
    2. 2:1:1
    3. 1:1:2
    4. 4:0
    5 4:1
    6. I do not know.

97. Advantages to using the garden pea for Mendel's experiments included all listed below except ...
    1. true-breeding varieties were scarce.
    2. he could expect to observe segregation of traits among the offspring.
    3. they have relatively short generation time.
    4. sex organs of the pea are enclosed within the flower.
    5 provided large population samples.
    6. I do not know.

98. The wobble hypothesis refers to the ...
    1. ability of tRNA to fit in many different positions on mRNA.
    2. ability of DNA to make more than one type of RNA.
    3. ability of tRNA to match with codons that may differ in the third base.
    4. shifting of the reading frame through the translocation of the ribosome during translation .
    5 ability of mRNA to attach to one tRNA.
    6. I do not know.

99. During initiation of prodkaryotic translation, formylmethionine binds to the ...
    1. 50S ribosomal subunit.
    2. 80S ribosome.
    3. 30S ribosomal subunit.
    4. 60S ribosome.
    5 70S ribosome.
    6. I do not know.

100. Which of the following is correct?
    1. Each chromosome has four chromatids at metaphase of mitosis.
    2. Each chromatid becomes a chromosome at metaphase of mitosis.
    3. Mitosis produces four genetically identical daughter cells.
    4. Centrioles are components of a centrosome.
    5 Each centriole has a set of three microtubules.
    6. I do not know

The genetic code

MIDDLE LETTER

FIRST LETTER (5' END)	U	C	A	G	THIRD LETTER (3' END)
U	UUU, UUC: phenyl - alanine UUA, UUG: Leucine	UCU, UCC, UCA, UCG: Serine	UAU, UAC: Tyrosine UAA* UAG*	UGU, UGC: Cysteine UGA* UGG: Trypto - phan	U C A G
C	CUU, CUC, CUA, CUG: Leucine	CCU, CCC, CCA, CCG: Proline	CAU, CAC: Histidine CAA, CAG: Glutamine	CGU, CGC, CGA, CGG: Arginine	U C A G
A	AUU, AUC, AUA: Isoleu - cine AUG†: Methio - nine	ACU, ACC, ACA, ACG: Threonine	AAU, AAC: Asparagine AAA, AAG: Lysine	AGU, AGC: Serine AGA, AGG: Arginine	U C A G
G	GUU, GUC, GUA, GUG†: Valine	GCU, GCC, GCA, GCG: Alanine	GAU, GAC: Aspartic acid GAA, GAG: Glutamic acid	GGU, GGC, GGA, GGG: Glycine	U C A G

http://images.tutorvista.com/content/gene-expression/genetic-codes.jpeg (retrieved 07/09/16)

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 2002: STATISTICAL ANALYSIS OF BIOLOGICAL DATA
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS; TWO FROM EACH SECTION AND THE FIFTH FROM EITHER SECTION. FOR EACH SECTION USE **SEPARATE ANSWER BOOKS**. ILLUSTRATE YOUR ANSWER WHERE NECESSARY.

SECTION A

1. In Table 1 are the lengths (to the nearest whole millimeter) of 100 shoots grown from seeds that were planted at the same time.

Table 1: Lengths of 100 shoots (mm).

76	73	75	73	74	74	74	74	74	77
74	72	75	76	73	71	73	80	75	75
68	72	78	74	75	74	69	77	77	72
72	76	76	77	70	77	72	74	77	76
78	72	70	74	76	72	73	71	74	74
75	79	75	74	75	74	71	73	75	73
75	70	73	75	70	72	72	71	76	73
74	76	74	75	74	76	75	75	73	73
78	74	73	75	74	73	72	76	73	76
74	71	72	71	79	78	69	77	73	71

a) By using a class interval of 1, prepare a frequency distribution for these data.
b) Determine the mean of the shoot- length measurements.
c) Determine the standard deviation of the 100 shoot-length measurements.

TURN OVER

2. Long- term studies of a pond community have shown that it is inhabited by only two species of meniscus midge (Diptera: Dixidae), namely *Dixella autumnalis* and *Dixella attica*.
The pupae, which are indistinguishable are dispersed randomly and independently in the habitat, are collected from emergent vegetation just above the water line, and emerge as adults within a few days in the captivity. On the basis of very large samples it is known that on average 80 out of every 100 pupae collected will emerge as D. *autumnalis* and the remainder as D. *attica*. It is also known that, on average, insects emerge in the ratio 1:1 males to females, i.e. 1 out of every 2 is a male, and the other a female. Assume that there is negligible mortality during pupation, and that an 'event' is the hatching of a pupa which has been selected at random.

   a) Determine the probability that the outcome of an event is *D. autumnalis*.
   b) Determine the probability that the outcome of an event will be a male.
   c) Estimate the probability that the outcome of an event will be either *D. autumnalis* or *D. attica*.
   d) Estimate the probability that the outcome of an event will be female *D. attica*.
   e) If the outcome of an event is described in terms of species and sex, show that the sum of the probability distribution for all possible outcomes is equal to 1.
   f) Using the probability distribution estimated in (e), determine the expected frequency of each outcome in terms of species and sex in a sample of 200 collected from a different pond if the same conditions are presumed to apply.

3. (a) Describe different types of graphical presentation of data.
   (b) Use the data in Table 2 to construct a multiple bar chart.

Table 2: Grain production for the period of 3 years (1969 – 1972).

Year	**Production (million tonnes)**		
	Rice	Wheat	Coarse grains
1969- 1970	40.43	25.09	17.29
1970- 1971	42.23	25.83	20.54
1971- 1972	42.74	24.47	26.39

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4. A testing lab wishes to test two experimental brands of outdoor paint to see how long each will last before fading. The testing lab makes 6 gallons of each paint to test. Since different chemical agents are added to each group and only six cans are involved, these two groups constitute two small populations. The results (in months) were as shown in Table 3 below.

Table 3: Fading period (in months) of outdoor paint

Brand X	**Brand Y**
10	35
60	45
50	30
30	35
40	40
20	25

(a) Find the mean time for each group of paint.
(b) Determine the spread or variability of the data set using the range, variance and standard deviation.

SECTION B

5. (a) Making a type I error than type II error is more common in statistics.
(i) Differentiate type I from type II error~~s~~.
(ii) Explain how type I error can be overcome.
(b) ~~(iii)~~ List three conditions that are necessary in conducting ANOVA test.
(c) State what letters A to F in Table 4 represent.

Table 4: Sample t – test.

One – sample t - test		Two – sample t - test	
null hypothesis	alternative hypothesis	null hypothesis	alternative hypothesis
$\mu \leq \mu_0$	A	$\mu_1 \leq \mu_2$	D
B	$\mu \neq \mu_0$	E	$\mu_1 \neq \mu_2$
C	$\mu < \mu_0$	F	$\mu_1 < \mu_2$

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6. A random sample of 10 young men was taken and the heart rate (HR) in beats /minute of each young man was measured before and after taking a cup of caffeinated coffee. The measurements were recorded in Table 5.

Table 5: Heart rate measurements (beats/minute) in 10 young men.

Subject	HR (beats/minute) Before	HR (beats/minute) After
1	68	74
2	64	68
3	52	60
4	76	72
5	78	76
6	62	68
7	66	72
8	76	76
9	78	80
10	60	64

(a) Using data provided in Table 5, explain if it can be concluded that caffeinated coffee has an effect on the heart rate of young men. (Level of significance = 0.05)

(b) Determine the 95% confidence interval for mean differences.

7. You are provided with height and diameter measurements in table 6 taken from 12 plants selected randomly from a population.

Table 6: Diameter and height measurements.

Plant ID	Diameter (mm)	Height (m)
A1	4.3	0.102
A2	4.5	0.115
A3	5.2	0.123
A4	6.9	0.126
A5	7.3	0.135
A6	8	0.143
B1	8.5	0.157
B2	8.9	0.160
B3	9.2	0.161
B4	10	0.178
B5	11.5	0.200
B6	12.7	0.250

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Given that the linear regression of the data in Table 6 is y = 0.0149x + 0.0338, answer the following:

(a) Calculate the coefficient of determination.
(b) Draw a conclusion from the coefficient of determination calculated in part a above.
(c) Given that diameter of 12mm was measured on one plant, estimate the expected height of this plant.

8. Height measurements (m) were taken on five provenances (A to E) as indicated below:

A: 28 34 33 20 30
B: 33 31 37
C: 23 27
D: 21 28 12 15
E: 63 126 70

Using the data on height measurements for different provenances, determine if it can be concluded that all height means for provenances are equal.
(Level of significance = 0.05).

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 2302: BASIC MICROBIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS, **TWO** FROM EACH SECTION, AND THE **FIFTH** FROM EITHER SECTION. ILLUSTRATE YOUR ANSWER WHERE NECESSARY. USE **SEPERATE ANSWER BOOKLETS** FOR EACH SECTION.

SECTION A

1. Describe bacterial growth where marked differences appear between the parent cell and daughter cell. Give examples.

2. Describe methods by which bacteria develop genetic variants.

3. (a) Describe the arrangement of prokaryotic flagellum.
   (b) Describe the ultra structure and the mechanism of prokaryotic flagellum movement.
4. Discribe the structure and function of mesosomes and ribosomes in prokaryotes.

SECTION B

5. Describe the variations in viruses with reference to their shape, size, structure and envelope.

6. Summarise two of the following:
   (a) Lysogenic cycle in bacteriophages.
   (b) Criteria used for LHT system of virus classification.
   (c) Structure of Human Immunodeficiency Virus (HIV).

7. (a) Describe the methods used for isolation and cultivation of bacteriophages and animal viruses.
   (b) List the approved characters for the identification of viruses as suggested by Gibbs *et al.* in 1966.

8. Discuss Tobacco Mosaic Virus (TMV) in relation to its symptoms, structure, protein synthesis and mode of transmission.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 2701: BASIC PTHYSIOLOGY
HEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS; **TWO** FROM EACH SECTION AND THE **FIFTH** FROM EITHER SECTION. ILLUSTRATE YOUR ANSWER WHERE NECESSARY. USE **SEPARATE ANSWER BOOKS** FOR EACH SECTION.

SECTION A: Plant Physiology

1. (a) Discuss the internal and external factors, with respect to the plant, which affect water uptake from the soil by plant roots.
   (b) Calculate the hydraulic conductance of a mesophytic plant root system with the following parameters:
   Total surface area of root system = 7.5×10^{-3} m^2;
   Root resistance = 1.33×10^9 MPa s m^{-3}.

2. Draw a labelled diagram showing assimilation of carbon dioxide in a C_3 plant. Use chemical structures for the substances involved in the reactions, except for enzymes. On the diagram indicate the carboxylation, reduction and regeneration phases of the cycle.

3. (a) Explain the mechanism of each of the following processes:
   (i) Absorption of light energy by chloroplast photosynthetic pigment molecule.
   (ii) Energy transduction in the light-harvesting complexes until the reaction centers of PS I or PS II.
   (iii) Capture of light energy by chlorophyll P680 or P700.
   (b) Draw the current version of the "Z-scheme" of electron transport for O_2-evolving photosynthetic organisms.

4. (a) Draw the chemical structure of gibberellic acid 1 (GA_1).
   (b) Discuss the physiological effects and action of gibberellins in each of the following:
   (i) Stem growth.
   (ii) Cereal seed germination.

TURN OVER

SECTION B: Animal Physiology

5. (a) Draw a labelled diagram of the oxygen dissociation curves for adult haemoglobin, foetal haemoglobin and myoglobin.
   (b) Explain the significance of the O_2 dissociation curve for adult haemoglobin.
   (c) Explain the significance of the differences in the shapes of the curves for adult haemoglobin, foetal haemoglobin and myoglobin.

6. Discuss enzymatic protein digestion and absorption in the human alimentary canal.

7. (a) Draw a labelled diagram of a nephron.
   (b) Discuss the counter current multiplier mechanism in urine formation in the mammalian nephron.

8. Discuss the generation and propagation of an action potential in a myelinated neuron.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 2801: DIVERSITY OF PLANTS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS, TWO QUESTIONS FROM EACH SECTION AND THE FIFTH QUESTION FROM EITHER SECTION. USE SEPARATE ANSWER BOOKS FOR EACH SECTION. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY.

SECTION A

1. Describe chloroplast variability in Chlorophyta with reference to named examples.

2. Compare and contrast plant structure and reproduction in *Ulothrix* and *Spirogyra*.

3. (a) Describe special features of the Chaetophorales.
   (b) Compare and contrast plant structure in *Stigeoclonium*, *Draparnaldia* and *Draparnaldiopsis*.

4. Describe plant structure and sexual reproduction in *Oedogonium*.

SECTION B

5. (a) Describe the general vegetative and reproductive structures of *Isoetes*.
   (b) Describe the process from the vegetative stage to syngamy in *Isoetes*.

6. Describe the general structure and interaction of the male and female gametophytes in angiosperms.

7. (a) Contrast eusporangiate and leptosporangiate ferns.
   (b) Compare and contrast the strobilus structure of the genera *Equisetum* and *Selaginella*.

8. Describe the diversity, distribution and significant features of the family Arecaceae.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 2812: DIVERSITY OF ANIMALS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS; TWO FROM EACH SECTION AND THE FIFTH QUESTION FROM EITHER SECTION. ILLUSTRATE YOUR ANSWER WHERE NECESSARY. USE **SEPARATE ANSWER BOOKS** FOR EACH SECTION.

SECTION A: Invertebrates

1. Summarise each of the following:
   (a) Modes of reproduction in ciliates.
   (b) Theories of metazoan evolution.

2. (a) Describe the general body plan and cell types of members of the phylum porifera.
   (b) Describe the mode of nutrition of members of the phylum porifera.

3. Discuss each of the following in the phylum annelida:
   (a) Circulatory system.
   (b) Reproduction.
   (c) Osmoregulation and excretion.

4. (a) Describe features that distinguish members of the phylum echinodermata from all other invertebrate phyla.
   (b) Describe the distinguishing features of each of the classes under the sub-phylum uniramia.

SECTION B: Vertebrates

5. Summarise the characteristics of each of the following:
   (a) Ungulates
   (b) Pisces.
   (c) Actnopterygii.
   (d) Ichthyosauria.

6. Compare and contrast the respiratory systems in the super class pisces and class amphibia.

7. Justify placement of acorn worms of the sub-phylum hermichordata in the phylum chordata.

8. Describe the diversity of reproductive systems in the three sub classes of the class mammalia.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3421: MOLECULAR BIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS; **TWO** FROM EACH SECTION AND THE **FIFTH** FROM EITHER SECTION. USE **SEPARATE ANSWER BOOKS** FOR EACH SECTION. ILLUSTRATE YOUR ANSWER WHERE NECESSARY.

SECTION A

1. (a) Discuss the process of transcription in prokaryotes, highlighting the structure of the gene and the role of the promoter.
   (b) Explain the Rho-dependant and Rho independent termination mechanisms of transcription.

2. Discuss the four DNA repair mechanisms used by the cell to maintain the integrity of the genetic material using named mutations.

3. Discuss the process of DNA replication in eukaryotes.

4. (a) In a Molecular Biology research, the following three 4 nucleotide primers were used to amplify the DNA template using PCR. Show where each of the following 3 primers would anneal on the denatured strands below and indicate the direction of DNA synthesis.
   Primer 1: 5' – GTTC – 3'

   Primer 2: 5' – GCCC – 3'

   Primer 3: 5' – TATT – 3'

   5' ACTTCGTTCGCCGGGGCTCGATCGATATTTGGAAT 3'

   3'TGAAGCAAGCGGCCCCGAGCTAGCTATAAACCTTA 5'

(b) Determine the product of a PCR reaction using primers 2 and 3, and primer 1 and 3 from 1 (a)? Explain your answer.

(c) The nucleotide primers like the ones shown in part (a) would not be the best choice for PCR, why? Explain your answer.

(d) Design a new six residue primer that could be used in combination with the template given below and the six primer (5' – CTAGGT – 3') to exponentially amplify a 20 base pair product by polymerase chain reaction (PCR). Assume that the six residue primer would provide enough binding affinity and specificity to be successfully used in PCR.

3' – ACTGATCCAAGTCTAGGTATAGGCC – 5'

SECTION B

5. (a) Describe the structural features that all tRNA molecules have in common.
   (b) Discuss the significance of modified bases within the tRNA molecules.

6. In table 1 below is the genetic code. Use it to address this question.

Table 1: Standard Genetic Code for mRNA codons.

First letter	Second letter: U	Second letter: C	Second letter: A	Second letter: G	Third letter
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
U	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
U	UUA Leu	UCA Ser	UAA STOP	UGA STOP	A
U	UUG Leu	UCG Ser	UAG STOP	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
C	CUC Leu	CCC Pro	CAC His	CGC Arg	C
C	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
C	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
A	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
A	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
A	AUG Met	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGT Gly	U
G	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
G	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
G	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

Key:

Ala = Alanine (A)
Arg = Arginine (R)
Asn = Asparagine (N)
Asp = Aspartate (D)
Cys = Cysteine (C)
Gln = Glutamine (Q)
Glu = Glutamate (E)
Gly = Glycine (G)
His = Histidine (H)
Ile = Isoleucine (I)
Leu = Leucine (L)
Lys = Lysine (K)
Met = Methionine (M)
Phe = Phenylalanine (F)
Pro = Proline (P)
Ser = Serine (S)
Thr = Threonine (T)
Trp = Tryptophan (W)
Tyr = Tyrosine (Y)
Val = Valine (V)

(a) The following are base sequences of 4 named organisms. Determine their respective polypeptides and answer the questions that follow.

Human: C C A T A G C A C C T A   Cat: C C A T G T A A A C G A
Chimpanzee: C C A T A A C A C C T A   Pig: C C T A A A G G G A C G

(i) Explain which two organisms are the most closely related.

(ii) An unknown organism is found in the forest, and below is its gene sequence. Identify this kind of animal and explain your reasons.

Unknown: **C C A T G G A A T C G A.**

(b) Below are two partial sequences of DNA bases. Sequence 1 is from a human, and sequence 2 is from a cow. In both humans and cows, the sequence contains the gene to make the protein insulin.

Sequence 1: C C A T A G C A C G T T A C A A C G T G A A G G T A A
Sequence 2: C C G T A G C A T G T T A C A A C G C G A A G G C A C

(i) Comparing the human gene to the cow gene, determine the number of codons and amino acids in the sequence that are exactly the same.
(ii) Explain how two humans (or two cows) can have some differences in their DNA sequences for insulin, yet still make the exact same insulin proteins.

(c) Suppose a person has a mutation in his or her DNA and the first triplet for the insulin gene reads T A T and the normal gene reads T A G.
(i) Determine the amino acids that both the mutant DNA and the normal DNA code for, and explain whether the person with this mutation will be diabetic or not.
(ii) Another mutation changes the insulin gene to read T C T (instead of the normal T A G). Explain whether this person will be diabetic or not.

7. Compare and contrast the sequence organisation of composite and replicative transposons.

8. (a) Discuss the type of data that Barbara McClintock examined to determine that *Ds* in corn was occasionally moving from one chromosomal location to another.
(b) Discuss the qualities of *Drosophila melanogaster* as a model organism in molecular biology research.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATRUAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3501 MYCOLOGY
PRACTICAL PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS.

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1. You are provided with specimens **A** and **B**. Specimen **A** is supplied with all the nutrients required for maximum growth, whereas the medium for specimen **B** is deficient in nitrogen. Examine the colonies using a magnification glass and answer the following:

   (a) Compare and contrast the growth pattern and quality of mycelium in the two colonies.
   (b) Explain the differences observed between the two specimens.

2. You are provided with a specimen labelled **C** and an **ocular micrometre.**
   (a) Calibrate the ocular micrometre using the following information:
   10 divisions on the stage micrometre = 1 mm
   10 divisions on the ocular micrometre = 1 division on the stage micrometre
   1mm = 1000 micrometres

   (b) Determine the size of specimen **C** in μ.

3. You are provided with specimen **D**, which is a 10^{-4} dilution of soil suspension. Prepare a 10^{-6} soil suspension from specimen **D**, using the materials and apparatus provided. Pour out molten agar in the petri plate labelled **E** and inoculate it with 1 cm^3 of the diluted soil suspension.

   Indicate your computer number on the bottom of your petri plate and seal it with tape.

   Hand over the inoculated petri plate to the invigilator who will incubate it for you for assessment of fungal colony growth.

4. Identify and name the parts labelled **F** to **I** provided.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATRUAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3501 MYCOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS; **TWO** FROM EACH SECTION AND THE FIFTH FROM EITHER SECTION. USE **SEPARATE ANWER BOOKS** FOR EACH SECTION. ILLUSTRATE YOUR ANSWER WHERE NECESSARY.

SECTION A

1. Discuss the complete digestion of cellulose, by soil-inhabiting filamentous fungi.

2. Describe the two models that explain growth in filamentous fungi.

3. (a) Illustrate graphically, the growth rate of a batch culture of yeast cells, using the results in Table 1.

Table 1: Dry biomass of yeast cells harvested at intervals over a period of ten days.

Age in days	1	2	3	4	5	6	7	8	9	10
Log_e biomass	2.5	2.7	3.0	3.8	4.6	5.3	5.4	5.5	5.5	5.1

(b) Explain the significance of transforming the dry biomass of yeast cells into logarithmic values, using the graph developed in 3 (a) above.

4. (a) Describe the septal types of hyphae in named groups of fungi.
(b) Explain the importance of septation in fungi.

SECTION B

5. Describe the polyphyletic nature of fungi, and justify the system of classification that reflects their phylogenetic relationships.

TURN OVER

6. (a) Describe the distinguishing features of the class Chytridiomycetes.
   (b) Describe the characteristics and life cycle of *Blastocladiella*.

7. Discuss the genus *Monoblepharis* with particular reference to its habitat and methods of reproduction.

8. Discuss evolution of the spore from sporangiospores in Zygomycetes to conidia in Ascomycetes.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3612: BIOCHEMISTRY AND PHYSIOLOGY OF PARASITES
PRACTICAL PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS

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1. You are provided with specimens **A** to **E.**
(a) State the species name of each specimen.
(b) Identify which of the specimen is the intermediate host of *Schistosoma haematobium.*
(c) Draw a labelled diagram to show the general body structure of a snail.

2. Suppose that you were presented with a school boy who was infected with urinary schistosomiasis, describe an experiment that you would conduct in order to demonstrate the effect of hypotonicity on the rate of the hatching of the eggs of the parasite.

3. You are provided with specimens **F** to **I.** For each specimen, state the following:
(a) Specimen name.
(b) Type of life-cycle.
(c) Name of its parasite.
(d) Name of disease caused by its parasite.

4. You are provided with specimens **J** to **L**. for each specimen, state the following:
(a) Specimen name.
(b) Type of life-cycle.
(c) Name of disease caused by it.
(e) Sex.

5. (a) Identify specimen **M.**
(b) State its function.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3712: ANIMAL PHYSIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. ILLUSTRATE YOUR ANSWER WHERE NECESSARY.

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1. Discuss the hypothalamic regulation of food intake in mammals.

2. Compare and contrast respiration in fish and terrestrial insects.

3. Describe myogenic rhythmic cardiac contraction.

4. (a) Describe the osmoregulatory challenge and adaptation in marine reptiles.
   (b) Discuss core temperature regulation in mammals.

5. Discuss the mode of action of non-steroid hormones involving cyclic Adenosine Monophosphate (cAMP) as an example of a second messenger.

6. Discuss the fate of excess amino acids in mammalian protein metabolism.

7. Summarise each of the following:
   (a) Excitatory postsynaptic potential.
   (b) Inhibitory postsynaptic potential.
   (c) Electrical synaptic transmission.
   (d) Chemical synaptic transmission.

8. (a) Draw a labelled diagram of a sarcomere.
   (b) Discuss the role of hormones in insect molting and development.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3822: FISH BIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. ANSWER QUESTIONS **ONE** AND **TWO** AND ANY **OTHER THREE** QUESTIONS. ILLUSTRATE YOUR ANSWER WHERE NECESSARY

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1. Summarise each of the following structures related to fish description and identification:
   (a) Dorsal fins.
   (b) Spots on anal fin.
   (c) Trunk.

2. (a) Describe a method for determining fish growth using hard parts.
   (b) Summarise advantages of the method described in 2(a) above compared to tagging methods.

3. Compare and contrast diagnostic characteristic of any two classes of the super class Pisces.

4. (a) Describe the two main lineages of the family Cichlidae.
   (b) Summarise characteristics of the lineage best suitable for recreational fisheries.

5. Compare and contrast characteristics and morphological features the families Clariidae and Bagridae.

6. Discuss the reproductive strategies in Tilapiines that ensure successful fertilisation and survival of the offspring.

7. Describe the natural stages in the life cycle of fish.

8. Compare and contrast reproductive patterns in classes Chondrichthyes and Osteichthyes.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3841: EVOLUTIONARY BIOLOGY

THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS; **TWO** QUESTIONS FROM EACH SECTION AND THE FIFTH QUESTION FROM EITHER SECTION. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY. USE SEPARATE ANSWER BOOKS FOR EACH SECTION.

SECTION A

1. Explain how the Galápagos Islands finches illustrate Charles Darwin's four postulates of biological evolution.

2. (a) State the major categories of evidence for biological evolution.
   (b) Describe one example of a piece of evidence presented for each of the categories in 2(a).

3. Explain the phenomenon of ring species with the help of an empirical example.

4. Describe frequency dependent selection and explain its potential contribution to the maintenance of polymorphisms in populations.

SECTION B

5. Variation in the beak depth of ground finches is controlled by three genes with two alleles each; the dominant allele of each gene is responsible for one additional unit of beak depth while the recessive allele adds zero unit of beak depth. Using A, B and C to represent the three genes, answer the questions below.

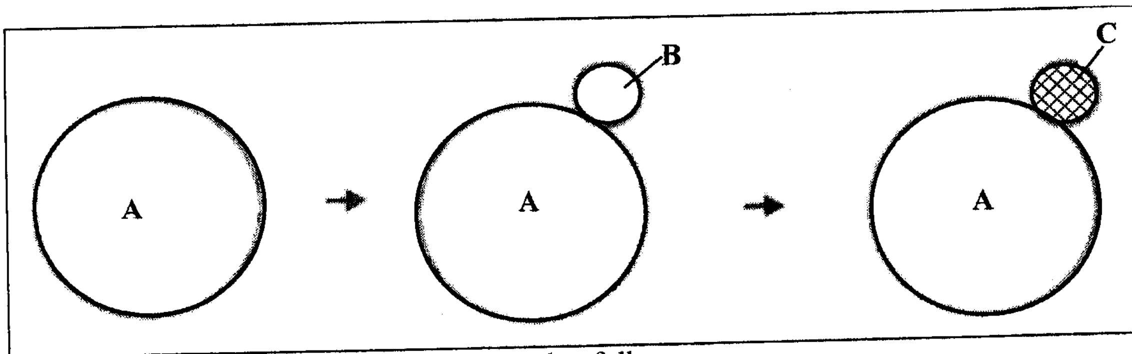
   (a) Illustrate the trihybrid cross that would generate the typical population (F_2 generation) of ground finches.
   (b) Determine the frequencies of each possible beak-size class that would be expected in the population of ground finches in 5(a).
   (c) Plot the frequency distribution using data in 5(b).
   (d) Briefly explain character displacement that was observed in a population of ground finches by Grant and Grant (2008).

6. (a) Describe the various types of social behaviour
   (b) Discus the costs and benefits of social behaviour.

TURN OVER

7 (a) Discuss human morphological evolution.

(b) Contrast human morphological evolution from evolution of human culture.



8. Study Figure 1 and answer the questions that follow.

Figure 1: Model of species evolution.

(a) Label A – C the figure 1.
(b) Name the type of species evolution represented by this model.
(c) Explain the sequence of events that are associated with this model.
(d) Explain the major drivers of such speciation.
(e) Give an example of one species that evolved through such a mechanism.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 4161: FRESHWATER ECOLOGY
PRACTICAL PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS.

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1. Table 1 shows results of a limnological investigation conducted on a lake where temperature measurements, dissolved oxygen concentrations and densities of the most abundant phytoplankton species, (*Melosira granulata*) were determined in summer.

   Study the table below and answer the questions that follow.

Table 1: Values of temperature (°C), dissolved oxygen concentrations (O_2 mg l^{-1}) and *Melosira granulata* density (cells per cm^3) at different depths for the lake.

Depth (m)	0	1	2	5	7	10	12	15	20	25	30	40	50	60	70	80	90
Temp (°C)	25.5	25	25	25	25	25	25	24	20	16	15	15	15	15	15	15	15
O_2 mg l^{-1}	4	4.5	5	6	8	8	12	14	8	7	2	1	0	0	0	0	0
Melosira granulata (cells m^3)	19	25	28	30	50	60	84	98	150	75	30	15	15	15	15	15	15

(a) Construct an appropriate diagram useful in characterising the lake showing profiles of temperature, dissolved oxygen concentrations and phytoplankton densities.
(b) Describe the dissolved oxygen depth-profile for the lake investigated.
(c) Assess the effect of the phytoplankton on the oxygen depth-profile.

TURN OVER

2. Figure 1 is a bathymetric map of a lake that was investigated. The total surface area of the lake is 188 m^2 and areas corresponding to each depth are provided in Table 2. The volume of each stratum of the lake can be estimated using the formula given below.

$$V = {}^{h}/_{3}[A_1 + A_2 + (A_1 \times A_2)^{1/2}]$$

Study figure 2 and answer questions the questions below.

Table 2. Areas of the lake corresponding to each depth

Depth (m)	5	10	15	20	25	30	34
Area (m^2)	168	150	138	114	78	52	26

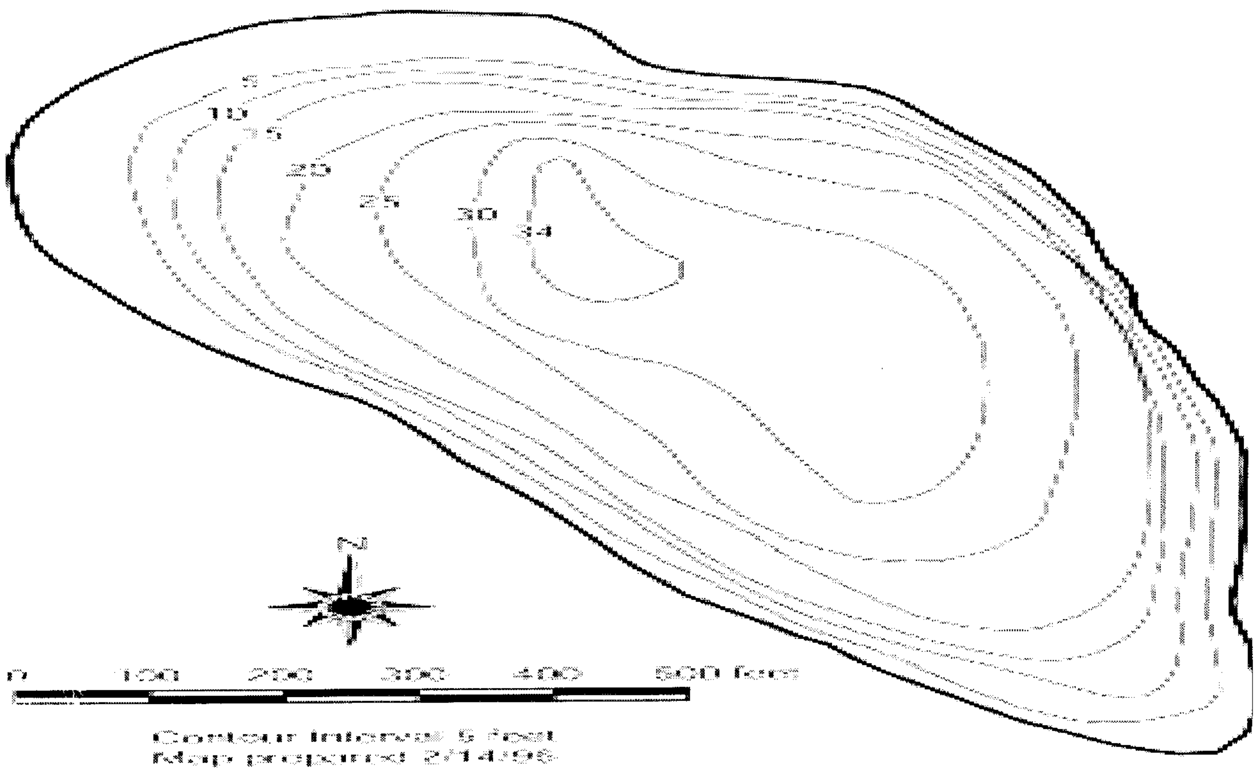

Figure 1: Bathymetric map of a lake

(a) Approximate the total volume of the lake.
(b) Construct an appropriate hyposographic depth- area curve for the lake.
(c) Construct an appropriate hyposographic depth – volume curve for the lake.

PROCEED TO THE NEXT PAGE

3. Figure 2 represents variation of inorganic carbon with changes in the pH and demonstrates the buffering capacity of aquatic ecosystems. Study the figure and answer the questions below.

Region I   Region 2

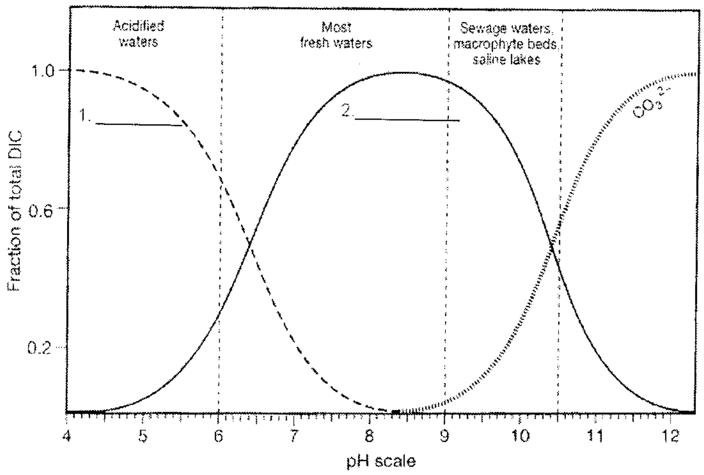

Fig 2: Relationships between different carbon compounds and pH.

(a) Describe dominant carbon compounds found in regions 1 and 2 of fig 2 above.
(b) Explain how the carbonate buffering system is critical for aquatic organisms.
(c) Illustrate how the carbonate buffering system regulates the pH in aquatic ecosystems.

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 4171: POPULATION ECOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS: QUESTIONS **ONE** AND **TWO** AND ANY OTHER **THREE** QUESTIONS. ILLUSTRATE YOUR ANSWER WHERE NECESSARY.

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1. Using the Lotka-Volterra equations based on the logistic model,
   (a) Describe the interaction of two species which are competing for food or space.
   (b) Discuss the four outcomes of this interaction between these two competing species.
   (c) Describe the interaction by predation of the prey (sp1) and the predator (sp2).
   (d) Discuss the functional and numerical responses of this relationship between prey (sp1) and the predator (sp2).

2. Fifty-two Sudan Plated Lizards (*Gerrhossaurus major*) were reared in a city zoo and their survivorship was recorded as given in Table 2. Study the table and answer the questions.

   Table 2: Number of dead lizards in the city zoo for each age class.

Age class (years)	Dead lizards
0-1	12
1-2	8
2-3	6
3-4	9
4-5	7
5-6	4
6-7	5
7-8	1
8-9	0

   (a) Construct a life table of this population.
   (b) Assuming that m_x for the species is known to be 0.5 for all age classes except for 0 to 1 age class, determine R_o and r_m for the species population.

TURN OVER

3. Lamont Cole (1954) noted that natural history of species population could be summarised by parameters $\mathbf{l_x}$ and $\mathbf{m_x}$,
   (a) Discuss parameters $\mathbf{l_x}$ and $\mathbf{m_x}$ in population growth as applied to a single population model.
   (b) Describe methods used to derive these parameters.

4. Discuss **two** of the following concepts as used in population ecology:
   (a) Resource tracking.
   (b) Ecological niche.
   (c) Survivorship curves.

5. Compare and contrast the following concepts of life history of a species population:
   (a) Limiting similarity and character displacement in competing species.
   (b) k- Selection and r- Selection strategies.

6. Summarise each of the following:
   (a) King census methods.
   (b) $N_t = N_0 e^{rt}$.
   (c) Point Centered Quarter Method.
   (d) Bitterlich method.

7. Discuss limitations of each of the following:
   (a) Determination of r_m of a free range animal species population.
   (b) Transect method in estimating animal populations.
   (c) Quadrat method in counting plant species.

8. (a) Discuss the concept of carrying capacity and its limitations in population ecology.
   (b) Describe aerial census method for estimating animal population.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 4230: INSECT ECOLOGY AND PEST MANAGEMENT
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS; **TWO** QUESTIONS FROM EACH SECTION AND THE FIFTH QUESTION FROM EITHER SECTION. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY. USE **SEPARATE ANSWER BOOKS** FOR EACH SECTION.

SECTION A

1. Compare and contrast population density and dispersion.

2. Discuss the r/K selection theory in the study of insect ecology.

3. Summarise each of the following:
   (a) Mortality.
   (b) Exponential growth curve.
   (c) Sample size.
   (d) Field based sampling.

4. (a) Construct a life table of an insect you are familiar with.
   (b) Discuss the significance of an insect life table.

SECTION B

5. Discuss the prospects and constraints of introducing Integrated Pest Management (IPM) in Zambia.

6. Summarise each of the following in relation to Integrated Pest Management (IPM).
   (a) Economic threshold.
   (b) Pesticide era.
   (c) Genetic control.
   (d) Key pest.

7. At a price of K65 per 50 kg bag, the cost of producing a hectare of maize in Lusaka, Zambia, (Agro-ecological Zone II) during the 2012/13 growing season was K 8,870 per hectare and the value of the crop on the market was K13,000 per hectare. The cost of controlling the African armyworm, *Spodoptera exempta* (Wlk.), including labour, was K225 per hectare.
   (a) Suppose that farmers in Lusaka Province that year had an average infestation of 100,000 armyworm caterpillars per hectare causing a mean injury 20% to the maize crop, calculate the Economic Injury Level (EIL) and Economic Threshold (ET) of the maize crop by the armyworm for that season.
   (b) State the advice you would have given the five farmers using the information in Table 1, concerning the management of the armyworm in their maize fields that season.

Turn over

Table 1. Pest densities of armyworms in maize fields of Lusaka farmers during the 2012/13 growing season.

Farmer	Number of armyworms per hectare
1	1622
2	13260
3	7829
4	2524
5	8680

(c) Explain the significance of knowing the EIL and ET of crops in insect pest management.

8. (a) Explain what the three "R"s of the pest management awareness are.
   (b) Indicate how the three "R"s of the pest management awareness arise and how they are resolved in managing insect pests in agro-ecosystems.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2012 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BIO 4325: ECOLOGY AND EPIDEMIOLOGY OF PARASITIC DISEASES
PRACTICAL PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS.

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1. You are provided with specimen **A**, (a parasite), a stage micrometer, an ocular micrometer and a microscope;
   (a) Identify the specimen.
   (b) Briefly, outline the steps taken in calibrating the eye piece.
   (c) Measure and state the size of the specimen **A** using x10 and x40 objectives.

2. You are provided with a prepared slide **B**.
   (a) Identify the parasite to genus level.
   (b) Determine the intensity of infection.

3. (a) Describe the KATO/KATZ procedure used to examine stool samples for parasitic infection.
   (b) You are provided with two (2) slides **C** and **D**. Examine both slides, identify the disease caused by each and give the species name of each specimen.

4. Suppose that you conducted a parasitological survey for *Schistosoma haematobium* at a rural school in Zambia. Twenty five (25) pupils were examined from grade five class. However, on the first day of the exercise, it was discovered that the filter membranes were forgotten after the specimens were collected. The samples were therefore examined using a sedimentation method. Since you needed to quantify the infections, you repeated the examination on the specimens the following day using the filtration method. The samples were well stored in the fridge at 4°C assuming that no degeneration occurred. The results from the two methods are given in Table 1.

   Study table 1 and answer the following questions:
   (a) Determine the prevalence of infection by the two methods used.
   (b) Determine the intensity of infection on the basis that more than 50 eggs/10 ml of urine was considered as heavy infection.
   (c) Make 3 recommendations to the head teacher which would improve the situation within 6 months.
   (d) Comment on the results of the two methods.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR

FINAL EXAMINATIONS

BIO 4341: INDUSTRIAL MICROBIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS; **TWO** FROM EACH SECTION AND THE **FIFTH** FROM EITHER SECTION. USE **SEPARAE ANSWER BOOKS** FOR EACH SECTION. ILLUSTRATE YOUR ANSWER WHERE NECESSARY.

SECTION A

1. (a) Discuss lacto-fermentation by four lactic acid bacteria involved in the process.
   (b) Describe benefits of human consumption of lacto fermented food.

2. Discuss microbial inoculants and their importance in plant growth improvement.

3. Discuss the original method of citric acid production and explain why microbial production has superseded the original method, citing appropriate examples of microorganisms.

4. Discuss humulin and its industrial production.

SECTION B

5. Describe fruit juice extraction and the role of microbial pectinases in the production process.

6. Discuss the use of microbial enzymes in the preparation of detergents over other enzymes from other sources.

7. (a) Discuss the importance of mesophilic and thermophilic starter cultures of named microbes in the production of cheese.
   (b) Explain why microbial substitutes for animal rennet are important.

8. Describe the uses of microbial carbohydrates such as dextran and xanthan as molecular sieves and additives to industrial products.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 4452 TECHNIQUES IN RECOMBINANT DNA TECHNOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS; **TWO** FROM EACH SECTION AND THE **FIFTH** FROM EITHER SECTION. **QUESTION 1 IS COMPULSORY**. ILLUSTRATE YOUR ANSWER WHERE NECESSARY. USE SEPARATE ANSWER BOOKS FOR EACH SECTION

SECTION A

1. In the DNA sequence below, the underlined nucleotides are codons that are also restriction endonuclease sites for blunt-end cutting enzymes (doubly underlined) and over-hang cutters (singly underlined). Study the nucleotide sequence and answer the questions below.
   TAT CCC GGG CAG GAA TTC GGC GAT ATC GGC CAA CCT TTT
   GGA TCC GTC CCT GGT AAA GGA TCC AGA TCT CCC GGT ACT

   (a) Design three different strategies you would use to mutagenize the sequence based on the underlined sites. Your strategy should clearly explain the steps, tools and alternative approaches you would use.
   (b) Suppose that the last underlined nucleotide sequence coded for two codons hypothesized to be part of a catalytic site for a glucosidase (an enzyme known to catalyze the removal of a sugar from a secondary metabolite), explain how you would test the involvement of the amino acids coded for by the two codons (AGA and TCT) in glucosidase activity.
   (c) State two advantages of *in vitro* mutagenesis over random mutagenesis.

2. If you knew that honey contains DNA from plant pollen, describe how you would use amplified fragment length polymorphisms (AFLPs) and cleaved amplified polymorphisms (CAPs) markers to distinguish honey brands from Kapirimposhi from that originating from Mwinilunga Districts of Zambia.

3. (a) State six different parts of a general protein expression vector and describe the function of each part.
   (b) Describe four challenges in attempting to express a eukaryotic protein in a prokaryotic cell system and suggest one strategy to address each respective challenge.

TURN OVER

4. Summarize each of the following:
   (a) Protein tagging with three named examples of tags and their applications.
   (b) Vector cassettes for gene knock-out experiments and the logic of such vectors.
   (c) Split fluorescent reporter assays for protein interaction analysis.

SECTION B

5. (a) Discuss the important features of pUC19 plasmid vector.
   (b) Explain the disadvantages of using plasmid vectors in gene cloning.
   (c) Describe the application of shuttle vectors in agriculture of tobacco.

6. Describe the process of generating a human pancreas cDNA library and its screening for the for human insulin gene.

7. Study the results of a restriction enzyme digest of a DNA molecule in table 1 and answer the questions that follow:

Table 1: Results of a restriction enzyme-digest of a DNA molecule.

Restriction Enzyme	**Number of base pairs**	
*BamH*I	87.2	
*Eco*RI	87.2	
*Hind*III	87.2	
*Eco*RI/*Hind*III	79.6	7.6
*Eco*RI/*BamH*I	72.2	15.0
*BamH*I/*Hind*III	64.6	22.6

   (a) Draw a gel electrophoresis photograph of these results.
   (b) Determine the structure of the DNA molecule and explain your reasoning.
   (c) Draw the restriction enzyme map of the DNA molecule.

8. (a) Describe in detail the process of cloning Dolly from Finnish Dorset (white face) and Scottish Blackface ewes (both female sheep).
   (b) Explain the phenotypic and genetic features of Dolly that qualify her to be a clone of the Finnish Dorset and not the progeny of the unsuspected mating of the surrogate mother.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 4632: MOLECULAR PARASITOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. ILLUSTRATE YOUR ANSWER WHERE NECESSARY

---

1. Discuss the unique mechanism of antigenic variation of African trypanosomes that enables the parasite to evade its host immune defences.

2. Discuss the role of small nuclear ribonucleoprotein particles (SnRNPs) during splicing to remove all introns from pre-mRNA in a parasitic protozoan.

3. Discuss the mechanism of trans-splicing that has been demonstrated in all pre-mRNA of trypanosomes to synthesize Variant Surface Glycoprotein (VSG) m-RNA.

4. (a) Describe cDNA and explain how it can be synthesized from mRNA in a parasitic helminth.
   (b) Describe the composition of the Kinetoplast DNA in *Trypanosoma brucei rhodesiense*.

5. With the aid of a diagram, describe the stages of cloning a parasite DNA fragment into the polycloning site of the vector pUC_{19}.

6. Discuss the molecular approach to rational chemotherapy in the control of parasitic diseases.

7. Explain how differences in folate metabolism in humans and protozoa have led to the development of anti-malaria drugs.

8. Discuss the role of guide RNAs (gRNAs) in mitochondrial gene expression to produce Cytochrome oxidase (COII) mRNA of *Trypanosoma brucei rhodesiense*.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 4632: MOLECULAR PARASITOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. ILLUSTRATE YOUR ANSWER WHERE NECESSARY

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END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

BS 4182: WILDLIFE AND RANGELAND MANAGEMENT
PRACTICAL PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS. USE ILLUSTRATIONS WHERE NECESSARY.

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1. Study specimens labeled **A** to **E.** For each specimen:
   (a) State the scientific name.
   (b) Describe the habitat in which the species is co-dominant

2. Examine specimens labeled **F1** to **F10**. For each specimen:
   (a) State the scientific name.
   (b) Describe the habitat in which it is commonly found.
   (c) State sex dimorphism of the species.

3. Study the map given in Figure 1 for the Lower Zambezi National Park and answer the following questions:
   (a) Describe the *Munga –Combretum* thicket habitat.
   (b) Describe the *Mopane* Woodland habitat in this national park.

TURN OVER

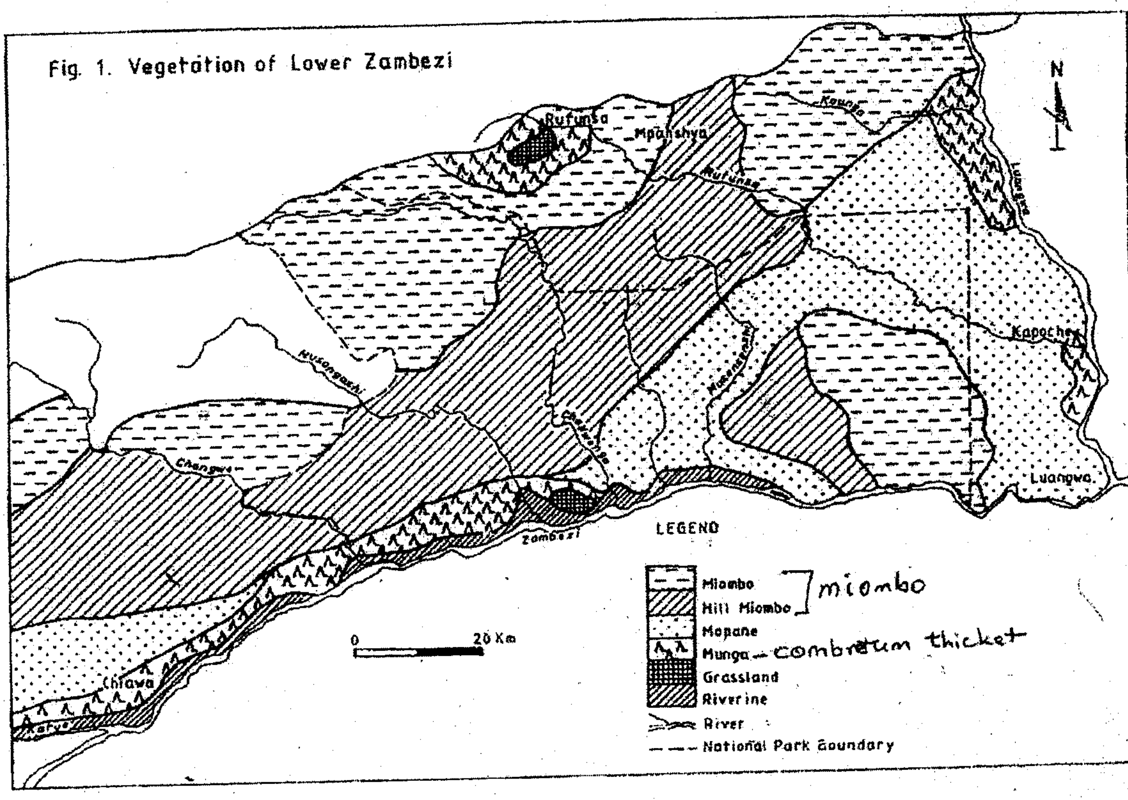


Figure 1: Lower Zambezi National Park showing habitat types

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
FINAL EXAMINATIONS 2015/2016 ACADEMIC YEAR, SEPTEMBER 2016
C2615: BASIC PHYSICAL CHEMISTRY

Duration: Three (3) Hour

Instructions:

Answer any **four (4) questions.**

Answer each question in a **separate answer booklet.**

All questions carry equal marks.

You are reminded to answer questions in a clear and logical manner.

Useful Information and Constants:

R= 8.314 $Jmol^{-1} K^{-1}$, h= 6.63 x 10^{-34} J s, Molar volume of gas at STP = 22.4 dm^3mol^{-1}, STP = 273 K and 1 atm, Avogadro's constant = 6.02 x 10^{23} mol^{-1}, 1 cal = 4.18 J

Question 1

(a) A steel tank having a volume of 6.823 L contains 5.227 g of CH_4 and 9.840 g of NO at 38.5 °C.What is the total pressure exerted by this gas mixture? Note that the gas constant R has a value of 0.08206 L atm K^{-1} mol^{-1}.
Atomic weights: H = 1.008 g mol^{-1} C = 12.01 g mol^{-1} N = 14.01 g mol^{-1}
O = 16.00 g mol^{-1} **[5]**

(b) Determine the pressure in atm exerted by 1 mole of methane placed into a bulb with a volume of 244.6 mL at 25°C. Carry out two calculations: in the first calculation, assume that methane behaves as an ideal gas; in the second calculation, assume that methane behaves as a real gas and obeys the van der Waals equation.(a = 2.300 atm L^2mol^{-2}, b = L mol^{-1}) **[7]**

(c) If it takes 48.17 minutes for CO_2 to effuse through a small hole in its container, how long would it take for NH_3 to effuse under the same conditions of temperature and pressure for the same number of moles of effused gas)? Atomic weights: H = 1.008 g mol^{-1}
C = 12.01 g mol^{-1}, N = 14.01 g mol^{-1} O = 16.00 g mol^{-1} **[3]**

Question 2

(a) Calculatetheworkdoneonaclosedsystemconsistingof50.00gofargon, assumed ideal, when it expands isothermally and reversibly from a volume of 5.000L to a volume of 10.00Lat a temperature of 298.15K. **[3]**

(b) The molar heat capacity of water vapor at a constant pressure of 1.000atm is represented by

$$C_{P,m} = 30.54 JK^{-1}\,mol^{-1} + (0.01029 JK^{-2}\,mol^{-1})T$$

where T is the Kelvin temperature. Find the amount of heat required to raise the temperature of 2.000mol of water vapor from 100.0°C to 500.0°C. **[4]**

(c) A pellet of naphthalene of mass 1.234 g is burned in a bomb calorimeter with C_{cal} = 14225 JK^{-1}. If the initial temperature is 298.150 K and the final temperature is 301.634 K, find ΔU and ΔH for 1mol of reaction, with liquid water as one of the products. Neglect the heat of combustion of the wire fuse. **[4]**

(d) Calculate the entropy change for the following process: A sample containing 2.000 mol of helium gas originally at 298.15K and1.000bar is cooled to its normal boiling temperature of 4.00K, condensed to a liquid, and then cooled further to 2.00K, where it undergoes another phase transition to a second liquid form, called liquid helium II. This liquid phase is suddenly vaporized by a beam of laser light, and the helium is brought to a temperature of 298.15K and a pressure of 0.500 bar. **[4]**

Question 3

(a) The initial rate of reaction between ester **A** and aqueous sodium hydroxide was measured in a series of experiments at a constant temperature. The data obtained are shown below.

Experiment	Initial concentration of NaOH / $moldm^{-3}$	Initial concentration of **A** / $moldm^{-3}$	Initial rate / $moldm^{-3}\,s^{-1}$
1	0.040	0.030	4.0×10^{-4}
2	0.040	0.045	6.0×10^{-4}
3	0.060	0.045	9.0×10^{-4}
4	0.120	0.060	to be calculated

Use the data in the table to deduce the order of reaction with respect to Aand the order of reaction with respect to NaOH. Hence, calculate the initial rate of reaction in Experiment 4. **[4]**

(b) In a further experiment at a different temperature, the initial rate of reaction was found to be 9.0×10^{-3}mol dm^{-3}s^{-1}when the initial concentration of **A** was 0.020 mol dm^{-3}and the initial concentration of NaOH was 2.00 mol dm^{-3}.

Under these new conditions with the much higher concentration of sodium hydroxide, the reaction is first order with respect to **A** and appears to be zero order with respect to sodium hydroxide.

(i) Write a rate equation for the reaction under these new conditions. **[2]**

(ii) Calculate a value for the rate constant under these new conditions and state its units. **[3]**

(iii) Suggest why the order of reaction with respect to sodium hydroxide appears to be zero under these new conditions. **[2]**

(c) The rate equation for the decomposition of a compound **N** has a rate constant with the unit s^{-1}. The rate constant is 4.31×10^{3} s^{-1}at 700 K and 1.78×10^{4} s^{-1}at a temperature,*T*. Use this information to deduce the overall order of reaction and whether temperature *T* is greater or smaller than 700 K. **[4]**

Question 4

(a) The mobility, μ_{+}°,of K^{+} ion is 7.6178 x10^{-8} m^{2}V^{-1}s^{-1}at 25°C. Calculate ionic molar conductance, Λ_{+}°, of K^{+} ion. F = 96485 C mol^{-1}. **[3]**

(b) An aqueous solution of 0.0200 M of KCl has conductance, L, of 1.923 x $10^{-3}\,\Omega^{-1}$ in a conductance cell with a cell constant of 143.87 m^{-1}.

(i) Calculate specific conductance of the solution. **[4]**

(ii) Find molar conductance of KCl solution. **[4]**

(c) Kohlrausch's square root law is

$$\Lambda_m = \Lambda_m^{\circ} - k\sqrt{c}$$

Molar conductance of aqueous KCl solution at different concentrations is given below.

c (mol L^{-1})	Λ_m (Ω^{-1}m^{2}mol^{-1})
5.00 x10^{-4}	0.014781
1.00 x10^{-3}	0.014695
5.00 x10^{-3}	0.014355
1.00 x 10^{-2}	0.014127

Use linear regression to determine molar conductance at infinity dilution of KCl. **[4]**

Question 5

Consider the following cell at 25 °C

$$Cu(s)|CuCl_2(c=0.0100\,mol\,L^{-1})\{Cl_2(p=120.0\,kPa)|Pt(s)$$

The standard reduction potentials are

$$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq) \qquad E^\circ = +1.358\,V$$

$$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s) \qquad E^\circ = +0.337\,V$$

The cell reaction is

$$Cu(s) + Cl_2(g) \rightleftharpoons Cu^{2=}(aq) + 2Cl^-(aq)$$

(a) Calculate the mean activity coefficient, $\gamma_\pm$, of an aqueous $CuCl_2$ solution using the Debye – Hūckell limiting law. $A=0.509(L\,mol^{-1})^{1/2}$. **[4]**

(b) Determine the standard cell potential, E°_{cell}. [5]

(d) The Nernst equation for the above cell is

$$E_{cell} = E^\circ_{cell} \frac{-0.05916}{2} \log \frac{(a_{Cu^{2+}})(a_{Cl^-})^2}{(a_{Cl_2})}$$

andp°= 100.0 kPa. Calculate the emf of the cell. [7]

- END OF EXAMINATION -

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

CHE1000: INTRODUCTION TO CHEMISTRY

TIME: THREE (3) HOURS

INSTRUCTIONS TO THE CANDIDATES

1. Indicate your **student ID number** and **TG number** on **ALL** your answer booklets.

2. This examination paper consists of two **(2)** sections: **A** and **B**

3. Section **A** has ten **(10)** short answer questions. Questions carry equal marks.(Total marks = **40**).

   ANSWER ALL QUESTIONS IN SECTION A IN THE MAIN ANSWER BOOKLET

4. Section **B** has five **(5)** long answer questions. Questions carry equal marks. (Total marks = **60**).

   ANSWER QUESTION B1 and ANY THREE QUESTIONS, EACH QUESTION IN A SEPARATE ANSWER BOOKLET.

6. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.**

7. **ENSURE** that you have seven (7) printed pages and Periodic Table.

ADDITIONAL INFORMATION TO THE CANDIDATES:

Useful data is provided on page 7 and 8.

SECTION A **ANSWER ALL QUESTIONS**

Question A1

A sample contains 27.1 g of calcium oxide.

(a) Give the formula of calcium oxide.
(b) Calculate the number of moles of calcium oxide in the sample.

Question A2

(a) How many grams of carbon dioxide are there in a container with a volume of 4.50 L at STP?

(b) How many oxygen atoms are there in this amount of carbon dioxide?

Question A3

Consider the following redox reaction.

$Br_2(aq) + 2V^{3+}(aq) + 2H_2O(l) \rightarrow 2VO^{2+}(aq) + 4H^{+}(aq) + 2Br^{-}(aq)$

Given that $E^{o}{}_{cell} = +1.39$ V and $E^{o}_{Br_2/Br^-} = +1.07\ V$

(a) calculate E^{o} for V^{3+}
(b) Is the reaction spontaneous?

Question A4

(a) Draw a fully labeled diagram that shows the transition of an electron in the hydrogen atom from n = 4 to n = 2.
(b) Does the transition represent an emission or absorption?

Question A5

For the simple decomposition reaction

$$AB(g) \rightarrow A(g) + B(g)$$

the rate law is rate = $k[AB]^2$, and the rate constant, k, is 0.200 $M^{-1}s^{-}1$. How long will it take for [AB] to reach 1/3 of its initial concentration of 1.500 M?

QuestionA6

(a) Explain why ethanol (C_2H_5OH) dissolves in water.
(b) Name the two intermolecular forces involved when ethanol dissolves in water.

Question A7

For the reaction: $NO_2Cl(g) + NO(g) \rightarrow NO_2(g) + NOCl(g)$

the pre-exponential factor, A, is $1.00 \times 10^{10}\ M^{-1}s^{-1}$ and the activation energy of 40.00 k J mol^{-1}. The rate equation is first order in NO_2Cl and first order in NO.

(a) Write the rate law for the reaction.

(b) Calculate the value of the rate constant, k, at 500.0 K and its units.

Question A8

Soft drinks fizz on opening. Calculate the concentration of CO_2 when a drink is bottled at 455.96 kPa. For CO_2 in water, Henry's constant, k_H, is 3.356×10^{-4} M / kPa.

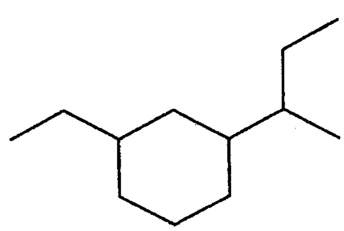
Question A9

A sample of 0.500 g of hemoglobin, a non-electrolyte, was dissolved in water in a volumetric flask to give 1.00 L of solution. The osmotic pressure of this solution was then measured at 25°C and found to be 1.776×10^{-3}atm. Calculate molar mass of hemoglobin.

Question A10

(a) Provide a line-bond structure for 4-*tert*-butyl-7-methylnona-1,3-dien-8-yne.

(b) Give the IUPAC name for the following molecule:



SECTION B — ANSWER QUESTION B1 AND ANY THREE QUESTIONS

Question B1

In the Lab you performed a chemical kinetics experiment on the effect of temperature on the rate of reaction. In the experiment, the rate of reaction at different temperatures was given by

$$Rate_0 = \frac{\text{constant}}{\text{t}} = k[H^+(aq)]_0^m[S_2SO_3^{2-}(aq)]_0^n$$

(a) In the experiment, how was the reaction time, t. changing with the increase in temperature? [3]

(b) What parameter in the rate equation was responsible for the increase in the rate of reaction when temperature was increased? [2]

(c) Write an equation that relates the parameter identified in (b) with temperature, T and define the terms in the equation. [5]

(d) A plot of a graph of – ln (t) versus 1/T gave a gradient of – 4.710 x10^3 K. Calculate the activation energy of the reaction. [5]

Question B2

Given the following galvanic cell at 25 °C and K_{eq} for this reaction is 2.79 x 10^7,

Pt(s) | Cr^{2+} (0.3M), Cr^{3+} (2.0M) || Co^{2+} (0.20M) | Co(s)

(a) Draw a fully labeled cell diagram for the above notation. [6]

(b) Write a balanced overall cell reaction. [3]

(c) Calculate the cell potential Ɛ and [3]

(d) ΔG for this reaction at the given temperature. [3]

Question B3

(a) Hydrogen has a red emission line at 656.3 nm, what is the energy and frequency of a photon of this light? [4]

(b) Refer to the periodic table arrange the following in order of increasing atomic radius: Al, C, Si. [3]

(c) Show using appropriate orbital energy diagram that the elements C and Si have similar chemical Properties. Justify in one sentence. [3]

(d) Consider the molecule H_2O:

(i) Draw the Lewis structure of the molecule and determine its geometry about the central atom using the VSEPR model. [2]

(ii) Determine the hybrid orbitals on the oxygen atom using an appropriate hybridization scheme to justify the geometry identified in d(i) above. [3]

Question B4

(a) Pure ethanoic acid (CH_3COOH, also known as glacial acetic acid) has a concentration of 17.54 M. If 8.55 mL of pure acid are diluted to 770 mL, what is the ethanoic acid concentration? [3]

(b) If 26 mL of this diluted ethanoic acid in (a) has pH of 2.74.

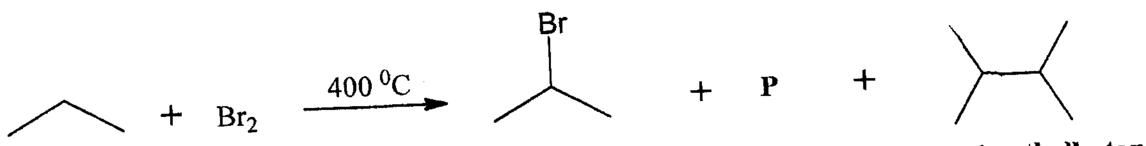
(i) What is the hydrogen ion concentration in the solution? [2]

(ii) Calculate K_a for ethanoic acid. [4]

(c) If 13.2 g CH_3COONa are added to the 800 mL of solution in (b) what is resulting pH? [6]

Question B5

(a) Under certain reaction conditions, mono-bromination of propane gave a mixture of two mono-brominated products, 2-bromopropane and **P**. In addition to mono-brominated products, traces of 2,3-dimethylbutane were also detected in the reaction mixture.



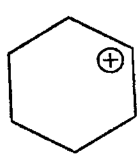
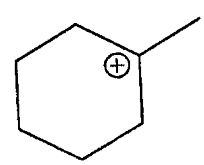
Propane **2-Bromopropane** **2,3-Dimethylbutane (traces)**

(i) Give the structure of the mono-brominated product **P**. [1]

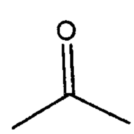
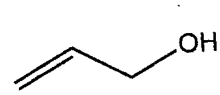
(ii) Suggest mechanism of the reaction for formation of 2-bromopropane. [6]

(iii) Propose a possible mechanism to account for formation of 2,3-dimethyl- butane in this reaction. [2]

(b) Arrange the following reactive intermediates in order of decreasing stability: [3]

(i)  (ii) $\overset{\oplus}{C}H_3$ (iii)  (iv) $CH_3\overset{\oplus}{C}H_2$

(c) (i) Identify the relationship between the following pair of molecules as Identical, chain isomers, positional isomers, functional isomers or geometrical isomers. [1.5]

 and 

(ii) Provide the stereochemical structure for a *Trans*-alkene, C_4H_8, with two vinylic hydrogens and two allylic carbons. [1.5]

END OF EXAM

USEFUL DATA

Physical contants

Avogadro constant, N_A	6.022×10^{23} mol^{-1}
Acceleration due to gravity	9.8 m s^{-2}
Faraday's constant, F	96485 C mol^{-1}
Mass of electron, m_e	9.11×10^{-31} kg
Planck's constant, h	6.626×10^{-34} J s
Rydberg constant, R_H	1.097×10^{7} m^{-1}
Speed of light, c	3.00×10^{8} m s^{-1}
Universal gas constant, R	8.3145 J mol^{-1} K^{-1}
	0.083145 L bar mol^{-1} K^{-1}
	0.08206 L atm mol^{-1} K^{-1}
	62.364 L torr mol^{-1} K^{-1}
	62.364 L mmHg mol^{-1} K^{-1}

Pressure conversions

1 atm = 1.01325×10^5 Pa = 1.01325×10^5 N m^{-2} = 760 torr = 760 mmHg = 1.01325 bar

1 bar = 1.00000×10^5 Pa
= 1.00000×10^5 N m^{-2}

Other conversion factors

V = J C^{-1} 1 eV = 1.602×10^{-19} J
1 J = 1 kg m^{2}s^{-2}

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number
X
Atomic mass
Name of the element X

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01 Hydrogen																1 **H** 1.01 Hydrogen	2 **He** 4.00 Helium
3 **Li** 6.94 Lithium	4 **Be** 9.01 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium											13 **Al** 26.98 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.55 Copper	30 **Zn** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 71.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 Selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
37 **Rb** 85.47 Rubidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** 97.91 Technetium	44 **Ru** 101.07 Ruthenium	45 **Rh** 102.91 Rhodium	46 **Pd** 106.42 Palladium	47 **Ag** 107.87 Silver	48 **Cd** 112.41 Cadmium	49 **In** 114.82 Inidum	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 Tellurium	53 **I** 126.90 Iodine	54 **Xe** 131.29 Xenon
55 **Cs** 132.91 Caesium	56 **Ba** 137.33 Barium	57 – 71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.84 Tungsten	75 **Re** 186.21 Rhenium	76 **Os** 190.23 Osmium	77 **Ir** 192.22 Iridium	78 **Pt** 195.08 Platinum	79 **Au** 196.97 Gold	80 **Hg** 200.59 Mercury	81 **Tl** 204.38 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 208.98 Bismuth	84 **Po** 208.98 Polonium	85 **At** 209.99 Astatine	86 **Rn** 222.02 Radon
87 **Fr** (223.02) Francium	88 **Ra** 226.03 Radium	89 - 103	104 **Unq** 261.11	105 **Unp** 262.11	106 **Unh** 263.12	107 **Uns** 262.12	108 **Uno** 265.00	109 **Une** 265									
		57 **La** 138.91 Lanthanum	58 **Ce** 140.12 Cerium	59 **Pr** 140.91 Praseodymium	60 **Nd** 144.24 Neodymium	61 **Pm** 144.91 Promethium	62 **Sm** 150.36 Samarium	63 **Eu** 151.97 Europium	64 **Gd** 157.25 Gadolinium	65 **Tb** 158.93 Terbium	66 **Dy** 162.50 Dysprosium	67 **Ho** 164.93 Holmium	68 **Er** 167.26 Erbium	69 **Tm** 168.93 Thulium	70 **Yb** 173.04 Ytterbium	71 **Lu** 174.97 Lutetium	
		89 **Ac** 227.03 Actinium	90 **Th** 232.04 Thorium	91 **Pa** 231.04 Protactinium	92 **U** 238.03 Uranium	93 **Np** 237.05 Neptunium	94 **Pu** 244.0 Plutonium	95 **Am** 243.06 Americium	96 **Cm** 247.07 Curium	97 **Bk** 247.07 Berkelium	98 **Cf** 251.08 Californium	99 **Es** 252.08 Einstienium	100 **Fm** 257.10 Fermium	101 **Md** 260 Mendelevium	102 **No** 259.10 Nobelium	103 **Lr** 262.11 Lawrencium	

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2015/16 ACADEMIC YEAR MID – YEAR EXAMINATIONS

CHE 2001 AGRICULTURAL AND VETERINARY CHEMISTRY

TIME: **THREE HOURS**

INSTRUCTIONS

1 There are **six** questions in this Examination Paper.

2 Answer any **four** questions. Each question should be written in a separate answer booklet. Questions carry equal marks.

3 Essential information and data are provided for this paper

Question 1

(a) Why should you prefer dry-ashing to wet-ashing of a food sample such as cabbage?

(b) A new gravimetric method is developed for iron (III) in which the iron is precipitated in crystalline form with an organo boron 'cage' compound. The accuracy of the method is checked by analyzing the iron in an ore sample and comparing with the results using the standard precipitation with ammonia and weighing of Fe_2O_3. The results, reported as %Fe for each analysis, were as follows:-

<u>TEST METHOD (%)</u>	<u>REFERENCE METHOD (%)</u>
20.10	18.89
20.50	19.20
18.65	19.00
19.40	19.70
19.99	19.40

Is there a significant difference between the two methods at 95% confidence level?

(c) Give IUPAC names for the following compounds

(i) 

(ii) $CH_3CH_2CH{=}CH\ CH_3$

(iii) $CH_3CH{=}CH\text{-}CH_2\text{-}CH\ (CH_3)_2$

(d) Write the solubility product expression for:

(i) $Ca_3(PO_4)_2$

(ii) Ag_2CrO_4

(iii) $PbCl_2$

Question 2

(a) Twenty millimetres of 0.100M $AgNO_3$ were added to 100.0ml of 0.050M NaCl during titration. Calculate the chloride and silver ion concentration in the resulting solution. Ksp (AgCl) = 1.75×10^{-10}

(b) (i) Give the structure and name of the alkene that yields on ozonolysis

$$CH_3\underset{\underset{O}{\|}}{C}\ CH_2\ CH_2\ CH_2\ \underset{\underset{O}{\|}}{C}\ CH_3$$

(ii) You are given a liquid that could be either cyclohexane or cyclohexene. What simple test could you perform to tell which it is? Describe exactly what you would do and what you would see in each case.

(iii) Complete the following reactions

(1) $CH_3CH{=}CH_2 \xrightarrow[NaOH]{cold\ KMnO_4(aq)}$

(2) $CH_3\underset{Br}{\underset{|}{C}}H\text{-}\underset{Br}{\underset{|}{C}}HCH_2CH_3 + Zn \longrightarrow$

(c) There are three isomeric alkanes of molecular formula C_5H_{12}. Isomer A gives a mixture of four monochlorination products when reacted with chlorine gas at 300°C. Under the same conditions, isomer **B** gives a mixture of three monochlorination products while isomer C gives only one monochlorination product. From this information assign structural formulas to isomer A, **B** and C.

(d) (i) With a suitable example explain the difference between a chiral carbon and achiral carbon.

(ii) Draw structural formulas for the isomeric chloropropenes (C_3H_5Cl).

Question 3

(a) Draw structural formulas for all compounds of molecular formula C_5H_{10} that are:

(i) Alkenes that do show cis-trans isomerism

(ii) Cycloalkanes that do show cis-trans isomerism

(b) (i) Explain, using formulas, the difference between a D-sugar and an L-sugar.

(ii) What is the diffrerence in structure between D-ribose and 2-deoxy-D-ribose?

(iii) Write the possible dipeptide structures that can be obtained by joining alanine, CH_3-$CH(NH_2)$ COOH, and glycine, $CH_2(NH_2)$-COOH, by a peptide bond.

(c) The solubility product of the compound M_2X was found equal to 3.58×10^{-13} on the basis of solubility measurements and the assumption of quantitative ionisation to M^+ and X^{2-} ions. Later it was found that the compound is quantitatively ionised to M_2^{2+} ions. Calculate the real solubility product of M_2X.

(d) Draw Haworth structures of α-D-glucose and β-D-glucose. Are α-D-glucose and β-D-glucose enantiomers? Explain

Question 3

(a) A calibration curve for the colorimetric determination of phosphorus in soil is prepared by reacting standard solutions of phosphate with molybdenum (IV) and reducing the phosphomolybdic acid complex to produce a characteristic blue colour. The measured absorbamce A is plotted against the concentration of phosphorus. From the following data determine the linear least squares line and calculate the pjhosphorus concentration in the urine sample:

Phosphorus (ppm)	**Absorbance**
1.0	0.205
2.0	0.410
3.0	0.615
4.0	0.820
Soil sample	0.625

(b) Replicate water samples are analyzed for water hardness with the following results: 102.2, 102.8, 103.1 and 102.5ppm $CaCO_3$. Calculate:-

(i) The relative standard deviation

(ii) The relative standard deviation of the mean

(c) Give the stereo chemical structure (s) or the product (s) that would be obtained when 2-butyne is hydrogenated in the presence of Lindlar`s catalyst and Na/NH_3.

(d) Describe four functions of carbohydrates in living organisms.

Question 4

(a) (i) Explain the difference, if any, between a Mohr titration and a Volhard titration.

(ii) A food sample was found to contain 0.203mg of zinc. If the sample was 0.156g, what is the concentration in parts per million and parts per billion?

(b) The following results were obtained in the determination of calcium in serum by two methods, fluorimetry and atomic absorption spectrophotometry (AAS). Is there a significant difference in the precision of the two methods?

Ca, mg/100ml

AAS	Fluorimetry
11.4	9.7
10.6	10.2
11.1	12.0
11.7	12.1
10.2	9.8
10.5	10.6
	11.7

(c) A solid food sample is known to contain only NaCl (MM 58.44) and KCl (MM 74.56). A 2.00g sample of this solid is dissolved in water and all the chloride ion is precipitated as AgCl by the addition of $50.0cm^3$ of 0.60M $AgNO_3$ solution. What is the percentage of KCl in the mixture?

(d) Alanine exists as two optical isomers. Draw diagrams to show the structures of the two optical isomers. Explain why alanine has a relatively high melting temperature (290°C).

Question 5

(a) Classify each of the following processes as endothermic or exothermic. In each case, draw an energy diagram to illustrate the heat content (enthalpy), reactants or products.

I. combustion of natural gas
II. condensation of water vapour

(b) 1674 J of heat are absorbed by 25.0 mL of an aqueous solution of NaOH (ρ = 1.10 g/mL, specific heat = 4.10 J/g °C). The temperature of the solution goes up how many degrees?

(c) 50.0 g of iron that has an initial temperature of 225 °C and 50.0 g of gold that has an initial temperature of 25.0 °C are brought into contact with one another. Assuming no heat is lost to the surroundings, what will be the temperature when the two metals reach thermal equilibrium? The specific heat capacity of iron = 0.449 J/g°C and gold = 0.128 J/g°C.

(d) Calculate ΔH for the reaction: $N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2\,H_2O(l)$

Given the following data:

$$2\,NH_3(g) + 3\,N_2O(g) \rightarrow 4\,N_2(g) + 3\,H_2O(l) \quad \Delta H = -1010\text{ kJ}$$
$$N_2O(g) + 3\,H_2(g) \rightarrow N_2H_4(l) + H_2O(l) \quad \Delta H = -317\text{ kJ}$$
$$2\,NH_3(g) + \tfrac{1}{2}\,O_2(g) \rightarrow N_2H_4(l) + H_2O(l) \quad \Delta H = -143\text{ kJ}$$
$$H_2(g) + \tfrac{1}{2}\,O_2(g) \rightarrow H_2O(l) \quad \Delta H = -286\text{ kJ}$$

Question 6

(a) Classify each of the following systems and list the characteristics of each system.

(i) Liquid in a beaker with a watch glass over it.
(ii) Coffee in a closed thermos bottle.

(b) What is the final temperature when 150.0 mL of water at 90.0 °C is added to 100.0 mL of water at 30.0 °C? Assuming that there is no loss to the surroundings.

(c) A 25.0 g piece of iron at 398 K is placed in a styro-foam coffee cup containing 25.0 mL of water at 298 K. Assuming that no heat is lost to the cup or the surroundings, what will the final temperature of the water be? The specific heat capacity of iron = 0.449 J/g°C and water = 4.18 J/g°C.

(d) Given the following chemical equation for the complete combustion of liquid benzene, C_6H_6. Use Hess' Law to calculate ΔH for this reaction with the help of the reactions and the respective enthalpy given.

$$2\,C_6H_6(l) + 15\,O_2(g) \rightarrow 12\,CO_2(g) + 6\,H_2O(l)$$

(i)	$6\,C(s) + 3\,H_2(g) \rightarrow C_6H_6(l)$	$\Delta H = +48.5$ kJ
(ii)	$C(s) + O_2(g) \rightarrow CO_2(g)$	$\Delta H = -393.5$ kJ
(iii)	$H_2(g) + 0.5\,O_2(g) \rightarrow H_2O(l)$	$\Delta H = -285.8$ kJ

END OF EXAMINATION

Universal Statistical Tables: C 225 / C205 / CAV 251.

1. Rejection Quotient, Q, at Different Confidence Limits.

Number of Observations	Confidence Level Q_{90}	Q_{95}	Q_{99}
3	0.941	0.970	0.004
4	0.765	0.829	0.926
5	0.642	0.710	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568
15	0.338	0.384	0.475
20	0.300	0.342	0.425
25	0.277	0.317	0.393
30	0.260	0.298	0.372

2. Values of t for v Degrees of Freedom at Different Confidence Limits.

Number of Degrees of Freedom	Confidence Level 90%	95%	99%	99.5%
1	6.314	12.706	63.657	127.32
2	2.920	4.303	9.925	14.089
3	2.353	3.182	5.841	7.453
4	2.132	2.776	4.604	5.598
5	2.015	2.571	4.032	4.773
6	1.943	2.441	3.707	4.317
7	1.895	2.365	3.500	4.029
8	1.860	2.306	3.355	3.832
9	1.833	2.262	3.250	3.690
10	1.812	2.228	3.169	3.581
15	1.753	2.131	2.947	3.252
20	1.725	2.086	2.845	3.153
25	1.708	2.060	2.787	3.078
Infinite	1.645	1.960	2.576	2.807

3. Values of F at the 95% Confidence Level

$v_1 =$		2	3	4	5	6	7	8	9	10	15	20	30
$v_2 =$	2	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.42.	19.4	19.4	19.4	19.
	3	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.70	8.66	8.6
	4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.86	5.80	5.
	5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.62	4.56	4.
	6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	3.94	3.87	3.
	7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.51	3.44	3.3
	8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.22	3.15	3.0
	9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.01	2.94	2.8
	10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.85	2.77	2.7
	15	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.40	2.33	2.2
	20	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.20	2.12	2.
	30	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.01	1.93	[illegible]

The Periodic Table of Elements

Key

relative atomic mass **atomic symbol** name atomic (proton) number

1	2											3	4	5	6	7	0 (8)
							1.0 **H** hydrogen 1										*(18)* 4.0 **He** helium 2
(1)	*(2)*											*(13)*	*(14)*	*(15)*	*(16)*	*(17)*	
6.9 **Li** lithium 3	9.0 **Be** beryllium 4											10.8 **B** boron 5	12.0 **C** carbon 6	14.0 **N** nitrogen 7	16.0 **O** oxygen 8	19.0 **F** fluorine 9	20.2 **Ne** neon 10
23.0 **Na** sodium 11	24.3 **Mg** magnesium 12	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	27.0 **Al** aluminium 13	28.1 **Si** silicon 14	31.0 **P** phosphorus 15	32.1 **S** sulfur 16	35.5 **Cl** chlorine 17	39.9 **Ar** argon 18
39.1 **K** potassium 19	40.1 **Ca** calcium 20	45.0 **Sc** scandium 21	47.9 **Ti** titanium 22	50.9 **V** vanadium 23	52.0 **Cr** chromium 24	54.9 **Mn** manganese 25	55.8 **Fe** iron 26	58.9 **Co** cobalt 27	58.7 **Ni** nickel 28	63.5 **Cu** copper 29	65.4 **Zn** zinc 30	69.7 **Ga** gallium 31	72.6 **Ge** germanium 32	74.9 **As** arsenic 33	79.0 **Se** selenium 34	79.9 **Br** bromine 35	83.8 **Kr** krypton 36
85.5 **Rb** rubidium 37	87.6 **Sr** strontium 38	88.9 **Y** yttrium 39	91.2 **Zr** zirconium 40	92.9 **Nb** niobium 41	95.9 **Mo** molybdenum 42	[98] **Tc** technetium 43	101.1 **Ru** ruthenium 44	102.9 **Rh** rhodium 45	106.4 **Pd** palladium 46	107.9 **Ag** silver 47	112.4 **Cd** cadmium 48	114.8 **In** indium 49	118.7 **Sn** tin 50	121.8 **Sb** antimony 51	127.6 **Te** tellurium 52	126.9 **I** iodine 53	131.3 **Xe** xenon 54
132.9 **Cs** caesium 55	137.3 **Ba** barium 56	138.9 **La*** lanthanum 57	178.5 **Hf** hafnium 72	180.9 **Ta** tantalum 73	183.8 **W** tungsten 74	186.2 **Re** rhenium 75	190.2 **Os** osmium 76	192.2 **Ir** iridium 77	195.1 **Pt** platinum 78	197.0 **Au** gold 79	200.6 **Hg** mercury 80	204.4 **Tl** thallium 81	207.2 **Pb** lead 82	209.0 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 **Ce** cerium 58	141 **Pr** praseodymium 59	144 **Nd** neodymium 60	[147] **Pm** promethium 61	150 **Sm** samarium 62	152 **Eu** europium 63	157 **Gd** gadolinium 64	159 **Tb** terbium 65	163 **Dy** dysprosium 66	165 **Ho** holmium 67	167 **Er** erbium 68	169 **Tm** thulium 69	173 **Yb** ytterbium 70	175 **Lu** lutetium 71
* Actinide series	232 **Th** thorium 90	[231] **Pa** protactinium 91	238 **U** uranium 92	[237] **Np** neptunium 93	[242] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[245] **Bk** berkelium 97	[251] **Cf** californium 98	[254] **Es** einsteinium 99	[253] **Fm** fermium 100	[256] **Md** mendelevium 101	[254] **No** nobelium 102	[257] **Lr** lawrencium 103

N 3 7 9 6 3 A 0 2 4 2 4

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR FINAL EXAMINATIONS

CHE 2112: INTRODUCTORY BIOCHEMISTRY

TIME: THREE HOURS

INSTRUCTIONS:

1. Answer any **FIVE (5)** questions
2. There are **FOUR (4)** printed pages in this examination paper
3. Each question carries **TWENTY (20)** marks

Question 1

a) **Explain** the following terms and/or expressions:

i) Endergonic reaction
ii) Coenzyme
iii) Prosthetic group
iv) Entropy
v) Allosteric

[5 marks]

b) Assuming that you are given a solution of 0.1 M glucose -1-phosphate. To this you add the phosphomutase, which catalyses the reaction:

Glucose-1-phosphate ⇄ glucose-6-phosphate

i) **Does** this reaction proceed as written, and if so, **what** are final concentrations of G-6-P and G-1-P? **[10 marks]**

ii) **What** cellular conditions would allow continuous production of G-1-P? **[5 marks]**

$\Delta G^{0'} = -1800$ *cal/mol*; $R = 1.987$ *cal/mol/^{0}K*

Question 2

a) For an enzyme that follows Michaelis-Menten (M-M) kinetics, **calculate** the ratio of [S] to K_m when velocity is 75 % of V_{max}. **[5 marks]**

b) Starting with the basic M-M equation, **show** that v can be expressed as a function of v/[S] and draw an estimated curve for this relationship. **[10 marks]**

c) Consider the following reaction:

$$C_3H_3O_3^- \textit{ (pyruvate)} + NADH + H^+ \longrightarrow C_3H_5O_3^- \textit{ (lactate)} + NAD^+$$

i) **What** class of enzymes catalyzes this reaction? **[2 marks]**

ii) **Yes or No; would** monitoring pH (over time using a pH meter) be an appropriate method for measuring the rate of this reaction? **Explain.** **[3 marks]**

Question 3

a) **Explain** how the following properties of water help in sustenance of life.

i) High heat of vaporization
ii) High specific heat capacity
iii) High heat of fusion
iv) High dielectric constant
v) Hydrogen bonding

[5 marks]

b) **State** the Henderson-Hasselbalch equation. **[3 marks]**

c) Using the equation in (b), **calculate** the pH of a buffer composed of 0.060 mol NaH_2PO_4 and 0.040 mol Na_2HPO_4 in a total volume of 1.00 L of aqueous solution, given

$H_2PO_4^- + H_2O \rightarrow HPO_4^{2-} + H_3O^+$ **pKa= 6.76** **[6 marks]**

d) Consider the following nona peptide dissolved in the buffer at the pH (**rounded off to the nearest whole number**) in **part (c).**

Gly-Asp-Cys-Phe-Trp-Arg-Gly-Asp-Ser

Amino acid	N-Gly	Asp	Cys	Arg	Asp	Ser-C
pKa value	9.6	3.9	8.3	12.5	3.9	2.2

i) Draw the peptide side structure **[4 marks]**
ii) Calculate the net charge of this peptide **[4 marks]**

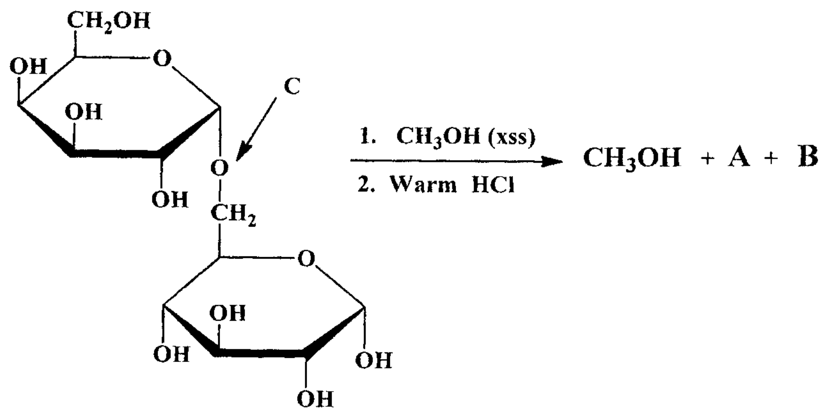
Question 4

a) Consider glucose and galactose.

   i) **Explain** the term **epimer** using open chain structures of the two sugars. **[4 marks]**

   ii) **Draw** the **anomeric** forms of glucose **[6 marks]**

b) The following disaccharide was subjected to exhaustive methylation followed by warm acid hydrolysis.



   i) **Name** the type of the bond labeled C. **[2 marks]**

   ii) **Why** is methanol a product? **[2 marks]**

   iii) **Draw** and give **names** of the methylated products **A** and **B** **[6 marks]**

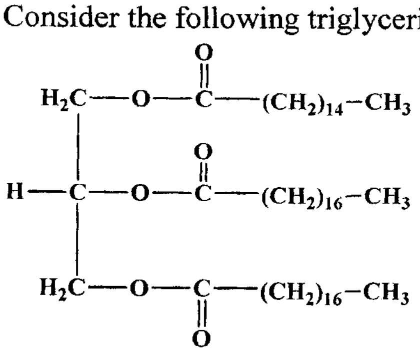
Question 5

a) **Give** the common **name** and **skeletal structure** for the following compounds.

   i) $CH_3\text{–}(CH_2)_{14}\text{–}COOH$ **[3 marks]**

   ii) $18{:}3(^{\Delta\,9,12,15})$ **[3 marks]**

b) Consider the following triglyceride



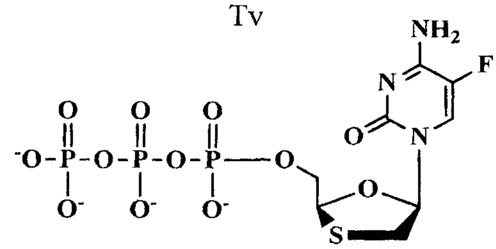
   i) **True** or **False**, this **structure is** optically active? **[2 marks]**

   ii) Using the structure in part b(i) **explain saponification** (alkaline hydrolysis) and give **names** of products upon complete reaction. **[12 marks]**

Question 6

a) Using Truvada (Tv) an analogue of CTP as an example, **explain** the mechanism of how viral DNA synthesis is blocked. (*Hint: show the normal incorporation of CTP before Tv*) **[10 marks]**

Tv



5'-A T G C A A G—OH

3'- T A C G T T C G G A-5'

b) Write in point form the features of B-DNA **[5 marks]**

c) A sample of DNA purified from Mycobacterium tuberculosis contains 15.1% adenine on a molar basis. What are the percentages of other bases present? **[5 marks]**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015/16 MID YEAR EXAMINATIONS

CHE2219: CHEMICAL ANALYSIS

TIME: Three (03) Hours.

INSTRUCTIONS:
1. **This Paper Contains Five (05) Questions.**
2. **Answer Any Four (04) Questions.**
3. **Each Question Carries 15 Marks.**
4. **Show All Your Working Clearly.**
5. **Essential Data and Tables Are Attached.**

Question 1.
(a).
The 2nd year Chemistry Laboratory Manual includes an experiment with the title "Determination of the Fluoride Content of Tooth Paste" which exemplifies "gravimetric Analysis". (i). What is 'gravimetric analysis'? (ii). What type of equilibrium is involved in the experiment? (iii). Name the new compound formed in the reaction used.

(b).
In order to ensure accuracy in quantitative analyses, primary standards are used to prepare standard solutions for use in titrimetric analysis.
(i). Define the term "Quantitative analysis"
(ii). State three characteristics of a primary standard

(c).
To recover levels of tin from foodstuffs, samples are boiled for different times in an open vessel as follows:

30 minute boiling:	57, 57,55,56,56,55,56,55
75 minute boiling:	51, 60,48,32,46,58,56,51

Test whether the boiling time affects the variability of the results and the mean of the recovery of tin at 95% confidence limit.

Question 2.
(a).
A 2.645g of powdered milk containing 53.5% calcium (Ca) is dissolved and diluted to 250ml. A spectroscopic method gave the following results for the solution: 5.90, 5.77, 5.75, 5.73, 5.71, 5.70, 5.68 and 5.66mg/ml.
(i).
Decide whether the accuracy is satisfactory or not if the maximum acceptable error is less than 1%.
(ii).
Estimate the standard deviation

Question 2 (continued).

(b).

Figur 1 below shows a special molecule belonging to the larger class of of substances.

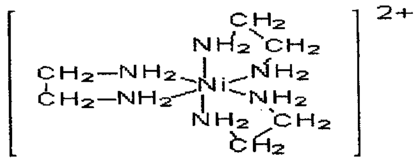


Figure 1.

(i).

Name the compound in Figure 1.

(ii).

Give the number and names of the ligands involved in the molecule in Figure 1.

(iii).

What is meant by the term "co-ordination number of the central atom in Figure 1.

(c).

A 2.645g of powdered milk containing 53.5% calcium (Ca) is dissolved and diluted to 250ml. A spectroscopic method gave the following results for the solution: 5.90, 5.77, 5.75, 5.73, 5.71, 5.70, 5.68 and 5.66 mg/ml.

(i)

Decide whether the accuracy is satisfactory or not if the maximum acceptable error is less than 1%.

(ii)

Estimate the standard deviation

Question 3.

(a).

The three ionisation constants for orthophosphoric acid, H_3PO_4, in aqueous media are listed as $Ka_1 = 7.11 \times 10^{-3}$; $Ka_2 = 6.23 \times 10^{-8}$ and $Ka_3 = 4.55 \times 10^{-13}$. Determine the fractional concentration of the conjugate base of H_3PO_4 at pH 1 in a 0.100 M acid solution; and, the value of K_a for the acid.

(b).

A calibration curve for the colorimetric determination of phosphorus in urine is prepared by reacting standard solutions of phosphate with molybdenum (IV) and reducing the phosphomolybdic acid complex to produce a characteristic blue colour. The measured absorbamce A is plotted against the concentration of phosphorus. From the following data determine the linear least squares line and calculate the phosphorus concentration in the urine sample:

Phosphorus (ppm)	Absorbance
1.0	0.205
2.0	0.410
3.0	0.615
4.0	0.820
Urine sample	0.625

Question 3 (continued).

(c).

(i).

Certain compounds are known to hydrolyse in aqueous medium. Define the term 'hydrolysis, and name one such compound.

(ii).

What degree of hydrolysis of a 0.10 M solution of ammonium ethanoate, (NaOAc) for ethanoic acid, $K_a = 1.75 \times 10^{-5}$?

Question 4.

(a).

(i).

Distinguish between the following pairs of terms by providing a definition for each term- Sample and analyte, major and minor constituents of a sample; and, Solubility and Solubility Product of silver chloride.

(ii).

Both acid-base and redox equilibria are used in chemical analysis. Explain the major difference between the two types of equilibria.

(b).

If 0.05 mole of NH_4Cl is added per litre of solution to a 0.01M aqueous ammonia solution (for ammonia, $K_b = 1.75 \times 10^{-5}$). Calculate the pH of the resulting solution.

(c).

The tin and zinc contents of a brass sample are analyzed with the following results:

Zn: 33.27, 33.37, and 33.34%

Sn: 0.022, 0.025, and 0.026%

Calculate the standard error and the coefficient of variation for the analysis.

Question 5.

(a).

(i).

Define the term "Titration" as used in chemical analysis.

(ii).

Determine if a precipitate form if 20.0 mL of 0.038 M $Pb(NO_3)_2$ and 30.0mL of 0.018 M KCl are mixed given that at 25^0C, in water, K_{sp} for $PbCl_2$ is 1.7×10^{-5}?

(b).

Name two of the key elements involved in the analytical process in chemistry. How many are the key elements in total? Give a detailed description of one of them.

(c).

The Manager of a Food Processing Company was trying to decide whether or not to keep a young, recently hired food technologist. The Manager decided to see if the new food technologist's work was of the same quality as that of the other staff. She asked both a senior food technologist and the new food technologist to analyze the same food sample using the same procedure, reagents and instruments. They obtained the following results:

Senior Food Technologist (% Ca)	**New Food Technologist** (%Ca)
18.89	20.10
19.20	20.50
19.00	18.65
19.70	19.25
19.40	19.40
	19.99

Determine if there is a significant difference in the precision of the data at 95% confidence level.

END OF EXAMINATION

Universal Statistical Tables: C 225 / C205 / CAV 251.

1. Rejection Quotient, Q, at Different Confidence Limits.

Number of Observations	Confidence Level Q_{90}	Q_{95}	Q_{99}
3	0.941	0.970	0.004
4	0.765	0.829	0.926
5	0.642	0.710	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568
15	0.338	0.384	0.475
20	0.300	0.342	0.425
25	0.277	0.317	0.393
30	0.260	0.298	0.372

2. Values of t for v Degrees of Freedom at Different Confidence Limits.

Number of Degrees of Freedom	Confidence Level 90%	95%	99%	99.5%
1	6.314	12.706	63.657	127.32
2	2.920	4.303	9.925	14.089
3	2.353	3.182	5.841	7.453
4	2.132	2.776	4.604	5.598
5	2.015	2.571	4.032	4.773
6	1.943	2.441	3.707	4.317
7	1.895	2.365	3.500	4.029
8	1.860	2.306	3.355	3.832
9	1.833	2.262	3.250	3.690
10	1.812	2.228	3.169	3.581
15	1.753	2.131	2.947	3.252
20	1.725	2.086	2.845	3.153
25	1.708	2.060	2.787	3.078
Infinite	1.645	1.960	2.576	2.807

3. Values of F at the 95% Confidence Level

$v_1 =$		2	3	4	5	6	7	8	9	10	15	20
$v_2 =$	2	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.42.	19.4	19.4	19.4
	3	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.70	8.66
	4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.86	5.80
	5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.62	4.56
	6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	3.94	3.87
	7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.51	3.44
	8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.22	3.15
	9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.01	2.94
	10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.85	2.77
	15	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.40	2.33
	20	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.20	2.12
	30	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.01	1.93

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 MID YEAR FINAL EXAMINATIONS

CHE2415: BASIC INORGANIC CHEMISTRY

TIME: THREE HOURS

INSTRUCTIONS:

ALL QUESTIONS CARRY EQUAL MARKS

ANSWER ANY FOUR QUESTIONS

ANSWER EACH QUESTION ON A FRESH PAGE

Some Universal Constants

Quantity	Symbol	Value and Units
Avogadro's number	N_A,L	$6.022 \times 10^{23} mol^{-1}$
Electron mass	m_e	$9.109 \times 10^{-31} kg$
Electron charge	-e	1.602×10^{-19}C, 4.8×10^{-10} e.s.u
Planck's constant	h	$6.626 \times 10^{-34} Js$
Permittivity of free space	ε_o	$8.854 \times 10^{-12} C^2N^{-1}m^{-2}$
Speed of light	c	$2.998 \times 10^8 ms^{-1}$

QUESTION 1

(a) The energy of electron in Hydrogen atom is $\frac{-21.7 \times 10^{-12}}{n^2}$ *ergs*. Calculate the wavelength of light that can be used to cause a transition for n = 2 level to n = ∞

(b) Calculate the radii (in Å) of the first three orbits of the above species if, $r = n^2a_0 = n^2(5.29 \times 10^{-11}\ m)$

(c) Ionic radius (Å) of Na^+ is 1.02 and ionic mobility at infinite dilution ($m^2/s/volt$) is 43.5. Ionic radius of Cs^+ is 1.67 and ionic mobility at infinite dilution is 68.0. Account for this trend.

QUESTION 2

(a) Write the d-orbital electronic configuration for the following octahedral complexes

(i) An Ir(III) complex if Δo is greater than electron pairing energy.

(ii) Mn(II) complex if Δo is less than pairing energy.

(b) Predict the color of Zn, Cd and Hg salts. Suggest a reason for your choice.

(c) By using the complexes $[FeF_6]^{4-}$ and $[Fe(CN)_6]^{4-}$, describe the inner and outer orbital modes of bonding in complexes.

QUESTION 3

(a) Determine the hybridization state of the central atom in each of the following

(i) ICl_2^- (ii) OIF_5

(b) CCl_4 does not react with water, while $SiCl_4$ reacts vigorously with cold water giving steamy fumes and gelatinous precipitate. Give a balanced equation and suggest a reason for the reaction of $SiCl_4$.

(c) Discuss the crystal field split of d-orbitals in a square planar ligand field.

QUESTION 4

(a) Which substance has bonds of greater ionic character? What is the percentage ionic character of each?

(i) BaO: Bond length (Å) 1.94, μ_{exp} (debye) 3.5

(ii) KI: Bond length(Å) 3.05, μ_{exp} (debye) 9.23

(b) Consider He atom in which one of the electrons has been excited to 4s level, i.e an atom with electronic configuration $1s^1\ 4s^1$. Comment on the stability of this He atom based on its $Z_{eff.}$.

(c) Trimethylamine, $(CH_3)_3N$ is capable of forming adducts and trisilylamine, $(SiH_3)_3N$ is not capable of that. Justify this observation by commenting on its nature of bonding.

QUESTION 5

(a) Draw the π bonding molecular orbital and π^* antibonding molecular orbital formed by the overlap of a 'p' orbital and a'd' orbital.

(b) Explain using Fajans rule why Lithium iodide, LI has more covalent character than Sodium iodide, NaI?

(c) Draw the structure of (i) $B_3N_3H_6$

(ii) B_2H_6

(iii) $(BN)_x$

END OF EXAMINATION

DATA SHEET
The Periodic Table of the Elements

Group

I	II											III	IV	V	VI	VII	0
							1 **H** Hydrogen 1										4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulphur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	64 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	**Po** Polonium 84	**At** Astatine 85	**Rn** Radon 86
Fr Francium 87	226 **Ra** Radium 88	227 **Ac** Actinium 89 †															

*58-71 Lanthanoid series
†90-103 Actinoid series

140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	**Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	162 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
232 **Th** Thorium 90	**Pa** Protactinium 91	238 **U** Uranium 92	**Np** Neptunium 93	**Pu** Plutonium 94	**Am** Americium 95	**Cm** Curium 96	**Bk** Berkelium 97	**Cf** Californium 98	**Es** Einsteinium 99	**Fm** Fermium 100	**Md** Mendelevium 101	**No** Nobelium 102	**Lr** Lawrencium 103

Key

a **X** b

a = relative atomic mass
X = atomic symbol
b = proton (atomic) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.)

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
MID YEAR EXAMINATIONS

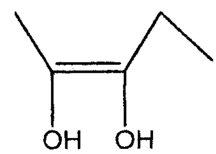
CHE 2511: BASIC ORGANIC CHEMISTRY

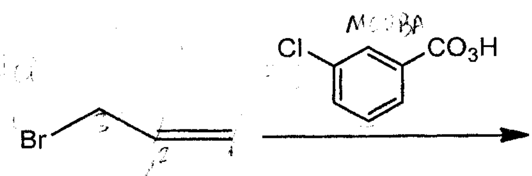
INSTRUCTIONS:

1. **TIME: THREE (3) HOURS**
2. This paper contains **five (5) questions** and has five (5) printed pages. Please ensure that you have all printed pages.
2. **Answer any four (4) questions.**
3. Questions carry equal marks, twenty five (25).
4. Write your TG number (example: TG 5) on the cover page of each answer booklet.
5. Please present your answers in a logical manner.
6. Please be neat and tidy.

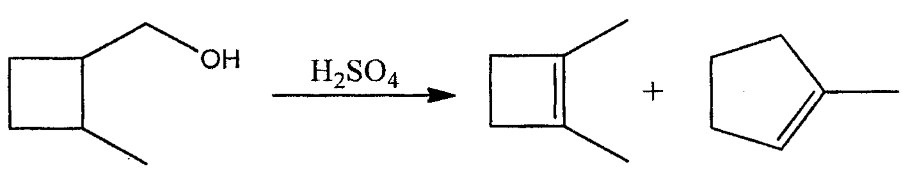
QUESTION 1

(a) Provide the missing starting materials/reagents/solvents/conditions/products of the following reactions. Show the stereochemistry of reactants/products, where necessary.

(i) *Cis*- 2-pentene $\xrightarrow{OsO_4}$ **A** $\xrightarrow{\textbf{reagent?}}$  **(2 marks)**

(ii) **B** $\xrightarrow[\textbf{conditions?}]{\textbf{reagent?}}$  **C** **(4 marks)**

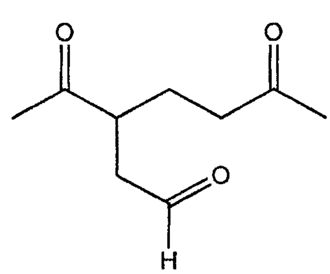
(b) Treatment of the alcohol **D** with sulphuric acid gives a complex mixture of products, including **E** and **F**. Propose a plausible mechanistic explanation to account for the products **E** and **F**. **(9 marks)**



+ **other products**

D **E** **F**

(c) Limonene, $C_{10}H_{16}$, is a terpene found in lemonand orange oils. Upon treatment with excess hydrogen over a platinum catalyst, limonene gives 1-isopropyl-4-methyl-cyclohexane. Upon treatment with ozone and then with zinc and acetic acid, limonene gives methanal and a compound **G**:

Compound G: 

(i) Calculate IHD of limonene and interpret it. **(2 marks)**

(ii) Propose a structure for limonene that is consistent with the results given. Justify your answer. **(7 marks)**

(iii) Provide the IUPAC name for compound **G**. **(1 mark)**

QUESTION 2

(a) Use Fischer projections to draw all the stereoisomers of 3-amino-2-butanol. Give the complete name for **any two** of the stereoisomers. **(9 marks)**

(b) Write all steps for mono-bromination of ethane in the reaction given below. **(6 marks)**

$$CH_3CH_3 \ + \ Br_2 \xrightarrow{\text{heat}} CH_3CH_2Br \ + \ HBr$$

(c) Draw the following : **(2 marks each)**

- (i) A stable butterfly conformer for methylcyclobutane.
- (ii) A stable envelope conformer for ethylcyclopentane.
- (iii) A stable chair conformer for *Cis*-1,3-diisopropylcyclohexane.

(d) Give structures of the products from the following reactions. Reaction mechanisms are **not** required to be shown. **(2 marks each)**

- (i) Treatment of methylcyclohexene with cold basic potassium permanganate.
- (ii) Treatment of methylcyclopentene with hydrogen chloride.

QUESTION 3

(a) Draw the Newman projections for staggered and eclipsed conformers of butane along the C2-C3 bond and arrange them in increasing order of energy. **(6 marks)**

(b) Predict the organic product of the following reactions. Do not write reaction mechanisms. **(2 marks each)**

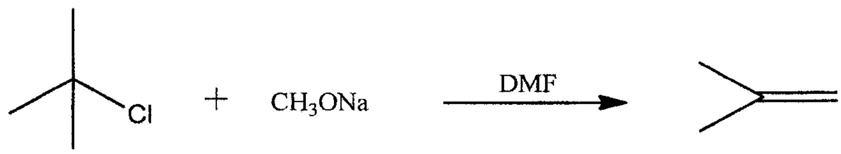
- (i) Reaction of 1-butyne with aqueous sulphuric acid in presence of mercuric ions.
- (ii) Reaction of cyclohexene with CH_2N_2in presence of uv radiation.

(c) Propose a Grignard synthesis of 3-hexanol from 1-propanol as the only source of carbon atoms and any needed reagents. Show all steps clearly, including the reagents, solvents, conditions and intermediates for each step. *DO NOT write reaction mechanisms*. **(8 marks)**

(d) Write mechanism for the reaction of 2-butanol with thionyl chloride in presence of pyridine. **(7 marks)**

QUESTION 4

(a) A CHE2511student attempted to prepare *Tert*-butyl methyl ether, $(CH_3)_3COCH_3$, by Williamson ether synthesis by reacting *Tert*-butyl chloride with sodium methoxide, but instead of the ether, she obtained an alkene, 2-methylpropene.



tert-Butyl chloride **2-methylpropene**

(i) Briefly explain why T*ert*-butyl methyl ether was not obtained. **(2 marks)**

(ii) Give a mechanism to account for the 2-methylpropene product. **(2 marks)**

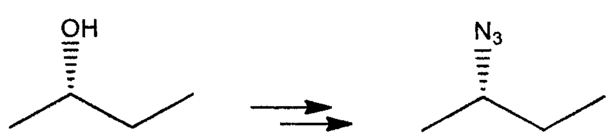
(iii) Show how you would prepare*Tert*-butyl methyl ether by Williamson ether synthesis. **(3 marks)**

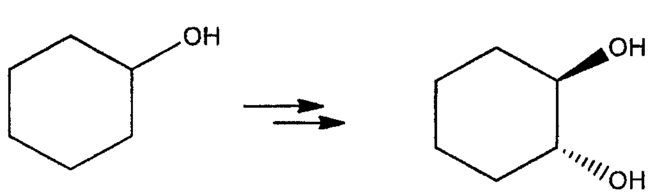
(b) Predict the major organic product and give mechanism of the following reaction:

$$\text{Propene} \xrightarrow[\text{(ii) } H_2O_2,\ \overset{\ominus}{O}H,\ H_2O]{\text{(i) } (CH_3)_2CBH,\ THF} \textbf{organic product?}$$

(8 marks)

(c) Suggest how the following transformations can be achieved. More than one step is required, show all steps clearly. <u>*Reaction mechanisms are NOT required*</u>.

(i)  **(5 marks)**

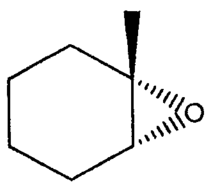
(ii)  **(5 marks)**

QUESTION 5

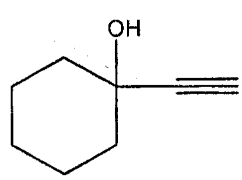
(a) Suggest the structure of alkyl halide that gives only *E*- 3-methyl-2-phenyl-2-pentene and none of the *Z*-isomer upon E2 elimination. Show the reaction. **(4 marks)**

(b) Identify the organic product(s), including pertinent stereochemistry, and give mechanisms of the following reactions:

(i) (R)- 2-Butanol $\xrightarrow[\text{Pyridine}]{\text{TsCl}}$ **P** $\xrightarrow[\text{THF}]{\text{KSH}}$ **Q** **(6 marks)**

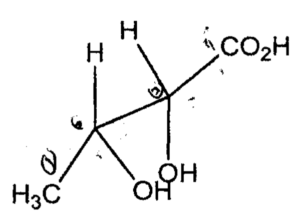
(ii)  $\xrightarrow[\text{(ii) } H_3O^{\oplus}]{\text{(i) } CH_3ONa}$ **R** **(4 marks)**

(c) Suggest a synthesis for compound **S** from any alcohol containing not more than six carbons and a hydrocarbon with two carbon atoms. Show all steps clearly. *Do not write reaction mechanisms.* **(5 marks)**

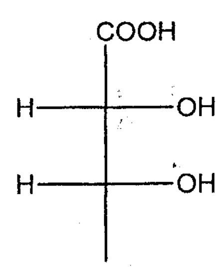


S

(d) State the isomeric relationship between the following pair of compounds. **(6 marks)**



and



END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR FINAL EXAMINATIONS

CHE 3122: ENERGY TRANSDUCTION SYSTEMS

TIME: THREE HOURS

INSTRUCTIONS:

1. Answer any **FOUR (4)** questions
2. There are **THREE (3)** printed pages in this examination paper
3. Each question carries **TWENTY (25)** marks

Question 1

a) **Draw** a schematic diagram of the ATP synthase and **give** the compositional analysis of all subunits and movement of protons when ATP is synthesized. **[8 marks]**

b) How many degrees does the rotor (CF_1) part move if 6 moles of ATP are synthesized? **[2 marks]**

c) **Describe** Calvins experiment **clearly** showing the intermediates. **[15 marks]**

Question 2

During photosynthesis, eight photons (4 electrons for both photosystems) are absorbed for every O_2 molecule produced:

$$2H_2O + 2NADP^+ + 8 \text{ photons} \rightarrow 2NADPH + 2H^+ + O_2$$

Suppose that these photons have a wavelength of 700 nm.

a) **Calculate** $\Delta E^{o'}$ and $\Delta G^{o'}$ for the reaction. **[10 marks]**

b) Assuming the process is 100 % efficient;

i) **Calculate** the free-energy change of 1 mole of photons
($Hint: E = \frac{hc}{\lambda} N_A = \frac{0.1196\, J.m.mol^{-1}}{\lambda}$) **[5 marks]**

ii) **Calculate** overall free-energy change for the absorption process. **[10 marks]**

Useful information is found on page 3

Question 3

a) **What** theory is now accepted as explanation for how oxidation of NADH is coupled to the phosphorylation of ADP to form ATP? *Just give the name of the theory – NO EXPLANATION!* **[2 mark]**

b) **What** is the name of the scientist who proposed this theory (or hypothesis), and why do you think it was difficult for other scientists to accept this hypothesis? **[5 mark]**

c) Given the following information on page 3, **show** by clear calculation that the oxidation of $FADH_2$ by oxygen in mitochondria can result in enough energy to cause synthesis of ATP. **[12 marks]**

d) Using the answer you get in 1 a) above, **calculate** the number of ATP that can be made from the oxidation of 1 mole of $FADH_2$ (*Hint: ATP hydrolysis under standard conditions yields -7,300 cal/mol.*) Useful information is found on page 3 **[6 marks]**

Question 4

a) Name **TWO** types of proteins found in biological membranes. Experimentally, how might you distinguish the two? **[5 marks]**

b) With regard to Na^+ ions, **what** transport system(s) is responsible for its inward flow into the cell? What system(s) moves these ions out? By means of diagrams, **explain** the probable mechanism of the system that moves Na^+ out of the cell. **Highlight** the role of ATP, if applicable. **[15 marks]**

c) If a solute across a membrane system has attained an equilibrium constant of 1.97 at 25 ^oC, **what** is the $\Delta G^{0'}$ for this process? (R = 8.314) **show** all the steps clearly! **[5 marks]**

Question 5

a) **Name** any THREE molecules and/or ions involved in muscle contraction. **[9 marks]**

b) By means of a neat diagram, **explain** how skeletal muscle contraction occurs highlighting the roles of THE THREE molecules and/or ions you have given question 5 a) above. **[16 marks]**

END OF EXAMINATION

Useful information

$ATP + H_2O \longrightarrow ADP + Pi$ $\Delta G^{0'} = -7{,}300$ cal/mol

Standard reduction potentials (Volts)

$NADP^+ + 2e^- + H^+ \rightarrow NADPH$	-0.320 V
$FAD + 2H^+ + 2e^- \rightarrow FADH_2$	-0.22 V
$O_2 + 4H^+ + 4e^- \rightarrow H_2O$	+0.82 V

Constants

Gas constant, R	$8.3145\ J.K^{-1}.mol^{-1}$
Faraday's constant, F	$96{,}485\ J.\ V^{-1}.\ mol^{-1}$
	$23{,}061$ cal $V^{-1}g^{-1}$ equivalent
Avogadro's constant	$6.022 \times 10^{23}\ .mol^{-1}$

Unit conversions

273.15 K = 0 °C

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2015/16 ACADEMIC YEAR MID – YEAR EXAMINATIONS

CHE 3211 SPECTROSCOPIC METHODS OF ANALYSIS

TIME: **THREE HOURS**

INSTRUCTIONS

1 There are **six** questions in this Examination Paper.

2 Answer any **four** questions. Each question should be written in a separate answer booklet. Questions carry equal marks.

3 Essential information and data are provided for this paper

Question 1

(a) (i) Describe briefly the different sources that can be used to generate UV light for a UV/Vis spectrophotometer.

(ii) I have a linear molecule with 4 atoms. How many normal mode vibrations should I expect in an IR spectrum ?

(iii) Describe four kinds of electronic transitions that can occur in UV /Vis Spectroscopy

(b) Carbon monoxide (CO) can be determined at trace levels using IR absorption spectrophotometry. Using a 100.0-cm pathlength gas cell, a standard containing 10.0 ppm CO gave an absorbance of 0.050 at 2170 cm^{-1}. Calculate the concentration (ppm) of a gas sample, analyzed using the same gas cell, which gives an absorbance of 0.005 at the same wavenumber. Assume the system obeys Beer's Law over the concentration range investigated.

(c) In absorption spectroscopy, what materials are used to make cells for UV, VIS, and IR ranges? What are the differences among them?

Question 2

(a) (i) Describe the different sources used to create IR radiation

(ii) Ammonia gas (NH_3) can be determined at trace levels using IR absorption spectrophotometry. Using a 10.0-m pathlength gas cell, a standard containing 25.0 ppm NH_3 gave an absorbance of 0.900 at 968 cm-1. Calculate the concentration (ppm) of a gas sample, analyzed using the same gas cell, which gives an absorbance of 0.005 at the same wavenumber. Assume the system obeys Beer's Law over the concentration range investigated.

(b) Warfarin ($C_{19}H_{16}O_4$), the active ingredient in rodenticides, will fluoresce at 385nm. A 0.842 g sample was brought into solution and diluted to 1.00liter. The fluorescence of this solution was found to be 596 (arbitrary units) at 385nm. Mixture of a 25.00 ml aliquot of the sample with 5.00 ml of standard 0.250ppm warfarin yielded a solution with an intensity of 670. Calculate the percentage of warfarin in the sample.
[C = 12.0, O = 16.0]

(c) Outline Job's method for the evaluation of the stoichiometry of a coloured food complex.

Question 3

(a) (i) State three factors that would cause a positive or negative deviation from Beer's law.

(ii) Explain the theory and instrumentation of phosphorimettry. Mention few applications of this technique.

(b) A 100.0ml solution of a drug gave an instrumental reading of 24.5. A 10.2mg sample of the pure drug (MW 848) was added to the solution and dissolved. The new solution gave an instrumental reading of 65.0. Calculate the concentration of the drug in the original solution.

(c) If the wavelength of a particular form of electromagnetic radiation (emr) in a vacuum is 522nm; calculate the frequency and the energy of the radiation. Given that Planck's constant, $h = 6.62 \times 10^{-34}$Js and the speed of light in vacuum, $c = 3.0 \times 10^{8}$m/s.

Question 4

(a) When you carry out elemental analysis in atomic spectroscopy, explain we need to use two different fuel/oxidant mixtures to determine for the concentrations of sodium and zinc in an aqueous sample?

(b) The flame has been extensively used in both AAS and AES. In traditional FES analysis of Group IIA elements, the flame provides two functions. Briefly describe each one of the functions.

(c) (i) Name and explain two (02) fundamental principles upon which the use of a calibration curve is based.

(ii) Describe how you would deliver the sample into an atomic absorption spectrometer

Question 5

(a) **Explain** chemical shift? Use of an **equation** is highly recommended.

(b) Using 1,1,2-Tribromoethane as an example, **clearly** draw the display structure and **show** how a proton NMR spectrum will look like assuming other conditions are constant.

(c) An instrument has magnetic field of $B_o = 4.69$ T (Tesla, 1 T = 10^4 G) for H-1, Calculate the frequency at which the proton absorbs.(γ_H=2.68 $\times 10^8 T^{-1} s^{-1}$)

Question 6

(a) Describe in detail, any two processes that $CaCl_{2(aq)}$ undergoes from being sample solution to being atoms that are used to determine calcium content in AES. State clearly the atomiser and light sources.

(b) Explain two (2) initial settings you would make as you change lamps (HCL) in an AAS/AES spectrometer as you switch from analysis of copper (Cu) to iron ((Fe) in aqueous medium.

(c) Inductively coupled plasma, flame and electric spark are used as atomisation methods in atomic spectroscopy. Only one of these would really be suitable for the determination of sodium and calcium in water. Name the method, and explain your choice.

END OF EXAMINATION

The Periodic Table of Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1 (1)	2 (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (8) (18)
							1.0 **H** hydrogen 1										4.0 **He** helium 2
6.9 **Li** lithium 3	9.0 **Be** beryllium 4											10.8 **B** boron 5	12.0 **C** carbon 6	14.0 **N** nitrogen 7	16.0 **O** oxygen 8	19.0 **F** fluorine 9	20.2 **Ne** neon 10
23.0 **Na** sodium 11	24.3 **Mg** magnesium 12											27.0 **Al** aluminium 13	28.1 **Si** silicon 14	31.0 **P** phosphorus 15	32.1 **S** sulfur 16	35.5 **Cl** chlorine 17	39.9 **Ar** argon 18
39.1 **K** potassium 19	40.1 **Ca** calcium 20	45.0 **Sc** scandium 21	47.9 **Ti** titanium 22	50.9 **V** vanadium 23	52.0 **Cr** chromium 24	54.9 **Mn** manganese 25	55.8 **Fe** iron 26	58.9 **Co** cobalt 27	58.7 **Ni** nickel 28	63.5 **Cu** copper 29	65.4 **Zn** zinc 30	69.7 **Ga** gallium 31	72.6 **Ge** germanium 32	74.9 **As** arsenic 33	79.0 **Se** selenium 34	79.9 **Br** bromine 35	83.8 **Kr** krypton 36
85.5 **Rb** rubidium 37	87.6 **Sr** strontium 38	88.9 **Y** yttrium 39	91.2 **Zr** zirconium 40	92.9 **Nb** niobium 41	95.9 **Mo** molybdenum 42	[98] **Tc** technetium 43	101.1 **Ru** ruthenium 44	102.9 **Rh** rhodium 45	106.4 **Pd** palladium 46	107.9 **Ag** silver 47	112.4 **Cd** cadmium 48	114.8 **In** indium 49	118.7 **Sn** tin 50	121.8 **Sb** antimony 51	127.6 **Te** tellurium 52	126.9 **I** iodine 53	131.3 **Xe** xenon 54
132.9 **Cs** caesium 55	137.3 **Ba** barium 56	138.9 **La*** lanthanum 57	178.5 **Hf** hafnium 72	180.9 **Ta** tantalum 73	183.8 **W** tungsten 74	186.2 **Re** rhenium 75	190.2 **Os** osmium 76	192.2 **Ir** iridium 77	195.1 **Pt** platinum 78	197.0 **Au** gold 79	200.6 **Hg** mercury 80	204.4 **Tl** thallium 81	207.2 **Pb** lead 82	209.0 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 **Ce** cerium 58	141 **Pr** praseodymium 59	144 **Nd** neodymium 60	[147] **Pm** promethium 61	150 **Sm** samarium 62	152 **Eu** europium 63	157 **Gd** gadolinium 64	159 **Tb** terbium 65	163 **Dy** dysprosium 66	165 **Ho** holmium 67	167 **Er** erbium 68	169 **Tm** thulium 69	173 **Yb** ytterbium 70	175 **Lu** lutetium 71
232 **Th** thorium 90	[231] **Pa** protactinium 91	238 **U** uranium 92	[237] **Np** neptunium 93	[242] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[245] **Bk** berkelium 97	[251] **Cf** californium 98	[254] **Es** einsteinium 99	[253] **Fm** fermium 100	[256] **Md** mendelevium 101	[254] **No** nobelium 102	[257] **Lr** lawrencium 103

* Lanthanide series
* Actinide series

N 3 7 6 9 0 A 0 1 2 1 2

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR FINAL EXAMINATIONS

CHE3222: SPECTROSCOPIC METHODS OF ANALYSIS

TIME: **THREE HOURS.**

INSTRUCTIONS

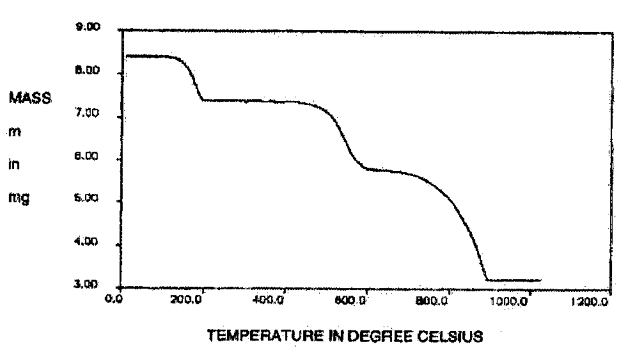
1 There are **six** (06) questions in this examination paper.
2 Answer any **four** (04) questions.
3 All questions carry equal marks.
4 Show your reasoning and/or calculations clearly.

Question 1.

(a) Briefly explain the roles of the working, counter and reference electrodes in potentiostatic electrolytic cell.

(b) Describe three mechanisms responsible for the transport of dissolved species to and from an electrode surface.

(c) The thermogram below is for the stepwise decomposition of a sample of calcium oxalate monohydrate powder ($Ca(COO)_2.H_2O$) as a function of temperature to yield CaO at temperatures above 900°C. From the thermogram, suggest a mechanism for each step in the decomposition.



(d) The determination of riboflavin in vitamin formulations can be carried out polarographically because it is more easily reduced than other vitamin B factors. A 250.1 mg vitamin tablet is dissolved to form a 100.00ml solution. A 10.0ml aliquot of this solution was added to a 0.1M phosphate supporting electrolyte at pH 7.2 and diluted to 50ml. The diffusion limited current was 0.28 μA. A 50.0ml standard 4.10ppm riboflavin solution in the same electrolyte gave diffusion limited current of 0.45μA. Calculate the riboflavin concentration in the diet supplement.

Question 2

(a) Ion selective electrode and reference electrode pair was placed in exactly 100ml of the food sample; a reading of 21.6mV was obtained. After the addition of exactly 10ml of a standard solution with a concentration of 100μg/ml, the electrode pair reading gave a reading of 43.7mV. The response slope of the indicator electrode was previously determined to be 57.8mV. What is the food sample concentration?

(b) (i) Distinguish the difference between voltammetry and polarography.

(ii) Explain the differences between concentration polarization and kinetic polarization in Electrogravimetry.

(c) Explain how you would determine the molar conductivity at infinite dilution for a strong and weak electrolyte in a food sample

(d) What is the short-wavelength limit, in angstroms, to the continuum radiation produced by a X-ray tube with a molybdenum target that is impacted by electrons driven by a 50 kV potential? The Duane-Hunt equation is: $eV_0 = \frac{hc}{\lambda_{min}} = h\nu_{max}$

Note: 1 angstrom (Å) is 10^{-10} meters.

Question 3

(a) Draw the nature of curve for the conductometric titration of a mixture of a strong acid and a weak acid VS a strong base (NaOH). Explain the salient features of titration curve.

(b) In coulometric titration of Fe^{2+} with Ce^{4+} which were generated at the cathode the resistance was R = 150 Ω, potential was 0.705V and the end point was reached after 352 seconds. Calculate the amount of iron in microgrammes (μg). [Atomic mass Fe = 55.85; F = 96487 Coulomb/mol]

(c) The purity of a sample of $Na_2S_2O_3$ was determined by a coulometric redox titration using I^- as a mediator, and I_3^- as the 'titrant'. A sample weighing 0.1342g is transferred to a 100ml volumetric flask and diluted to volume with distilled water. A 10.00ml portion is transferred to an electrochemical cell along with 25ml of 1M KI, 75ml of pH 7.0 phosphate buffer, and several drops of a starch indicator solution. Electrolysis at a constant current of 36.45mA required 221.8s to reach the starch indicator end point. Determine the purity of the sample.

(d) (i) What is a reference electrode? Name two indicator electrodes and two reference electrodes.

(ii) Give two reasons for using a supporting electrolyte in polarography.

Question 4

(a) What is "good resolution" as applied to GC separations?

(b) Two samples of different alcohols were separated on a capillary GC column. Retention times recorded were 370 and 385seconds respectively with peak base widths of 16.0 s and 17.0 s while an un-retained air peak occurred at 10.0s. Calculate the resolution, R_s, for the two compounds.

(c) A solution contains 1.0 g of iodine dissolved in 20.0 cm^3 of potassium iodide solution. If we shook this solution with 20.0 cm^3 of tetrachloromethane (assume **x** g of iodine was removed from the aqueous phase) how much iodine will be transferred into the tetrachloromethane, given that K_D for water/chloroform at 25°C is 85?

(d) Describe solvent extraction as both a separation and quantitative analytical method, as compared to chromatography.

Question 5

(a) Define the term "retention time"; then draw an illustrative schematic diagram to show the chromatogram for analytes **x**, **y** and **z** given that $t_{Ry} > t_{Rx} > t_{Rz}$.

(b) Compare the efficiency of two chromatographic separations whose retention factors (R_f values) were found to be 0.90 and 0.25 respectively, with clear reference to the mobile and stationary phases of the separatory system.

(c) Tale 1. Data

Analyte/Specie	Retention Time, (min)	Width of Peak at base (W, min)
Non-retained	3.1	Ref
A	5.4	0.41
B	13.3	1.07
C	14.1	1.16

Use data from Table 1 to determine the following:-

(i) The number of plates for the column with respect to peak C

(ii) Rs for peaks A and B

(d) What is the difference between gas-solid (GC) and gas-liquid chromatography (GLC). In your answer explain the chemistry of separation involved. Give an example of each one of the two types.

Question 6

(a) What is the Van Deemter equation?

(b) Data for a mixture for chromatographic separation contained two analytes, A and B, with retention times of 16.4min and 17.63 min respectively on a 48 in long column. An un-retained species passed through the column in 1.30 min. The peak widths at base for the two analytes were 1.11min and 1.21 min respectively.

(i) Define the term "residence time" for analytes separated using chromatography

The Periodic Table of Elements

Key

relative atomic mass **atomic symbol** name atomic (proton) number

1.0 **H** hydrogen 1

1 (1)	2 (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (8) (18)
																	4.0 **He** helium 2
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THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY

2015 ACADEMIC YEAR
MID-YEAR EXAMINATIONS

CHE 3411: CHEMISTRY OF MAIN GROUP ELEMENTS AND TRANSITION METAL COMPLEXES

INSTRUCTIONS:

1. TIME ALLOWED: **THREE (3)** HOURS ONLY
2. ENSURE YOU HAVE **FIVE (5)** PRINTED PAGES
3. THIS EXAM PAPER CONSISTS OF **TWO (2)** SECTIONS
4. EACH SECTION HAS **THREE (3)** QUESTIONS
5. ATTEMPT A **TOTAL OF FOUR (4)** QUESTIONS; **TWO (2)** FROM EACH SECTION
6. EACH QUESTION CARRIES **15 MARKS**
7. ANSWER EACH QUESTION IN A **SEPARATE** ANSWER BOOKLET
8. PLEASE PRESENT YOUR WORK IN A **TIDY AND ORDERLY MANNER**
9. THE PERIODIC TABLE IS ON PAGE **FIVE**

Section A

Instructions:
1. Attempt any **two (2)** questions from this section
2. Answer each question in a **separate** answer booklet

Question One

(a) Draw the structure of the complex
   (i) μ-amido bis[pentaminecobalt(III)]nitrate
   (ii) Tetrakis(ethylenediamine) μ-hydroxo μ-imido dicobalt(III) ion.

(b) Get all hydrate isomers possible with the complex $[Fe(H_2O)_6]Cl_3$. Also arrange them in the increasing conducting power.

(c) Indicate whether the following statements are TRUE or FALSE.
   (i) The IUPAC name of $K_3[VF_6]$ is potassium hexafluorovanadate(III).
   (ii) $Ni(CO)_4$ and $Ni(CN)_4^{2-}$ both are tetrahedral in shape.
   (iii) The complex ion $[Cr(en)_3]^{3+}$ shows optical isomerism.

Question Two

(a) Cr^{3+} in emerald (an octahedral complex) shows 3 peaks at 16260 cm^{-1}, 23700 cm^{-1} and 23740 cm^{-1}. Assign the bands.

(b) Select from the following list:
NO, Br_2, O_2, $H_2C{=}O$, CCl_4, $CH_3\text{-}CH_2\text{-}Cl$, CH_3CH_2OH

   (i) those which give more than one NMR band.
   (ii) those which are rotational inactive.

(c) How does alkyl substitution in π e system affect the UV absorption band?
Arrange methyl, ethyl, isopropyl and *t*- butyl groups in the increasing order of their ability to cause bathochromic shift.

Question Three

(a) What is a charge transfer band? Which species between $Cr_2O_7^{2-}$ and $[Ni(en)_3]^{2+}$ is likely to have a charge transfer band? Explain.

(b) Account for the variation of ionic radii of divalent first row transition metal ion in a weak tetrahedral field.

(c) Given that the maximum absorption in the d-d peak for $[Ti(H_2O)_6]^{3+}$ occurs at 20300 cm^{-1}, predict where the peaks for $[Ti(CN)_6]^{3-}$ and $[TiCl_6]^{3-}$.

Section B

Instructions:

1. Attempt any **two (2)** questions from this section
2. Answer each question in a **separate** answer booklet

Question One

(a) (i) The *p*-block of the modern Periodic Table is home to non-metals, metalloids, metals, gases and a liquid. Suggest **three** tests that can be used to distinguish a metal from a non-metal.

(ii) Name **five (5)** of the twenty (20) chemicals produced in greatest amounts by the developed nations' chemical industry (*e.g.*, US chemical industry).

(b) (i) Write **brief**, but concise notes on the Valence Shell Electron Pair Repulsion (VSEPR) theory in predicting the shapes of molecular species.

(ii) Use the VSEPR model to predict the probable shapes of the following species:
(i) XeF_5^+ (ii) SF_5^- (iii) IF_7 (iv) SiF_3^+ (v) SbF_4^+

(c) Most oxides of non-metals are acid anhydrides, *i.e.*, they dissolve in water to yield acids. Provide the names of the following acids.
(i) H_4XeO_6 (ii) H_3PO_2 (iii) H_5IO_6
(iv) $H_2S_2O_3$ (v) H_2CO_3

Question Two

(a) (i) Write balanced equations for the industrial preparation of HNO_3, starting with N_2.
(ii) When aqueous HNO_3 reacts with Cu turnings in a test tube, a colourless gas is formed that turns brown near the mouth of the tube. Explain the observations and write equations for the reactions involved.

(b) Suggest an explanation for each of the following observations
(i) Carbon monoxide (CO) is a good ligand and is toxic while the isoelectronic dinitrogen, (N_2), is not toxic.
(ii) SF_4 is prone to hydrolysis but SF_6 is not.
(iii) $[PCl_6]^-$ forms whereas $[SiCl_6]^{2-}$ does not.

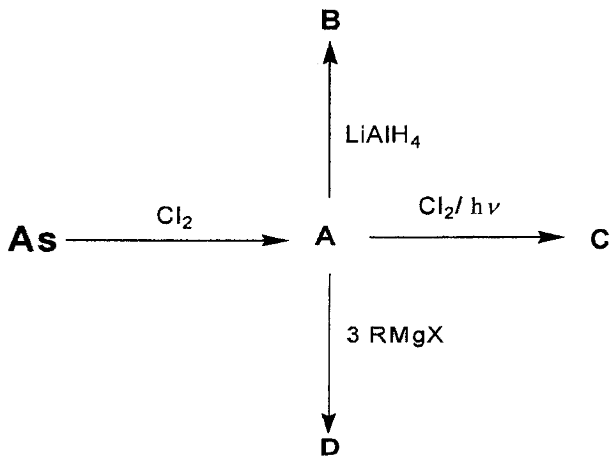
(c) Give balanced chemical equations for each of the following reactions:
(i) oxidation of P_4 with excess oxygen,
(ii) reaction of the product from part (i) with excess water,
(iii) reaction of the product from part (ii) with a solution of $CaCl_2$, and name the product.

(d) What would happen on this planet if hydrogen bonding bonding ceased to exist between water molecules?

Question Three

(a) (i) What known compounds, related in bonding and structure to the xenon halides, should have prompted a search for xenon halides earlier?

(ii) Identify compounds **A**, **B**, **C**, and **D** in the following reaction scheme involving arsenic.



(b) (i) Explain why the ozone molecule has a dipole moment.

(ii) It is said: "Some explosions do save lives, literally."
Write down a balanced chemical equation for the explosive, decomposition reaction that leads to the inflation of airbags in cars.

(c) Write balanced half reactions for the following redox couples in acidic solution:
(i) ClO_4^-/ClO_3
(ii) $ClO_3^-/HClO_2$
(iii) $HClO_2/HClO$

(d) (i) Sulfuric acid is synthesized by the chemical industry in larger quantities than any other chemical. Write down balanced chemical equations for the steps involved in the manufacture of sulfuric acid by the **Contact Process**.

(ii) The members of Group 18 have been called by several names, for example, rare gases, inert gases, *etc.*. **Briefly** explain why these names were inappropriate compared to the currently accepted name of noble gases.

END OF EXAMINATION

PERIODIC TABLE OF THE ELEMENTS

KEY: Atomic number / **X** / Atomic mass / Name of the element X

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01 Hydrogen																1 **H** 1.01 Hydrogen	2 **He** 4.00 Helium
3 **Li** 6.94 Lithium	4 **Be** 9.01 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium											13 **Al** 26.98 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.55 Copper	30 **Zn** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 71.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 Selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
37 **Rb** 85.47 Rubidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** 97.91 Technetium	44 **Ru** 101.07 Ruthenium	45 **Rh** 102.91 Rhodium	46 **Pd** 106.42 Palladium	47 **Ag** 107.87 Silver	48 **Cd** 112.41 Cadmium	49 **In** 114.82 Indium	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 Tellurium	53 **I** 126.90 Iodine	54 **Xe** 131.29 Xenon
55 **Cs** 132.91 Caesium	56 **Ba** 137.33 Barium	57 – 71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.84 Tungsten	75 **Re** 186.21 Rhenium	76 **Os** 190.23 Osmium	77 **Ir** 192.22 Iridium	78 **Pt** 195.08 Platinum	79 **Au** 196.97 Gold	80 **Hg** 200.59 Mercury	81 **Tl** 204.38 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 208.98 Bismuth	84 **Po** 208.98 Polonium	85 **At** 209.99 Astatine	86 **Rn** 222.02 Radon
87 **Fr** (223.02) Francium	88 **Ra** 226.03 Radium	89 - 103	104 **Unq** 261.11	105 **Unp** 262.11	106 **Unh** 263.12	107 **Uns** 262.12	108 **Uno** 265.00	109 **Une** 265									

57 **La** 138.91 Lanthanum	58 **Ce** 140.12 Cerium	59 **Pr** 140.91 Praseodymium	60 **Nd** 144.24 Neodymium	61 **Pm** 144.91 Promethium	62 **Sm** 150.36 Samarium	63 **Eu** 151.97 Europium	64 **Gd** 157.25 Gadolinium	65 **Tb** 158.93 Terbium	66 **Dy** 162.50 Dysprosium	67 **Ho** 164.93 Holmium	68 **Er** 167.26 Erbium	69 **Tm** 168.93 Thulium	70 **Yb** 173.04 Ytterbium	71 **Lu** 174.97 Lutetium
89 **Ac** 227.03 Actinium	90 **Th** 232.04 Thorium	91 **Pa** 231.04 Protactinium	92 **U** 238.03 Uranium	93 **Np** 237.05 Neptunium	94 **Pu** 244.0 Plutonium	95 **Am** 243.06 Americium	96 **Cm** 247.07 Curium	97 **Bk** 247.07 Berkelium	98 **Cf** 251.08 Californium	99 **Es** 252.08 Einsteinium	100 **Fm** 257.10 Fermium	101 **Md** 260 Mendelevium	102 **No** 259.10 Nobelium	103 **Lr** 262.11 Lawrencium

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR FINAL EXAMINATIONS

CHE3422: Organometallics and Reaction Mechanisms

TIME : THREE HOURS

Instructions:

Answer any four (4) questions

All questions carry equal marks

Periodic Table is attached

QUESTION 1

(a) A number of lanthanide minerals (e.g monozite) are usually deficient in Europium, which is found among Calcium minerals. Comment.

(b) What is the possible reaction between lanthanide metal and liquid ammonia? Give the chemical equation.

(c) Actinides form oxocations like UO_2^{2+} but lanthanides don't. Explain.

QUESTION 2

(a) What happens when

(i) Ammonium diuranate is calcined.
(ii) Sodiumdiuranate is digested with ammonium carbonate.

(b) Give the chemical equation showing the reaction between $H_2S_2O_7$ and H_2SO_4. Which is the stronger acid? Why?

(c) Show the self ionization of the solvent SO_2. How does thionyl chloride and ceasium sulphite react? What is its importance?

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number
X
Atomic mass
Name of the element X

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.01 Hydrogen																1 H 1.01 Hydrogen	2 He 4.00 Helium
3 Li 6.94 Lithium	4 Be 9.01 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 23.00 Sodium	12 Mg 24.31 magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.99 Phosphorus	16 S 32.07 Sulphur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.88 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 71.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc 97.91 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Inidum	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 Tellurium	53 I 126.90 Iodine	54 Xe 131.29 Xenon
55 Cs 132.91 Caesium	56 Ba 137.33 Barium	57 – 71	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantalum	74 W 183.84 Tungsten	75 Re 186.21 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.97 Gold	80 Hg 200.59 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po 208.98 Polonium	85 At 209.99 Astatine	86 Rn 222.02 Radon
87 Fr (223.02) Francium	88 Ra 226.03 Radium	89 - 103	104 Unq 261.11	105 Unp 262.11	106 Unh 263.12	107 Uns 262.12	108 Uno 265.00	109 Une 265									

57 La 138.91 Lanthanum	58 Ce 140.12 Cerium	59 Pr 140.91 Praseodymium	60 Nd 144.24 Neodymium	61 Pm 144.91 Promethium	62 Sm 150.36 Samarium	63 Eu 151.97 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.93 Terbium	66 Dy 162.50 Dysprosium	67 Ho 164.93 Holmium	68 Er 167.26 Erbium	69 Tm 168.93 Thulium	70 Yb 173.04 Ytterbium	71 Lu 174.97 Lutetium
89 Ac 227.03 Actinium	90 Th 232.04 Thorium	91 Pa 231.04 Protactinium	92 U 238.03 Uranium	93 Np 237.05 Neptunium	94 Pu 244.0 Plutonium	95 Am 243.06 Americium	96 Cm 247.07 Curium	97 Bk 247.07 Berkelium	98 Cf 251.08 Californium	99 Es 252.08 Einstienium	100 Fm 257.10 Fermium	101 Md 260 Mendelevium	102 No 259.10 Nobelium	103 Lr 262.11 Lawrencium

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR
FINAL EXAMINATIONS

CHE 3522
POLYFUNCTIONAL COMPOUNDS, MOLECULAR REARRANGEMENTS AND ORGANIC SYNTHESIS

TIME ALLOWED: THREE (3) HOURS

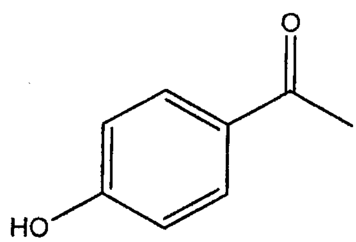
INSTRUCTIONS:

1. This paper contains five questions and has 5 printed pages. Ensure you have all printed pages.
2. Answer any four questions.
3. Each question carries 25 marks
4. Please present your answers in a logical manner.

QUESTION ONE

(a) Predict the major organic product and give mechanism of the following Dakin reaction:

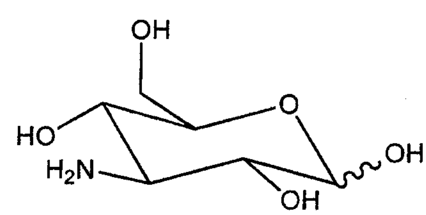
(5 marks)



$\xrightarrow[\overset{\oplus}{O}H/\ H_2O]{H_2O_2}$ **A**, $C_6H_6O_2$

(b) Suggest how the following multistep transformations can be achieved in good yield. Show all steps, including intermediate for each step, clearly. Please <u>do not</u> write reaction mechanisms.

(i) D-Glucose $\longrightarrow\longrightarrow$



(I)

(8 marks)

(ii) D- Glucose $\longrightarrow\longrightarrow$ D-Mannose

(5 marks)

(c) Ruff degradation of a D-aldopentose, **B**, gave a D-aldotetrose **C.** Upon nitric acid oxidation, **B** gave an optically *inactive* aldaric acid **D**, while **E** gave an optically *active* aldaric acid **D.**

(i) Propose structures for **B-E.** **(4 marks)**

(ii) Show all reactions involved in the transformation of **B** into **C.** **(3 marks)**

QUESTION TWO

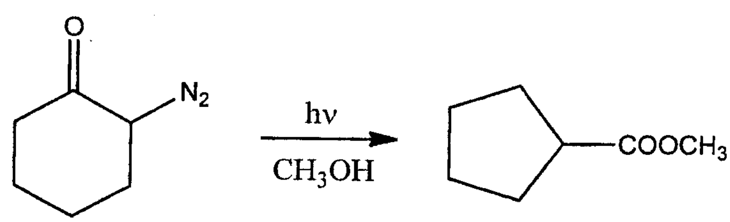
(a) When borneol (ROH), a toxic substance, is fed to dog, it is excreted as the metabolite **E**, $C_6H_9O_6$-OR, where R stands for bornyl group, in urine. The metabolite **E** does not reduce Benedict's solution but it reacts with aqueous sodium bicarbonate with liberation of a gas. Treatment of **E** with aqueous acid yields borneol and D-glucuronic acid, which is oxidized by bromine water to D-glucaric acid.

(i) Interpret the given data and deduce the structure of metabolite **E**, draw the pyranose form. **(7 marks)**

(ii) Show all reactions involved. **(3 marks)**

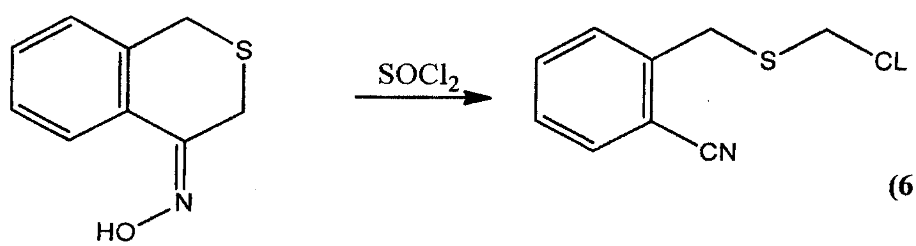
(b) Propose plausible mechanism to account for the products of the following rearrangement reactions:

(i)



(6 marks)

(ii)



(6 marks)

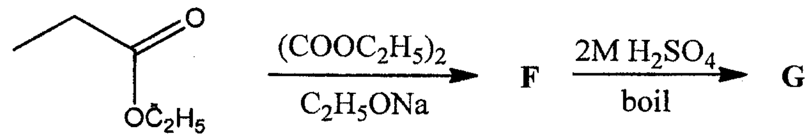
(c) Give the structure of a ketohexose that gives the same osazone as D-galactose and the reagents needed for osazone formation. **(3 marks)**

QUESTION THREE

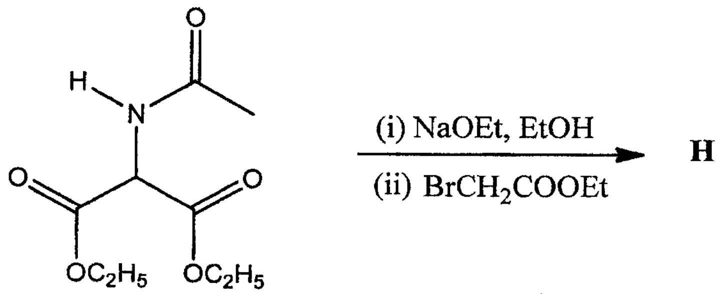
(a) Show all steps involved in a synthesis of the peptide *phe-ala* using the Merrifield procedure. **(9 marks)**

(b) Identify the products, **F-H**, of the following reactions: **(6 marks)**

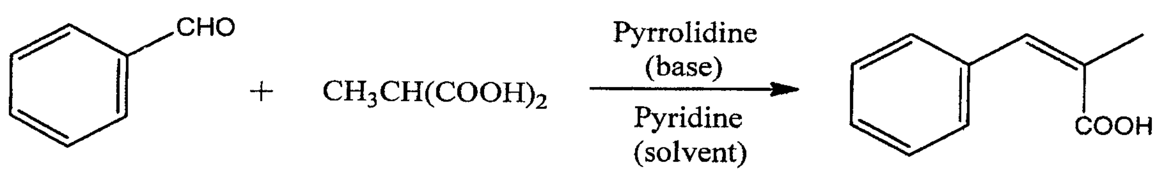
(i)



(ii)



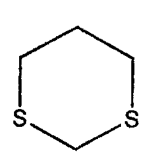
(c) When Knoevenagel condensation is carried out in pyridine solution, the condensation product usually decarboxylates in the reaction mixture to give an α,β-unsaturated compound. For example:



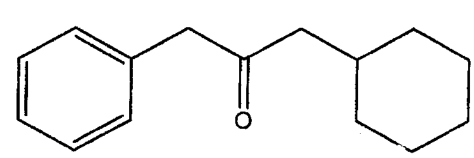
Suggest a plausible mechanism for the above reaction. **(10 marks)**

QUESTION FOUR

(a) Suggest a synthesis of the molecule **I**, from dithiane, allyl bromide, $H_2C{=}CHCH_2Br$, and any other needed reagents/solvents. Show all steps clearly, including the intermediate for each step. **(6 marks)**



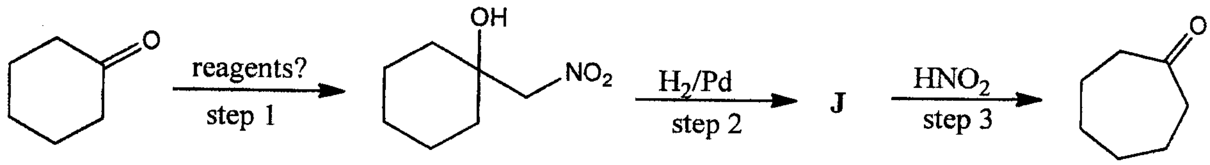
Dithiane



I

(ii) How you would prepare dithiane in one step. **(2 marks)**

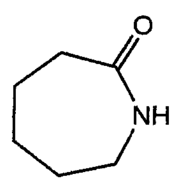
(b) A procedure for homologation of cyclic ketones by Tiffeanov-Demyanov reaction is outlined below:



(i) Provide the missing reagents for step 1. **(2 marks)**
(ii) Give the structure of the step 2 product **J**. **(1 mark)**
(iii) Give a plausible mechanism for step 3, show all steps. **(7 marks)**
(iv) Suggest the structure of one other possible product that can be expected to be formed in step 3. Briefly explain. **(3 marks)**

(c) What is the structure of nylon-6, made by alkaline polymerization of caprolactam? **(4 marks)**

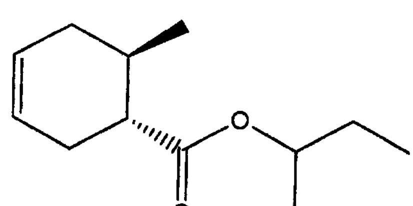
Caprolactam:



QUESTION FIVE

Applying the disconnection approach, propose a synthesis for the following target molecules from indicated starting materials. Show the retrosynthetic analysis, and each step of the proposed synthesis, including intermediates, clearly. Please *do not* write reaction mechanisms. **(25 marks)**

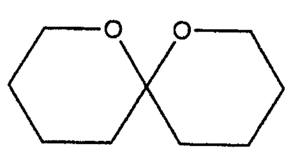
(i)



K

from 1,3-butadiene

(ii)



L

from 1,3-cycloheaxanedione

END OF EXAMINATION
GOOD LUCK!

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF CHEMISTRY

ACADEMIC YEAR 2015-2016 SESSIONAL EXAMINATIONS

CHE 3622 COLLOIDS AND ELECTROCHEMISTRY

TIME: THREE HOURS

INSTRUCTIONS: ANSWER *FOUR* QUESTIONS

DATA

$N_A = 6.022 \times 10^{23}$ mol^{-1}; $R = 8.314$ J.K^{-1}.mol^{-1}; $F = 96\,485$ C.mol^{-1};

1 Atm. = 1.01325 bar = 760 *mm*Hg;

H = 1.008; C = 12.00; Cl = 35.45; Mg = 24.31, Ca = 40.07

Charge on one electron = 1.602×10^{-19}C; $\frac{d\ln p}{dT} = \frac{\Delta_{vap}H}{RT^2}$

QUESTION 1 [*25 MARKS*]

a) The conductivity of a 0.0312 M solution of a weak base is 1.53×10^{-4}S.cm^{-1}. If the sum of the limiting ionic conductances of BH^+ and OH^- is 237.0 S.cm^2.mol^{-1}, what is the value of the base constant, K_b?

b) (i) What is meant by the terms *transport number* and *ionic mobility* of an ion?

(ii) How are these terms related to each other?

(iii) Give their units.

(iv) Describe, briefly, the moving boundary method for determination of transport number.

c) In moving boundary experiment with 0.100 M KCl using 0.065 M LiCl as indicator solution, a constant current of 0.005893 A was passed for 35.5 s. The boundary moved was observed to move through 56 mm in a tube of 0.1142 cm^2 cross section. Calculate the transport number of K^+ and Cl^-.

QUESTION 2 [*25 MARKS*]

The vapour pressure (*mm*Hg) of methyl chloride between 226.15 K and 263 .15 K as a function of temperature was found to be

$$\ln p = -\frac{2646.147}{T} + 17.229$$

a) Calculate the heat of vapourization of liquid methyl chloride in joules per gram.

b) Calculate the normal boiling point of methyl chloride.

c) Calculate the boiling point of methyl chloride using Trouton's Rule and compare your result with the value you calculated in part b). Comment by explaining why the two results are similar or different.

QUESTION 3 [*25 MARKS*]

a). For the reaction at an electrode : $Ox + e^- \rightarrow Red$

the net current flowing, *i*, depends on the applied potential E:

$$i = [\text{Red}]\left\{e^{-\alpha zF(E-E^{o})/RT}\right\} - [\text{Ox}]\left\{e^{(1-\alpha)zF(E-E^{o})/RT}\right\}$$

where E^o is he standard potential of the redox couple, F is the Faraday constant, and α is the transfer coefficient. The first term in the equation relates to the reduction of Ox; the second term relates to the oxidation of Red.

(i) Under what conditions can values of α be determined from plots of $\ln(|i|)$ against E?

(ii) For simple one-electron reactions, α commonly has values close to 0.5. For more complex, multi-electron reactions other values can arise which suggest a mechanism for the reaction. The rate of anodic (oxidative) dissolution of iron in $FeSO_4$(aq) has been studied and the following data obtained for the reaction:

$Fe(s) \rightarrow Fe^{2+}(aq) + e^-$

$(E - E^0)$/V	0.100	0.140	0.180	0.220
$\lvert j \rvert$ / A m^{-2}	1	10	100	1000

Use a graphical procedure to determine a value of α for the reaction.

Question 3 continues to the next page.

b) The electron transfer coefficient of a certain electrode in contact with the redox couple M^{3+}/M^{4+} in aqueous solution at 25 °C is 0.39. The current density is found to be 55.0 mA cm^{-2} when the overvoltage is 125 mV.

(i) What is the overvoltage for a current density 75.0 mA cm^{-2}?

(ii) What is the exchange current density?

QUESTION 4 [*25 MARKS*]

a). In in order to discourage guessing on this part a) of the question: *5 marks will be given for the right answer; -2 marks will be given for the wrong answer, 0 marks will be given for not answering the question.*

"At the first triple point of sulfur $\left(\frac{dp}{dT}\right)^l > \left(\frac{dp}{dT}\right)^s$"

Is the above statement TRUE or FALSE?

b) Give the best and concise description of a *critical point.*

c) A system is made up of a 10.0 molar aqueous solution of sulfuric acid which dissociates partly into hydrogen sulfate and sulfate ions at a pressure of 1 bar. Write the dissociation equation and give the number of components in the system and name them; and calculate the number of *degrees of freedom* of the system.

d) Briefly explain why the phase transition:

$$CO_2(s, T) \rightleftarrows CO_2(l, T)$$

does not occur at the normal pressure of 1.01325 bar.

e) Briefly distinguish between a *congruent* and an *incongruent* melting compound.

QUESTION 5 [*25 MARKS*]

A two component system made up of magnesium (melting point = 650°C) and calcium (melting point = 842°C) has two eutectic points. The first eutectic point is at 517°C with a composition of 15.2 % weight calcium and the second is at 715°C with composition 45 % weight calcium. The components form a compound (melting point = 715°C) with composition 45 % weight calcium.

a) Draw a T-%Wt. phase diagram of the magnesium and calcium system.

b) In each region of the phase diagram, write all the phases that are in equilibrium. (Note: writing a phase as, *s* (for *solid*) is not acceptable. Instead write as A(*s*)).

c) What is the formula of the compound formed?

d) A liquid melt of composition 70 % Wt. magnesium is cooled from 800°C to 300°C. At what temperature does the first solid phase appear? Name the solid phase that appears.

e) Calculate the degrees of freedom that a composition of 30% Wt. calcium has at 450°C.

QUESTION 6 [*25 MARKS*]

The molar enthalpy of fusion of ice, $\Delta_{fus}\bar{H}$ at 273.15 K and 101,325 Pa is 6010 J mol^{-1}, and $\Delta_{fus}\bar{V}$ under the same conditions is -1.63 cm^{3}mol^{-1}.

a) Write the change of state under the given conditions.

b) Explain why $\Delta_{fus}\bar{V}$ has a negative value.

c) Determine the value of $\left[\frac{dT}{dp}\right]_{s\to l}$ for ice at its normal melting point.

d) Calculate the estimated melting point of ice at 101.325 MPa.

e) The experimental value of the melting point of ice at 101.325 MPa is 263.7 K. Explain the discrepancy, if any, with your result in part d).

END OF CHE 3622 EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR FINAL EXAMINATIONS

CHE 4102: BIOCHEMICAL PROCESSES AND RESEARCH TECHNIQUES

TIME: THREE HOURS

INSTRUCTIONS:

1. Answer any **FOUR (4)** questions
2. There are **TWO** (2) printed pages in this examination paper
3. All questions carry **EQUAL MARKS**

Question 1

What is the biochemistry of cholera? **What** is a G-protein? **Explain** in detail the role of this protein in cholera (**include** a neat diagram).

[25 marks]

Question 2

a) Briefly **OUTLINE** any four elements of innate immunity.

b) Using a neat table, **name** any three (3) features distinguish immunoglobulin (Ig) from a T-cell receptor (TCR)?

c) **Explain** in detail the generation of Immunoglobulin (Ig) diversity. **Include** a neat and well labeled diagram

[25 marks]

Question 3

a) **Explain** this statement: "*Xenobiotic transformation is not necessarily detoxification*"

b) **Distinguish** clearly the roles of kidney and liver in xenobiotic transformation

[25 marks]

Question 4

a) **Define** the following terms

i) EMEM

ii) DMEM

iii) HAT

iv) Cell viability test (use a formula)

v) Senescence

b) What is the mechanism of HAT selection medium? (*Use of a diagram is highly recommended*)

[25 marks]

Question 5

a) **What** is the basis of separation, in size exclusion chromatography?

b) **Predict** the order of elution of the proteins, when a mixture containing the following, cytochrome c (MW 13,000), tryptophan synthetase (MW 117,000), hexokinase (MW 96,000), ATP sulfurylase (MW 440,000), glucose oxidase (MW 154,000) and xanthine oxidase (MW 300,000) is passed through a column containing a gel that excludes all proteins of MW 200,000 and higher.

c) Using the following information, **calculate** the molecular weight of an unknown protein which elutes from a superdex 200 Hiload 26/60 at a volume of 188.2 ml.

Protein marker	Mwt (Da)	Ev (ml)
Thyroglobulin	670,000	122.0
γ-globulin	158,000	160.05
Ovalbumin	17,000	238.14
Vitamin B 12	1,350	295.9

d) Thyroglobulin is a homodimer. If an SDS-PAGE experiment was run, **show** how the gel will look like including the unknown protein in part (c)?

[25 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMRNT OF CHEMISTRY

2015/2016 ACADEMIC YEAR

CHE4422 – Metal Chemistry and their Application to Organometallics and Catalysis

Time Allowed: **Three (3) Hours** ONLY

Instructions:

1. This exam paper consists of **five (5)** questions
2. Attempt any **three (3)** questions, including **Question One**
3. All questions carry **equal marks**
4. Answer each question in a **separate** answer booklet
5. You are reminded of the necessity for **tidy and orderly presentation** of your work.

Question One

Conversion of cycloheptatriene, C_7H_8, to the tropylium cation, $C_7H_7^+$, can be accomplished by treating cycloheptatriene with triphenylcarbonium perchlorate, $Ph_3C^+ ClO_4^-$,:

$$C_7H_8 + Ph_3C^+ ClO_4^- \longrightarrow C_7H_7^+ ClO_4^- + Ph_3CH$$

The tropylium cation, which is insoluble in non-polar solvents but dissolves readily in water, reacts with transition metal complexes to yield species containing the $(\eta^7\text{-}C_7H_7)M$ moiety, for example, $[(\eta^7\text{-}C_7H_7)Mo(CO)_3]^+$.

The Symmetry Adapted of Linear Combinations of Atomic Orbitals (SALCS) for $C_7H_7^+$ cation are given by the following expressions:

$$\Psi_A = \frac{1}{\sqrt{7}}(\Phi_1 + \Phi_2 + \Phi_3 + \Phi_4 + \Phi_5 + \Phi_6 + \Phi_7)$$

$$\Psi_{E1a} = \sqrt{\frac{2}{7}}(\Phi_1 + \Phi_2 \mathrm{Cos}\ \omega + \Phi_3 \mathrm{Cos}\ 2\omega + \Phi_4 \mathrm{Cos}\ 3\omega + \Phi_5 \mathrm{Cos}\ 3\omega + \Phi_6 \mathrm{Cos}\ 2\omega + \Phi_7 \mathrm{Cos}\ \omega)$$

$$\Psi_{E1b} = \sqrt{\frac{2}{7}}(\Phi_2 \mathrm{Sin}\ \omega + \Phi_3 \mathrm{Sin}\ 2\omega + \Phi_4 \mathrm{Sin}\ 3\omega - \Phi_5 \mathrm{Sin}\ 3\omega - \Phi_6 \mathrm{Sin}\ 2\omega - \Phi_7 \mathrm{Sin}\ \omega)$$

$$\Psi_{E2a} = \sqrt{\frac{2}{7}}(\Phi_1 + \Phi_2 \mathrm{Cos}\ 2\omega + \Phi_3 \mathrm{Cos}\ 3\omega + \Phi_4 \mathrm{Cos}\ \omega + \Phi_5 \mathrm{Cos}\ \omega + \Phi_6 \mathrm{Cos}\ 3\omega + \Phi_7 \mathrm{Cos}\ 2\omega)$$

$$\Psi_{E2b} = \sqrt{\frac{2}{7}}(\Phi_2 \mathrm{Sin}\ 2\omega - \Phi_3 \mathrm{Sin}\ 3\omega - \Phi_4 \mathrm{Sin}\ \omega + \Phi_5 \mathrm{Sin}\ \omega + \Phi_6 \mathrm{Sin}\ 3\omega - \Phi_7 \mathrm{Sin}\ 2\omega)$$

$$\Psi_{E3a} = \sqrt{\frac{2}{7}}(\Phi_1 + \Phi_2 \mathrm{Cos}\ 2\omega + \Phi_3 \mathrm{Cos}\ \omega + \Phi_4 \mathrm{Cos}\ 2\omega + \Phi_5 \mathrm{Cos}\ 2\omega + \Phi_6 \mathrm{Cos}\ \omega + \Phi_7 \mathrm{Cos}\ 3\omega)$$

$$\Psi_{E3b} = \sqrt{\frac{2}{7}}(\Phi_2 \mathrm{Sin}\ 3\omega - \Phi_3 \mathrm{Sin}\ \omega + \Phi_4 \mathrm{Sin}\ 2\omega - \Phi_5 \mathrm{Sin}\ 2\omega + \Phi_6 \mathrm{Sin}\ \omega - \Phi_7 \mathrm{Sin}\ 3\omega)$$

where $\omega = \dfrac{2\pi}{7}$

(a) Is the cation $C_7H_7^+$ aromatic? Explain your answer.

(b) Draw the shapes of the SALCS and briefly explain how you arrive at each shape.

(c) By inspection, deduce the suitable metal atomic orbitals that would coordinate to $C_7H_7^+$ if $C_7H_7^+$ were to form a η^7–coordination compound with a metal centre.

(d) Arrange the SALCS in order of increasing energy and complete the qualitative energy level diagram by filling in the available electrons.

(e) The energies of planar, cyclic C_nH_n, π–systems may also be obtained **without** calculation. Briefly explain how this can be done, using $C_7H_7^+$ as an example.

(f) Hence, construct a qualitative molecular orbital (MO) energy level diagram for $[(\eta^7\text{-}C_7H_7)Mo(CO)_3]^+$.

Question Two

"Homogeneous catalysis mediated by complexes of transition elements relies primarily on the ability of such complexes to undergo oxidative addition/ reductive elimination."

By way of a catalytic cycle, propose a suitable mechanism for each of each the following processes:

(a) $$C_6H_5CH_2C(=O)\text{-}Cl \xrightarrow[\Delta]{RhCl(PPh_3)_3} C_6H_5CH_2Cl \quad + \quad CO$$

(b) $$CH_3CH_2OH \quad + \quad CO \xrightarrow{[RhI_2(CO)_2]^- / HI} CH_3CH_2COOH$$

(c) $$CH_3CH_2CH_2CH_2CH_2\text{-}C(=O)\text{-}H \xrightarrow[\Delta]{RhCl(PPh_3)_3} CH_3CH_2CH_2CH_2CH_3 \quad + \quad CO$$

(d) $$H_3C{-}C{\equiv}C{-}H \; + \; CO \; + \; MeOH \xrightarrow{Ni(H)Cl(CO)_2} (H)(H)C{=}C(CH_3)(COOMe)$$

Question Three

(a) Compounds of Au(III) are under investigation as anticancer drugs. Predict some of the similarities and contrasts with Pt(II) compounds.

(b) For each of the following elements, identify **one** significant role in biological processes: Fe, Mn, Cu, Zn, I, Mg, Co, and Ca.

(c) Briefly describe the consequences of the deficiency in the trace elements Fe, Zn, Mn, and Cu. Include the remedy for the deficiency in those trace elements in the human body.

(d) Explain the chemical properties of Pt complexes that suit them as anticancer drugs.

Question Four

(a) Explain the terms α–and β–hydrogen transfer. Give an example in each case.

The butane product from the reaction:

$(\eta^5\text{–}C_5H_5)Fe(CO)(PPh_3)(n\text{-}C_4H_9) \longrightarrow (\eta^5\text{–}C_5H_5)Fe(CO)(PPh_3)H \quad + \quad \text{butene}$

consists of 1-butene as well as *cis*- and *trans*-2-butene. Keeping in mind the reversibility of the β–hydrogen elimination, write a mechanism to account for this.

(b) Explain, with examples, the oxidative-addition reaction and discuss those features that favour the occurrence of such a reaction.

(c) The reaction of $CH_3Mn(CO)_5$ with PPh_3 produces $(CH_3CO)Mn(CO)_4(PPh_3)$. Draw the geometry of the product acetyl-complex and explain the term migratory-insertion reaction.

(d) Explain the term *cyclometallation*. Give examples of the different rings that may result and point out the features that drive this reaction.

Question Five

(a) In his 1981 Nobel lecture, **Roald Hoffmann** defined molecular fragments to be *isolobal*:

"if the number, symmetry properties, approximate energy and shape of the frontier orbitals and the number of electrons in them are similar — not identical, but similar."

(i) Limiting yourself to the ligand CO and first-row transition metal elements, propose examples of organometallic fragments isolobal with $CH_3^{\cdot}$, CH_3^+, $CH_2^{\cdot}$, CH_2^+, and $CH^{\cdot}$.

(b) The water Gas Shift Reaction:

$$H_2O \quad + \quad CO \rightleftharpoons H_2 \quad + \quad CO_2 \qquad \Delta H = +42\ kJ\ mol^{-1},$$

is widely used to generate hydrogen gas. The reaction proceeds homogeneously using various metal carbonyls in basic solution in methanol. Propose a catalytic cycle for a $Fe(CO)_5$-catalysed water shift reaction.gas

(c) Copper bracelets have long been thought to have beneficial effects for rheumatism sufferers. Without speculating on the possible molecular mechanism of action at the target site, describe the chemical principles that are likely to determine how Cu enters the body and is delivered to tissues.

(d) Identify the following reactions by type and predict the product:

(i) $Re_2(CO)_{10}$ + Na/ Hg $\longrightarrow$

(ii) $[RhCl_2(CO)_2]^-$ + CH_3I $\longrightarrow$

(iii) Cp_2Fe + *n*-BuLi $\longrightarrow$

(iv) $CH_3Mn(CO)_5$ + $C_6H_5NH_2$ $\longrightarrow$

(v) $Ru(H)_2(PPh_3)_2$ + C_2H_4 $\longrightarrow$

***

END OF CHE4422 EXAMINATION for 2015/2016 ACADEMIC YEAR EXAMIN

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number
X
Atomic mass
Name of the element X

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01 Hydrogen																1 **H** 1.01 Hydrogen	2 **He** 4.00 Helium
3 **Li** 6.94 Lithium	4 **Be** 9.01 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium											13 **Al** 26.98 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.55 Copper	30 **Zn** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 71.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 Selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
37 **Rb** 85.47 Rubidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** 97.91 Technetium	44 **Ru** 101.07 Ruthenium	45 **Rh** 102.91 Rhodium	46 **Pd** 106.42 Palladium	47 **Ag** 107.87 Silver	48 **Cd** 112.41 Cadmium	49 **In** 114.82 Indium	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 Tellurium	53 **I** 126.90 Iodine	54 **Xe** 131.29 Xenon
55 **Cs** 132.91 Caesium	56 **Ba** 137.33 Barium	57 – 71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.84 Tungsten	75 **Re** 186.21 Rhenium	76 **Os** 190.23 Osmium	77 **Ir** 192.22 Iridium	78 **Pt** 195.08 Platinum	79 **Au** 196.97 Gold	80 **Hg** 200.59 Mercury	81 **Tl** 204.38 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 208.98 Bismuth	84 **Po** 208.98 Polonium	85 **At** 209.99 Astatine	86 **Rn** 222.02 Radon
87 **Fr** (223.02) Francium	88 **Ra** 226.03 Radium	89 - 103	104 **Unq** 261.11	105 **Unp** 262.11	106 **Unh** 263.12	107 **Uns** 262.12	108 **Uno** 265.00	109 **Une** 265									

57 **La** 138.91 Lanthanum	58 **Ce** 140.12 Cerium	59 **Pr** 140.91 Praseodymium	60 **Nd** 144.24 Neodymium	61 **Pm** 144.91 Promethium	62 **Sm** 150.36 Samarium	63 **Eu** 151.97 Europium	64 **Gd** 157.25 Gadolinium	65 **Tb** 158.93 Terbium	66 **Dy** 162.50 Dysprosium	67 **Ho** 164.93 Holmium	68 **Er** 167.26 Erbium	69 **Tm** 168.93 Thulium	70 **Yb** 173.04 Ytterbium	71 **Lu** 174.97 Lutetium
89 **Ac** 227.03 Actinium	90 **Th** 232.04 Thorium	91 **Pa** 231.04 Protactinium	92 **U** 238.03 Uranium	93 **Np** 237.05 Neptunium	94 **Pu** 244.0 Plutonium	95 **Am** 243.06 Americium	96 **Cm** 247.07 Curium	97 **Bk** 247.07 Berkelium	98 **Cf** 251.08 Californium	99 **Es** 252.08 Einsteinium	100 **Fm** 257.10 Fermium	101 **Md** 260 Mendelevium	102 **No** 259.10 Nobelium	103 **Lr** 262.11 Lawrencium

THE UNIVERSITY OF ZMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF CHEMISTRY

9 MARCH 2016

2015/2016 ACADEMIC YEAR SESSIONAL EXAMINATIONS TERMS I&II

CHE 4611: QUANTUM CHEMISTRY AND MOLECULAR SPECTROSCOPY

TIME: THREE HOURS

INSTRUCTIONS: ANSWER QUESTION 1 AND ANY THREE OTHERS.

DATA

Some constants and formulae you may find useful are given as an *Attachment.*

QUESTION 1 (55 *MARKS*)

a) *10 marks*

The wave function for a state $n_x = 0$ and $n_y = 1$ is given by

$\psi_{0,1}(x,y) = N_{0,1} y e^{-\frac{\alpha}{2}(x^2+2y^2)}$, where $N_{0,1}$ is a normalization constant and $\alpha = \frac{(km)^{1/2}}{\hbar}$. A new coordinate system is introduced where $x = \rho cos\theta$ and $y = \frac{\rho}{\sqrt{2}} sin\theta$.

(i) Write the wave function in terms of the new coordinates ρ and θ. Simplify if possible.

(ii) Is the wave function $\psi_{0,1}(\rho,\theta)$ an eigenfunction of the operator $P_\theta = -\hbar^2 \frac{\partial^2}{d\theta^2}$. If yes, what is the eigenvalue?

b) *10 marks*

(i) The classical expression for the *z*-component of angular momentum is $l_z = xp_y - yp_x$. Derive the quantum mechanical operator for l_z.

(ii) The wave function for a rigid rotating particle of mass μ on a fixed-radius ring of constant potential is given by $\psi(\varphi) = \frac{1}{\sqrt{2\pi}} e^{im\varphi}$, where $m = 0, \pm 1, \pm 2, \ldots$ and the energy $E_m = \frac{m^2\hbar^2}{2I}$. In its ground state the particle is at rest on the ring. Is this consistent with the Heisenberg Uncertainty principle? If yes, explain your answer.

c) *5 marks*

It is experimentally possible to observe the spectra of ionized atoms. Apart from a scale factor for the frequencies, the spectrum of an ion M^{++} should resemble most closely those of:

i) The neutral atom M;
ii) The neutral atom two rows above M in the Periodic Table;
iii) The neutral atom two rows below M in the Periodic Table;
iv) The neutral atom of atomic number two less than that of M;
v) The neutral atom of atomic number two more than that of M;

Which of the above statements is correct?

d) *10 marks*

The frequency of the N–H stretching vibration in the infrared spectra of primary amines occurs at 3400 cm^{-1}. Calculate the frequency of the N–D stretching vibration in deuterated primary amines. Assume that the force constant is the same.

e) *10 marks*

What is meant by a "*black body*" in quantum mechanics? Draw on the same labeled sketch diagram to show how the radiation density, $\rho(\nu)$ from a black body varies with frequency, ν, or how the radiation density, $\rho(\lambda)$ from a black body varies with wavelength, λ:

(i) experimentally; and
(ii) in accordance with the Rayleigh- Jeans' Law.

What was the implication of the Rayleigh-Jeans Law theoretical result?

f) *10 marks*

Calculate the energy change ΔE in kilojoules for the following chemical reaction on the assumption that atoms of both reactants and products are in their ground states:

$$Na(g) + Li^{+}(g) \rightleftharpoons Na^{+}(g) + Li(g)$$

The ionization potentials of sodium and lithium are 5.138 eV and 5.390 eV respectively. 1eV = 96.50 kJ mol^{-1}.

QUESTION 2 (*15 MARKS*)

The harmonic oscillator wave functions for the levels $n = 0$ and $n = 1$ are:

$\psi_0(x) = \left(\frac{\alpha}{\pi}\right)^{\frac{1}{4}} e^{-\alpha x^2/2}$ and $\psi_1(x) = \frac{1}{\sqrt{2}}\left(\frac{\alpha}{\pi}\right)^{\frac{1}{4}}(2\sqrt{\alpha}x)e^{-\alpha x^2/2}$. The functions are normalized. The energy levels of the oscillator are given by: $E_n = (n + ½)h\nu$, where $n = 0, 1, 2, \ldots$, and ν = vibrational frequency in Hz.

a) (5 *marks*)
Show that the functions $\psi_0(x)$ and $\psi_1(x)$ are orthogonal.

b) (5 *marks*)
The selection rule for emission or absorption of a photon by an oscillator is $\Delta n = \pm 1$. What will be the frequency observed in the spectrum of the harmonic oscillator for the transition $n = 4 \rightarrow n = 5$?

c) (5 *marks*)
If the result in part b) was generalized to any transition but the selection rule was changed to $\Delta n = \pm 2$, what frequency or frequencies would be observed in the spectrum?

QUESTION 3 (*15 MARKS*)

It can be shown that the relative number of molecules in any given initial rotational state (n,J) with energy $E_{n,J}$ is proportional to the Boltzmann factor:

$N_{n,J} = g_J e^{-E_{n,J}/k_B T}$, where g_J = degeneracy of the energy level J; k_B = Boltzmann constant. Since $E_{n,J}$ increases with increasing J, the exponential factor decreases. However the degeneracy g_J increases with J. Therefore, the relative number of molecule s $N_{n,J}$ has a maximum which occurs at:

$$J_{max.} = \left[\frac{k_B T}{B}\right]^{1/2} - 0.5$$

a) (4 *marks*)
   What is the degeneracy g_J of the rotational energy level $E_{n,J}$?
b) (6 *marks*)
   Calculate the rotational constant B for the hydride $^7Li^1H$ whose inter-nuclear distance r_e = 0.16 nm.
c) (5 *marks*)
   Which transition in the rotational absorption spectrum of lithium hydride has maximum intensity at T = 1000K?

QUESTION 4 (*15 MARKS*)

Consider a particle of mass m confined in a box with the following potential energy:

Inside the box		outside the box	
$V(x) = 0$	$0 \le x \le a$	$V(x) = \infty$	$x > a$
$V(y) = 0$	$0 \le y \le b$	$V(y) = \infty$	$y > b$
$V(z) = 0$	$0 \le z \le c$	$V(z) = \infty$	$z > c$

a) (4 *marks*)
   Write the Schrödinger equation for this system. Do not just write $\hat{H}\psi = E\psi$. Write the left hand side in detail.

b) $(2\ marks)$
Show that the Hamiltonian operator for this system $\hat{H}_{x,y,z}$ can be written as a sum of three harmonic oscillator Hamiltonian operators: $\hat{H}_x + \hat{H}_y + \hat{H}_z$.

c) $(3\ marks)$
Write an expression for the energies of the particle in terms of the integers, n_x, n_y, and n_z.

d) $(6\ marks)$
If the box were a cube, what is the degeneracy, g_n of the level that has an energy three times that of the lowest level?

QUESTION 5 (*15 MARKS*)

In a lecture, the total energy of a classical harmonic oscillator was calculated to be $E_T = ½kX_0^2$.

a) $(3\ marks)$
Identify the terms "k" and "X_0^2".

b) $(8\ marks)$
Compare and contrast the total energy of the classical harmonic oscillator with that of a quantum mechanical harmonic oscillator.

c) $(4\ marks)$
Draw a labeled sketch diagram of the potential energy V(r) versus the inter-nuclear distance r of an anharmonic diatomic molecule oscillator. On the diagram indicate the value of the dissociation energy, D_0, the equilibrium dissociation energy, $D_e$and the *zero* point energy.

QUESTION 6 $(15\ MARKS)$

Many proteins contain metal porphyrin molecules. The porphyrin molecule is planar and so we can approximate the π-electrons as being confined inside a square. The porphyrin molecule has 22 π-electrons.

a) $(4\ marks)$
What are the energy levels and degeneracies of a particle in a square of side a?

b) (8 *marks*)

If we approximate the length of the molecule to be 1000 pm, calculate the lowest energy absorption of the porphyrin molecule.

c) (3 *maks*)

What is the frequency, in cm^{-1}, associated with the lowest energy absorption?

END OF CHE 4611 EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF CHEMISTRY

9 MARCH 2016

2015/2016 ACADEMIC YEAR SESSIONAL EXAMINATIONS TERMS I&II

CHE 4611: QUANTUM CHEMISTRY AND MOLECULAR SPECTROSCOPY

ATTACHMENT

$h = 6.63 \times 10^{-34}$ J s $\quad$ $c = 3.00 \times 10^{8}$ m s^{-1} $\quad$ $k_B = 1.38 \times 10^{-23}$ J K^{-1}

$N_A = 6.02 \times 10^{23}$ mol^{-1} $\quad$ $m_e = 9.11 \times 10^{-31}$ kg $\quad$ $R_\infty = 1.0973732 \times 10^{7}$ m^{-1}

Atomic mass constant, $amu = m_u = 1.661 \times 10^{-27}$ kg

1 m^{-1} = 1.987×10^{-25} J $\quad$ 1J = kg m^2 s^{-2}

1 eV = 1.602×10^{-19} J = 96.5 kJ mol^{-1}

$E_n = \frac{n^2}{8ma^2}$ $\quad$ $\psi(0 \le x \le a) = \left(\frac{2}{a}\right)^{½} sin\left(\frac{n\pi x}{a}\right)$

$E_n = (n + ½)hv$ $\quad$ $E_{n,J} = (n + ½)hv + \frac{h^2}{8\pi^2 I}J(J+1)$

$Y_{0,0} = \left(\frac{1}{4\pi}\right)^{½}$ $\quad$ $Y_{1,0} = \left(\frac{3}{4\pi}\right)^{½}\cos\theta$

$\int_{-\infty}^{\infty} e^{-ax^2}dx = \left(\frac{\pi}{a}\right)^{½}$ $\quad$ $\int_{0}^{\infty} e^{-ax^2}dx = \frac{1}{2}\left(\frac{\pi}{a}\right)^{½}$ $\quad$ $\int_{0}^{\infty} xe^{-ax^2}dx = \frac{1}{2a}$

$\int_{0}^{\infty} x^2e^{-ax^2}dx = \frac{\pi^{½}}{4a^{3/2}}$ $\quad$ $\int_{0}^{\infty} x^n e^{-ax}dx = \frac{n!}{a^{n+1}}; n > 0$

H = 1.01 $\quad$ Li = 6.94 $\quad$ N = 14.01

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY

2015/16 ACADEMIC YEAR MID-YEAR FINAL EXAMINATIONS

CHE 4811
INORGANIC INDUSTRIAL CHEMISTRY

Duration: THREE (3) HOURS

INSTRUCTIONS TO THE CANDIDATES:

1. THIS PAPER CARRIES 100 MARKS AND HAS A TOTAL OF SIX (6) QUESTIONS.
2. EACH QUESTION CARRIES 20 MARKS.
3. ANSWER ANY 5 QUESTIONS ONLY.
4. ANSWER EACH QUESTION IN A SEPARATE ANSWER BOOKLET PROVIDED.

1.

a) A standard grain size analysis test was carried out in order to determine the relative proportions of different grain sizes as they are distributed among certain size ranges. The following results were obtained in the table shown below.

sieve #	Sieve size mm	% mass Retained	Cumulative % retained	% finer
4	4.75	154		
8	2.36	72		
16	1.18	72		
30	0.6	141		
40	0.425	85		
50	0.30	80		
100	0.15	149		
200	0.075	45		
Pan		24		

I. Given that the mass of sample - Wt = 824g, copy and complete the table of results. Show only one sample calculation for each column.

II. From the graph paper provided , plot a graph of sieve size vs. % finer

(10 marks)

b) Calculate the total % mass lose during this sieve analysis?

(5 marks)

c) From the graph, obtain diameters Corresponding to 10%, 30% and 60% finer. Label your lines clearly in ink on your graph.

(5 marks)

2.

a) List and explain briefly three main changes that may occur when a solid is exposed to mechanical forces during Grinding. What are the main purpose of Grinding.

(4 marks)

b) Explain how grinding results can be evaluated in terms of Grinding degree referring to grain and specific surface.

(6 marks)

c) What is the power required to crush 100 ton/h of limestone if 80% of the feed pass a 2-in screen and 80% of the product a 1/8 in screen? The work index for limestone is 12.74.

(10 marks)

3.

a) List and explain briefly the three grinding laws. Express these laws in terms of half empirical models used for different particle size.

(6 marks)

b) List the three main classes of Jaw Crushers and briefly explain the position of the pivoting jaw for each?

(6 marks)

c) A material is crushed in a Blake jaw crusher (The work index -12.74) that the average size of particles is reduced from 50 mm to 10 mm, with the consumption of energy of 13.0 kW. What will be the consumption of energy needed to crush material of average size 75 mm to average size of 25 mm.

a) Assuming Rittinger's law applies.

b) Assuming kick's law applies.

(8 marks)

4.

a) List and explain briefly three main changes that may occur when a solid is exposed to mechanical forces during Grinding. What are the main purpose of Grinding.

(4 marks)

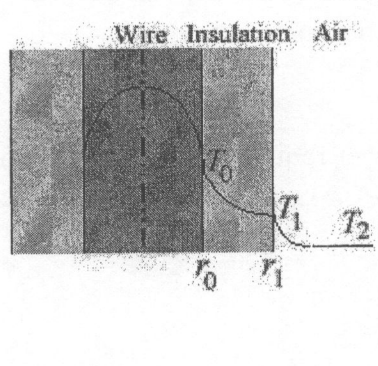
b) Explain the following and give examples of equipment used for each operation.

I. Primary Crushing.

II. Secondary Crushing.

(6 marks)

c) An electric wire with radius r_0 of 0.50 mm is made of copper [electrical conductivity = 5.1 x 107 ohm^{-1} m^{-1} and thermal conductivity = 380 W/(m K)]. It is insulated (see figure) to an outer radius r_1 of 1.50 mm with plastic [thermal conductivity = 0.350 W/(m K)]. The ambient air is at 38.0oC and the heat transfer coefficient from the outer insulated surface to the surrounding air is 8.500 W/(m^2 K). Determine the maximum current in amperes that can flow at steady-state in the wire without any portion of the insulation getting heated above its maximum allowable temperature of 93.0°C.



(10 marks)

5.

a) What is the effect of the Prandtl number of a fluid on the relative thicknesses of velocity and temperature boundary layers when the fluid flow is parallel to a flat plate?

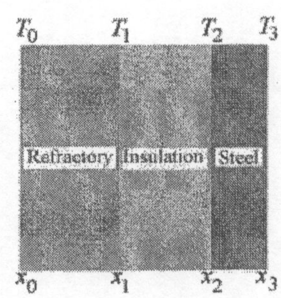
(4 marks)

b) The inner and outer surface temperatures of a glass window 5 mm thick are 15 and 5°C, respectively. What is the heat loss through a window that is 1 m by 3 m on a side? The thermal conductivity of glass is 1.4 W/mK.

(6 marks)

c) The wall of a furnace comprises three layers as shown in the figure. The first layer is refractory (whose maximum allowable temperature is 1400oC) while the second layer is insulation (whose maximum allowable temperature is 1093°C). The third layer is a plate of 6.35 mm thickness of steel [thermal conductivity = 45 W/(m K)]. Assume the layers to be in very good thermal contact. The temperature T0 on the inside of the refractory is 1370°C, while the temperature T_3 on the outside of the steel plate is 37.8°C. The heat loss through the furnace wall is expected to be 15800 W/m^2. Determine the thickness of refractory and insulation that results in the minimum total thickness of the wall.

Given thermal conductivities in W/(m K)		
Layer	*k* at 37.8°C	*k* at 1093°C
Refractory	3.12	6.23
Insulation	1.56	3.12



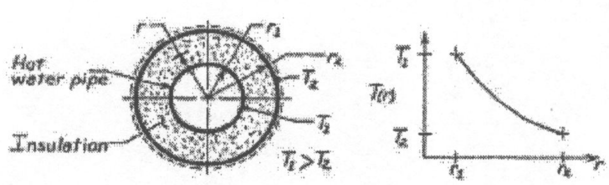
(10 marks)

6.

a) Two fluids, with different properties, flow with equal free stream velocities parallel to a flat plate. What property of the fluid determines whether the velocity boundary layer of one is thicker than the other ?

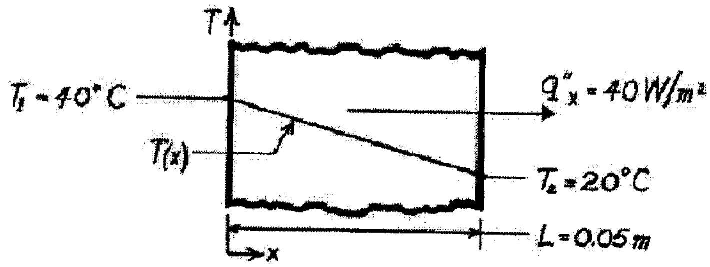
(4 marks)

b) A hot water pipe with outside radius r_1 has a temperature T_1. A thick insulation applied to reduce the heat loss has an outer radius r_2 and temperature T_2. On T–r coordinates, sketch the temperature distribution in the insulation for one-dimensional, steady-state heat transfer with constant properties. Give a brief explanation, justifying the shape of the curve shown.



(6 marks)

c) A rectangular slab of wood that is 50 mm thick has a known heat flux of 40 W/m^2. The surface temperatures on both sides of the wood slab are 40 °C and 20 °C, respectively. Calculate the thermal conductivity of the wood and the thickness of an aluminum slab that would be required to achieve the same heat flux for the same temperatures.



(10 marks)

THE END

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
FINAL EXAMINATIONS, 2015/2016 ACADEMIC YEAR
CHE 4922: ORGANIC INDUSTRIAL CHEMISTRY II

INSTRUCTIONS

Duration: Three (3) hours
Answer any four (4) questions
All questions carry equal marks

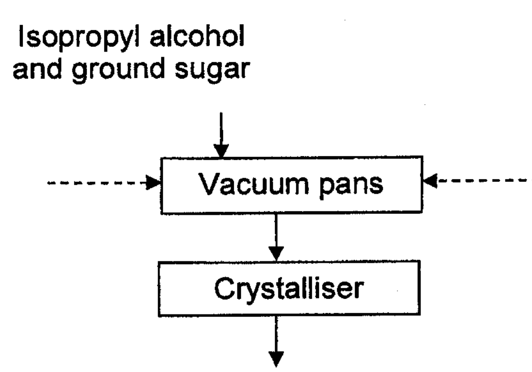
QUESTION 1 (15 marks)

A graduate chemist from the University of Zambia wished to set-up an industry for the manufacture of fabric for the high end fashion market. The entrepreneur chemist proposed to acquired equipment that allowed the production of synthetic fibres (nylon) that would subsequently be dyed and woven into fabric.

(a) Write the reaction equation showing the synthesis of nylon 6.6.
(b) The production of nylon is via a manufacturing process known as bulk polymerisation. Compare and contrast bulk polymerisation of nylon and that of styrene. Indicate the advantageous or disadvantages associated with each polymerisation.
(c) Suppose the pellets of nylon from (b) above were to made into fibres. Use a suitable schematic diagram to illustrate the fibre spinning process.

QUESTION 2 (15 marks)

(a) Draw a simple flow diagram illustrating the main unit operations in the production of sugar.
(b) The diagram below shows a flow chart of part of sugar refining.

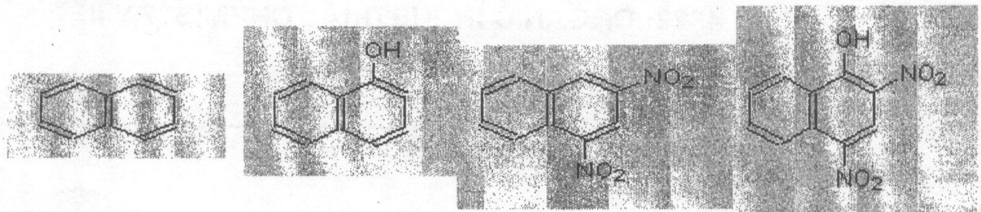


What are the processes and conditions in these units?

(c) Decolourisation is an important part of sugar refining. Describe the use of carbonaceous adsorbents to decolourise sugar crystals.

QUESTION 3 (15 marks)

(a) The following compounds have a similar base structure that of naphthalene.



(A) (B) (C) (E)

Explain the change in chemical and physical properties of the chemical compounds in moving from A to E.

(b) Describe the process of producing the dye known as indigo. Indicate the type, characteristics and use of this type of dye.

(c) Describe two processes used for dyeing fabrics: (i) piece jig dyeing and piece pad dyeing. Outline the principle differences and advantages for each method.

QUESTION 4 (15 marks)

(a) Soaking and fat liquoring are two similar processes, one being a pre-tanning process and the other post tanning. Explain what is involved in each of the processes of the two processes indicating their significance in the processing of leather.

(b) Leather is sometimes classified on the basis of the tanning processes one of which is chrome tanning. Outline in brief the process of tanning referred to as chrome tanning.

(c) What are the critical factors for consideration when drying vegetable tanned leather?

QUESTION 5 (15 marks)

(a) What is an explosive substance? Give a brief explanation.

(b) Differentiate the difference between deflagrating and detonating explosives

(c) Describe and explain the main characteristic of the detonation of a high explosive in terms of pressure changes, heat, and shockwave. Use appropriate diagrams where necessarily.

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
Department of Computer Science

FINAL EXAMINATION

COMPUTER PROGRAMMING
CSC 2000

Date:	9th SEPTEMBER 2016
Time:	09:00hrs – 12:00hrs
Duration:	3 Hours
Venue:	API

Instructions

1. *Answer **all** the questions in Section A.*
2. Choose ***any two*** *(2) questions from Section B.*

SECTION A
ANSWER <u>ALL QUESTIONS</u> IN THIS SECTION

1. Analyse the java code below and answer all the questions that follows;

```
public class Animal{
   private double height;
  public String name;
  int number;
  static String species;

 public Animal(String name, int number, String species){
    this.name = name;
   this.number = number;
  this.species = species;
 }

 public void do(){
   int a = 3;
   a = a * 3;
  System.out.println(a);
 System.out.println(height);
 System.out.println(species);
 }
}//end Animal class

public class AnimalTest{
    public static void main(String args[]){
       Animal a1 = new Animal("Snake",1,"Reptile");
      Animal a2 = new Animal("Monkey", 2,"primate")
     a1.do();
    }
}//end AnimalTest class
```

a) What is a difference between a local variable and an instance variable? **[1 Mark]**

b) Identify all the instances variables and local variables in the Animal class above **[4 Marks]**

c) Identify and explain all the access modifiers used by the instance variables in Animal class **[3 Marks]**

d) What is the difference between a class and an object? **[1 Mark]**

e) Identify all the classes and objects in the above code **[2 Marks]**

f) What is the output when AnimalTest runs? **[3 Marks]**

2. Study a piece of a java code below and answer all the questions below;

```
int i = 30;
while(i >= 0){
 if(i % 2 > 0){
   continue;
 }
System.out.println(i);
i--;
}
```

a) What is the output of the above code? **[2 Marks]**
b) Rewrite the above code using the for loop **[2 Marks]**
c) Rewrite the above code using the do while loop **[2 Marks]**

3. Discuss how deadlock can be avoided in threads. **[4 Marks]**

4. Explain the use of the following in java coding statements: **[4 Marks]**
   - this.
   - this()

5. What does it mean for a class to be immutable? Give TWO examples from the JDK. **[4 Marks]**

6. What is the differences between Inheritance and Interface in the Java Platform? **[4 Marks]**

7. The Java programming language includes features for multithreading. It helps with operating system scheduling and concurrency programming. Give a brief description of multithreading. **[4 Marks]**

TOTAL 40 MARKS

SECTION B
ANSWER <u>ANY TWO</u> QUESTIONS IN THIS SECTION
[Each question is worth 30 Marks]

QUESTION 1

a) Write a program in Java that displays the grade of a mark. The grade system is as follows;

90 – 100 A+
80 – 89 A
70 – 79 B+
60 – 69 B
50 – 59 C+
45 – 49 C
0 – 44 D

Your program must not allow marks below 0 and above 100. Use the command line both for prompting the user for a mark and displaying the grade. **[20 Marks]**

b) Describe the following Swing components:

I. JColorChooser **[2 Marks]**

II. JComboBox **[2 Marks]**

III. JFrame **[2 Marks]**

IV. JPasswordField **[2 Marks]**

V. JProgressBar **[2 Marks]**

QUESTION 2

a) Create a class that holds 10 grades in an array data structures. **[2 Marks]**

a) Loop through the data structure and compute the sum of grades **[2 Marks]**
b) Loop through the data structure and compute the average of grades **[4 Marks]**
c) Loop through the data structure and print the biggest grade **[4 Marks]**
d) Loop through the data structure and print the lowest grade **[4 Marks]**
e) Print the grades in the descending order of indexes **[4 Marks]**

b)

I. Briefly explain the role InputStreamReader plays in System.in. **[2 Marks]**

II. State the reason for using a BufferedReader object. **[2 Marks]**

III. Interpret the Java statements below: **[3 Marks]**

```
BufferedReader br = new BufferReader(new InputStreamReader(System.in));
String line = br.readLine();
```

IV. Given File inputFile = new File(args [0]);

a. Create an input stream object to read from the inputFile. **[2 Marks]**

b. Construct a channel for the stream object. **[1 Marks]**

QUESTION 3

a) Write a java program that prompts a user for two (2) integers. Read the numbers using the Scanner class and divide the two integers and print the quotient. Handle all the possible exceptions in your code using the try and catch. If an exception occurs, your program must give an appropriate error message to the user and loop through again to ask the user to re-enter the numbers. If no exception occurs, the program must print the quotient and exit.

[20 Marks]

b) Given the following CHESSCLUB table:

CHESSCLUB

memberID	name	grade
10	Peter	1900
11	Allan	2350

Write a Java statement or statements to perform the following tasks:

i. Create a Statement object so that you can execute SQL statements. **[2 Marks]**

ii. Retrieve the grade of Peter from the table. **[4 Marks]**

iii. Remove the member with memberID 11. **[4 Marks]**

END OF PAPER

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF COMPUTER SCIENCE

CSC 2202 – INTRODUCTION TO OPERATING SYSTEMS

DURATION: 3 HOURS

DATE: 15TH SEPTEMBER, 2016

INSTRUCTIONS

- This paper has a total of seven questions
- You must answer a total of five (5) questions
    - Section A is compulsory for all
    - Section B has five (5) questions, attempt any three (3)
- All questions carry equal marks (20 marks each)
- Clearly number all your answers
- Use the marks as a guide to the detail required in your answers while keeping your answers concise and relevant

SECTION A (Answer all questions)

QUESTION 1 (20 marks)

A. Let's assume you have exactly three page frames and they contain the pages A, B, and C. Construct a page reference sequence of 10 page accesses, including A, B, C and any other pages you want demonstrating that MIN produces a better hit rate than does LRU. Include the hit rates for each algorithm. **[2marks]**

B. What are the three main purposes of an operating system? **[3 marks]**

C. A system is designed with the condition that no thread holding lock A can acquire lock B. What problem is this system designed to prevent? **[1 mark]**

D. What is the difference between a program (an executable file) and a process and how is a program transformed into a process? A process is an instantiation of a program. **[2 marks]**

E. Mrs. Kumar is playing with kittens. She throws out a yarn ball and the kittens all race to fetch it, but only one succeeds. There are 12 kittens. After playing with the ball for amoment, the kitten brings the yarn ball back, returns it to Professor Seltzer and gets a treat. Which of deadlock, race condition, or starvation can occur? Please explain. **[2 marks]**

F. Explain how a scheduling algorithm could produce good throughput, but poor response time. Then explain how a scheduling algorithm could produce good response time, but poor throughput. **[4 marks]**

G. State three advantages of placing functionality in a device controller, rather than in the kernel. State three disadvantages. **[6 marks]**

QUESTION 2 (20 marks)

A. Give two reasons why caches are useful. What problems do they solve? What problems do they cause? If a cache can be made as large as the device for which it is caching (for instance, a cache as large as a disk), why not make it that large and eliminate the device? **[5 marks]**

B. What are the five major activities of an operating system with regard to process management? **[5 marks]**

C. What are two differences between user-level threads and kernel-level threads? Under what circumstances is one type better than the other? **[6 marks]**

D. Some systems automatically delete all user files when a user logs off or a job terminates, unless the user explicitly requests that they be kept; other systems keep all files unless the user explicitly deletes them. Discuss the relative merits of each approach. **[4 marks]**

SECTION B (Choose any three)

QUESTION 3 (20 marks)

A. What are preemptive and non-preemptive scheduling policies? Elaborate your answer **[2 marks]**

B. Five processes A, B, C, D and E arrived in this order at the same time with thefollowing CPU burst and priority values. A smaller value means a higher priority **[12 marks]**

	CPU Burst	*Priority*
A	3	3
B	7	5
C	5	1
D	2	4
E	6	2

Fill the entries of the following table with waiting time and average waiting time for each indicated scheduling policy and each process. Ignore context switching overhead.

Scheduling Policy	*Waiting Time*					Average Waiting Time
	A	*B*	*C*	*D*	*E*	
First-Come-First-Served						
Non-Preemptive Shortest-Job First						
Priority						
Round-Robin (time quantum=2)						

Scheduling Policy	*Waiting Time*					*Average Waiting Time*
	A	*B*	*C*	*D*	*E*	
First-Come-First-Served	0	3	10	15	17	$45/5 = 9$
Non-Preemptive Shortest-Job First	2	16	5	0	10	$33/5=6.6$
Priority	11	16	0	14	5	$46/5=9.2$
Round-Robin (time quantum=2)	8	16	15	6	16	$61/5=12.2$

C. Describe the two general roles of an operating system, and elaborate why these roles areimportant. **[4 marks]**

D. What is a translation look-aside buffer? **[2 marks]**

QUESTION 4 (20 marks)

A. What are three requirements of any solution to the critical sections problem? Why are the requirements needed? **[6 marks]**

B. Describe the page replacement algorithms below. Critically compare them with each other **[4 marks]**

   i. Least Recently Used (LRU)

   ii. Clock

C. Explain why mobile operating systems such as iOS and Android do not support swapping? **[2 marks]**

D. Many CPU-scheduling algorithms are parameterized. For example, the Round Robin (RR) algorithm requires a parameter to indicate the time slice. Multilevel feedback queues require parameters to define the number of queues, the scheduling algorithms for each queue, the criteria used to move processes between queues, and so on.

   These algorithms are thus really sets of algorithms (for example, the set of RR algorithms for all time slices, and so on). One set of algorithms may include another (for example, the First Come First Serve (FCFS) algorithm is the RR algorithm with an infinite time quantum).What (if any) relation holds between the following pairs of algorithm sets?

   [8 marks]

   i. Priority and SJF

   ii. Multilevel feedback queues and FCFS

   iii. Priority and FCFS

   iv. RR and SJF

QUESTION 5 (20 marks)

A. Device controllers are generally becoming more complex in the functionality they provide (e.g. think about the difference between implementing a serial port with a flip-flop controlledby the CPU and a multi-gigabit network adapter with the TCP/IP stack on the card itself).What effect might this have on the operating system and system performance? **[2 marks]**

B. Consider a logical address space of 32 pages of 2048 words each, mapped onto a physical memory of 8 frames. **[8 marks]**

   i. How many bits are needed for addressing the total logical address?

   ii. How many bits are needed to indicate the page number?

   iii. How many bits are needed for addressing the physical address?

   iv. What is the effect of allowing more than one entry in a page table (each entry belongs to a process) to point to the same frame in physical memory?

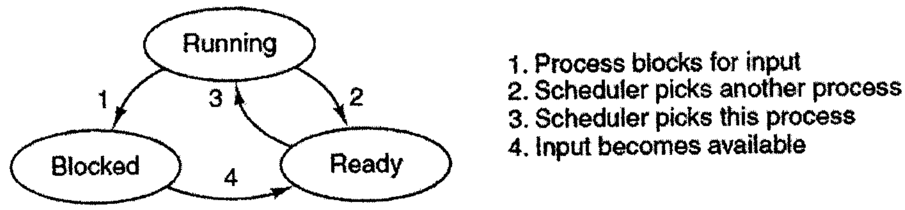
C. Why do some systems keep track of the type of a file, while others leave it to the user and others simply do not implement multiple file types? Which system is "better?" **[5 marks]**

D. How does DMA increase system concurrency? How does it complicate hardware design? **[3 marks]**

E. What are the major benefits of using threads other than responsiveness? **[2 marks]**

QUESTION 6

A. Describe the three state process model, describe what transitions are valid between thethree states, and describe an event that might cause such a transition. **[7 marks]**



B. What is a critical region? How do they relate to controlling access to shared resources?

[4 marks]

C. Suppose that a 10-MB file is stored on a disk on the same track (track 50) in consecutive sectors. The disk arm is currently situated over track number 100. How long will it take to retrieve this file from the disk? Assume that it takes about 1 ms to move the arm from one cylinder to the next and about 5 ms for the sector where the beginning of the file is stored to rotate under the head. Also, assume that reading occurs at a rate of 200 MB/s.

[5 marks]

D. Why is it important to scale up system-bus and device speeds as CPU speed increases?

[4 marks]

QUESTION 7

A. The readers and writers problem can be formulated in several ways with regard towhich category of processes can be started when. Carefully describe ***three*** differentvariations of the problem, each one favoring (or not favoring) some category of processes.For each variation, specify what happens when a reader or a writer becomesready to access the database, and what happens when a process is finished. **[6 marks]**

B. Two computer science students, Keziah and Haward, are having a discussion about inodes. Bwalya maintains that memories have gotten so large and so cheap that when afile is opened, it is simpler and faster just to fetch a new copy of the i-node into the inodetable, rather than search the entire table to see if it is already there. Haward disagrees. Who is right and why?

[4 marks]

C. A typical printed page of text contains 50 lines of 80 characters each. Imagine that acertain printer can print 6 pages per minute and that the time to write a character to theprinter's output register is so short it can be ignored. Does it make sense to run thisprinter using interrupt-driven I/O if each character printed requires an interrupt thattakes 50 μ sec all-in to service?

[5 marks]

D. In which of the four I/O software layers is each of the following done. **[2 marks]**

a. Computing the track, sector, and head for a disk read.
b. Writing commands to the device registers.
c. Checking to see if the user is permitted to use the device.
d. Converting binary integers to ASCII for printing.

E. RAID level 3 is able to correct single-bit errors using only one parity drive. What is thepoint of RAID level 2? After all, it also can only correct one error and takes moredrives to do so.

[3 marks]

END OF EXAM

All the best!!!

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
Department of Computer Science

FINAL EXAMINATION

DATABASES AND INFORMATIONS MANAGEMENT SYSTEMS
CSC 2702

Date:	20th SEPTEMBER 2016
Time:	14:00hrs – 17:00hrs
Duration:	3 Hours
Venue:	NELT

Instructions

1. *Answer **all** the questions in Section A.*
2. Choose ***any THREE** (3) questions in Section B.*

SECTION A

Answer ALL Questions in this section. Both questions carry an equal weight of **20 Marks**.

Question 1 [20 Marks]

i. Define the following terms briefly in not more than 3 lines: [**5 Marks**]

a. Database

b. Database program

c. Database System

d. Record

e. Attribute

ii. What is a DBMS, and what are its functions? (list at least 3 functions) [**5 Marks**]

iii. Describe the main components you are likely to find in a DBMS environment? [**5 Marks**]

iv. Give at least 5 reasons why the file based system approach is desirable over the database approach. [**5 Marks**]

Question 2 [20 Marks]

i. Explain what it means to say a database displays both *entity integrity* and *referential integrity*? [**4 Marks**]

ii. Define the following terms in relation to the database: [**4 Marks**]

a. Intentions

b. Extension

iii. Draw a well labelled diagram of the ANSI-SPARC DBMS architecture and describe the different aspect of it. [**6 Marks**]

iv. What are the three components that describe a data model? [**3 Marks**]

v. State three categories in which you can classify data models? [**3 Marks**]

SECTION B

There are FOUR questions in this section. All questions carry an equal weight of **20 Marks**. Choose only **three (3)** question!

Question 1

i. In relation to Relational Database Model, list at least five (5) attributes that differentiate relations from tables. **[5 Marks]**

ii. Suppose you wanted to apply for a Job in a database computing environment, what are the five (5) different roles you may likely find? **[5 Marks]**

iii. What do you mean when you say "cardinality of the relation" and "degree of the relation" when you are talking about relational databases? **[4 Marks]**

iv. What two conditions must be met before an entity can be classified as a weak entity? Give an example of a weak **[2 Marks]**

v. Discuss the difference between a composite key and a composite attribute. How would each be indicated in an Entity Relationship Diagram? **[4 Marks]**

Question 2

i. Define the following terms: **[5 Marks]**

   a. Composite key

   b. Super key

   c. Candidate key

   d. Foreign key

   e. Primary key

ii. Briefly describe the four (4) integrity constraints that are associated with relational database model? **[4 Marks]**

iii. What is the difference between a "view" and "base relation"? **[2 Marks]**

iv. Give at least 3 reasons why the file based system approach is undesirable over manual filing system? **[3 Marks]**

v. What three data anomalies are likely to be the result of data redundancy? **[6 Marks]**

Question 3

i. What is a partial dependency? With what normal form is it associated? **[4 Marks]**

ii. Explain the difference between "Functional Dependency" and "Transitive Dependency". **[4 Marks]**

iii. What two conditions must be met before an entity can be classified as a weak entity? Give an example of a weak **[4 Marks]**

iv. Discuss the difference between a composite key and a composite attribute. How would each be indicated in an Entity Relationship Diagram? **[4 Marks]**

v. Briefly, but precisely, explain the difference between single-valued attributes and simple attributes. Give an example of each. **[4 Marks]**

Question 4

i. In database development process, what does the term "fact-finding" mean? **[2 Marks]**

ii. State when "fact-finding" in Q3 (i) is particularly important during database development life cycle? **[2 Marks]**

iii. Explain why "fact-finding" is crucial to the database development process? Especially to phase you have stated in Q3 (ii). **[4 Marks]**

iv. State and briefly explain the five (5) most used fact-finding techniques you may adopt for your database design.**[10 Marks]**

v. Why is a table whose primary key consists of a single attribute automatically in 2NF when it is in 1NF? **[2 Marks]**

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Studies

MID YEAR - FINAL EXAMINATION

DISCRETE STRUCTURES
CSC 2901

Date:	FRIDAY, 10^{TH} JUNE, 2016
Time:	12:00hrs – 17:00hrs
Duration:	3 Hours
Venue:	P207

Instructions

a) *There are EIGHT (8) questions in this paper and you are required to answer ANY FIVE (5) OF THEM IN ANY ORDER.*

b) *All questions have carry the weight of 20 marks each*

c) *Each question should start on its separate page or booklet*

1.

a. Let x and y be non-negative numbers. Prove that if $\sqrt{xy} = (x+y)/2$ then $x = y$

b. Let a, b and c be lengths of the sides and hypotenuse, respectively, of a right angled triangle. Prove that if the area of the triangle is equal to $c^2/4$, then the triangle is isosceles triangle.

c. Prove that $\sin x \leq x$ for all non-negative real numbers x

2.

a. Explain what each of the following properties of a relation R on a set A.
   i. Reflexive
   ii. Symmetric
   iii. Antisymmetric
   iv. Transitive

b. Let R = {(a,a), (c,c), (a,b), (b,a), (a,c)} be a relation on a set A = {a, b, c}. Explain if R is
   i. Reflexive
   ii. Symmetric
   iii. Antisymmetric
   iv. Transitive

c. Let R = {(1,2), (2,3), (2,4)}
   i. Show that R is not transitive.
   ii. Find the transitive closure of R

3.

a. Suppose A and B are sets, define the following
   i. $A - B$
   ii. $A \subseteq B$
   iii. $A = B$

b. hence, show that $(A \cap B)' = A' \cup B'$

c. Suppose A and B are sets, use Venn diagrams to illustrate the following sets
   i. $A - B$
   ii. $A - (A - B)$

d. Using analytical means, show that $A - (A - B) = A \cap B$ [Hint: $A - B = A \cap B^c$]

4.

a. Derive the formula for finding the sum of the first n odd numbers. [Hint: look at the sums of the first 1, 2, 3 and 4 odd numbers and then generalise and that the nth odd number is expressed as $2n - 1$]

b. Use the principle of Mathematical induction to prove that your formula is correct.

c. You are tasked with implementing a Computer network backbone consisting of n networking devices using a full mesh topology (meaning that every networking device should have a link to all other devices in the network). Showing your work, how many links are required to achieve this.

5.

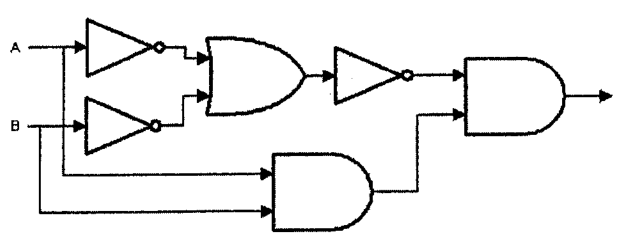
a. Given the truth table below for the operation °.

x	y	x°y
0	0	1
0	1	0
1	0	1
1	1	0

i. What is the Boolean expression for this operation?

ii. Draw the logic network for the operation above.

b. Consider the logic network below



i. Write the Boolean expression for this logic network.

ii. Draw the truth table for the logic network above.

iii. Simplify the expression in i) above.

6.

a. In BASIC programming language, the variables can either be a single alphabetical letter or a single alphabetical letter followed by a single decimal digit. How many possible variables are there in the BASIC language? [Note: there are 26 letters and 10 decimal digits]

b. Suppose a fair coin with a head (H) on one side and a tail (T) on the other side, is tossed three times. What is the probability of obtaining at least one head after these three tosses?

c. Suppose that you are in a class of n students and the instructor intends to select a team of m people (where m < n) from class to send to the competition.

   i. How many m-person teams can possibly be selected in terms of m and n?
   ii. Show that the probability of you making it to the team, if all have an equal chance of getting selected, is m/n.

7.

a. Show that for elements x, y *and* z in a Boolean algebra

   i. $xy + x'y = y$
   ii. $x + x'y = x + y$

b. Consider the four variable Boolean expression below

$$E = u'xy'z + u'xy'z' + u'x'y'z + u'x'y'z'$$

Find the minimum sums of products for E

   i. Using analytical means
   ii. Use the Karnaugh map

8. a) Use the truth table to show that $p \to q \leftrightarrow \neg p \vee q$

b. Prove that $(p \wedge (p \to q)) \to q$ is valid using

   i. the truth table
   ii. analytical methods

c. Consider the following

"The system is in a multiuser state if and only if it is operating normally. If the system is operating normally, the kernel is functioning. Either the kernel is not functioning or the system is in interrupt mode. If the system is not in multiuser state, then it is in interrupt mode. The system is not in interrupt mode."

   i. Convert the statement into propositional logic.
   ii. From the premises, conclude that the system is in Interrupt mode

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Studies

<u>END OF YEAR - FINAL EXAMINATION</u>

NUMERICAL ANALYSIS
CSC 2912

Date:	MONDAY, 5TH SEPTEMBER 2016
Time:	12:00hrs – 14:00hrs
Duration:	3 Hours
Venue:	NSLT

<u>Instructions</u>

a) *There are Two(2) Sections in this Exam, Section A and Section B. Answer ALL questions in Section A and ANY THREE (3) OF The FIVE(5) in Section B IN ANY ORDER.*

b) *Section A has* ***<u>40 Marks</u>*** *and all questions in Section B carry the weight of* ***<u>20 marks</u>*** *each.*

c) *Each question should start on its separate page or booklet.*

PART A: Answer all questions in this section. [40 Marks]

1. [8 Marks] Define the following
    a. Continuity of a function f at a point x_0
    b. Differentiability of a function f at a point x_0
    c. Relative error of an approximation
    d. Absolute error of an approximation

2. [4 Marks] What is (i) the absolute error (ii) The relative error in the approximating p by $p*$ where $p = \pi$ and $p^* = \frac{22}{7}$

3. [4 Marks] Suppose p^* approximates p to three significant digits. Find the interval in which p^* must lie if p is 150

4. [16 Marks] State, without proof, the following theorems
    a. Rolle's Theorem
    b. Intermediate value theorem
    c. Taylor theorem
    d. Fixed point theorem

5. [8 Marks] Derive the three-point formulas for approximating $f'(x_0)$, $f'(x_1)$ and $f'(x_2)$ using numerical differentiation, given the three points (x_0, y_0), (x_1, y_1) and (x_2, y_2) and that $x_2 - x_1 = x_1 - x_0 = h$

PART B: Answer 3 of the 5 questions in this section. Each question carries 20 marks. [60 Marks]

1.
    a. Generate P_4, the fourth Maclaurin polynomial for $f(x) = e^x$.
    b. Use P_4 to approximate $f(0.5)$
    c. Use the value in b) to approximate the value of the constant e.
    d. What is the absolute error of the approximation of e in c?

2.
    a. Show that the number of iterations, n, required to approximate the root $p \in [a, b]$, of a function f to the accuracy Tol, using the Bisection method is expressed in the following inequality.

$$\frac{(b - a)}{2^n} \leq Tol$$

    b. Hence find the number of iterations required to approximate the root p $\in$ [1, 2], of the function$f$, defined below, to 10^{-2} accuracy.

$$f(x) = \frac{x^3 + x - 1}{x^2}$$

    c. Find this approximation. [Show the table of derivations of successful p_ns]

3.

a. Show that function

$$g(x) = 1 + \frac{1}{x^2}$$

has a fixed point at $p \in [1, 2]$ precisely when $f(p) = 0$, where

$$f(x) = x^3 - x^2 - 1$$

b. Hence, approximate the solution to $f(x) = 0$, to 10^{-3} accuracy, using the fixed point iteration. Take $p_0 = 1$. [Show the table of derivations of successive $p_i s$

4. Consider the following table of the function $f(r) = \pi r^2$, giving the area of a circle of radius r.

x	0.4	0.8	1.2
f(x)	0.5026	2.0106	4.5238

a. Use P_2 , the Lagrange polynomial which agrees with f at the given points , to approximate $f(1)$

b. Note that $f'(r) = 2\pi r$ = the circumference of the circle of radius r.

   i. Calculate the actual circumference of the circle of radius $r = 0.4$ (Take $\pi = 3.14152$)

   ii. Approximate the circumference of the circle of radius 0.4 using the appropriate formula using the points in the table above.

   iii. What is the relative error of the approximation?

5.

a. Consider the function defined by the table below

x	0.0000	0.5000	1.0000	1.5000	2.0000
f(x)	1.0000	1.2840	1.6487	2.1170	2.7183

Approximate

$$\int_0^2 f(x)dx$$

Using

   i. Composite Trapezoidal rule with h = 1.0

   ii. Composite Simpson rule with h = 0.5

******END OF EXAMINATION******

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Studies

MID YEAR - FINAL EXAMINATION

ALGORITHMS AND COMPLEXITY
CSC 3011

Date: THURSDAY, 9TH JUNE, 2016
Time: 09:00hrs – 12:00hrs
Duration: 3 Hours
Venue: P206

Instructions

a) *There are EIGHT (8) questions in this paper and you are required to answer ANY FIVE (5) OF THEM IN ANY ORDER.*
b) *All questions have carry the weight of 20 marks each*
c) *Each question should start on its separate page or booklet*

1)

a)

i) Define f(n) = O(g(n))

ii) Hence show that if $T_1(n) = O(f(n))$ and $T_2(n) = O(f(n))$ then $T_1(n) + T_2(n) = O(f(n))$

b) Suppose $Log(A) = x, Log(B) = y \; and \; Log(C) = z$. Write the following in terms of $x, y \; and \; z$

i) B + C

ii) Log(A) $*$ Log(B)

iii) Log(AC)

iv) Log(C^n)

c) Convert $\text{Log}_a x$ to base b.

2)

a) Show that $N \; logN$ grows slower the N^2.

b) Al and Bill are arguing about the performance of their sorting algorithms. Al claims that his $O(N \; logN)$-time algorithm is always faster than Bill's $O(N^2)$-time algorithm. To settle the issue, they implement and run the two algorithms on many randomly generated data sets. To Al's dismay, they find that if N < 100 the $O(N^2)$-time algorithm actually runs faster, and only when $N \geq 100$ the $O(N \; logN)$)-time one is better. Explain why the above scenario is possible. You may give numerical examples.[Hint: take f(n) = $\alpha \, N \; logN$, g(n) = βN^2, where α and β are arbitrary constants]

c) Suppose algorithm A is of $O(Nlog(N))$ and it is known that it takes t_0 to process N_0 items. Show that it would take $2t_0 \left[1 + \frac{1}{logN_0}\right]$ to process $2N_0$ items. [Note: use log base 2]

3)

a) Describe the four fundamental rules of recursion.

b) Ben Bitdiddle implements algorithm twoToThePower(n) recursively to receive the 0 or any positive integers and returns 2^n.

```
Algorithm twoToThePower(n)
    Input: n = 0, 1, 2.....
    Output: 2^n
    If n = 0 then
            Return 1
    Else
            Return twoToThePower(n-1) + twoToThePower(n-1)
    End if
End.
```

i) Show how twoToThePower(3) is evaluated.

ii) To his dismay, Ben realises that for large numbers of n, the function takes awfully long to execute. Given that the running time function for twoToThePower(n) is expressed as the following recurrence relation

$T(0) = 2$

$T(n) = 2T(n-1) + 4$

(1) State the order of twoToThePower(n) by solving the recurrence relation.

(2) What fundamental rule did Ben break in implementing twoToThePower(n).

4)

a) Define what a stack data structure is

b) Consider the following arithmetic expression below.

$$1 - 3x(3 + 1) \div 2 + 5$$

i) Show the order in which this expression is evaluated, taking operator precedence into consideration

ii) Using a stack show how the expression is converted to postfix (reverse polish) notation.

iii) With the help of a stack show how the postfix expression in ii) is evaluated.

5)

a) Given an array of n elements. What is the maximum number of comparisons are required in sorting the array using bubble sort?

b) Given the array below

51	3	144	7	14	102	57	79	103	72	8	56

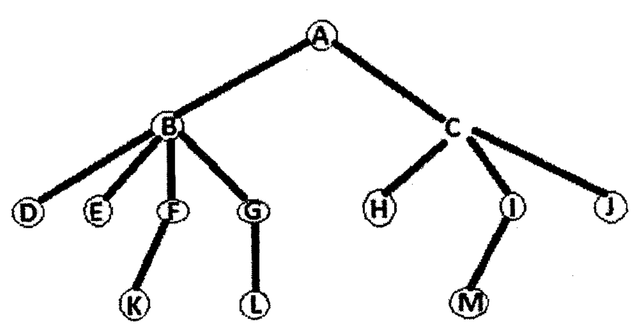
i) Show that it is not a minheap

ii) Convert it into a minheap

iii) Use HeapSort to sort the numbers in descending order

6)

a) Consider the tree below



i) What is the height of the tree?

ii) How many leaves are in this tree?

iii) Which node has the highest order?

b) List the order in which the tree is traversed using
   i) Breadth first-search
   ii) Depth-first search
c) Describe how a general tree can be implemented in Java

7)
a) What is the balance condition for an AVL tree?
b) What are the kinds of imbalance conditions possible in the AVL tree and how is each one resolved? (Just mention the resolution method without demonstration)
c) Given the list of numbers below,

51	3	144	7	14	102	57	79	103	72	8	56

   i) Add these numbers to an initially empty AVL tree clearly indicating the possible imbalances introduced and how they are dealt with. (Scan the numbers from left to right).
   ii) What is the height of the tree after all the nodes have been inserted?

8)
a) In Hashing describe the following.
   i) A Collision.
   ii) Separate chaining
   iii) Probing
b) Using h(x) = x % n as a hash, add the following numbers 6, 21, 13, 19, 5, into a table of size 7 with
   i) Linear probing
   ii) Quadratic probing

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF COMPUTER SCIENCE

2015/16 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATION

CSC3120: Analogy and Digital Electronics

TIME: THREE HOURS MAXIMUM MARKS : 100

Answer **all** questions in **SECTION A.**
Attempt only **two** questions from **SECTION B.**

All questions carry equal marks. The number of marks is given in brackets [ ] at the end of each question or part question.

SECTION A

Answer all questions.

Q1. (a) (i) Explain the formation of depletion layer across a pn junction. [4]

(ii) With figure, illustrate what happens to the pn junction under conditions of forward and reverse bias. [4+4]

(b) A resistor passing 20mA current is in parallel with a 5 kΩ resistor. This combination is in series with another 5 kΩ resistor, the whole network being connected to a source of voltage 500V.

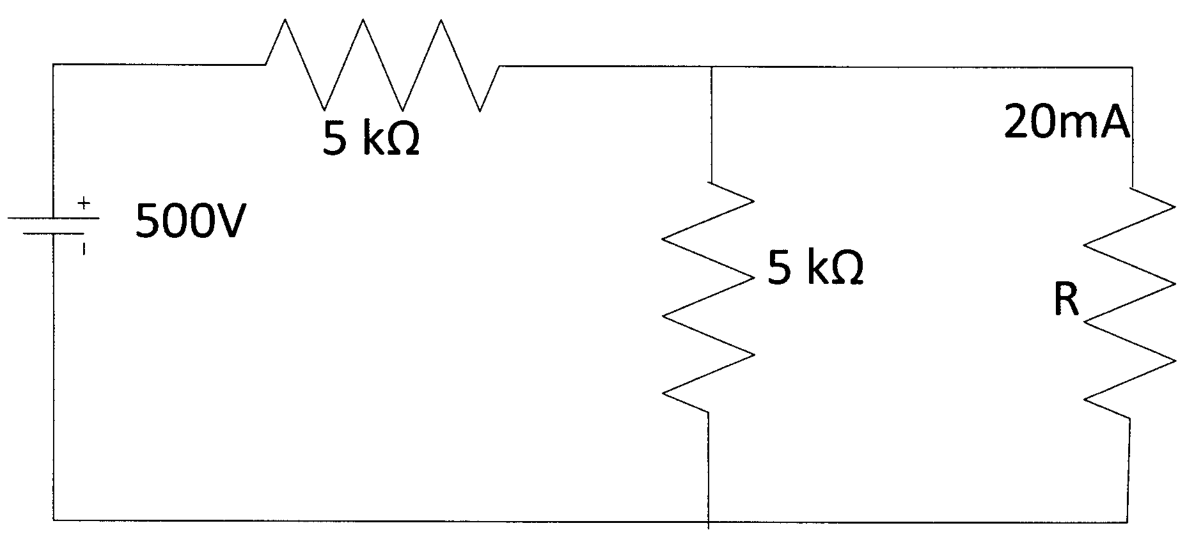


Figure 1

Using Thevenin's theorem, find out the resistance of the resistor which is passing 20mA current. [10]

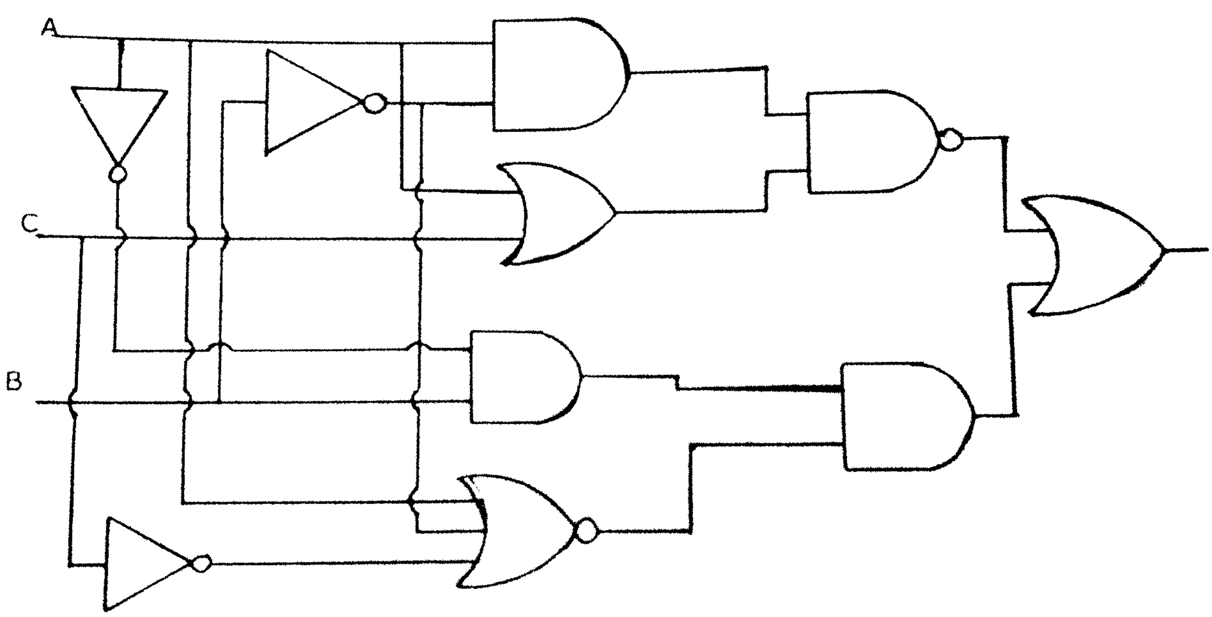
(c) Write short notes on forbidden energy gap in conductors, insulators and semiconductors. [3]

Q2. (a) (i) Prove the following Boolean identity. [6]

$$(A+B)(A+\bar{B})(\bar{A}+C)=AC$$

(ii) Convert $(34.6875)_{10}$ to binary. [5]

(b) Using Boolean algebra, simplify the following logic circuit. Draw the simplified circuit using basic logic gates. [10]



(c) Write the complete logical expression for the minterm designation [4]

$Y=\sum m\,(1, 3, 5, 7)$

SECTION B

Attempt any **two** questions from **SECTION B.**

Q3. (a) (i) State Norton's theorem. [3]

(ii) Obtain the Norton equivalent of the network shown in the circuit below and find the current in the 8 Ω resistor. [10]

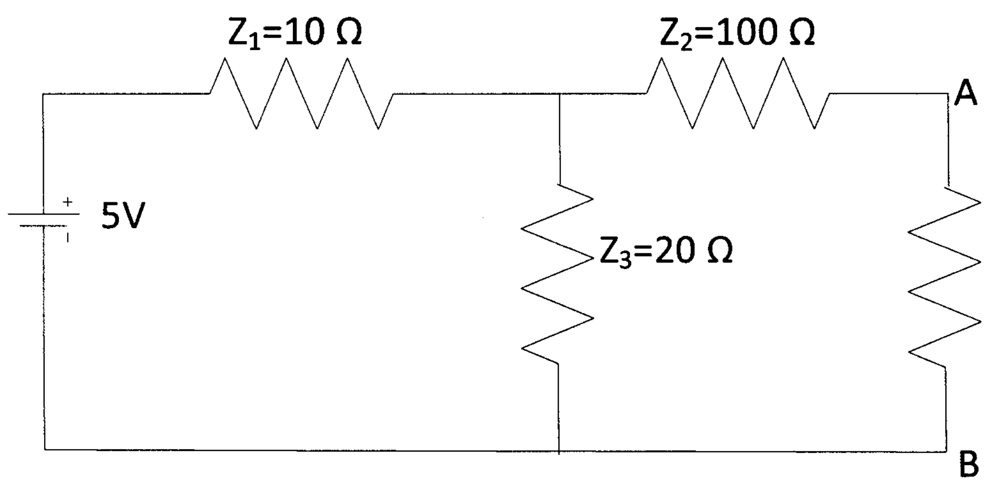


Figure 2

(b) Explain the formation of a p-type semiconductor with figure. [8]

(c) Define current gain (γ) of a transistor. Show that $\gamma = \frac{1}{1-\alpha}$. [4]

Q4 (a) Draw the circuit of a decimal-to- binary encoder for 10 inputs and explain how it works. [10]

(b) (i) Draw the circuit diagram of a 4-bit twisted ring counter (Johnson counter) using D flip flops. Show the truth table and explain how it works. [11]

(ii) What are the main differences between a ring counter and a twisted ring counter? [4]

Q5 **(a)** (i) Draw the circuit diagram of an adder/subtractor circuit. [6]

(ii) Illustrate the subtraction operation using the numbers 42 and 23. [5]

(b) Draw the circuit diagram of a positive edge triggered JK flip flop and show its truth table. [7]

(c) Design the circuit of a 4-bit Parallel-In-Serial-Out (PISO) register for storing the data 0110. [7]

Q6. (a) Show the symbol of a (3×8) demultiplexer (DEMUX) and design the circuit. Your answer should include the truth table and the corresponding logic functions. [3+8+8]

(b) Explain why the preset and clear inputs of flip flops are important in the design of sequential systems. [6]

END OF CSC3120 EXAMINATION

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
Department of Computer Science

PROGRAMMING LANGUAGE DESIGN AND PARADIGMS

CSC 3301

2015-2016 MID-YEAR FINAL EXAM

Date:	Wednesday, 8th June, 2016
Venue:	P207
Time:	14hrs-17hrs
Duration:	3 Hours

Instructions

1. There are **six questions** in this exam.
2. Attempt **any five (5)** questions.
3. All questions carry **equal** weight of **20 marks**.
4. Write your answers on the answer sheet provided.

Question One [20 Marks]

a. Consider the following context free grammar, in which the alphabet is $\sum$= {a, b, c} and the start symbol is **S**:

$$S \rightarrow Sab$$

$$S \rightarrow SS$$

$$S \rightarrow C$$

Which of the following strings can be generated by this grammar? (Show your works)For the strings that belong to the language generated by the grammar show a leftmost derivation.

i. cabab
ii. ccacab
iii. cccabc
iv. cabcc
v. cabcab

Question Two [20 Marks]

a. Consider the following context free grammar for simple Boolean expressions:

<expr> → <expr> and <expr>

→ <expr> or <expr>

→ A|B|C

i. Prove that the grammar is ambiguous.
ii. Write an equivalent grammar that encodes the operator precedence rule for "and" and "or" in Boolean expressions.

Question Three [20 Marks]

a. What is the distinction between *type checking* and *coercion*?

b. Briefly state and describe the four programming language paradigms

c. Convert the following context free grammar into EBNF:

<expr> → <expr> + <term> | <expr> - <term> | <term>

<term> = <term> * <factor> | <term> / <factor> | <factor>

<factor> = <exp> ** <factor> | <exp>

<exp> → (<expr>) | id

Question Four [20 Marks]

a. Consider the following simple assignment statement:

count = count + 1;

For each component of the statement, list the various bindings that are required to determine the semantics when the statement is executed. And, for each binding, indicate the binding time used for the language.

b. Consider the following Ada program:

```
procedure main:
        A, C, Y, Z: Integer
        procedure sub1:
                A, B, Y: Integer;
                begin  - of sub1
                ..........
                end   - of sub1
        procedure sub2:
                A, Z, W: Integer;
                procedure sub3:
                        A, B, X, Z: Integer;
                        Begin – of sub3
                        .....
                        End – of sub3
                begin – of sub2
                ....
                end – of sub2
        procedure sub4:
                B, X, Y, Z: Integer;
                begin – of sub4
                .....
                end – of sub 4
        begin – of main
        ...
        end – of main
```

Given the following calling sequences and assuming that dynamic scoping is used, what variables are visible during execution of the last subprogram activated? Include with each visible variable the name of the unit where it is declared

i. Main calls sub1: sub1 calls sub2; sub2 calls sub3;

ii. Main calls sub2; sub2 calls sub3;

iii. Main calls sub4; sub4 calls sub2; sub2 calls sub1;

Question Five [20 Marks]

a. List *six (6) attributes* that characterise a variable in programming languages.

b. State and explain the *three models* of parameter passing in subprograms. Also, for each model, give an example of *parameter passing method* that is implemented using that model.

c. Consider the following C program:

```
void sub (int a, int b){
        a+=a;
        b+=b;
        }
void main (){
        int list[3] = {1,2,3};
        sub (list [1], list[0]);
        }
```

What are the values of the list array after execution, if the parameter passing method is:

a. Passing by value

b. Passing by reference

Question Six [20 Marks]

a. Consider the following context free grammar:

<assign> → <id> = <expr>
<id> → A|B|C
<expr> → <expr> + <term>
        | <term>
<term> → <term> * <factor>
        | <factor>
<factor> → (<term>)
        | id

i. Show whether the grammar above violates the precedence rule of operators.

ii. Generate the parse tree of the sentence, **A = A * (A + (C))**, using the grammar above.

THE UNIVERSITY OF ZAMBIA

Department of Computer Science

END OF YEAR - FINAL EXAMINATION

Fundamentals of Artificial Intelligence
CSC 3402

Date:	TUESDAY 13TH September, 2016
Time:	09:00hrs – 12:00hrs
Duration:	3 Hours
Venue:	GLT

INSTRUCTIONS

a) *There are TWO Parts in this examination paper. In Part I, you are required to answer all the questions. Part II has five (5) questions and you are required to answer any three (3) of them in any order.*

b) *All questions in Part II carry the weight of 20 marks each*

c) *Be as concise as precise as possible. The marks allocated to a question should guide you on the detail required. Good Luck!*

PART I: ANSWER ALL THE QUESTIONS IS THIS SECTION. [40 MARKS]

1.

a. List the four types of agents. [2 Marks]

b. Consider the following DrRacket code implementing the vacuum-cleaner agent discussed in class. The environment for this agent has two locations A on the left and B on the right, which can either be dirty or clean with state representation [status-a, status, location-agent]. Note that the *env* argument is the vacuum-cleaner state e.g. ['clean', 'dirty', 'a'] means location a is clean and location b is dirty and agent is in location a.

```
(define (agent env)
  (if (eq? (location env) 'a)
      (if (eq? (status env) 'dirty)
          (suck env)
          (move-right env))
      (if (eq? (status env) 'dirty)
          (suck env)
          (move-left env))))
```

i. Which type, of the four agents in part a, is this implementation? [2 Mark]

ii. What would be the performance measure of this agent? [2 Mark]

c. Explain whether this environment of the agent in b) is:

i. Fully observable [2 Marks]

ii. Dynamic [2 Marks]

d. Suppose the current state, *env,* is ['clean', 'clean', 'a'].

i. What would the agent do on executing this function? [1 Mark]

ii. Is that a wise decision for the agent? Explain why? [2 Marks]

iii. How would you improve the performance of this agent [2 Mark]

2.

a. Write a high-level pseudocode or description of how search algorithms carry out the search operations. [2 Marks]

b. Explain, in relation to the pseudocode above, how depth first search (DFS) differs from Breadth first search (BFS). [2 Marks]

c. Search algorithms are evaluated based on the following criteria. Briefly explain what each one of them is.

i. Completeness. [1 Mark]

ii. Optimality. [1 Mark]

iii. Time requirements. [1 Mark]

iv. Space requirements. [1 Marks]

3. In informed search algorithms, heuristics are used to improve the search mechanism.
   a. Explain what an admissible heuristic is. [2 Marks]
   b. Explain what an optimistic heuristic is. [2 Marks]
   c. List two examples of informed search algorithms. [1 Mark]

4.
   a. Briefly describe how the min-max algorithm is used in the implementation of a two-player game, giving examples. [3 Marks]

   b. How does the alpha-beta improve the adversarial search like min-max? [3 Marks]

5. Explain what the following heuristics are, and how they are used in the process of assigning variables in a constraint satisfaction problem
   i. Minimum-Remaining Values (MRV) [2 Marks]
   ii. Most constraining variable (MCV) [2 Marks]
   iii. Least-constraining value (LCV) [2 Marks]

PART II: ANSWER THREE (3) OF THE FIVE (5) QUESTIONS IN THIS SECTION. ALL QUESTIONS HAVE AN EQUAL WEIGHT OF 20 MARKS EACH.

1. [20 Marks]
   a. Show that if a search tree has a branching factor of b and a depth of d, then the space requirements for
      i. BFS is of $O(b^d)$. [5 Marks]
      ii. DFS is of O(bd). [5 Marks]
   b. Depth first search (DFS) is said to be not complete. Explain? [4 Marks]
   c. Depth-limited search (DLS) tries to improve on the non-completeness of DFS. Describe DLS and explain its disadvantage. [6 Marks]

2. [20 Marks]
   a. Consider a search space in which each state is represented by the state XYZ, where X, Y, Z $\in$ {0, 1}. There are three operators, flipX, flipY and flipZ, which applies a NOT operator to the digits stated e.g. of n = 101, then flipX(n) = 001, flipY(n) = 111, and flipZ(n) = 100. [Note NOT(0) = 1 and NOT(1) = 0].
      i. How many states are in this search space [2 Marks]

   b. Each operator costs 1 unit to execute. Suppose the start state is 000 and we wish to get to 111. Take the heuristic h, which subtracts the number of one digits in the state from 3 i.e. h(n) = 3 – number of one bits in n e.g. h(000) = 3 – 0 = 3. Using the no return to ancestor, applying the operators in the order flipX(n), flipY(n) and flipZ(n) in generating the search tree and and visiting the leftmost node in the tree as tie-breakers, show how the following search mechanisms solve this problem by indicating the
      - Search tree
      - Order of node visitation,
      - Path to goal (sequence of operators applied) and

- Cost of getting to the goal from the start.

i. Uniform-cost search. [6 Marks]
ii. A* Search. [6 Marks]

c. Suppose you have two heuristics h1 and h2, which are admissible. Take the positive constants $\alpha 1$ and $\alpha 2$ such that $\alpha_1 + \alpha_2 = 1$, show that the heuristic

$$h(n) = \alpha_1 h_1(n) + \alpha_2 h_2(n)$$

is also admissible. [6 Marks]

[Hint: take h*(n) to be the actual cost of getting to the goal and that if h is admissible, then $h(n) \leq h^*(n)$ for all n in the search space]

3. [20 Marks]
   a. Describe general basic operations of a local search. [4 Marks]
   b. Briefly explain how each the Beam search algorithms function [4 Marks]
   c. Consider the following population of genes represented by the string abcd of binary digits a, b, c, and d.

	a	b	c	d
i	1	0	1	0
ii	0	0	0	1
iii	0	1	0	1
iv	1	0	1	1

   d. Suppose the fitness function is f(n) = a + b + c + d
      i. What is the fitness of each gene? [2 Marks]
      ii. What is the cumulative fitness of the population? [1 Mark]
   e. Suppose the fittest is selected twice and the weakest is left out, while the other two are crossed over between chromosomes a and b.
      i. What is the new population? [6 Marks]
      ii. What is the fitness of the new population? [3 Marks]

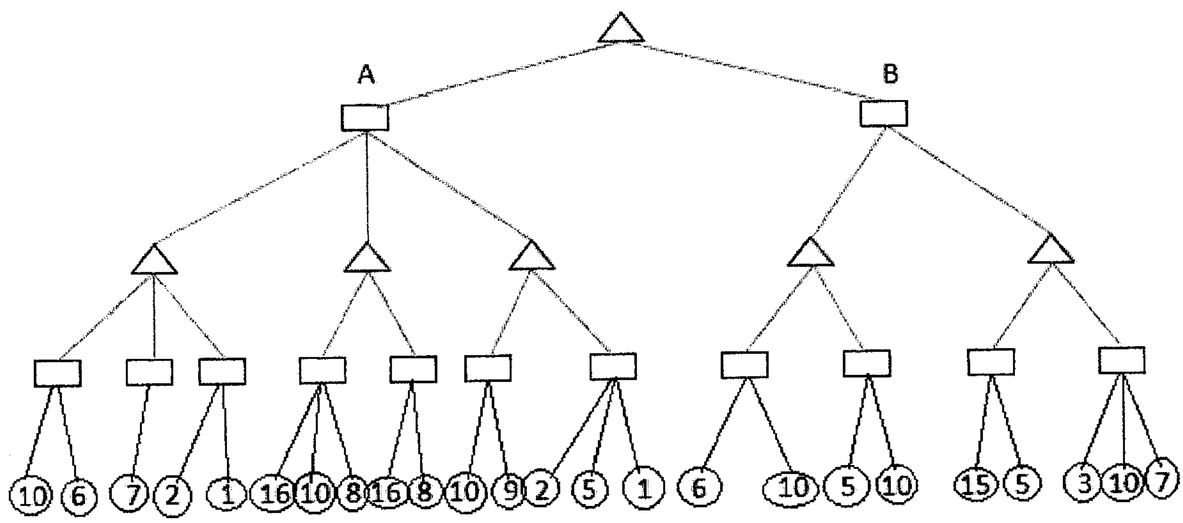
4. [20 Marks]
   a. Consider the following constraint satisfaction problem (CSP) with the following sets of variables, their respective domains and constraints.

V = {P, Q, R, S}
D = {1, 2, 3, 4, 5}
Constraints include the following

- No two alphabetically adjacent variables should have the same value
- P is an odd number and should be
- P > S.
- R + 3 < P
- Q < S

i. Draw the constraint graph. [5 Marks]
ii. Show how the order in which the assignment of values to variables is done, applying all the necessary CSP heuristics and conducting arc-consistency check after each assignment. [15 Marks]

5. [20 Marks]
   a. Consider the game tree shown below.



i. Using the MinMax algorithm, show how the numbers are cascaded up the tree and show which move Max plays. [5 Marks]

ii. Show how the alpha-beta algorithm improves the search. [15 Marks]

************************END OF EXAMINATION************************

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

SOFTWARE ENGINEERING
CSC 3600

2015-2016 FINAL EXAM

Date:	22nd September 2016
Venue:	P207
Time:	09:00hrs – 12:00hrs
Duration:	3 Hours

Instructions

1. *This examination has two sections*
2. *Answer all questions in Section A. Each question carries 20 marks*
3. *Answer any three questions in Section B. Each question carries 20 marks*

Section B – Optional

Answer any three questions. Each question carries 20 marks.

Question 3 [20 marks]

1. Suggest four reasons why the productivity rate of programmers working as a pair might be more than half that of two programmers working individually.**[4 marks]**
2. Explain the principles of agile method? **[5 marks]**
3. Extreme programming expresses user requirements as stories, with each story written on a card. Discuss the advantages and disadvantages of this approach to requirements description. **[6 marks]**
4. What is pair programming? Give some advantages of pair programming? [5 marks]

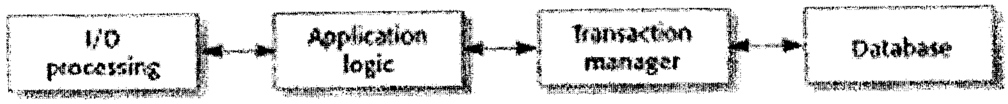
Question 4 [20 marks]

1. There is a five different ways of writing a system requirements specification. State and explain any two ways of writing requirements specification? **[5 marks]**
2. What checks should be applied during requirements validation? **[5 marks]**
3. What are the stages included in Requirement elicitation and briefly explain each stages? **[4 marks]**
4. Explain any three nonfunctional requirements with example? **[6 marks]**

Question 5 [20 marks]

1. State and explain the advantages of having an explicit architecture in a software development project? **[3 marks]**
2. As a systems analyst state four things you would ask or consider when designing the architecture of a software? **[4 marks]**
3. Highlight two examples of how the system architecture used determines which system characteristics are realized. **[2 marks]**
4. Explain the 4 + 1 view model of software architecture **[5 marks]**
5. What is an architectural pattern? Your answer must also include what they include and how they are represented. **[4 marks]**

6. Identify and explain the type of application architecture that the structure in the diagram represents. **[2 marks]**



Question 6 [20 marks]

1. What are the two main goals of testing? Your answer should include what constitutes a successful test for each goal given? **[4 marks]**
2. Give two advantages of software inspections. **[2 marks]**
3. State and explain the three main stages of software testing. **[3 marks]**
4. In unit testing, what does complete test coverage of a class involve? **[3 marks]**
5. A 2005 study found that using Test Driven Development leads to programmers being more productive. Give two advantages of TDD that lead to this productivity. **[2 marks]**
6. Describe the three types of user testing **[6 marks]**

- END -

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
Department of Computer Science

IT PROJECT MANAGEMENT
CSC 3612

2015-2016 FINAL EXAM

Date:	14^{th} September 2016
Venue:	G3
Time:	09:00hrs – 12:00hrs
Duration:	3 Hours

Instructions

1. *This examination has two sections*
2. *Answer all questions in Section A. Each question carries 20 marks*
3. *Answer any three questions in Section B. Each question carries 20 marks*

Section A

2 x 20= 40 Marks

Answer all the questions. Each question carries 20 Marks.

Question #1:

A. What is Project Management? Explain the tools and techniques used in the following four core knowledge areas (Scope, Time, Cost, and Quality) and Integration management? **[10]**

B. What is the common definition of project success? List any 5 factors that can lead to project success?**[5]**

C. Explain a system view of Project Management? **[5]**

Question #2:

A. Explain the Processes involved in Project Integration Management?**[7]**

B. Provide detailed explanation for Integrated Change Control? **[8]**

C. How can you categorize information technology projects? **[5]**

Section B

3 x 20= 60 Marks

Answer any three (3) Questions. Each question carries 20 Marks.

Question #3

A. Explain the main processes involved in project scope management? **[5]**

B. Create a WBS for how you would go about finding a job? **[5]**

C. What are the different approaches to creating a WBS? **[5]**

D. Explain the sample contents found in the Scope statement? **[5]**

Question #4

A. Explain the different types of Network diagrams? **[8]**

B. Consider the following table, Network Diagram Data for a Small Project. All duration estimates or estimated times are in days; and the network proceeds from Node 1 to Node 9.

Table: Network Diagram for a small project

Activity	Initial Node	Final Node	Estimated Duration
A	1	2	10
B	1	3	12
C	1	4	8
D	2	3	4
E	2	5	8
F	3	4	6
G	4	5	4
H	4	6	8
I	5	6	6
J	5	8	12
K	6	7	8
L	7	8	10

i. Draw an AOA network diagram representing the project. Put the node in numbers in circles and draw arrows from node to node, labelling each arrow with the activity letter and estimated time.**[3]**

ii. Identify all of the paths on the network diagram and note how long they are.**[1]**

iii. What is the critical path for this project and how long is it?**[1]**

iv. What is the shortest possible time it will take to complete this project**[1]**

C. Using critical path analysis explain how schedule Trade-offs can be made?**[6]**

Question #5

A. What is cost estimating? What are the different types of cost estimates? Explain the basic tools and techniques used for cost estimates? Give some reasons of problems faced in cost estimates **[10]**

B. Given the following information for a one-year project, answer the following questions.

Planned Value (PV)	= $240,000
Earned Value (EV)	= $230,000
Actual Cost (AC)	= $250,000
Budget at completion (BAC)	= $600,000

i. What is the cost variance, schedule variance, cost performance index (CPI), and schedule performance index (SPI) for the project **[2]**

ii. How is the project doing? Is it ahead of schedule or behind of schedule? Is it under budget or over budget? **[2]**

iii. Use the CPI to calculate the estimate at completion (EAC) for this project, Is the project performing better or worse than planned? **[2]**

iv. Use the SPI to estimate how long it will take to finish this project. **[2]**

v. Sketch the earned value chart based for this project. **[2]**

Question #6

A. Explain the different types of cost categories related to quality? **[6]**

B. Explain the seven basic tools of quality that help in performing in quality control? **[14]**

ALL THE BEST

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
Department of Computer Science

FINAL EXAMINATION

HARDWARE DESIGN AND IMPLEMENTATION
CSC 4130

Date: 8th SEPTEMBER 2016
Time: 14:00hrs – 17:00hrs
Duration: 3 Hours
Venue: P207

Instructions

1. *Answer **all** the questions in Section A.*
2. Choose ***any two*** *(2) questions from Section B.*

SECTION A
ANSWER <u>ALL QUESTIONS</u> IN THIS SECTION

1. For each of the following five questions, use these propositions below:
   p: Peter is driving his own car.
   a: Andrew is late.
   m: Max has caught the bus.

a) Write each of the following in symbols: **[5 marks]**

   I. Andrew is late and Peter is driving his own car.
   II. Either Max has caught the bus or else Andrew is late.
   III. Either Peter is driving his own car and Andrew is late or else Max has not caught the bus.
   IV. Peter is driving his own car and either Andrew is late or else Max has caught the bus.
   V. Max has caught the bus but Andrew is not late.

2. Construct truth tables for the following propositions: **[8 marks]**

   I. $(p \vee \sim q) \wedge (\sim p \vee q)$

   II. (ii) $(q \wedge \sim r) \vee (\sim p \wedge r)$

   III. $((p \wedge \sim q) \rightarrow r) \wedge (\sim p \rightarrow \sim r)$

   IV. (iv) $((r \rightarrow (q \rightarrow p)) \wedge \sim p) \rightarrow \sim r$

3. List three broad classifications of external, or peripheral, devices. **[3 marks]**

4. What is the difference between memory-mapped I/O and isolated I/O? **[2 marks]**

5. On a typical microprocessor, a distinct I/O address is used to refer to the I/O data registers and a distinct address for the control and status registers in an I/O controller for a given device. Such registers are referred to as ports. In the Intel 8088, two I/O instruction formats are used. In one format, the 8-bit opcode specifies an I/O operation; this is followed by an 8-bit port address. Other I/O opcodes imply that the port address is in the 16-bit DX register. How many ports can the 8088 address in each I/O addressing mode?

[4 marks]

6. Highlight the advantages of Optical mass storage devices.

[4 marks]

7. Briefly discuss the differences between SRAM vs. DRAM.

[4 marks]

8. How does the technique of pipelining increase performance? Explain the increased instruction throughput, compared with a multicycle non pipelined processor. Does pipelining reduce the execution time for individual instructions? Why? **[3 marks]**

9. Give three advantages of programming in a higher level language (like C) over programming in assembler (like MIPS). **[3 marks]**

10. The fetch-decode-execute cycle is the key to program execution in a standard Von Neumann architecture. Describe the basic steps in the cycle, and the role key components play in the cycle (especially the program counter, status register, instruction register, memory, the bus, the CPU's decoding logic) **[4 marks]**

SECTION B
ANSWER <u>ANY TWO</u> QUESTIONS IN THIS SECTION

Question 1

For each of the following six questions, use these definitions:

b: bats are black
g: geese are grey
w: wombats are white

For each question:

I. rewrite the given verbal argument in symbols;
II. construct truth tables for each premise and the conclusion;
III. state whether or not the argument is valid.

a) If either bats are black or wombats are not white then geese are grey. Wombats are white and bats are not black. Therefore geese are not grey.

[5 marks]

b) If bats are not black then geese are grey. If wombats are not white then geese are not grey. Wombats are not white. Therefore bats are black.

[5 marks]

c) If geese are not grey then either bats are black or wombats are not white. Wombats are white. Bats are not black. Therefore geese are not grey.

[5 marks]

d) Either wombats are not white or geese are not grey. Either bats are not black or geese are grey. Bats are black. Therefore wombats are not white.

[5 marks]

e) If geese are grey then bats are not black. Either bats are black or wombats are not white. Wombats are white. Therefore geese are grey.

[5 marks]

f) If bats are not black then either geese are grey or else wombats are white. If geese are grey then wombats are white. Therefore, if wombats are not white then bats are black.

[5 marks]

Question 2

a) Drive spins at 7200RPM and has average seek time of 8ms. The disk has 24 sectors per track. What is the average access time? **[4 marks]**

b) Describe the storage device characteristics and their relationship to cost **[10marks]**

c) Suppose we have a magnetic disk (resembling an IBM Microdrive) with the following parameters:

Average seek time	12 ms
Rotation rate	3600 RPM
Transfer rate	3.5 MB/second
# sectors per track	64
Sector size	512 bytes
Controller overhead	5.5 ms

Answer the following questions. (Note: you may leave any answer as a fraction.)

I. What is the average time to read a single sector?
[2marks]

II. What is the average time to read 8 KB in 16 consecutive sectors in the same cylinder?
[2marks]

III. Now suppose we have an array of 4 of these disks. They are all synchronized such that the arms on all the disks are always on the same sector within the track. The data is striped across the 4 disks so that 4 logically consecutive sectors can be read in parallel. What is the average time to read 32 consecutive KB from the disk array?
[2marks]

d) What is an embedded system? **[2marks]**

e) Translate the following instructions to assembly code. **[3 marks]**

f = (g+h) - (i+j)

f) Define the following terms: **[3 marks]**

I. Data bus

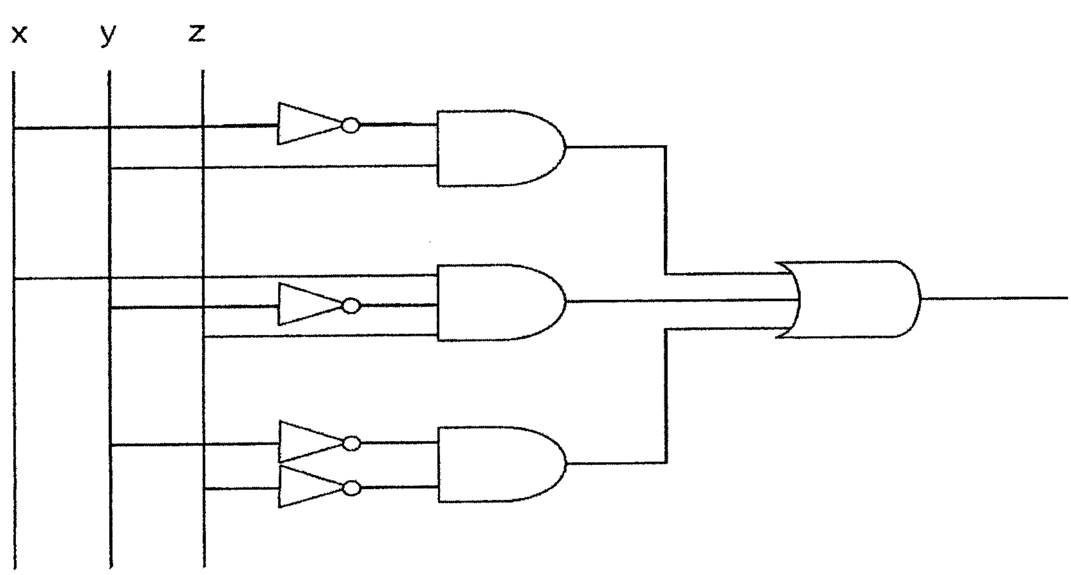
II. Address bus

III. Control bus

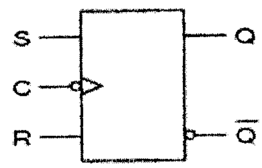
g) What is a PIC Microcontroller? **[2 marks]**

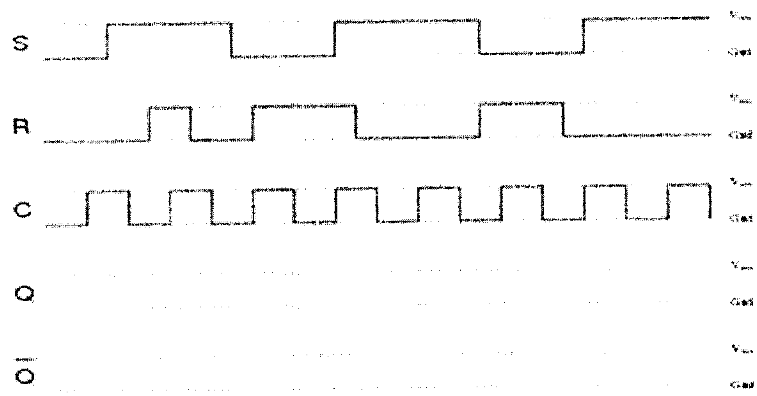
Question 3

a) Find a Boolean expression corresponding to the logic circuit shown:
[2 marks]

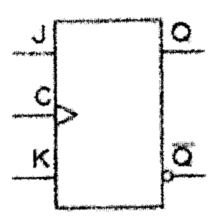


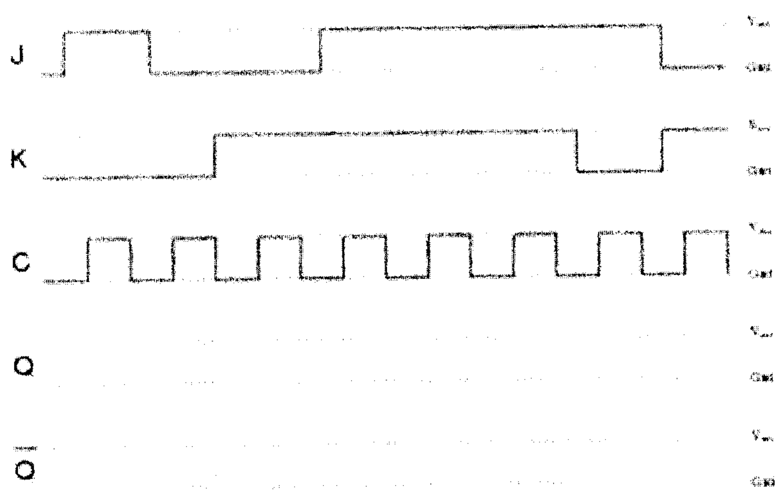
b) Determine the output states for this S-R flip-flop, given the pulse inputs shown: **[5 marks]**



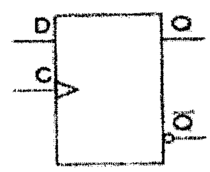


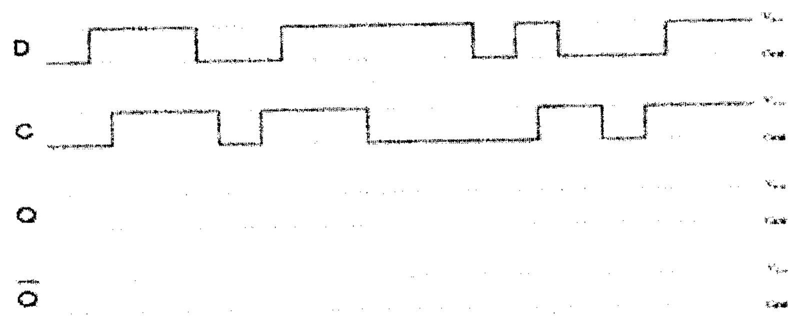
c) Determine the output states for this J-K flip-flop, given the pulse inputs shown: **[5 marks]**



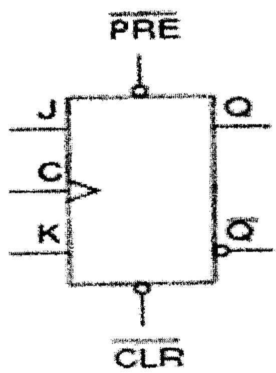


d) Determine the output states for this D flip-flop, given the pulse inputs shown: **[5 marks]**



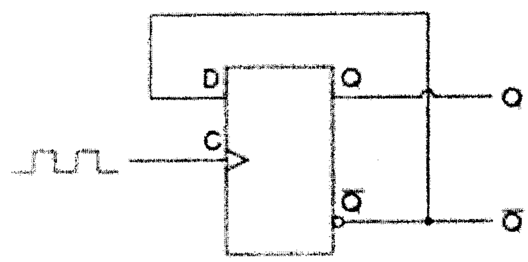


e) Flip-flops often come equipped with asynchronous input lines as well as synchronous input lines. This J-K flip-flop, for example, has both "preset" and "clear" asynchronous inputs:



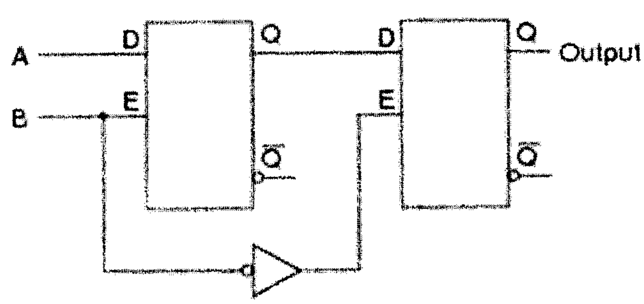
- Describe the functions of these inputs. Why would we ever want to use them in a circuit? Explain what the "synchronous" inputs are, and why they are designated by that term. **[3 marks]**
- Also, note that both of the asynchronous inputs are active-low. As a rule, asynchronous inputs are almost always active-low rather than active-high, even if all the other inputs on the flip-flop are active-high. Why do you suppose this is? **[2 marks]**

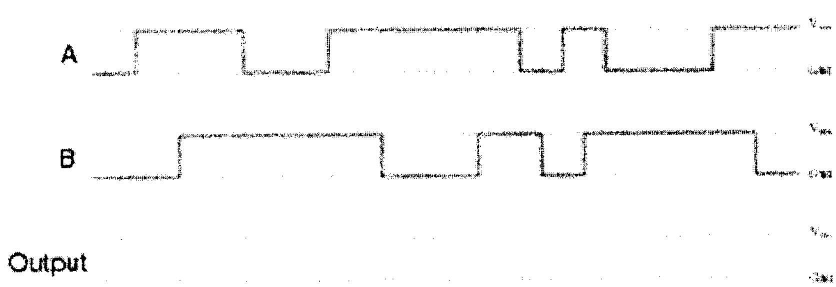
f) Although the toggle function of the J-K flip-flop is one of its most popular uses, this is not the only type of flip-flop capable of performing a toggle function. Behold the surprisingly versatile D-type flip-flop configured to do the same thing:



I. Explain how this circuit performs the "toggle" function more commonly associated with J-K flip-flops. **[3marks]**

g) Determine the final output states over time for the following circuit, built from D-type gated latches:





I. At what specific times in the pulse diagram does the final output assume the input's state? How does this behaviour differ from the normal response of a D-type latch? **[5marks]**

END OF PAPER

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC 4505
GRAPHIC AND VISUAL COMPUTING

Date:	21st SEPTEMBER 2016
Time:	14:00hrs – 17:00hrs
Duration:	3 Hours
Venue:	Upper Dining Hall

Instructions

1. There are five (5) questions and **two (2) sections** in this paper.
2. *Answer all the questions in Section A* and choose *any two (2) question from Section B*

SECTION A

ANSWER ALL THE QUESTIONS IN THIS SECTION

Q. 1

a) List the goals one should achieve when drawing a line. (2 marks)

b) What is the purpose of the following: rotation, scaling and translation? (3 marks)

c) What is involved in Shearing about an arbitrary point P in space? (2 marks)

d) Define Pixelization and name one other term you can use in its place. (2 marks)

e) The emitted light by phosphor in CRT fades very quickly and the technique is needed to maintain the screen picture. Name and explain it? (2 marks)

f) What do you know about the two broad classifications of computer-graphics software? (2 marks)

g) Explain how to eliminate a flicker in an Opengl program. (1 mark)

h) How do sophisticated graphics systems, which are becoming increasingly common these days, achieve their great speed? (1 mark)

i) What are the functions of glMatrixMode (GL_PROJECTION)? (2 marks)

j) Define depth. (1 mark)

k) Callbacks are used for two purposes, what are the purposes? (1 mark)

l) What do know about commutivity of Transformations? (1 mark)

Total Marks 20

Q. 2

a) What are the problems one should face when drawing a line? (2 marks)

b) What are we suppose to do if we want to apply a series of transformations T1, T2 and T3 to a set of points? (2 marks)

c) What is involved in Rotation about an arbitrary point P in space rotation? (3 marks)

d) List three reasons why we need computer graphics. (3 marks)

e) What is the purpose of the shadow mask in the CRT? (1 mark)

f) What makes the DDA not a very good algorithm of drawing a line and how can we improve its performance? (2 mark)

g) Name the two types of refresh. (2 marks)

h) How many colors does 8-bit-deep buffer allows? (1 mark)

i) Systems can display sufficient colors to represent most images realistically. Why is it that such systems are called true-color systems, or RGB-color systems? (2 marks)

j) Color CRTs have three different colored phosphors (red, green, and blue), arranged in small groups. What are the arrangements called? (1 mark)

k) What are homogeneous coordinates? (1 marks)

Total Marks 20

SECTION B

ANSWER ANY TWO (2) QUESTIONS IN THIS SECTION

Q. 3

a) Explain briefly about Shearing and Translations. (4 marks)

b) Explain the differences between the OpenGL core library, the OpenGL Utility and OpenGL Utility Toolkit. (3 marks)

c) Discuss liquid-crystal displays (LCDs) and plasma panels. (4 marks)

d) What is involved in Reflection through an arbitrary line? (4 marks)

e) We can correctly clip a polygon by processing the polygon boundary as a whole against each window edge. This could be accomplished by processing all polygon vertices against each clip rectangle boundary in turn. Write the Sutherland – Hodgeman clipping algorithm. (4 marks)

f) What can you say about the following devices space ball and joystick? (3 marks)

g) Write an Opengl program which draws the Spinning Triangle. (4 marks)

h) Explain briefly on the graphics rendering pipeline. (4 marks)

Total Marks 30

Q. 4

a) Discuss about the graphics functions. (3 marks)

b) Scaling is one of the forms of 2D transformation. What do know about scaling? (3 marks)

c) Line drawing is accomplished by calculating intermediate positions along the line path between two specified endpoint positions. Write two line drawings algorithms. (6 marks)

d) Briefly explain on the following display technologies: liquid-crystal display (LCD), and electrophoretic display. (4 marks)

e) Write an OpenGL program which draws the Spinning Teapot. (4 marks)

f) The circle is a frequently used component in pictures and graphs, a procedure for generating either full circles or circular arcs is included in most graphics packages. Write two midpoint circle drawing algorithms. (6 marks)

g) Explain in detail the eight neighbor polygon filling algorithm. (4 marks)

Total Marks 30

Q.5

a) Discuss about graphics networks and graphics on the internet. (4 marks)

b) Generally, any procedure that identifies those portions of a picture that is either inside or outside of a specified region of space is referred to as a clipping algorithm. Explain briefly about point and line clipping. (6 marks)

c) Explain briefly the use of computer graphics in user interfaces. (4 marks)

d) Write an OpenGL program which draws the 6 sided polygon. (4 marks)

e) We can correctly clip a polygon by processing the polygon boundary as a whole against each window edge. This could be accomplished by processing all polygon vertices against each clip rectangle boundary in turn. Write the Sutherland – Hodgeman clipping algorithm. (4 marks)

f) Explain briefly the use of computer graphics in Simulation and Animation. (4 marks)

g) Explain briefly the scan conversion of the simple polygon. (4 marks)

Total Marks 30

THE END

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

CSC4630 – Advanced Software Engineering

2015/2016 FINAL EXAM

Date: Tuesday 27th September 2016
Venue: Library Basement
Time: 09:00 – 12:00 hrs
Duration: 3 Hours

Instructions

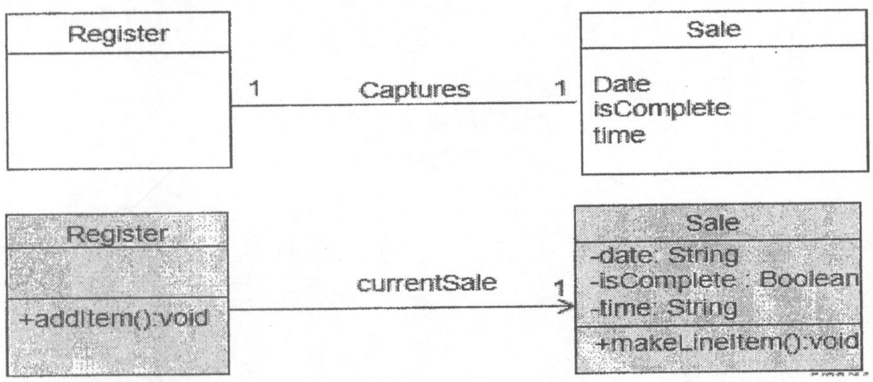
1. This exam has two sections A and B.
2. Answer **ALL** questions in **Section A.**
3. Answer **any three (3)** questions in **Section B.**
4. **Total number of questions answered should be 5.**

SECTION A

Answer all questions in this section. Each question carries 20 marks.

QUESTION 1 [20 marks]

Study the OOAD artefacts below and answer all the questions that follows;



1. What OOAD artefacts are shown in the above diagram? **[1 Mark]**
2. Give four differences between the two artefacts shown above. **[4 Marks]**
3. Map the second OOAD artefact above to java code. **[7 Marks]**
4. List and explain five GRASP design patterns used to assign responsibilities to objects. **[5 Marks]**
5. Explain the following types of software testing. **[3 Marks]**
   a. Alpha Testing
   b. Beta Testing
   c. Acceptance Testing

QUESTION 2 [20 marks]

1. Explain the principle of separation of concerns in the field of software engineering and what benefit results from applying it to a program. **[3 marks]**
2. What issues exit with cross-cutting concerns? **[2 marks]**

3. The architecture of an aspect-oriented system is based around a core system plus extensions. Describe 2 types of extension **[2 marks]**

4. Explain what aspect weaving is and describe 3 ways of doing it **[4 marks]**

5. Describe the 3 general steps that occur in an Aspect-Oriented Software Engineering project. **[6 marks]**

6. Give 3 problems that arise when testing an aspect-oriented program? **[3 marks]**

SECTION B

Answer three (3) questions in this section. Each question carries 20 marks.

QUESTION 3 [20 marks]

The triangle problem accepts three integers (a, b and c) as its input, each of which are taken to be sides of a triangle. The values of these inputs are used to determine the type of the triangle (Equilateral, Isosceles, Scalene or not a triangle).

For the inputs to be declared as being a triangle they must satisfy the six conditions:

C1. $1 \leq a \leq 200$

C2. $1 \leq b \leq 200$

C3. $1 \leq c \leq 200$

C4. $a < b + c$

C5. $b < a + c$

C6. $c < a + b$

Otherwise this is declared not to be a triangle. The type of the triangle, provided the conditions are met, is determined as follows:

a) If all three sides are equal, the output is Equilateral.
b) If exactly one pair of sides is equal, the output is Isosceles.
c) If no pair of sides is equal, the output is Scalene.

1. What is robustness testing? **[1 Mark]**

2. Design the robustness test cases for the triangle problem above. **[19 Marks]**

QUESTION 4 [20 marks]

The Unified Modelling Language (UML) is a general-purpose, developmental, modelling language in the field of software engineering that is intended to provide a standard way to visualize the design of a system

1. Show the UML notation for the following OOAD artefacts;
   a) Use case **[1 Marks]**
   b) Use case actor **[1 Marks]**
   c) Class **[2 Marks]**
   d) Interface **[2 Marks]**
   e) Package **[2 Marks]**
   f) Deployment diagram **[2 Marks]**
   g) Dependencies relationship **[1 Mark]**

2. Use UML notation to write a sequence diagram for the following scenario;
   ATM object creates three Account objects and initializes each Account object with the account number. Every time the Account object is created, the ATM object send the Account object to the DAO object for saving. **[9 Marks]**

QUESTION 5 [20 marks]

You are part of a team that has been contracted to develop a distributed system that will allow farmers in the rural parts of Zambia to sell their produce online to factories and retail supermarkets in the cities. It will be integrated with 3rd party systems such as payment gateways and fulfillment delivery portals. The system is called R2C.

1. There are a number of issues to consider when designing R2C. Explain in detail issues to consider when dealing with Transparency and Failure Management of the system. **[8 Marks]**

2. R2C should be able to scale-up and scale-out depending on the load. What is the difference between scaling up and scaling out? **[1 marks]**

3. Describe 2 types of attacks R2C must defend itself against. **[2 marks]**

4. Describe 3 architectural patterns that you can consider when designing R2C. **[6 marks]**

5. If the software becomes successful the funders, COMESA, would like R2C to be replicated in other member countries. Your team lead suggests SaaS to achieve this. Explain the SaaS concept of multi-tenancy. **[3 marks]**

QUESTION 6 [20 marks]

1. Define Service-Oriented Architecture and give 4 of its benefits? **[5 Marks]**

2. Draw a diagram depicting the steps involved and artefacts produced when engineering systems that are based on a service oriented architecture. **[7 marks]**

3. Give 3 reasons why is it important for a software system to be dependable? **[3 marks]**

4. Briefly describe the principal properties of dependability. **[4 marks]**

5. What constitutes a system failure in terms of reliability**? [1 mark]**

- END -

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
Department of Computer Science

FINAL EXAMINATION

DISTRIBUTED SYSTEMS
CSC 4722

Date:	20th SEPTEMBER 2016
Time:	09:00hrs – 12:00hrs
Duration:	3 Hours
Venue:	UPPER D/HALL

Instructions

1. *Answer **all** the questions in Section A.*
2. *Choose **any two** (2) questions from Section B.*
3. *Each question carries 20 marks.*

SECTION A [60 marks]

Attempt all questions in this section.

1. Question One. **[20 marks]**
   a) The following statement is attributed to Thomas j. Watson, Chairman and CEO of International Business Machines (IBM), in 1943 : "I think there is a world market for maybe *five* computers". Please state the key consequences for distributed systems if this sentence had been the correct version. **[1.5 marks]**
   b) In the classification of distributed systems, we looked at four aspects that guide this classification. State these four aspects and give two examples of each. **[8 marks]**
   c) Mr T owns a small computer company in Zambia and wants to setup a distributed system of his servers in Kabwe, Mansa, Lusaka and Ndola. He consults with you as a Computer Science specialist on how to go about this mission. State at least three challenges Mr T should look out for and what three mechanisms discussed in the course would help deal with these challenges you've stated. **[4.5 marks]**
   d) One of the known mutual exclusion challenges is the Dinning Philosopher's problem. Philosophers do only two things; think and eat. There are five philosophers and five forks but each philosopher must eat using two forks. Write an algorithm (using pseudo code), that resolves the Dining Philosopher's problem. Your algorithm should be fully distributed and must avoid deadlocks, live locks and starvation. **[5 marks]**
   e) Why does your solution work? **[1 mark]**

2. Question Two. **[20 marks]**
   a) What is the difference between Mutual exclusion and Leader election in Distributed systems? **[2 marks]**
   b) After discussion with you as an expert, Mr T decides to use one of the three known permission based algorithms for mutual exclusion, namely the Centralised Algorithm, but he is not sure of how it works and what its pros and cons are. Describe to Mr T, with the aid of a diagram, how the centralized algorithm works to achieve mutual exclusion and give him one advantage and two disadvantages of using this algorithm. **[6 marks]**
   c) Tony is a Software Developer working for Mr T and he's been assigned to implement an algorithm that would be able to elect one of Mr T's servers (Kabwe, Mansa, Lusaka or Ndola) as a leader in a distributed computation. Tony heard of the Bully Algorithm and the Ring algorithm but he wants to use the former. Describe to Tony how the Bully algorithm works to achieve leader election and tell him what its message overhead is (i.e. of what order is it and why?).Also tell Tony how the Bully algorithm handles failing nodes so that may implement that in his leader election task. **[6 marks]**
   d) Mr T wants to use a distributed hash table for some key resolution in his system. You have learnt about Chord, a distributed Hash Table that is used in key resolution, so you decide to recommend it to Mr T. Please explain to Mr T how

how

efficient Chord is compared to some naïve algorithms for key resolution i.e tell him what the time complexity of Chord is? Describe the steps of the key resolution algorithm of Chord so that Mr T could understand how it works and how he can use it on his servers. **[6 marks]**

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3. Question 3 [20 marks]

a) You have explained to Mr T the importance of synchronizing his server's clocks to ensure things like concurrent access to resources and coordination of joint activities. Describe to Mr T, with the aid of a diagram and an example, how the SNTP algorithm works to achieve clock synchronization. **[4 marks]**

b) Define the following terms with regard to obtaining a consistent global snapshot of a distributed system. **[2 marks]**

- Passive Monitoring
- Active Monitoring

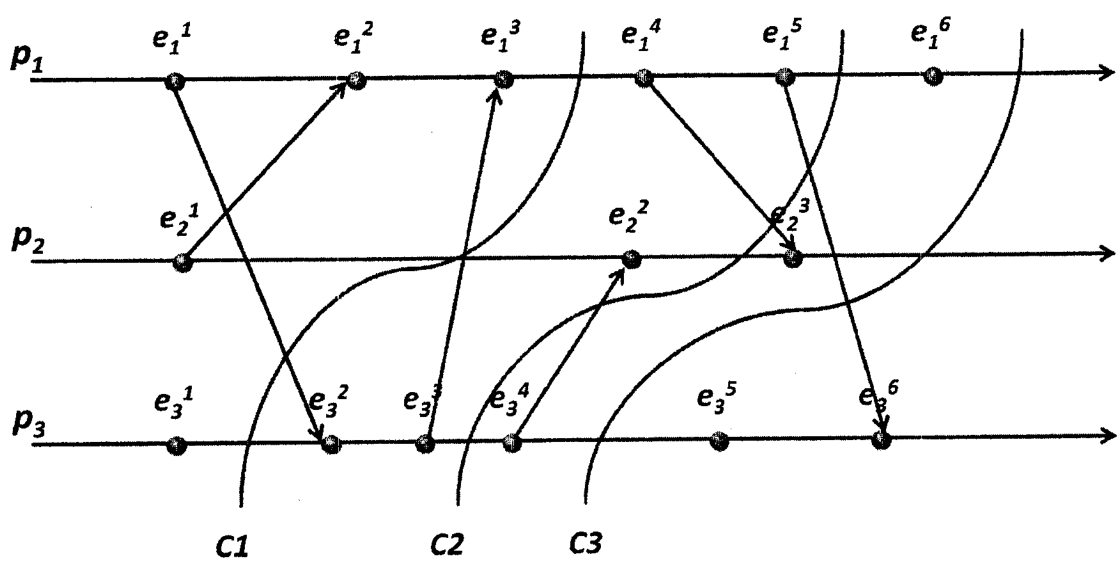
c) Give formal definitions of the following. **[4 marks]**

- Total ordering
- Sequential Ordering
- Causal Ordering
- Pairwise Inconsistency

d) Given two vector clocks from two nodes, how can one tell whether two events are causally related or concurrent? Give an example in your explanation. **[4 marks]**

e) What is a consistent cut (formal definition)? **[3 marks]**

f) Indicate whether each of the following cuts C1, C2 and C3 is consistent and state why. **[3 marks]**

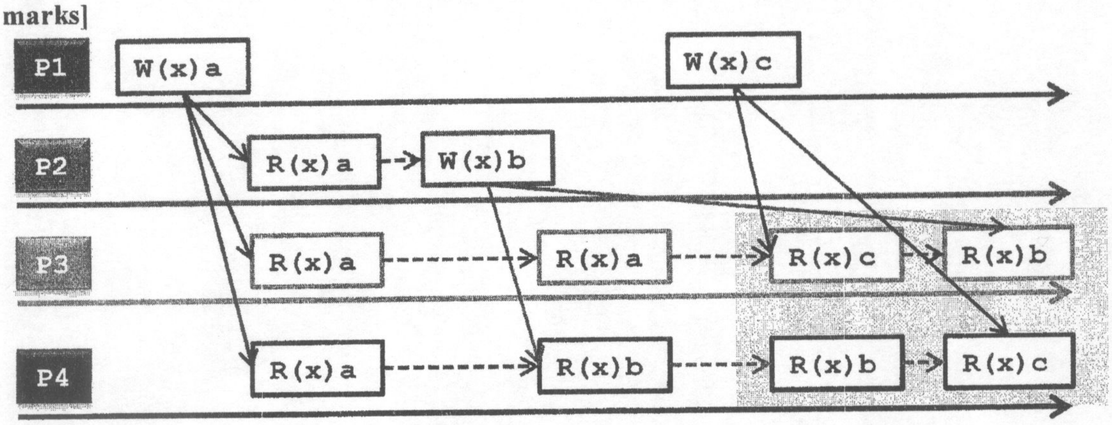


SECTION B [40 marks]

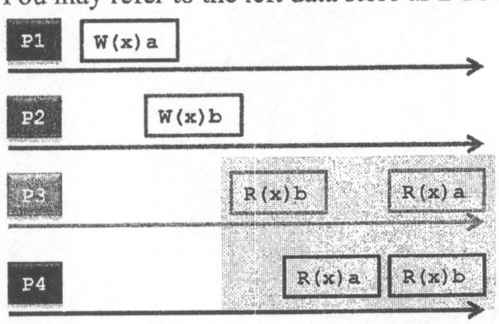
Choose any **two** questions from this section

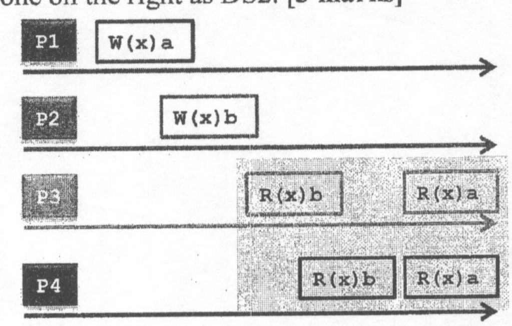
4. Question 4. [20 marks]

a) Explain whether the following data store fulfills causal order and sequential order. [3 **marks]**



b) Explain whether the following data stores fulfill sequential order. Explain your reasoning. You may refer to the left data store as DS1 and the one on the right as DS2. [3 **marks]**

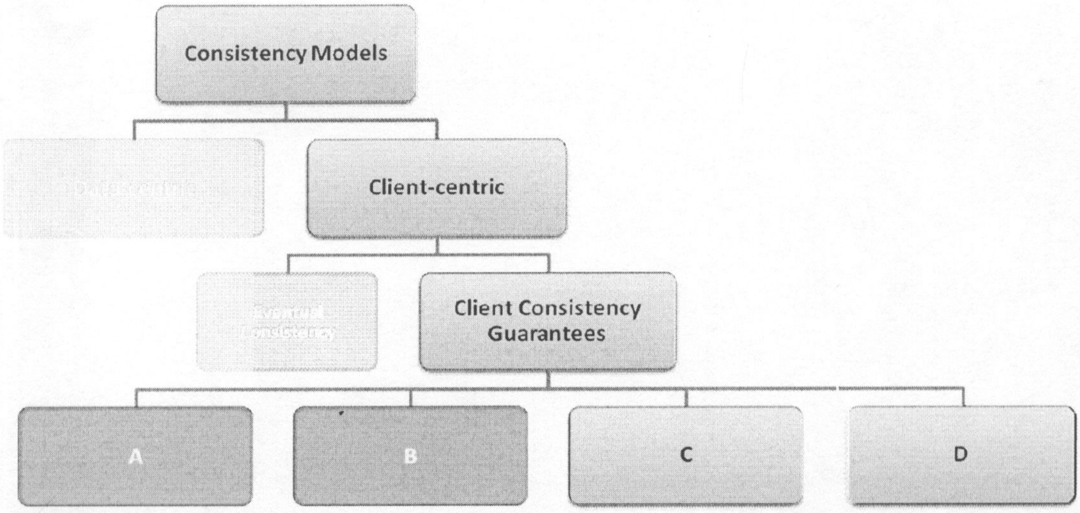




c) Describe with the aid of a diagram how the centralized active replication protocol works to ensure data consistency. [**8 marks]**

d) We discussed data centric models and client centric models for consistency, what is the difference between these two types of models? [**2 marks]**

e) Fill in the names of the missing client consistency guarantees in the diagram below. [**4 marks]**



5. **Question 5. [20 marks]**

a) List three requirements of a fault tolerant system. **[3 marks]**

b) List and describe the five types of failures discussed under Failure models. **[5 marks]**

c) What is a dependable system? **[4 marks]**

d) We discussed the "Byzantine Generals Problem". **[8 marks]**

- In the "Byzantine Generals Problem" there are honest generals and dishonest generals (traitors). What is the goal of the honest generals? What is the goal of the traitors?
- In the lecture we introduced an algorithm with multiple phases to enable consensus among the generals. Explain the algorithm and its different phases (plus steps).
- Under what conditions can the generals achieve consensus. How many honest generals are required, assuming that there are ***k*** dishonest ones?

6. **Question 6. [20 marks]**

a) In a distributed system, cache inconsistencies can be typically detected at three stages. List and briefly describe three cache coherence detection strategies. **[3 marks]**

b) Once cache inconsistencies are detected, two approaches are taken to enforce consistency. Discuss these two approaches. **[2 marks]**

c) State the formal definition of "Monotonic Writes". **[3 marks]**

d) Discuss which of the following diagrams provide monotonic writes. **[6 marks]**

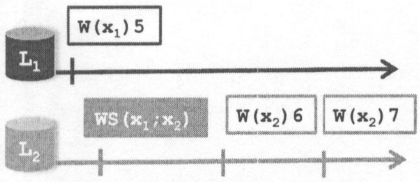


FIGURE 1

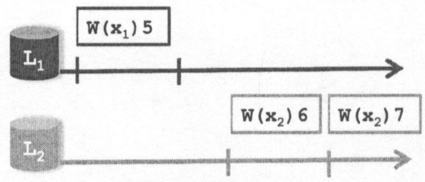


FIGURE 2

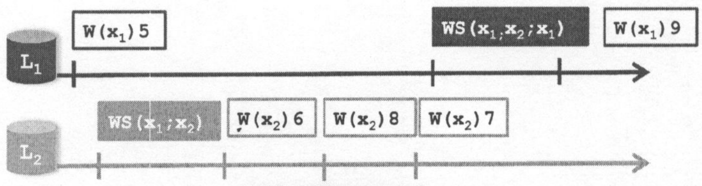


FIGURE 3

e) Explain the Greedy Approach to Replica Server Placement. **[6 marks]**

THE UNIVERSITY OF ZAMBIA
SCHOOL OF HUMANITIES AND SOCIAL SCIENCES
2015 ACADEMIC YEAR
END OF YEAR FINAL EXAMINATIONS

ECN 9135:	AGRICULTURAL ECONOMICS
TIME:	TWO (2) HOURS
INSTRUCTIONS:	ANSWER ALL QUESTIONS, USING WELL LABELLED DIAGRAMS WHERE NECESSARY.

QUESTION ONE.

Distinguish between physical and economic relationships in the theory of production.

QUESTION TWO.

a. Explain the concept of externalities in Agriculture.
b. In his address to Parliament, the President stated in part as follows, "My government will, therefore, ... make dipping, vaccination and treatment of diseases of all cattle compulsory".
    i. Discuss the likely impact of such a policy on livestock farming.
    ii. Explain the factors that might lead to such a move as opposed to just ensuring the availability of medicine on the market.

QUESTION THREE

Agriculture is often viewed as a risky sector. For this reason, the private is unlikely to optimally invest in the sector. As a policy advisor, identify and explain one way in which the state can assist the sector in view of the stated problem.

QUESTION FOUR

In 2013, Government plans to expand the scope of the Farmer Input Support Programme (FISP) to include and cover other crops among them soya beans.

a. Explain with well labelled diagram(s) how such a move would affect the market for soya beans.
b. What are its merits and demerits?

END OF FINAL EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR FINAL EXAMINATIONS

GES 1310: INTRODUCTION TO GEOGRAPHY

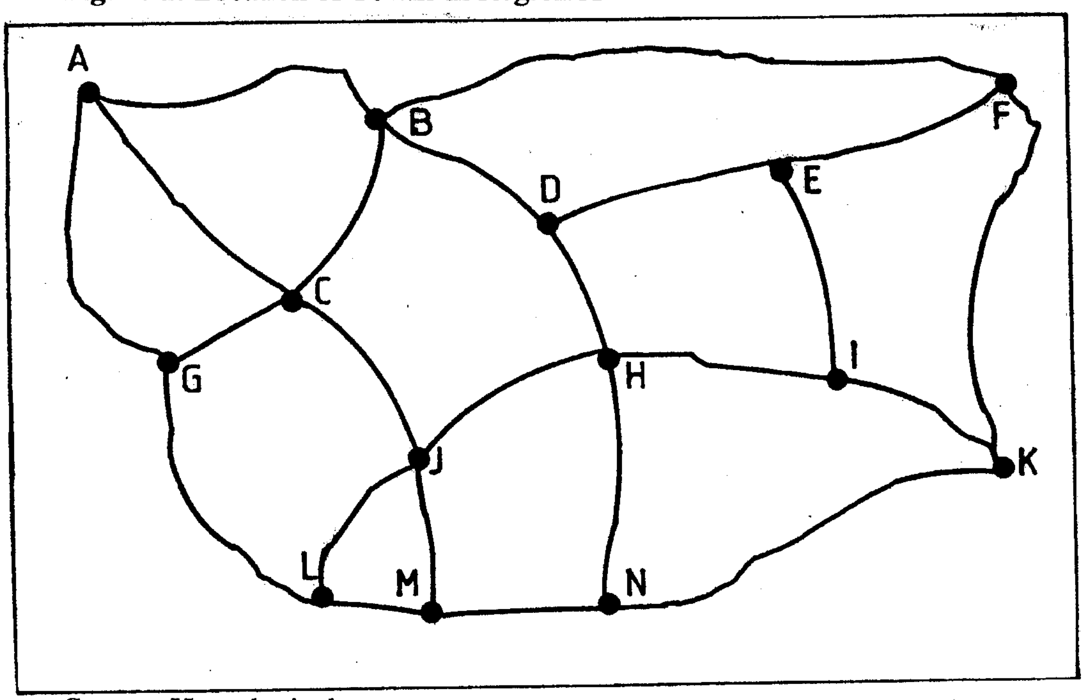
TIME: Three (3) hours

INSTRUCTIONS: Answer Two (2) questions from each section. **Question 1 (40 marks)** is compulsory.
Use of an **approved** calculator is allowed. Candidates are encouraged to use illustrations wherever appropriate.

SECTION I

1. Use Figure 1 to answer the following questions.

Figure 1: Location of Towns in Region X



Source: Hypothetical

a) Calculate the Nearest Neighbour Index (NNI) for Region X.
b) What is the NNI at 0.005 level of significance?

2. Write short explanatory notes on **ALL** of the following:
a) Expansion diffusion
b) Settlement hierarchy
c) Edward Ullman's three necessary conditions for spatial interaction
d) The wave in profile.

3. Discuss the view that culture is a determinant of resource utilisation in any given society.

4. State the rules of Hagerstrand's model and explain how some of them were relaxed.

SECTION II

5. Explain how erosion is achieved by fluvial (river), aeolian (wind) and glacial (ice) processes.

6. Using illustrations, describe the features formed by the solidification of magma in the earth's crust.

7. Explain the theory of plate tectonics.

8. Describe the following soil-forming processes:
   a) Laterisation (ferralitisation)
   b) Solodisation
   c) Podzolisation
   d) Calcification

END OF EXAMINATION

C11a Critical Values of the Nearest-Neighbour Index, R (One-Tailed)

n	Clustered pattern 0.1	0.05	0.01	0.005	0.001	Dispersed pattern 0.1	0.05	0.01	0.005	0.001
2	0.527	0.392	0.140	0.048		1.473	1.608	1.860	1.952	2.139
3	0.614	0.504	0.298	0.223	0.071	1.386	1.497	1.702	1.777	1.930
4	0.666	0.570	0.392	0.327	0.195	1.335	1.430	1.608	1.673	1.805
5	0.701	0.616	0.456	0.398	0.280	1.299	1.385	1.544	1.602	1.720
6	0.727	0.649	0.504	0.451	0.343	1.273	1.351	1.497	1.550	1.657
7	0.747	0.675	0.540	0.491	0.392	1.253	1.325	1.460	1.509	1.609
8	0.764	0.696	0.570	0.524	0.431	1.237	1.304	1.430	1.476	1.569
9	0.777	0.713	0.595	0.551	0.463	1.223	1.287	1.406	1.449	1.537
10	0.789	0.728	0.615	0.574	0.491	1.212	1.272	1.385	1.426	1.509
11	0.798	0.741	0.633	0.594	0.515	1.202	1.259	1.367	1.406	1.486
12	0.807	0.752	0.649	0.612	0.535	1.193	1.248	1.351	1.389	1.465
13	0.815	0.762	0.663	0.627	0.554	1.186	1.239	1.337	1.373	1.447
14	0.821	0.770	0.675	0.640	0.570	1.179	1.230	1.325	1.360	1.430
15	0.827	0.778	0.686	0.653	0.584	1.173	1.222	1.314	1.348	1.416
16	0.833	0.785	0.696	0.664	0.598	1.167	1.215	1.304	1.337	1.403
17	0.838	0.792	0.705	0.674	0.610	1.162	1.209	1.295	1.327	1.391
18	0.842	0.797	0.713	0.683	0.621	1.158	1.203	1.287	1.317	1.380
19	0.847	0.803	0.721	0.691	0.631	1.154	1.197	1.279	1.309	1.369
20	0.850	0.808	0.728	0.699	0.640	1.150	1.192	1.272	1.301	1.360
21	0.854	0.812	0.735	0.706	0.649	1.146	1.188	1.266	1.294	1.351
22	0.857	0.817	0.741	0.713	0.657	1.143	1.183	1.259	1.287	1.343
23	0.861	0.821	0.746	0.719	0.664	1.140	1.179	1.254	1.281	1.336
24	0.864	0.825	0.752	0.725	0.671	1.137	1.176	1.248	1.275	1.329
25	0.866	0.828	0.757	0.731	0.678	1.134	1.172	1.243	1.269	1.322
26	0.869	0.831	0.762	0.736	0.684	1.131	1.169	1.239	1.264	1.316
27	0.871	0.835	0.766	0.741	0.690	1.129	1.166	1.234	1.259	1.310
28	0.874	0.838	0.770	0.746	0.696	1.127	1.163	1.230	1.254	1.304
29	0.876	0.840	0.774	0.750	0.701	1.124	1.160	1.226	1.250	1.299
30	0.878	0.843	0.778	0.754	0.706	1.122	1.157	1.222	1.246	1.294
31	0.880	0.846	0.782	0.758	0.711	1.120	1.155	1.219	1.242	1.289
32	0.882	0.848	0.785	0.762	0.715	1.118	1.152	1.215	1.238	1.285
33	0.884	0.850	0.788	0.766	0.720	1.117	1.150	1.212	1.234	1.280
34	0.885	0.853	0.791	0.769	0.724	1.115	1.148	1.209	1.231	1.276
35	0.887	0.855	0.794	0.773	0.728	1.113	1.145	1.206	1.228	1.272
36	0.889	0.857	0.797	0.776	0.732	1.112	1.143	1.203	1.224	1.268
37	0.890	0.859	0.800	0.779	0.735	1.110	1.141	1.200	1.221	1.265
38	0.892	0.861	0.803	0.782	0.739	1.109	1.140	1.197	1.218	1.261
39	0.893	0.862	0.805	0.785	0.742	1.107	1.138	1.195	1.216	1.258
40	0.894	0.864	0.808	0.787	0.746	1.106	1.136	1.192	1.213	1.255
41	0.896	0.866	0.810	0.790	0.749	1.105	1.134	1.190	1.210	1.252
42	0.897	0.867	0.812	0.792	0.752	1.103	1.133	1.188	1.208	1.249
43	0.898	0.869	0.815	0.795	0.755	1.102	1.131	1.186	1.205	1.246
44	0.899	0.870	0.817	0.797	0.757	1.101	1.130	1.183	1.203	1.243

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR FINAL EXAMINATION

GES 2210: FUNDAMENTALS OF PHYSICAL GEOGRAPHY

TIME: Three hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks. Candidates are advised to make use of illustrations wherever appropriate. Use of an approved calculator is allowed.

---

1. Write short explanatory notes on **ALL** of the following:
   a) Vertical structure of the atmosphere
   b) Three cells model for global wind circulation systems
   c) Internal structure of the earth
   d) Ecological niche
   e) Soil catena

2. Using specific examples, explain the role of water and man as triggers of mass movement.

3. "During its evolutionary history, each species has developed a series of structural, behavioural and physiological properties which have resulted in its being well tuned to the demands of its environment" (Cox and Moore, 1985: 1). Discuss.

4. How do ocean currents influence the global weather and climate systems?

5. Explain at least five (5) pedogenic regimes controlled by climate.

6. Cleopatra's obelisk was a monument carved in Egypt around 1450B.C. The sides are carved with hieroglyphs, the writing of ancient Egypt. It stood in the dry, hot Egyptian desert for over 3000 years. During that time, the hieroglyphs remained distinct. In 1800, the monument was moved to New York City. Almost immediately, the hieroglyphs began to fade. In only a few years in the wet and variable climate of New York, the Egyptian writing became indistinct!
   a) Explain the factors that could have contributed to the fading of the writings on Cleopatra's obelisk
   b) How would the type of weathering on Cleopatra's obelisk have differed had the monument been transported to a cold and humid region.
   c) What factors affect the rate at which weathering occurs?
   d) How do the agents of chemical weathering differ from those of physical weathering?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2015 ACADEMIC YEAR FINAL EXAMINATIONS

GES 2411: MAPPING AND FIELD TECHNIQUES IN GEOGRAPHY

PAPER 1: THEORY

TIME: Three Hours

INSTRUCTIONS: Answer any four questions. The use of an approved calculator is Allowed and candidates are encouraged to make use of illustrations wherever appropriate.

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1. Write short explanatory notes on **ALL** of the following:
   (a) Equivalent map projections
   (b) Grid references
   (c) Elements of a good map
   (d) Vertical exaggeration on a profile
   (e) Oblique aerial photographs
2. It is generally said that 'air photo interpretation cannot be taught but there are clues that aid in the identification of features on air photos that can be discussed'. Outline and explain any five such clues.
3. Discuss the contention that 'a vertical air photograph has no definite scale, thus one can only talk of mean scale given the mean altitude of the terrain'.
4. What are the advantages of maps over air photographs in studying the face of the earth?
5. With the help of a sketch map, show how you would calculate gradient on any topographical map.
6. With the help of an example, explain how you would interpret the relief of any given topographical map.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR FINAL EXAMINATIONS

GES 2422: STATISTICAL METHODS IN GEOGRAPHY

TIME: Three hours

INSTRUCTIONS: Answer any FOUR questions. All questions carry equal marks and use of an approved calculator is allowed. Candidates are encouraged to make use of illustrations wherever appropriate.

---

1. Write short explanatory notes on ALL of the following:
   a) Extraneous variables
   b) Action research
   c) Snowball sampling
   d) Benefits of sampling
   e) Quota sampling

2. A second year student at the University of Zambia wanted to assess whether there was a relationship between tree height and weight. She measured the heights (meters) and weights (kilograms) of tree logs that a forester had delivered to her department and the measurements are presented in Table 1.

Table 1: Measurements of tree height and weight

Height (meters)	56.2	65.3	65.7	50.2	25.3	87.7	44.2	35.8	56.5
Weight (kgs)	87.8	85.1	91.8	75.5	28.9	122.3	66.9	58.3	91.7

Source: *Hypothetical*

At $\alpha = 0.05$ and assuming that the samples are random and normally distributed, what conclusion did the student make about her study?

3. Human–wildlife conflict is a growing problem in today's crowded world and can have significant impact on both human and wildlife populations. You decide to conduct a study on the human-wildlife conflict in Livingstone, the tourist capital of Zambia.

a) Formulate a statement of the problem
b) Formulate the aim and three (3) objectives of the study
c) Construct a questionnaire for collecting such data.

4. Table 2 shows the availability of health facilities in a number of provinces in a certain country. The number of people (measured in thousands) per doctor in each province, and the number of hospital beds per 100 people in each province are compared.

Table 2: Availability of health facilities in a number of provinces

Province	Number of people ('000)	Beds/100 people
A	30	1.0
B	03	5.0
C	16	3.0
D	25	1.5
E	14	4.0
F	30	0.5
G	05	4.0
H	23	2.0
I	20	2.5
J	06	3.5
K	10	6.0
L	02	7.0

Source: *Hypothetical*

Answer the following questions based on Table 2

a) Plot the data provided in the table
b) Conduct a regression analysis so as to come up with a regression equation related to data provided in the table
c) Draw a line of best fit in your scatter diagram.
d) Define your regression equation.
e) How many people ('000) would be expected if the number of hospital beds per 100 people was 11?

5. A GES 2422 student wanted to determine whether there was a difference between one's social status and sex. He interviewed a total of 610 female and male respondents as shown in Table 3.

Table 3: Social class and gender

Social class	Male	Female
Upper	33	29
Upper middle	153	181
Middle	103	81
Lower	16	14

Source: *Hypothetical*

What conclusion did the student make about the study? Use 99 percent level of confidence.

6. Write short explanatory notes on ALL of the following
   a) Parametric and non-parametric tests
   b) Type I and type II errors in hypothesis testing
   c) Importance of statistics
   d) Any two levels of measuring geographical data
   e) Any two measures of central tendency and any two measures of variability

---

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES
2016 ACADEMIC YEAR FINAL EXAMINATIONS

GES 3330: ENVIRONMENT AND DEVELOPMENT

TIME: Three hours

INSTRUCTIONS: Answer any FOUR questions. All questions carry equal marks.

---

1. Write short explanatory notes on **ALL** of the following:

a) Environmental Conflict
b) Sustainable Development
c) Anthropocene
d) Environmental Crisis
e) Acid rain

2. Explain both the direct and underlying causes of deforestation and forest degradation.

3. 'Most traditional systems of agriculture have fewer negative impacts on the environment because they foster environmental self-regeneration'. In what ways are systems deemed more environmentally friendly than conventional systems of agriculture.

4. 'Economic and domestic activities negatively impact on the environment'. Elucidate.

5. With the help of examples, explain the main components of an ecosystem and the processes that support their interaction.

6. Explain the three pillars of sustainable development.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR FINAL EXAMINATIONS

GES 3342: ENVIRONMENTAL PLANNING AND MANAGEMENT

TIME: Three Hours

INSTRUCTIONS: Answer any four (4) questions. All questions carry equal marks. Candidates are encouraged to make use of illustrations wherever appropriate.

---

1. Write short explanatory notes on **ALL** of the following:

   a) Precautionary principle
   b) Scoping stage in Environmental Impact Assessment
   c) Functions of the Polluter Pays Principle
   d) Types of Property Rights
   e) Biodiversity conservation

2. Discuss the assertion that 'a decentralized system of managing natural resources is better than a centralized system'.

3. With the help of examples, explain any one type of environmental policy instrument suitable for pollution control in a developing country context and justify its relevance.

4. With the aid of practical examples, discuss the 'tragedy of the commons'.

5. Outline and explain the values of biodiversity to humankind.

6. Explain the concept of equity principle in the context of sustainable management of natural resources.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR FINAL EXAMINATIONS

GES 4372: TOURISM, ENVIRONMENT AND DEVELOPMENT

TIME: Three (3) hours

INSTRUCTIONS: Answer **Question 1** and any other 3 Questions. All questions carry equal marks. Candidates are encouraged to use illustrations wherever appropriate.

---

1. Write short explanatory notes on **ALL** of the following:
   a) Typologies of tourist
   b) Ecotourism
   c) Types of carrying capacity
   d) Destination accessibility
   e) Environmental Impact Assessment

2. Explain how Information Communication Technology (ICT) has influenced the development of international tourism in Zambia.

3. Describe the types of pollution generated by the tourism sector.

4. Evaluate the importance of community participation in tourism planning.

5. Discuss the merits and demerits of the 'Uni-visa system' for Zambia's tourism development.

6. Explain how carrying capacity and limits of acceptable change can aid in the attainment of sustainable tourism.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2015 ACADEMIC YEAR FINAL EXAMINATIONS

GES 4451: CARTOGRAPHY

TIME: Three Hours

INSTRUCTIONS: Answer any four questions. The use of an approved calculator is Allowed and candidates are encouraged to make use of illustrations Wherever appropriate.

---

1. Write short explanatory notes on **ALL** of the following:
   (a) Computer-assisted cartography
   (b) Controls of generalization
   (c) Universal Transverse Mercator (UTM) grid system
   (d) Classification of map projections
   (e) Robinson *et al.* (1984) stages in the map design process.
2. Outline and explain the elements of symbolization that differentiate data.
3. "Computer-assisted cartography involves the development and integration of three components of any computer system" (Robinson *et al.*, 1984: 48). Elucidate.
4. With the help of examples, show how the three classes of map symbols may be used to portray some kinds of nominal, ordinal and interval data.
5. With the aid of specific examples drawn from Figure 1, identify and explain the general rules about positioning lettering on a map that have been violated.
6. 'The need for maps has never disappeared. It has always been there and will continue to be there'. Discuss.

END OF EXAMINATION

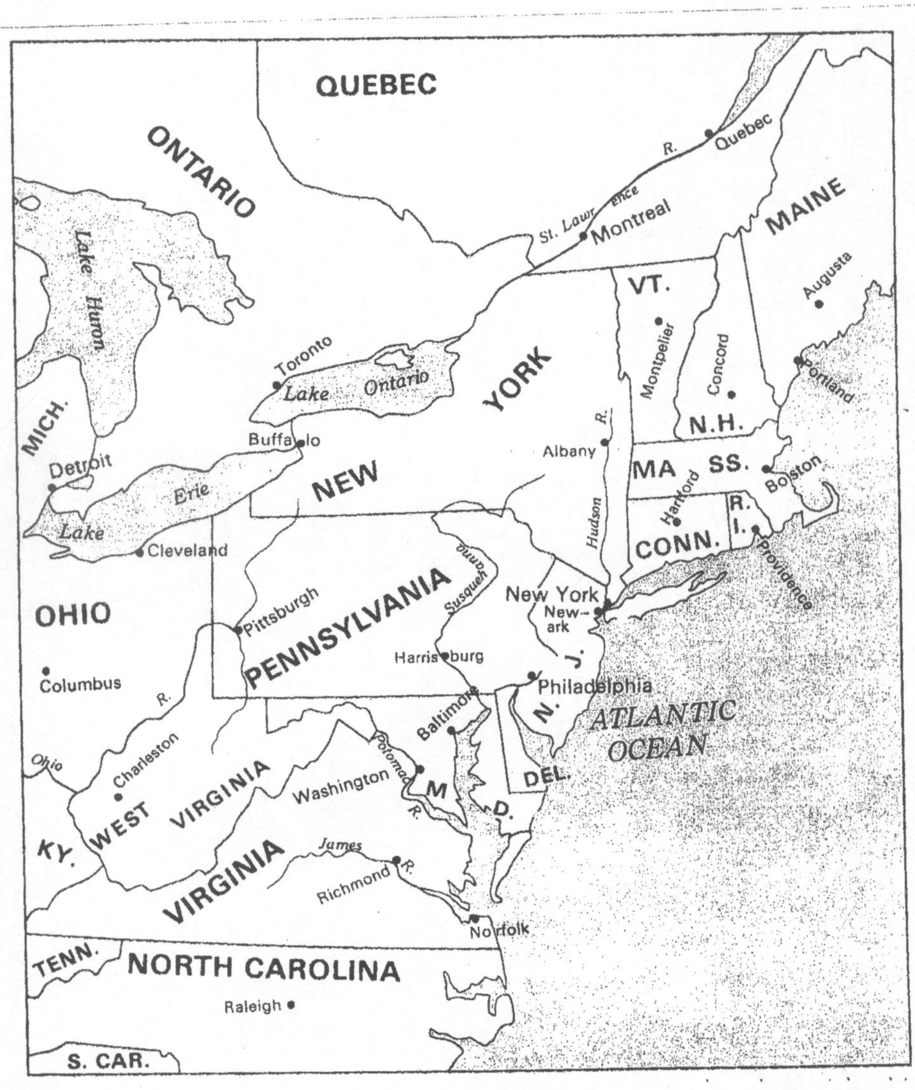

Figure 1: Positioning lettering on a map

The University of Zambia
School of Natural Sciences
Department of Mathematics & Statistics

2015 Academic Year Final Examinations

MAT1100 – Foundation Mathematics

5th September, 2016

INSTRUCTIONS: (1) Write down your **Computer number** and the **TG number** on each answer booklet used. (**Do Not write your Name**)

(2)There seven (7) questions in this examination. **Answer** any **Five (5)**.

(3)Show all essential working to avoid loss of marks.

(4) Write down the **number** of each question attempted on the cover of the main answer booklet.

(5) Calculators and Mathematical Tables are **not allowed** in this Examination paper.

TIME ALLOWED: Three (3) hours.

Q1. (a) Given that $= \begin{pmatrix} 1 & 0 \\ 2 & 1 \\ 3 & 1 \end{pmatrix}$, $B = \begin{pmatrix} 1 & 0 & 1 \\ -1 & 2 & 3 \end{pmatrix}$ and $C = \begin{pmatrix} 1 & -1 & 1 \\ 1 & 1 & 3 \\ -2 & 1 & 1 \end{pmatrix}$.

Find the following matrices:

(i) $5A - 2B^T$

(ii) BC

(iii) C^{-1}.

(b) Find the value(s) of α for which the matrix

$$A = \begin{pmatrix} \alpha & 1 & 1 \\ 1 & \alpha & -1 \\ 1 & -2 & 3 \end{pmatrix}$$

has no inverse.

(c) Express $\frac{1+2\sqrt{3}}{(2-\sqrt{3})^2}$ in the form $p + q\sqrt{3}$ where p and q are integers.

Q2 (a) (i) Let $A = \{x \in \mathbb{R} | x > 2\}$ and $B = \{x \in \mathbb{Z} | x \leq 2\}$ be subsets of $\mathbb{R}$, where $\mathbb{Z}$ is the set of integers. Find the set

$$(A \cup B')'.$$

(ii) State De-Morgans' laws.

(iii) Given that X and Y are sets, simplify

$$[X \cap (X' \cap Y)']',$$

as far as possible.

(b) Given the functions $f(x) = \dfrac{2}{2-x}$ and $g(x) = \dfrac{3+x}{x+1}$,

(i) find the domain and range of $f(x)$

(ii) find $(gof)(x)$ and, hence find $(gof)^{-1}(x)$.

(iii) solve the equation $(fog)(x) = \frac{3}{2}$.

(iv) sketch the graph of $y = g(x)$, showing clearly all the asymptotes.

(c) Use Cramer's rule to solve the system of equations:

$$\begin{aligned} x - 2y + \ z &= 6 \\ x + 5y + \ z &= -1 \\ 2x - \ y + 4z &= 15 \end{aligned}$$

Q3. (a) Evaluate the limits:

(i) $\lim\limits_{x \to 2} \dfrac{x^3 - 8}{x^2 - 4}$

(ii) $\lim\limits_{x \to +\infty} \dfrac{2x^3 + 1}{6 + x^2 - 3x^3}$

(b) Differentiate the function $f(x) = \sqrt{2x+1}$ from first principle.

(c) (i) Given that $y = \dfrac{(5x^2 - 4)^3}{e^{5x}}$, find $\dfrac{dy}{dx}$ at $x = 0$.

(ii) Find the equation of the normal to the curve $y = x^2 - 9x^{-1}$,

at the point (3,6), expressing it in the form $ax + by + c = 0$, where a, b and c are constants.

Q4 (a) (i) Determine whether the function $f(x) = 2 - 5x^2$ is even or odd or neither.

(ii) Find the range of values of k for which the quadratic equation

$$x^2 + (2-k)x + 1 - 2k = 0$$

has no real roots.

(b) (i) Prove the identity

$$(1 - cosA)(1 + secA) = sinA\ tanA.$$

(ii) Solve for x, the trigonometric equation $\cos 2x + 3\sin x - 2 = 0$, if $0 \le x \le 2\pi$.

(iii) Find the period and phase shift for the function $f(x) = 1 - \sin(2x + \pi)$. Hence or otherwise, sketch the curve for $-\pi \le \theta \le \pi$.

(c) (i) Sketch the graphs of the curves $y = 4x(5 - x)$ and $y = x^2$, on the same Diagram, and state their points of intersection.

(ii) Find the area of the region bounded by the two curves.

Q5 (a) Solve for x:

(i) $|3x - 2| = 4 + x$.

(ii) $\left|\frac{x}{2x-3}\right| < 4$.

(b) The points $P(3, -1)$ and $Q(5,3)$ are the end points of the diameter of a circle.

(i) Find the exact length of PQ.

(ii)Find the equation of the circle.

(c) Evaluate each of the following integrals:

(i) $\int \cos x\ sin^3 x dx$

(ii) $\int_0^{\pi/2} x \cos x dx$.

Q6. (a) (i) Express $2.32\bar{5}$ in the form $\frac{m}{n}$, where m and n are integers and $n \neq 0$

(ii) Find two complex numbers such that $(a + ib)^2 = 15 + 8i$, where a and b are constants.

(b) Expand $\sqrt{1-x}$ as a series in ascending powers of x, up to and including the term in x^3. State the range of values of x for which the expansion is valid.

(c) (i)Resolve $\frac{x^3}{x^2 - 4}$ into a sum of partial fractions.

(ii) Evaluate the integral $\int \frac{x^3}{x^2-4} dx$.

Q7 (a) Use the principle of Mathematical induction to prove that for $n \in \mathbb{Z}^+$,

$$1^2 + 2^2 + 3^2 + \cdots + n^2 = \frac{n}{6}(n+1)(2n+1).$$

(b) (i) The polynomial $p(x) = ax^3 + 5x^2 - bx + 6$ is divisible by $(x+2)$ but leaves a remainder of -12 when divided by $(x-1)$. Find the values of a and b.

(ii)Express $\dfrac{2+3i}{3-4i}$ in the form $p + iq$ where p and q are rational numbers.

(iii)Find the value of n if the coefficient of second term in the expansion of $(1-x)(1+2x)^n$ is 19.

(c) Consider an (idealized) experiment in which a colony of live bacteria is introduced to a limited food supply. Suppose the rate of change in the number N of live bacteria with respect to time is given by

$$N'(t) = 6000t^2 - 75t^4.$$

Find the size $N(t)$ of the population of the bacteria at time t if initially 1000 bacteria were introduced to the food supply.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF MATHEMATICS AND STATISTICS

END OF 2015/2016 ACADEMIC YEAR EXAMINATIONS

FRIDAY, 23^{RD} SEPTEMBER 2016

MAT3200 - ABSTRACT ALGEBRA

INSTRUCTIONS:

1. There are **six (6)** questions in this paper.
2. Answer any **five (5)** questions.
3. All questions carry equal marks.

TIME ALLOWED: Three (3) hours

[TURN OVER]

1. (a) Define each of the following:

   (i) a group G. [2]

   (ii) a subgoup H of a group G. [2]

   (iii) an equivalence relation. [2]

   (iv) the set of generator(s) of a group. [2]

   (b) (i) Show that the set of integers $\mathbb{Z}_4 = \{0, 1, 2, 3\}$ under multiplication modulo 4 is not a group. [2]

   (ii) Let G be a group and let H and K be subgroups of G. Prove that their intersection $H \cap K$ is a subgroup of G. [4]

   (c) Prove that the set $\mathbb{Q}^+$ of positive rationals is a group under multiplication. [3]

   (d) An equilateral triangle has $\mathbb{D}_3$ symmetry. Is $\mathbb{D}_3$ Abelian? Give reasons for your answer. [3]

---

2. (a) Define the following:

   (i) the order of a group. [2]

   (ii) the order of an element in a group. [2]

   (iii) a left coset of a subgroup H in a group G. [2]

   (iv) a normal subgroup N of G. [2]

   (b) State and prove Lagrange's theorem. [4]

   (c) Let $G = \mathbb{Z}_{p^2q}$ where p, q are odd primes. List all the subgroups of G and hence construct a subgroup lattice. [4]

   (d) Let G be a group and H a non empty subset of G. Prove that H is a subgroup of G if and only if for $x, y \in H$, $xy^{-1} \in H$. [4]

---

3. (a) Define the following:

   (i) the center $Z(G)$ of a group. [2]

   (ii) the normaliser of a subset S in a group G. [2]

   (iii) a group homomorphim.

   (iv) the kernel of a group homomorphism. [2]

   (b) (i) Let G be a group and let g be an element of order n in G. If $a^k = e$, then show that n divides k. [3]

   (ii) Consider the Klein four-group $V = \{(1), (12)(34), (13)(24), (14)(23)\}$ and $\Gamma_4 = \langle i \rangle = \{1, i, -1, -i\}$. Prove that V is not isomorphic to Γ_4. [3]

   (c) Prove that every cyclic group is abelian and by the use of an example, show that the converse is not always true. [3]

   (d) Determine if the subgroup $H = \langle (12) \rangle$ is normal in S_3. [3]

---

4. (a) Define each of the following:

   (i) a permutation of on a set A. [2]

   (ii) the parity of a permutation. [2]

   (iii) an even permutation. [2]

   (iv) an action of a group G on a set S. [2]

   (b) Let $\alpha = \begin{pmatrix} 1 & 2 & 3 & 4 \\ 1 & 4 & 3 & 2 \end{pmatrix}$ and $\beta = \begin{pmatrix} 1 & 2 & 3 & 4 \\ 3 & 1 & 4 & 2 \end{pmatrix}$. Compute each of the following:

   (i) $(\alpha \circ \beta)^{-1}$ [2]

   (ii) $\beta^{-1} \circ \alpha^{-1}$ [2]

   (c) (i) Prove that the set of even permutations in S_n forms a subgroup of S_n. [2]

   (ii) Determine the parity of $\alpha = \begin{pmatrix} 1 & 2 & 3 & 4 \\ 1 & 4 & 3 & 2 \end{pmatrix}$ [2]

   (d) (i) Write $(245)(1354)(125)$ as a product of disjoint cycles. [2]

   (ii) Prove that if α is an odd permutation, then so is α^{-1}. [2]

---

5. (a) Define the following:

   (i) a ring R. [2]

   (ii) a unit element in a ring R. [2]

   (iii) a unity element in a ring R. [2]

   (iv) an idempondent element in a ring R. [2]

   (b) Let $\mathbb{Z}[\sqrt{2}] = \{a + b\sqrt{2} | a, b \in \mathbb{Z}\}$. Prove that $\mathbb{Z}[\sqrt{2}]$ is a ring under ordinary multiplication. [4]

   (c) (i) Consider an integral domain $\mathbb{Z}[i]$. Determine if the element 5 is irreducible in $\mathbb{Z}[i]$? [3]

   (ii) By the use of an example, show that for fixed non zero elements a, b in a ring R, the equation $ax = b$ can have more than one solution. [3]

   (d) State (without proof). The subring test theorem for a subset S of a ring R. [3]

---

6. (a) Define the following:

   (i) a zero divisor in a ring. [2]

   (ii) an integral domain. [2]

   (iii) an ideal in a ring. [2]

   (iv) a maximal ideal in a ring. [2]

   (b) (i) Let R be the ring $\mathbb{Z}_n$ where n is not prime. Show that R is not an integral domain. [2]

   (ii) Let D be an integral domain of prime characteristic p. Show that D contains a subring isomorphic to $\mathbb{Z}_p$. [3].

   (c) Prove that if $\mathbb{F}$ is a field, then F has no ideals other than $\{0\}$ and F. [3]

   (d) (i) Show that 0 is the only nilpotent element in an integral domain. [2]

   (ii) How many elements are in $\mathbb{Z}[i]/ < 3 + i >$. Give reasons for your answer. [2]

■ END OF EXAMINATION ■

THE UNIVERSITY OF ZAMBIA

DEPT. OF MATHEMATICS & STATISTICS

MAT 2100 ANALYTIC GEOMETRY & CALCULUS

FINAL EXAMINATION 2016 TIME ALLOWED: THREE (3) Hours

Instructions

1. The Examination has **Six (6)** questions and a student is expected to attempt **Five (5)** questions only.
2. All questions carry equal Marks
3. All working must be shown clearly in order to earn full marks
4. Calculators are allowed in this Examination.

....

1. (a) (i) Evaluate $\int_{\sqrt{2}}^{\sqrt{3}} \frac{x^3}{\sqrt{x^2-1}}dx$

   (ii) Find the third Taylor polynomial for $f(x) = \sin x$, expanded about $c = \frac{\pi}{6}$.

   (b) The equation of a conic section is given by

   $$9y^2 - x^2 - 36y + 12x - 36 = 0$$

   (i) Express the conic in standard form

   (ii) Identify the conic

   Find its

   (iii) Centre

   (iv) Foci

   (v) vertices

   (vi) eccentricity

   Hence, sketch the conic section.

2. (a) Use the differential dz to approximate the change in $z^2 = 4 - x^2 - y^2$ as (x,y) moves from the point (1,1) to (1.01, 0.97). Compare this approximation with the exact change in z.

   (b) (i) Find the arc length of the curve given by $r(t) = ti + \frac{4}{3}t^{3/2}j + \frac{1}{2}t^2k$ for t = 0 to t = 2.

   (ii) Find the centre of mass of the lamina of uniform density ρ bounded by the graph of $f(x) = 4 - x^2$ and the x-axis.

3. (a) (i) State and prove the MEAN VALUE THEOREM.

(ii) Given that $y = Ae^{2x} + Be^{3x} + \frac{x^2}{6} + \frac{5x}{18} + \frac{19}{108}$. Show that y is a general Solution to the differential equation $\frac{d^2y}{dx^2} - 5\frac{dy}{dx} + 6y = x^2$

(b) (i) Using the substitution $x = 3(1 + \sin t)$. Evaluate $\int_3^{4.5} \frac{1}{(6x - x^2)^{1/2}} dx$

(ii) Evaluate $\lim_{x \to 3} \frac{e^{x-3} + e^{3-x} - 2}{1 - \cos(x-3)}$

4. (a) (i) Find the volume of the Tetrahedron having vertices $p_0 = (-1,2,4)$, $p_1 = (2,-3,4)$, $p_2 = (0,-3,5)$, and $p_3 = (5,-8,9)$

(ii) Find the radius of curvature at p(1,4) on the rectangular hyperbola with Equation xy = 4.

(b) (i) The polar equation of a conic section is given by $r = \frac{15}{3 - 2\cos\vartheta}$

Find its eccentricity and identify the curve

Hence, sketch the curve

(ii) For the function $f(x, y) = xe^{x^2 y}$, show that the second partial derivatives are equal. Hence, evaluate $f_{xy}(1, \ln 3)$

5. (a) Using the method of rotation of axes, Discuss the conic section with equation xy = 1. Hence, sketch the conic section.

(b) (i) Find the volume of the solid formed by revolving the region bounded by the graphs $y = x^2 + 1$, y = 0, x = 0 and x = 1, about the y axis.

(ii) Find the general solution of the ordinary differential equation $y' + xy = xe^{-x^2} y^{-3}$

6. (a) The possible error involved in measuring each dimension of a rectangular box is $\pm 0.1mm$. The dimensions of the box are x = 50cm, y = 20 cm and z = 15cm. Using the differential dV estimate

(i) the propagated error

(ii) the relative error

in the calculated volume V of the box.

(b) (i) Show that a reduction formula for $I_n = \int_0^{\frac{\pi}{2}} \sin^n x dx$, $n \geq 2$ is

$$I_n = \frac{(n-1)}{n} I_{n-2}.$$ Hence, Evaluate $\int_0^{\frac{\pi}{2}} \sin^7 x dx$

(ii) Find the power series of $f(x) = \sin^2 x$.

END of EXAMINATION

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF MATHEMATICS AND STATISTICS
MAT2110 FINAL EXAMINATION
16 SEPTEMBER 2016
TIME: THREE HOURS

PUT YOUR COMPUTER NUMBER ON EACH ANSWER BOOKLET
THERE ARE SEVEN QUESTIONS IN THIS PAPER
ANSWER ANY FIVE QUESTIONS

---

1 (a) Show that the Maclaurin expansion of $\cos x$ is

$$\cos x = 1 - \frac{x^2}{2} + \frac{x^4}{24} - ... = \sum_{n=0}^{\infty}(-1)^n \frac{x^{2n}}{(2n)!}$$

[6marks]

(b) Use the first four terms of the expansion for $\cos x$ to estimate the value of the integral

$$I = \int_1^2 \frac{\cos x}{x} dx$$

[6marks]

(c) Find

$$I = \int \frac{12x^2 + 4x - 8}{x^3 - 4x} dx$$

[8marks]

2 (a) The parametric equations of a certain curve are

$$x = \cos^2 t, \qquad y = \sin t$$

(i) Show that they represent a parabola.. [2marks]
(ii) Obtain the curvature of the parabola when $t = \pi/4$. [4marks]

(b) Solve the differential equation

$$\frac{2x}{y^3}dx + \frac{2y - 3x^2}{y^4}dy = 0$$

[8marks]

(c) A certain lamina in the xy plane consists of the quarter of the ellipse

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

lying in the first quadrant. Using the fact that the area of an ellipse is given by $A = \pi ab$, determine the centroid of the region.. [10marks]

3 **(a)** **(i)** Calculate the area enclosed between the curves $y = x$ and $y^2 = 5x-6$ in the first quadrant. [6marks]

(ii) Determine the angle between the curves at their points of intersection. [6marks]

(b) Find the integral

$$I = \int \frac{dx}{\sin x \cos x}$$

.. [8marks]

4 **(a)** A certain plane contains the vectors $\mathbf{v}_1 = (2, 1, 0)$ and $\mathbf{v}_2 = (1, 1, 1)$ and the origin.

(i) Determine the equation of the plane.. [3marks]

(ii) Determine where the plane intersects the line

$$\frac{x-1}{2} = \frac{y+2}{3} = z$$

.. [4marks]

(b)(i) Show that with the use of the integrating factor

$$\mu(x) = e^{\int p(x)dx}$$

the solution of the linear first-order equation

$$\frac{dy}{dx} + p(x)y = q(x)$$

can be written as

$$y = e^{-\int p(x)dx}\left[\int q(x)e^{\int p(x)dx}dx + C\right]$$

.. [7marks]

(ii) Solve the equation

$$\frac{dy}{dx} + \frac{y}{x} = \cos x$$

if $y(x = \pi/2) = 1$.

[6marks]

5 **(a)** Consider the function

$$y = \frac{\sqrt{x}}{3}(3 - x)$$

in the interval between $x = 0$ and $x = 3$.

(**i**) Determine the average value of the function. [3marks]
(**ii**) Calculate the volume of revolution of the function. [4marks]
(**iii**) Find the area of the surface of revolution. [6marks]

(**b**) Solve the differential equation

$$\frac{d^2y}{dx^2} - 2\frac{dy}{dx} - 3y = \sin x$$

[7marks]

6 (**a**) Find the solution of the differential equation

$$(3y - x\sec\left(\frac{y}{x}\right))dx - 3xdy = 0$$

[6marks]

(**b**) Find the centre of mass of a meter rule which has a density $\lambda(x) = 3x^3$ when it is placed between $x = 0$ and $x = 1$.

[3marks]

(**c**) A lamina in the first quadrant is defined by the coordinate axes and the line $2x + 3y = 1$.

(**i**) Calculate the moments of inertia of the lamina about the coordinate axes. [6marks]

(**ii**) Hence find the moment of inertia of the lamina about an axis perpendicular to the xy plane and passing through the origin. [1mark]

(**d**) Find the sum of the series

$$\sum_{k=0}^{\infty}\left(\frac{\sqrt{3}}{5}\right)^k e^{-2k}$$

and give the answer to two decimal places. [4mark]

7 (**a**) Coordinate systems OXY and $OX'Y'$ are such that the second is rotated an angle α anti-clockwise with respect to the first.

(**i**) Show that the coordinates (x, y) and (x', y') of a point in the respective coordinate systems are related by

$$\begin{aligned} x' &= x\cos\alpha + y\sin\alpha \\ y' &= -x\sin\alpha + y\cos\alpha \end{aligned}$$

[3marks]

(**b**) Under the rotation in (**a**) above, the conic section

$$Ax^2 + Bxy + Cy^2 + Dx + Ey + F = 0$$

transforms to

$$A'x'^2 + B'x'y' + C'y'^2 + D'x' + E'y' + F' = 0$$

where in particular

$$B' = B(\cos^2\alpha - \sin^2\alpha) + 2(C - A)\sin\alpha\cos\alpha$$

Show that the rotation angle which brings the conic section into standard orientation has the tangent

$$\tan\alpha = \frac{C - A}{B} + \sqrt{\left(\frac{C - A}{B}\right)^2 + 1}$$

[4marks]

(**c**) The equation of a certain conic section is

$$5x^2 - 6xy + 5y^2 = 32$$

(**i**) Identify the conic section without transforming the equation. [1mark]

(**ii**) Locate its centre and determine its eccentricity, its focus or foci, its axes of symmetry and its directrix or directrices. [12marks]

END OF EXAMINATION

The University of Zambia

School of Natural Sciences

Department of Mathematics & Statistics

2015/2016 Sessional Examinations - September 2016

MAT3100 - Multivariable Calculus

Time allowed : Three (3) hrs | Full marks : 100

Instructions:

- Attempt **any (5) five** questions. All questions carry equal marks.
- **Full credit** will only be given when **necessary work** is shown.
- Indicate your **computer number** on all answer booklets.
- Calculators are **not allowed** for this examination.

This paper consists of 4 pages of questions. Marks for each part of the question are indicated in square brackets at the end of each question.

---

1. **(a)** **(i)** Discuss the continuity of

$$f(x,y) = \begin{cases} \frac{x^2+\sin^2 y}{2x^2+y^2}, & \text{if } (x,y) \neq (0,0) \\ 0, & \text{if } (x,y) = (0,0) \end{cases}$$

at $(0,0)$.

(ii) Show that the functions

$$\begin{aligned} u &= y+z \\ v &= x+2z^2 \\ w &= x-4yz-2y^2, \end{aligned}$$

are functionally dependent, and show the functional relationship.

Please Turn Over/...

(b) Find the absolute maximum of $f(x, y) = 3x - 5y + 35$ subject to the constraint

$$x^2 + y^2 = 34.$$

(c) Given the curve

$$\mathbf{r}(t) = \left(\frac{2}{t^2+1} - 1\right)\mathbf{i} + \frac{2t}{t^2+1}\mathbf{j}$$

(i) Reparametrise $\mathbf{r}(t)$ with respect to arc length measured from the point $(1, 0)$ in the direction of increasing t and express the reparametrization in the simplest form.

(ii) What do you conclude about the curve?

[9,5,6]

2. (a) (i) Evaluate the integral

$$\int_0^1 \int_{x^2}^1 x^3 \sin(y^3)\,dy\,dx.$$

(ii) Sketch the solid E which lies above the cone $z = \sqrt{x^2 + y^2}$ and below the sphere $x^2 + y^2 + z^2 = 1$.

(iii) Use a tripple integral in cylindrical coordinates to find the volume of the solid E in (ii) above.

(b) (i) Evaluate the triple integral $\int\int\int_E x^2 e^y\,dV$, where E is bounded by the parabolic cylinder $z = 1 - y^2$ and the planes $z = 0$, $x = 1$ and $x = -1$.

(ii) Use inequalities involving spherical coordinates to describe the solid that lies above the cone $z = \sqrt{x^2 + y^2}$ and below the sphere $x^2 + y^2 + z^2 = z$.

(c) Use an appropriate change of variables to evaluate $\int\int_R (x+y)e^{x^2-y^2}\,dA$, where R is the region bounded by the lines

$$x - y = 0, \quad x - y = 2 \quad x + y = 0, \quad x + y = 3.$$

[7,8,5]

Please Turn Over/...

3. a) (i) Evaluate $\int\limits_C (x^2 + y^2 + z^2)ds$, where C is given by the parametric equations

$$x = t, \quad y = \cos 2t, \quad z = \sin 2t, \quad 0 \leq t \leq 2\pi.$$

(ii) Given the position vector $\mathbf{R} = x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$ and $r = |\mathbf{R}| = \sqrt{x^2 + y^2 + z^2}$. Show that $\nabla(r^n) = nr^{n-2}\mathbf{R}$.

(b) (i) State the Divergence theorem.

(ii) Sketch the region E bounded by the parabolic cylinder $z = 1 - x^2$ and the planes $z = 0$, $y = 0$, $y + z = 2$.

(iii) Use the Divergence theorem to calculate the surface integral $\int\int_S \mathbf{F} \cdot d\mathbf{S}$, where $\mathbf{F}(x, y, z) = (xy)\mathbf{i} + (y^2 + e^{xz^2})\mathbf{j} + \sin(xy)\mathbf{k}$ and S is the surface of the solid region E in (ii) above.

c) Given the vector field $\mathbf{F}(x, y) = (xy^2)\mathbf{i} + (x^2y)\mathbf{j}$

(i) Find a function f such that $\mathbf{F} = \nabla f$.

(ii) Evaluate $\int_C \mathbb{F} \cdot d\mathbf{r}$ where $\mathbf{F}(x, y) = (xy^2)\mathbf{i} + (x^2y)\mathbf{j}$ and the curve C is given by the vector function

$$\mathbf{r}(t) = \left(t + \sin\left(\frac{\pi}{2}t\right)\right)\mathbf{i} + \left(t + \cos\left(\frac{\pi}{2}t\right)\right)\mathbf{j}, \quad 0 \leq t \leq 1.$$

[7,7,6]

4. a) (i) Evaluate $\int_C (x^2y^3 - \sqrt{x})dy$, where C is the arc of the curve $y = \sqrt{x}$ from the point $(1, 1)$ to $(4, 2)$.

(ii) Find an equation of the tangent plane to the parametric surface given by the vector function

$$\mathbf{r}(u, v) = (u^2 + 1)\mathbf{i} + (v^3 + 1)\mathbf{i} + (u + v)\mathbf{i}$$

at the point $(5, 2, 3)$.

(b) (i) State Green's theorem in the plane.

(ii) Evaluate $\int_C (1 - y^3)dx + (x^3 + e^{y^2})dy$, where C is the boundary of the region between the circles $x^2 + y^2 = 4$ and $x^2 + y^2 = 9$

Please Turn Over/...

c) (i) If a surface S is given by the equation $z = g(x, y)$, where (x, y) lies in D and f has continuous partial derivatives show that the surface area of S is given by

$$A(S) = \int\int_D \sqrt{\left(\frac{\partial g}{\partial x}\right)^2 + \left(\frac{\partial g}{\partial y}\right)^2 + 1}\, dA.$$

(ii) Evaluate $\int\int_D y\, dS$ where S is the surface

$$z = x + y^2, \quad 0 \leq x \leq 1, \quad 0 \leq y \leq 2.$$

[7,6,7]

5. (a) Find the Fourier series of

$$f(x) = \begin{cases} x, & 0 < x < 1 \\ 1 - x, & 1 < x < 2 \end{cases}.$$

(b) (i) Determine the inverse Fourier transform of $e^{-|\omega|}$.

(ii) Hence, deduce that the Fourier transform of $\frac{1}{1+x^2}$ is $\pi e^{-|\omega|}$

(c) Show that the function $f_n(x) = \begin{cases} nx, & 0 \leq x < \frac{1}{n} \\ 1, & \frac{1}{n} \leq x < 1 \end{cases}$ converges in the mean to $f(x) = 1$

[12,4,4]

6. (a) (i) By definition, find the Laplace transform of $e^{i\omega t}$.

(ii) Hence, deduce that

$$\mathscr{L}\{\cos \omega t\} = \frac{s}{s^2 + \omega^2} \text{ and } \mathscr{L}\{\sin \omega t\} = \frac{\omega}{s^2 + \omega^2}.$$

(b) Find

(i) $F(s)$ if $f(t) = t^2[u(t) - u(t-1)]$, where $u(t-a)$ is a unit step function.

(ii) $f(t)$ if $F(s) = \frac{30s}{s^2+2s+2}$.

(c) By Laplace transform method, solve the initial value problem

$$x'' - 2x' - 24x = 0; \text{ with } x_0 = 1 \text{ and } x_0' = -14.$$

[7,7,6]

END!

The University of Zambia

School of Natural Sciences

Department of Mathematics & Statistics

2015/2016 Sessional Examinations-September 2016

MAT3110 – Engineering Mathematics II

Time allowed: Three (3) Hours | Full Marks: 100

Instructions:

- There are **two (2)** sections in this paper.
- Answer **any four (4)** questions from **section A** and **any one (1)** question from **section B.** All questions carry **equal marks**.
- **Full credit** will only be given when **necessary work** is shown.
- Indicate your **computer number** on all answer booklets.

SECTION A

Answer any four (4) questions from this section.

1. a. Find

   i) $F(s)$ if $f(t) = t^2[u(t) - u(t-1)]$; where $u(t-a)$ is a unit step function.

   ii) $f(t)$ if $F(s) = \frac{1}{s^3(s-1)^2}$.

   b. Solve the following system by Laplace transform method

$$x' + 2x + y = e^{-t}$$

$$y' - x = 0$$

   where $x_0 = y_0 = 0$.

2 a. i) Find the Fourier series of $f(x) = 1 + x^2$; $-1 < x < 1$.

   ii) Hence show that

$$1 - \frac{1}{4} + \frac{1}{9} - \frac{1}{16} + - \cdots = \frac{\pi^2}{12}$$

   b. i) Determine the inverse Fourier transform of $e^{-|w|}$

ii) Hence deduce that the Fourier transform of $\frac{1}{1+x^2}$ is $\sqrt{\frac{\pi}{2}}\, e^{-|w|}$

3 a. i) Evaluate $\int_0^{\sqrt{\frac{\pi}{2}}}\int_x^{\sqrt{\frac{\pi}{2}}}\int_1^3 \sin y^2\, dz dy dx$

ii) Verify the formula for the volume of a ball of radius 1 as $\frac{4}{3}\pi$.

b. Let P be the parallelogram bounded by y = 2x, y = 2x-2, y = x and y = x+ 1

Evaluate $\int_P xy dx dy$.

4 a. i) Find the directional derivative of $f(x, y) = 3x^2 - 2y^2$ at $(-\frac{3}{4},0)$ in the direction from $P(-\frac{3}{4},0)$ to $Q(0,1)$.

ii) Let $F = (xy^3, y + x)$. Integrate $(\nabla XF)\bullet k$ over the region in the first quadrant bounded by the curves $y = x^2$ and y = x

b. Let w be a region bounded by the planes $x = 0$, y = 0 , z = 2 and the surface $z = x^2 + y^2$, $x \geq 0$, $y \geq 0$

i) Sketch the solid w

ii) Compute $\int_w x dx dy dz$

5 a. i) Using cylindrical coordinates, find the mass of the ellipsoid solid Q given by $4x^2 + 4y^2 + z^2 = 16$ lying above the xy-plane. The density at a point in the solid is proportional to the distance between the point and the xy – plane.

ii) Find a potential function for $F(x, y, z) = 2xyi + (x^2 + y^2)j + 2zyk$.

b. Solve the following partial differential equation using Fourier transform method.

$u_{tt} = c^2 u_{xx}$ on $|x| < \infty$, t > 0

$u(x,0) = f(x)$ $u_t(x,0) = g(x)$ on $|x| < \infty$

u remains bounded at infinite $|\to\infty|$ and $t \to \infty$

SECTION B

Answer one (1) question only from this section.

6 a. An ambulance station receives on average one emergency call every hour. If there are three ambulances available and the average time for which an ambulance is out on a call is half an hour. What is the probability that the ambulance station cannot cover the emergency calls?

b. A certain brand of light bulbs has a life time which is normally distributed with mean 1500hrs and standard deviation of 50 hrs. What should the guarantee lifetime of the bulbs be so that only 5% of the bulbs will be replaced under guarantee?

7. a. In a manufacturing process, it is known that approximately 10% of the items produced are defectives. A quality control scheme is set up, by selecting twenty items out of a large batch, and rejecting the whole batch if three or more are defective.

(i) Find the probability that the batch is rejected

(ii) What is the expected number of defective items?

b. The diameter of washers produced by machine has a standard deviation of 0.1mm. What should the mean diameter be if there is to be a probability of only 3% that the diameter exceeds 2.0mm?

END OF EXAMINATION

The University of Zambia

Department of Mathematics & Statistics

2015 Academic Year Final Examinations

MAT3300 - Real Analysis

Time allowed : **Three (3) hours** Full marks : 100

Instructions:
- Attempt **any five (5)** questions. **All** questions carry **equal** marks.
- Indicate your **computer number** on all answer booklets used.
- No help materials allowed.

This paper consists of 3 pages of questions.

---

1. (a) Define the following:

    i. An interior point of a set.

    ii. An accumulation point of a set.

   (b) State and prove the Heine-Borel theorem.

   (c) Show that the open interval is not compact.

   (d) Find the interior points, isolated points, boundary points and accumulation points for the set

$$A = \left\{ \frac{1}{n} : n \in \mathbb{Z} \right\}.$$

2. (a) Define the following terms:

    i. A compact subset of $\mathbb{R}$.

    ii. A connected subset of $\mathbb{R}$.

   (b) i. Prove the intermediate value theorem.

    ii. Prove the fixed point theorem.

   (c) Dertemine whether the set $A = \{x : |2x - 1| + |x + 2| < 3\}$ is connected.

   (d) If f is a continuous function on $\mathbb{R}$ and A is a compact subset of $\mathbb{R}$, show that $f(A)$ is compact.

3. (a) i. State carefully the $\varepsilon - \delta$ definition that a function f is continuous at $c \in \mathbb{R}$.

ii. Prove that if f is continuous at $c \in \mathbb{R}$ and $f(c) \neq 0$, then $\exists \delta > 0$ such that $\forall x \in \mathbb{R}$,

$$|x - c| < \delta \implies |f(x)| > \frac{|f(c)|}{2}.$$

iii. Define the function $f : \mathbb{R} \to \mathbb{R}$ by

$$f(x) = \begin{cases} 1 & \text{if } x \text{ is rational,} \\ 0 & \text{if } x \text{ is irrational.} \end{cases}$$

Use the $\varepsilon - \delta$ definition to show that f is not continuous at $c \notin \mathbb{Q}$

(b) Let $f(x+)$ and $f(x-)$ respectively denote the right-hand and the left-hand limits of a function f at x. Suppose $f : (a, b) \to \mathbb{R}$ is a monotonically increasing function. Then $f(x+)$ and $f(x-)$ exist at every $x \in (a, b)$. Prove that

$$\sup_{a<t<x} f(t) = f(x-) \leq f(x) \leq f(x+) = \inf_{x<t<b} f(t),$$

and that if $a < x < y < b$, then $f(x+) \leq f(y-)$.

(c) If A is a nonempty subset of a set X, define the shortest distance from $x \in X$ to A by

$$d_A(x) = \inf_{z \in A} |x - z|$$

i. Prove that $d_A(x) = 0$ if and only if $x \in \bar{A}$, where bar denotes closure.

ii. Prove that d_A is uniformly continuous.

(d) Let $[x]$ denote the largest integer contained in x. Sketch the graph of the function

$$f(x) = x - [x] - \frac{1}{4}, \quad x \in \mathbb{R},$$

and indicate the discontinuities.

4. (a) i. State the interior minimum theorem.

ii. Assume that a real function f is differentiable on $[a, b]$ and $f'(a) < \lambda < f'(b)$. Prove that there exists $x \in (a, b)$ such that $f'(x) = \lambda$.

(b) Suppose a real function g on $\mathbb{R}$ has a bounded derivative. Fix $\varepsilon > 0$, and define

$$f(x) = x + \varepsilon g(x).$$

Use the mean value theorem to prove that f is one-to-one if ε is small enough.

(c) Suppose f' is continuous on $[a, b]$ and $\varepsilon > 0$. Prove that there exists $\delta > 0$ such that

$$\left| \frac{f(y) - f(x)}{y - x} - f'(x) \right| < \varepsilon$$

whenever $0 < |y - x| < \delta$, $a \leq x \leq b$ and $a \leq y \leq b$.

(d) Suppose that $f : \mathbb{R} \to \mathbb{R}$ is a C^2-function that satisfies $f \geq 0$ and $f'' \leq 0$ everywhere. Use Taylor's theorem to show that f is a constant function.

5. (a) Let $f : [a, b] \to \mathbb{R}$ be a bounded function. Define what is meant by
   i. P is a partition of $[a, b]$,
   ii. the upper and lower sums, $U(P, f)$ and $L(P, f)$ respectively,
   iii. the upper and lower integrals, $\overline{\int_a^b} f$ and $\underline{\int_a^b} f$ respectively,
   iv. f is Riemann integrable over $[a, b]$.

   (b) State and prove the Riemann-Stieltjes integrability criterion theorem.

   (c) Suppose $f : [0, 1] \to \mathbb{R}$ is a bounded function with upper and lower integrals

$$\overline{\int_0^1} f = 1 \quad \text{and} \quad \underline{\int_0^1} f = 0$$

   respectively. Prove that for every $\varepsilon > 0$ there exists a partition P of $[0, 1]$ such that the difference between the upper and lower sums of f on P satisfies

$$1 \leq U(P, f) - L(P, f) < 1 + \varepsilon.$$

   (d) i. Suppose f is continuous and nonnegative on $[0, 1]$, $0 \leq x_o \leq 1$, and $f(x_o) > 0$. Prove that f is integrable on $[0, 1]$, and that $\int_0^1 f\, dx > 0$.
   ii. Construct a nonnegative function f on $[0, 1]$ with $f(\frac{2}{7}) > 0$ but $\int_0^1 f\, dx = 0$.

6. (a) State the First Mean Value Theorem for integrals.

   (b) Suppose f is a real, continuously differentiable function on $[a, b]$, $f(a) = f(b) = 0$, and $\int_a^b f^2(x)\, dx = 1$. Prove that

$$\int_a^b x f(x) f'(x)\, dx < 0, \quad \text{and that} \quad \int_a^b [f'(x)]^2\, dx \cdot \int_a^b x^2 f^2(x)\, dx > 0.$$

   (c) Use the Schwarz inequality to find the values of the parameter λ for which

$$\lim_{\varepsilon \to 0+} \frac{1}{\varepsilon^\lambda} \int_0^\varepsilon f\, dx = 0$$

   for all $f \in L^2[0, 1]$.

   Hint: A function f is in $L^2[0, 1]$ if it satifies $\int_0^1 |f|^2\, dx < \infty$.

   (d) In the closed interval $[0, 1]$, a function f is defined as follows: $f(0) = 0$, $f(1) = 1$ and $f(m/n) = 1/n^3$, where m and n are positive integers such that $(m, n) = 1$. Furthermore, for irrational x, we define $f(x) = 0$. Show that f is of bounded variation.

   Hint: You may assume that $\sum_{n=1}^{\infty} 1/n^2 = \pi^2/6$.

END OF PAPER

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF MATHEMATICS & STATISTICS

2015 ACADEMIC YEAR FINAL EXAMINATIONS

MAT3902 : PROBABILITY THEORY

TIME ALLOWED : Three (3) hours

INSTRUCTIONS : Answer any **four** (4) questions. Full credit will only be given when all necessary working is shown.

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1. (a) (i) Let X and Y be independent binomial random variables with parameters (n, p) and (m, p), respectively. Find the probability distribution for X+Y.

(ii) Suppose n balls are selected at random from an urn which has N balls of which m are red. Let X denote the number of red balls selected, then X has a hypergeometric distribution. Derive the expected number of red balls selected i.e. E(X).

(b) Let $X_1, X_2, \ldots, X_n$ be a random sample from an exponential distribution with mean λ, i.e.

$$f_X(x,\lambda) = \frac{1}{\lambda}e^{-\frac{x}{\lambda}}\ ,\ x > 0\ ,\ \lambda > 0$$

Define $Y_j = \sum_{i=1}^{j} X_i\ ,\ j = 1, 2, \ldots, n$, find the following

(i) Joint probability function for $Y_1, Y_2, \ldots, Y_n$

(ii) Marginal probability function of Y_n.

(c) (i) State Jensen's inequality

(ii) Prove Jensen's inequality.

2. (a) Let $\{X_K\}$ be a sequence of independent and identically distributed random variables and let N be a non-negative integer valued random variable that is independent of the sequence $\{X_K\}$. Define $Y = \sum_{i=1}^{N} X_i$, derive the following:

(i) $E(e^{ty})$ i.e. moment generating function of Y

(ii) E(Y)

(iii) Var(Y)

(b) Let X be a random variable whose conditional distribution given that Y=P is binomial with parameters n and P. If Y has a uniform distribution over the interval (0,1). Find the following:

(i) Probability distribution of X

(ii) E(X)

(iii) Var(X)

(c) (i) State the weak law of large – numbers theorem

(ii) Prove the weak law of large – numbers theorem

3. (a) Let $X_1, X_2, \ldots, X_n$ be a random sample from a distribution with probability density function (pdf) $f_X(x, \lambda) = 2\lambda x e^{-\lambda x^2}$, $x > 0$, $\lambda > 0$
Find the following:

(i) pdf for $X_{(1)}$ and that of $X_{(n)}$

(ii) joint pdf of $X_{(1)}$ and $X_{(n)}$

(b) Suppose independent trials each resulting in a success with probability P are performed. Let X be the time of the first success. Derive the following:

(i) E(X)

(ii) Var(X)

(c) (i) Define a Poisson Process with rate λ.

(ii) Prove that for a Poisson Process with rate λ

$$P\{N(t) = 0\} = e^{-\lambda t}$$

where N(t) is the number of events that occur in a time interval [0, t].

4. (a) Define the following:

   (i) Recurrent state

   (ii) Transient state

   (iii) Martingale.

   (b) (i) State the Chapman – Kolmogrov equations

   (ii) Prove the Chapman – Kolmogrov equations

   (iii) Prove that if a Poisson Process has rate λ, then random variable $N(t)$ (the number of events that occur in time interval $(0, t)$) has a Poisson distribution with mean λt.

   (c) (i) State the central limit theorem

   (ii) Prove the central limit theorem

5. (a) Define the following:

   (i) A Markov Chain

   (ii) Transition function of a Markov Chain

   (iii) Hitting time T_j of state j.

   (b) Consider a gambler who at each play of the game either wins two (2) units with probability P or loses one (1) unit with probability $1 - P$. If we suppose that the gambler will stop playing when his fortune hits either 0 or m, then the gambler's sequence of fortunes is a Markov chain. Write down the transition probabilities.

   (c) (i) State the strong law of large numbers theorem

   (ii) Prove the strong law of large numbers theorem.

---*END OF EXAMINATION*-------------------------------------

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF MATHEMATICS & STATISTICS

END OF 2015/2016 ACADEMIC YEAR EXAMINATIONS

12^{th}SEPTEMBER 2016

MAT4100 - THEORY OF FUNCTIONS OF A COMPLEX VARIABLE

INSTRUCTIONS:

1. This exam paper consists of a total of four pages. The cover page and three pages of questions.
2. There are **six (6)** questions in this paper.
3. Answer any **five (5)** questions.
4. All questions carry equal marks.

TIME ALLOWED: **Three (3)** hours

[TURN OVER]

1. (a) (i) Let $z = x + iy$. By considering $\sin z$, prove that $|\sinh y| \leq |\sin z| \leq \cosh y$. [3]

(ii) Shade the domain of the region defined by $|z - 1 - i| < 1$, where $0 \leq \arg z \leq \frac{\pi}{4}$. [4]

(b) (i) Find the values and principle value for $z = (-i)^{-2i}$. [3]

(ii) Prove that for every complex number z, $-\text{Im } z = \text{Re } iz$. [3]

(c) (i) Solve the equation $z^6 + 1 = \sqrt{3}i$. [4]

(ii) Find all values of $\cosh^{-1} \dfrac{\sqrt{3}}{2}i$. [3]

2. (a) (i) Define an entire function. [2]

(ii) State (without proof) the Cauchy-Riemann equations in polar form. [2]

(b) (i) Discuss the differentiability of the function $f(z) = \dfrac{|z|^2}{z}$ at the point $z = 0$. [4]

(ii) Let $f(z)$ be analytic. Prove that

$$\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right) |f(z)|^2 = 4|f'(z)|^2$$

[6]

(c) (i) Evaluate the integral $\displaystyle\int_0^{2\pi} \frac{1}{2 + \cos^2 x}\, dx$. [6]

[TURN OVER]

3. (a) (i) Define the radius of convergence R of a power series $\sum_{n=0}^{\infty} a_n(z-z_0)^n$ of complex numbers about a point $z_0 \in \mathbb{C}$. [2]

(ii) Determine whether or not the following series converges.

$$\sum_{n=1}^{\infty} \frac{(i)^n}{n}$$

[4]

(b) Consider the series $\sum_{n=0}^{\infty} \frac{(z-i)^n}{4^n}$.

(i) Find the radius of convergence of the series and hence, [4]

(ii) Find the region of convergence for the series. [2]

(c) (i) Show that the Maclaurin series for $\sin z$ is

$\sum_{n=0}^{\infty} \frac{(-1)^n z^{2n+1}}{(2n+1)!}$ [4]

(ii) Given that $\frac{1}{1-z} = \sum_{n=0}^{\infty} z^n$.

Show that $\frac{1}{(1-z)^2} = \sum_{n=0}^{\infty} (n+1)z^n$, for $|z| < 1$. [4]

4. (a) Expand $f(z) = \frac{1}{z(1-2z)}$ in a Laurent series valid for each of the following regions.

(i) $|z| < \frac{1}{2}$. [3]

(ii) $|z - \frac{1}{2}| < 1$. [3]

(b) (i) Define a singular point z_0 for a function $f(z)$. [2]

(ii) When is an isolated singularity said to be essential? [2]

(c) Suppose $f(z)$ has a simple pole at z_0, prove that

$$\text{Res}[f(z), z_0] = \lim_{z \to z_0} (z - z_0) f(z).$$

[4]

(d) Identify and describe the nature of the singularities for each of the following functions

(i) $g(z) = \frac{z^2}{1+z}$. [3]

(ii) $f(z) = \frac{1}{\sin \frac{\pi}{z}}$. [3]

[TURN OVER]

5. (a) (i) Find the region onto which the half plane $y > 0$ is mapped by the transformation $w = (1+i)z$. [4]

(ii) Find a linear fractional transformation (LFT) that maps the points $z = 0, -i, -1$ onto $w = i, 1, 0$. [4]

(b) Show by direct calculation that if $\alpha = T(z)$ and $\beta = S(\alpha)$ are linear fractional transformations, then the composite $\gamma = S[T(z)]$ is also a linear fractional transformation. [6]

(c) Consider the linear fractional transformation $w = \dfrac{1-z}{1+iz}$. Find the the fixed points for $f(z)$. [6]

6. (a) State Jordans Lemma. [2]

(b) State and prove the Jordan's inequality. [5]

(c) (i) State (without proof) the Cauchy inequalities theorem. [3]

(ii) Verify the cauchy inequalities for $f(z) = \dfrac{1}{z+1}$ and z lies on the circle $|z-4| = 3$. [6]

(d) By evaluating the integral $\displaystyle\int_C \frac{1}{(z^2+1)^2}dz$ where C is the limit of the contour Γ_R as $R \longrightarrow \infty$ where Γ_R is a semi-circle of radius R, center 0 in the upper half of the $\mathbb{C}$ plane, show that $\displaystyle\int_{-\infty}^{\infty} \frac{1}{(x^2+1)^2}dx = \frac{\pi}{2}$. . [4]

■ END OF EXAMINATION ■

The University of Zambia

School of Natural Sciences

Department of Mathematics & Statistics

2015 Academic Year, Final Examinations

MAT 4212 - Module and Field Theory

Time allowed : Three (3) Hours　　　　Full marks : 100

Instructions:

1. There are **six (6)** questions in this paper.
2. Attempt any five (5) questions.
3. All questions carry equal marks.
4. **Full credit** will only be given when **necessary work** is shown.
5. Indicate your **computer number** on each answer booklets you have used.

This paper consists of 4 pages of questions.

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1 Section A - MODULE THEORY

1. **(a)** Let R be a commutative ring with unity (1), define the following:

   (i) a R- module homomorphism.

   (ii) the direct product of R-modules $M_1, M_2, \cdots, M_k$

   (b) (i) Let $N_1, N_2, \cdots N_k$ be submodules of the R- module M. Suppose that

$$\pi : N_1 \times N_2 \times \cdots \times N_k \longrightarrow \sum_{i=1}^{k} N_i$$

defined $\pi(a_1, \cdots, a_k) = \sum_{i=1}^{k} a_i$ is an isomorphism, show that

$$N_j \cap (N_i + \cdots + N_{j-1} + N_{j+1} + \cdots + N_k) = \{0\}$$

(ii) State and prove the first isomorphism theorem for modules.

(c) (i) Let M be an R-free module of rank n and let $f : M \longrightarrow R^n$ be defined by $f(\sum_{i=1}^{n} r_i x_i) = \sum_{i=1}^{n} r_i e_i$ where $R^n = \langle e_i : 1 \leq i \leq n \rangle$. Show that f is an R- module homomorphism.

(ii) Let $R = \mathbb{Z}$ and A be any additive abelian group.For any $n \in \mathbb{Z}$ and $x \in A$, define $nx = \begin{cases} x + x + \cdots + x(\text{n times}) & ; n > 0 \\ 0 & n = 0 \\ -x - x - \cdots - x(\text{-n times}) & ; n < 0. \end{cases}$
Show that A is a $\mathbb{Z}$ - module.

2. **(a)** Define the following:

(i) a torsion element of an R-module.

(ii) a free R- module M.

(b) **(i)** Let D be an integral domain and let M be a D-module. Prove that the torsion module, $Tor(M)$ is a submodule of M.

(ii) Let M be the module $R^n = \oplus_{i=1}^{n} R$ for a ring R. Prove that

$$A = \{(x_1, ..., x_n) | x_i \in R \quad \text{and} \quad x_1 + x_2 + \cdots + x_n = 0\}$$

is a submodule of M.

(c) **(i)** Let $\mathbb{Q}$ be a $\mathbb{Z}$-module. Show that $\mathbb{Q}$ is not a free $\mathbb{Z}$-module.

(ii) Let $R = \mathbb{Z}/6\mathbb{Z}$. Consider R as a module over itself and label it M. Show that $Tor(M)$ is not a submodule.

3. **(a)** **(i)** State the structure theorem for finitely generated modules over Principal Ideal Domains.

(ii) Define the p-primary component of an R- module M for some prime p.

(b) (i) Let M be a finitely generated torsion R-module over a principle Ideal domain. Show that M_p is zero for all but a finite number of primes say $p_1, p_2, ..., p_h$ and $M = M_{p1} \oplus M_{p2} \oplus \cdots \oplus M_{ph}$.

(ii) Prove that the p-primary component is a submodule.

(c) **(i)** Let R be a principle Ideal domain.Prove that if $M = R_x$ where $ann(x) = \langle d \rangle$ and $d = gh$ with $(g, h) = 1$, then $M = R_y \oplus R_z$ with $ann(y) = g$ and $ann(z) = h$.

(ii) Let G be a finite abelian group of order 80. By applying the structure theorem in $a, (i)$ find all the primary cyclic decomposition of G up to isomorphism.

2 Section B - FIELD AND GALOIS THEORY

4. **(a)** What is the meaning of each of the following:

(i) Galois group of a polynomial $f(x)$,

(ii) the splitting field of a polynomial $f(x)$ over a field $\mathbb{E}$.

(b) (i) Prove that any non-constant polynomial $f(x) \in \mathbb{E}[x]$ of positive degree has a splitting field.

(ii) Prove that if $\mathbb{E}$ is of characteristic zero, and $\mathbb{F}$ is the splitting field for the polynomial $x^p - 1 \in \mathbb{E}[x]$, where p is a prime, then the Galois group $G(\mathbb{F} : \mathbb{E})$ is abelian.

(c) (i) Find the Galois group of the field extension $\mathbb{Q}(\sqrt{2}, \sqrt{3})$.

(ii) Find the splitting field for $f(x) = x^3 - 1$.

5. **(a)** Define the following:

(i) a separable polynomial $f(x)$,

(ii) a simple extension of a field $\mathbb{E}$.

(b) **(i)** Show that if $\mathbb{F}$ is a splitting field over a field $\mathbb{E}$ of a separable polynomial $f(x)$ then $\mathbb{E} = Fix(G)$ for some finite group G of automorphsms of $\mathbb{F}$.

(ii) Let $f(x)$ be a monic polynomial of positive degree in $\mathbb{E}[x]$. Show that all the roots of $f(x)$ in any splitting field $\mathbb{F}$ of $f(x)$ are simple if and only if $f(x)$ and $f'(x)$ are relatively prime $((f(x), f'(x)) = 1)$.

(c) (i) Show that the subfield $\mathbb{Q}(\sqrt{2}, \sqrt{3})$ is a simple extension that coincides with the visibly extension $\mathbb{Q}(\sqrt{2} + \sqrt{3})$.

(ii) Let $A(\mathbb{C})$ be the set of all elements in $\mathbb{C}$ that are algebraic over $\mathbb{Q}$. Prove that $A(\mathbb{C})$ is a subfield of $\mathbb{C}$.

6. **(a)** What is the meaning of the following terms:

   (i) normal basis for a field extension,

   (ii) a polynomial f is solvable by radical.

   (b) (i) Let $\mathbb{F}$ be a finite Galois extension of $\mathbb{E}$. Show that if $G(\mathbb{F} : \mathbb{E})$ is cyclic, then $\mathbb{F}$ has a normal basis.

   (ii) Prove that if $\mathbb{K}$ contain n^{th} root of 1 then the Galois group for $x^n - a$ over $\mathbb{K}$ is cyclic whose order divides n.

   (c) Show that the polynomial $f(x) = 3x^4 + 12x^3 + 15x - 9 \in \mathbb{Q}$ is solvable by radical.

END OF EXAM!

THE UNIVERSITY OF ZAMBIA

2015/2016 ACADEMIC YEAR FINAL EXAMINATIONS

MSE 3060: CHEMISTRY TEACHING METHODS

Time: Three (3) Hours **Marks: 100**

INFORMATION

1. The question paper has **six** questions
2. Each question carries a maximum of **twenty** marks
3. Mark allocation is shown in brackets[ ]

INSTRUCTIONS

- Answer question **one**
- And any other **four** questions

Question 1

a. What is the coefficient of BiO_3^- (s) when the reaction below is balanced with smallest whole number coefficients? [04]

$$\_Mn^{2+} + \_BiO_3^- + \_H^+ \longrightarrow \_MnO_4^- + \_Bi^{3+} + \_H_2O$$

b. Design a classroom activity or demonstration that will make this topic to be taught interactively? [06]

c. Creativity is a unique human quality and the essence of *Higher Order Thinking.* In the Blooms Taxonomy Higher Order Thinking is associated with cognitive processes such as creating evaluating and analyzing.

Review the relevance to chemistry teaching, of any five stages involved in the creative process as described in the Integrated Eight-stage Framework developed by Sawyer (2012). [10]

Question 2

Teachers of chemistry are expected to use various types of teaching aids during lessons.

a. Explain what a teaching aid is. [02]
b. Discuss the value of using teaching aids during chemistry lessons. [10]
c. Identify three challenges of using teaching aids during chemistry lessons and explain how you can minimize each one of them. [06]
d. Describe two ways you can use teaching aids in the community for teaching chemistry. [02]

Question 3

A teacher of chemistry can apply the social constructivist theory of learning in a number of topics in the secondary school certificate syllabus.

a. Identify one suitable chemistry topic that can be taught by a teacher of chemistry who embraces the Social Constructivist theory [02]

b. In reference to the topic identified in (a) explain how each of the following are viewed from the Social Constructivist perspective:
   - (i) Knowledge, [04]
   - (ii) Learning, [04]
   - (iii) Motivation. [04]

c. Describe the implications for teaching the topic identified in (a) from the Social Constructivist's perspective. [06]

Question 4

a. In each of the following, explain the type of assessment being done.
   - (i) Giving an end of year chemistry theory examination to learners in your secondary school. [02]
   - (ii) Administering a chemistry test to grade 10 pupils on stoichiometry and the mole concept in week 2 of the first term. [02]
   - (iii) Asking learners three questions about alkenes as a way of summarizing the work done on a particular day. [02]

b.
   - (i) Construct a multiple choice question on esters. [02]
   - (ii) Explain four guidelines you considered when constructing the question above. [08]
   - (iii) Explain four ways in which lesson planning by a teacher of chemistry can indirectly help pupils to master the concepts being taught before any assessment is done. [04]

Question 5

a. Define the following and give appropriate examples.
   - i. Products of science [04]
   - ii. Processes of science [04]
   - iii. Ethics of science [04]

b. Innovation and creativity in science is best achieved through the teaching of Science Process Skills. Explain. [08]

Question 6

A chemistry syllabus is a vital document in the facilitation of effective chemistry teaching.

a. What do you understand by the term syllabus? [02]

b. Outline any four essential components that should be in a comprehensive chemistry syllabus. [04]

c. The following is an extract from the revised Zambian chemistry syllabus.

(i) Assign the missing headings as appropriate by filling in the gaps shown by dots in columns c(i)u, c(i)v, c(i)w, c(i)x, c(i)y, and c(i)z.

c(i)u	c(i)v	c(i)w	CONTENT		
			c(i)x	c(i)y	c(i)z ....
10.2 THE PARTICULATE NATURE OF MATTER	10.2.1 Matter and the Kinetic theory	10.2.1.1 Describe matter 10.2.1.2 Classify the basic units of matter 10.2.1.3 Classify the states of matter	• Anything that has **mass** and occupies space • Atoms, molecules, ions • The 3 states and the kinetic theory: in terms of particle arrangement and movement in solid, liquid and gas	**Classifying** the basic units and states of matter	**Appreciating** the basic units of matter and its existence in three states

[06]

(ii) Write two possible objectives for this topic and two sources of teaching materials. [04]

(iii) What rationale can you give for including this topic in the chemistry syllabus? [04]

End of Examination

THE UNIVERSITY OF ZAMBIA

2015/2016 ACADEMIC YEAR FINAL EXAMINATION

MSE 9040 ADVANCED BIOLOGY TEACHING METHODS

TIME THREE (3) HOURS **MARKS: 100**

Information

1. There are six (**6**) questions in this paper
2. Each question has **20** possible maximum marks

Instructions

1. Answer questions one (**1**) and
2. Any other four (**4**) questions

---

1. Teachers of Biology are encouraged to practice Reflective Teaching.

   a. What is Reflective Teaching? [2]

   b. Why is reflective teaching important? [3]

   c. Discuss how you would go about to implement Reflective Teaching during your Biology Teaching. [10]

   d. Identify two challenges you may encounter when implementing Reflective Teaching and explain how you can minimise each of these challenges. [5]

2. Upon completion of your studies at the University of Zambia, you are appointed to Head a Science Department at a New Secondary School. Discuss how you would go about to achieve the following:

   a. An effective communication system for communication of information within and outside the department, [7]

   b. An assessment system which ensures that teachers use assessment as part of the teaching learning process in order to promote a high standard of achievement, [7]

   c. Manage teachers in such a manner which encourage them to commit themselves to their work. [6]

3. There are a number of challenges teachers of Biology experience while teaching. For example poor participation of female pupils during lessons and lack of interest among pupils to learn Biology.

   a. Why is it important for a teacher of Biology to pay particular attention to challenges given above? [2]

   b. Discuss how you as a teacher of Biology can enhance:

      (i) Participation of female pupils during Biology lessons, [9]

      (ii) Interest of Pupils during Biology lessons. [9]

4. Resistance to change is quite common among our teachers in Zambian Schools.

   a. Describe with examples 10 typical reasons teachers advance in resisting change in their status in schools. [10]

   b. Resistance to change follows general patterns. Outline 5 patterns with examples of how people resist change. [10]

5. The Head of Biology Department is responsible for the delivery, teaching and learning of Biology at Grade 10 – 12 level of our secondary schools.

   a. Discuss briefly 10 priorities for the Head of Biology Department in any Secondary School in Zambia. [10]

   b. Discuss specific tools you would use in setting Biology exam questions for school certificate exams in Zambia. [5]

   c. Explain the three types of assessment applied in most Zambian Schools. [5]

6. The Co-business of the Science Standards Officers is to ensure that quality learning and teaching come first in all Education Institutions. However, this does not only refer to subject content, methodology and instructional materials but also to quality in the management of human material and financial resources.

   In order to achieve this, discuss at least 10 professional roles the Science Standards Officers are expected to follow in carrying out their co-business.
   [20]

END OF EXAMINATION

The University of Zambia
Department of Physics
University Examinations 2015-16
PHY1010: Introductory Physics

All questions carry equal marks. The marks are shown in brackets. Question 1 is compulsory. Attempt only four more questions. Clearly indicate the questions you have answered on the answer script cover page on the left column.

Time: Three hours. **Maximum marks = 100.**

Write clearly only your computer number on the answer book as well as on the answer sheet for Question 1. Tie them together. Show your working clearly. Omission of essential work will lead to loss of marks.

==

Wherever necessary use:

$g = 9.8$ m/s^2	1 metric ton = 1000 kg
$P_{atm} = 1.013 \times 10^5$ N/m^2	1 h.p. = 746 watts
1 cal. = 4.184 J	1 ton = 1000 kg
$c_{water} = 4184$ J/kg.°C = 1.0 cal/g.°C	1 litre = 1×10^{-3} m^3
$c_{ice} = 2100$ J/kg.°C = 0.5 cal/g.°C	$\rho_{water} = 1000$ kg/m^3
$R = 8.314$ J/mol.K	$M = 4$ for helium
1 pascal = 1 N/m^2	$G = 6.67 \times 10^{-11}$ Nm^2/kg^2
$c = 3 \times 10^8$ m/s	$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/Nm^2
$h = 6.63 \times 10^{-34}$ J-s	$\mu_0 = 4\pi \times 10^{-7}$ N/A^2
$k = 9 \times 10^9$ Nm^2/C^2	$m_e = 9.11 \times 10^{-31}$ kg
1eV = 1.6×10^{-19} J	$e = 1.6 \times 10^{-19}$ C

$k = 1.381 \times 10^{-23}$ J/K (Bolzmann's constant)

$c_{steam} = 1920$ J/kg.°C = 0.46 cal/g.°C (at 100^{0}C, constant volume)

Question 1: For <u>each</u> correct answer, 2 marks will be given. For <u>each</u> wrong answer, 0.67 will be deducted. For no answer, zero mark will be given. The minimum total mark for Question 1 is zero.

(A) A vector **A** lies in a plane and has the components A_x and A_y. The magnitude of A_x is equal to:

(a) $\sqrt{A^2 - A_y^2}$ (b) $A - A_y$ (c) $\sqrt{A} - \sqrt{A_y}$ (d) $\sqrt{A - A_y}$

(B) A ball is thrown vertically upwards in air. If air resistance can be neglected, then the acceleration of the ball at the highest point is

(a) $>g$ (b) g (c) $< 2g$ (d) zero

(C) An object that has momentum must also have:

(a) impulse (b) acceleration (c) potential energy (d) kinetic energy.

(D) The moment of inertia of an object does not depend on:

(a) its mass
(b) its size and shape
(c) its angular speed
(d) the location of the axis of rotation.

(E) The center of gravity of an object:

(a) is sometimes arbitrary
(b) may even be outside the object
(c) is always at its geometrical centre
(d) is always in the interior of the object.

(F) A cake of soap placed in a bathtub of water sinks. The buoyant force on the soap is:

(a) equal to its weight
(b) more than its weight
(c) zero
(d) less than its weight

(G) At normal temperature and pressure water boils at 100 ^{0}C. At the bottom of a deep mine, water will boil at a temperature of:

(a) 100 ^{0}C (b) greater than 100 ^{0}C
(c) less than 100 ^{0}C (d) will not boil at all.

(H) The internal energy of a mole of an ideal gas depends upon:

(a) The pressure alone.
(b) The volume of the gas.
(c) The absolute temperature alone.
(d) Both the temperature and pressure.

(I) When a 1 kg mass is suspended from a spring, the spring stretches by 50 mm. The force constant of the spring is: $f = -kx$

(a) 49 N/m (b) 196 N/m (c) 1.96 N/m (d) 0.20 N/m. $9.8 = -k$

(J) The quality of a sound depends upon the:

(a) wavelength
(b) frequency
(c) amplitude
(d) overtones.

Attempt any four (4) questions from the following:

Q.2(a) A man pushing a mop on the floor causes the mop to undergo two displacements. The first displacement has a magnitude of 150 cm and makes an angle of 120° with the positive x-axis. The resultant displacement has a magnitude of 140 cm and is directed at an angle of 35° to the positive x-axis.
Find the magnitude and direction of the second displacement. [9]

(b) If the decibel level of a certain sound is increased by a *factor* of 6, its intensity increases fivefold. What is the original intensity of the sound? [5]

(c) Two guitar strings are tuned to the same frequency of 294 Hz. The tension in one string is then decreased by 2%.
What will be the beat frequency when the two strings are played together? [6]

Q3(a) A girl throws a ball vertically upward at 10 m/s from the roof of a building 20 m high.

(i) How long will it take the ball to reach the ground?
(ii) What will its velocity be just before it strikes the ground? [8]

(b) A piano string fixed at both ends is 1.10 m long and has a mass of 9.0 g.

(i) How much tension must the string be under if it is to vibrate at a fundamental frequency of 131 Hz?

(ii) What are the frequencies of the second and third harmonics? [6]

(c) A brass bar of length 1 m and cross sectional area 2 cm^2 is cooled by ice at one end and heated by boiling water at the other end for a period of 10 minutes.
How much ice will melt in this period?
Given k_{brass} = 0.2 cal/cm.s.^{0}C, and H_f (ice) = 80 cal/g. [6]

Q4(a) A skier starts from rest and slides 50 m down a slope that makes an angle of 40^0 with the horizontal. She then continues sliding on level snow.

(i) If the coefficient of kinetic friction between skis and snow is 0.10 and air resistance is neglected, what is the speed of the skier at the foot of the slope?

(ii) How far away from the foot of the slope does she come to a stop? [10]

(b) An ideal gas of volume 1 litre at a pressure of eight atmospheres undergoes an adiabatic expansion until the pressure drops to 1 atmosphere.
Calculate (i) the final volume and (ii) the work done in joules during the expansion.
Given γ =1.40 [10]

Q5(a) A ski jumper slides down a 37^0 slope for 20 m before taking off from a negligibly short horizontal take-off. If the speed at take-off is 15 m/s, find the coefficient of kinetic friction on the slide. Use the principle of conservation of energy. [10]

(b) Consider the following two-step process. Heat is allowed to flow out of an ideal gas at constant volume so that its pressure drops from 2.2 atm to 1.4 atm. Then the gas expands at constant pressure, from a volume of 6.8 litres to 9.3 litres, where the temperature reaches its original value. [10]

Calculate

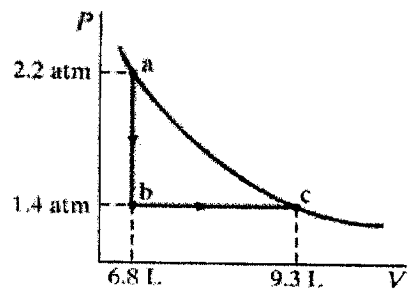
(i) the total work done by the gas in the process,

(ii) the change in internal energy of the gas in the process, and

(iii) the total flow of heat into or out of the gas.

atm L

$\frac{N}{m^2}$ m^3

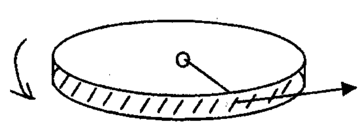


Q6(a) A billiard ball B at rest is struck by an identical billiard ball A moving with speed 20.0 m/s along the positive x-axis. After the collision, the two balls move off in directions that are perpendicular to each other, with ball A making 30^0 with the positive x-axis.
Find the final velocities (direction and magnitude) of both balls. [11]

(b) A 20 g lead bullet (at 50 ^{0}C) travelling at 400 m/s strikes a large block of ice at 0 ^{0}C and stops inside it. If all the energy lost by the bullet goes into melting the ice, how much ice melts? [specific heat capacity c for lead = 0.13 kJ/kg.^{0}C, heat of fusion of ice = 335 kJ/kg]

[9]

Q7(a) A merry-go-round has a mass of 100 kg and a radius of 1.6 m. Consider it as a uniform disk of moment of inertia $I = \frac{1}{2}mr^2$. A man pushes with a horizontal force of 80 N tangential to the merry-go-round. [10]



(i) What is the angular acceleration produced?

(ii) Starting from rest, how fast will the merry-go-round be moving (in rev/s) after 12 seconds of pushing?

(iii) How many revolutions would the merry-go-round have made in 12 seconds?

$w = mg$

kg

$kg \cdot m/s^2$

$kg\, m/s^2 = N$

$kg\, m/s^2$

$10 = v \cos 30$

(b) A 5 kg mass is hung from a vertical steel wire (Y = 2.0×10^{11} Pa) 2 m long and 4×10^{-6} m^2 in cross section. The wire is securely fastened to the ceiling. Calculate

(i) the amount the wire is stretched by the hanging mass,

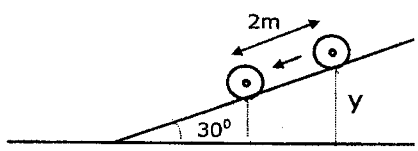
(ii) the external force P needed to pull the mass downward by 0.05 cm from its equilibrium position,

(iii) the work done by gravity when the mass moves downward by 0.05 cm,

(iv) the work done by the force P. [10]

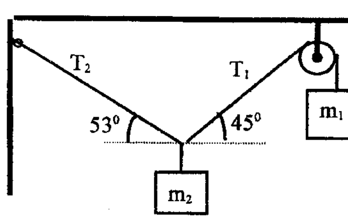
Q8(a) A disk of moment of inertia 0.1 kg.m^2 about its axis and radius 0.2 m is released from rest and it rolls down a plane inclined at 30^0 to the horizontal. The mass of the disk is 5 kg. Calculate the angular velocity (in radians/sec) after it has rolled 2 m down the plane.

[moment of inertia of a disk $=\frac{1}{2}mr^2$] [10]



$\omega r = v$

(b) The system in the figure is at equilibrium when m_1 = 10 kg. Assume the pulley to be massless and frictionless so that it does not alter the tension in the cord. Find the values of m_2, T_1 and T_2 . [10]



$m_1 = 10$ kg

==End of PHY1010 2016 Exam==

Some Useful Equations

Uniformly accelerated motion:

$x = \bar{v}t \qquad \bar{v} = \frac{1}{2}(v_f + v_i) \qquad v_f = v_i + at \qquad v_f^2 = v_i^2 + 2ax \qquad x = v_i t + \frac{1}{2}at^2$

Projectile motion:

$v_x = v_i \cos\theta_i$ = constant $\qquad v_y = v_i \sin\theta_i - gt \qquad y = (v_i \sin\theta_i)t - \frac{1}{2}gt^2$

$y = (\tan\theta_i)x - \left[\frac{g}{2v_i^2(\cos^2\theta_i)}\right]x^2 \qquad R = \frac{v_i^2}{g}\sin 2\theta \qquad t = \frac{2v_i \sin\theta}{g}$

Force and motion:

$F = ma \qquad w = mg \qquad F_{AB} = -F_{BA} \qquad F_f = \mu F_N$

Energy:

$PE = wh = mgh \qquad KE = \frac{1}{2}mv^2 \qquad W = Fx\cos\theta \qquad P = \frac{W}{t} = Fv\cos\theta$

Linear momentum:

$p = mv \qquad F\Delta t = \Delta mv = m(v_f - v_0)$

Circular motion and gravitation:

$T = \frac{2\pi r}{v} \qquad a_c = \frac{v^2}{r} \qquad F_c = \frac{mv^2}{r} \qquad F_{grav} = G\frac{m_A m_B}{r^2} \qquad 1rev = 360^0 = 2\pi\, rad$

$v_T = \frac{2\pi r}{T}: \quad \tan\theta = \frac{v^2}{rg}$

Rotational motion and angular momentum:

$\theta = \frac{s}{r} = \left(\frac{\omega_i + \omega_f}{2}\right)t \qquad \omega = \frac{\theta}{t} \qquad \theta = \omega_i t + \frac{1}{2}\alpha t^2 \qquad \omega_f = \omega_i + \alpha t \qquad v = \omega r$

$\omega_f^2 = \omega_i^2 + 2\alpha\theta \qquad \alpha = \frac{\Delta\omega}{\Delta t} = \frac{a_T}{r} \qquad I = \sum mr^2 \qquad I = mk^2 \qquad \tau = FL = I\alpha$

$KE_{rot} = \frac{1}{2}I\omega^2 \qquad KE_{total} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 \qquad W = \tau\theta \qquad P = \tau\omega \qquad L = I\omega$

Properties of matter:

$\rho = \frac{m}{V} \qquad F_{restore} = -kx \qquad Y = \frac{F/A}{\Delta L/L_0} \qquad \phi = \frac{s}{d} = \frac{1}{s}\frac{F}{A} \qquad B = -\frac{\Delta P}{\Delta V/V_0}$

$W_{app} = mg - B.F. \qquad W_{app} = W\left(1 - \frac{\rho_{fluid}}{\rho}\right) \qquad F_B = \rho V g$, submerged object

$F_B = Mg$ (floating M) $\qquad P = \rho gh \qquad EPE = \frac{1}{2}kx^2 \qquad K.E. + E.P.E. = \frac{1}{2}kx_0^2$

Thermal Properties of matter:

$PV = nRT$: $\Delta Q = mc\Delta T = nC\Delta T$: $\Delta L = \alpha L \Delta T$: $L_t = L_0(1+\alpha t)$: $\Delta V = \gamma V \Delta T$:

$\Delta W = P\Delta V$ $\quad (\Delta Q / \Delta t) = (kA\Delta T)/\Delta L$ $\quad : m = V \times \rho$ $\quad \frac{Q}{t} = eA\sigma T^4$ $\quad C_P = C_V + R$

$\left[\frac{1}{2}mv^2\right]_{avg} = \frac{3}{2}kT$

Thermodynamics:

$\Delta Q = \Delta U + \Delta W$: $\quad PV = nRT \quad P_1V_1^{\gamma} = P_2V_2^{\gamma} \quad T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1} \quad W = p.\Delta V$

$e = 1 - \frac{T_c}{T_h} = \frac{\textit{work done}}{\textit{input heat at high temp}} \quad COP_{ref} = \frac{Q_C}{W} \quad COP_{heat\ pump} = \frac{Q_H}{W} \quad \Delta S = \frac{\Delta Q}{T}$

$W_{isothermal} = nRT\ln\frac{V_2}{V_1} \quad W_{adiabatic} = \frac{1}{\gamma - 1}(P_1V_1 - P_2V_2) \quad COP_{\max-ref} = \frac{T_C}{W} \quad COP_{\max-heat\ pump} = \frac{T_H}{W}$

Waves and Sound:

$f = \frac{1}{\tau} \quad v = \pm\sqrt{\frac{k}{m}(x_0^2 - x^2)} \quad v = \sqrt{\frac{T}{m/L}} \quad \tau = \frac{1}{f} = 2\pi\sqrt{\frac{m}{k}} \quad a = -\left(\frac{k}{m}\right)x \quad v = \sqrt{\frac{Y}{\rho}}$

$v = \sqrt{\frac{B}{\rho}} \quad f' = f\,\frac{v \pm v_L}{v \mp v_S} \quad dB = 10.\log\frac{I}{I_0} \quad \omega = 2\pi f \quad v = \lambda f \quad K.E. + E.P.E. = \frac{1}{2}kx_0^2$

$\tau = \frac{2\pi\, x_0}{v_0} = 2\pi\left(\frac{x_0}{v_0}\right) = \frac{2\pi}{\omega} \qquad x = x_0\cos(\omega t)$

Volume of a sphere $= (4/3)\pi r^3$; Surface area of a sphere $= 4\pi r^2$

Surface area of a cylinder $= 2\pi r L$

specific heat capacity of water = 1.00 cal/g.^{0}C = 4200 J/kg.^{0}C

specific heat capacity of ice = 0.5 cal/g.^{0}C = 2100 J/kg.^{0}C

specific heat capacity of steam = 0.46 cal/g.^{0}C = 1920 J/kg.^{0}C (at 100^{0}C, constant volume)

The University of Zambia
School of Natural Sciences
Department of Physics
2015-16 Academic Year
End of Year University Examinations
PHY2112: Atomic & Modern Physics

Attempt any five questions. The marks are shown in brackets.
Time: Three hours. [Maximum marks = 100.]

Write clearly your computer number on the answer book.

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Below is a table of constants that might be useful.

Acceleration due to gravity $g = 9.8$ m/s^2	Avogadro's number $N_A = 6.023 \times 10^{23}$ per mole	Speed of light $c = 3.0 \times 10^8$m/s
electron charge $e = -1.6 \times 10^{-19}$C	Electron volt $1eV = 1.6 \times 10^{-19}$J	Atomic no Molybdenum $Z = 42$
Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ T.m/A	Permitivity of free space $\epsilon_0 = 8.85 \times 10^{-12}$C^2/N.m^2	Angstroms to Meters $1\AA = 10^{-10}$ m.
Stefan's constant $\sigma = 5.67 \times 10^{-8}$Wm^{-2}K^{-4}	Planck's constant $h = 6.63 \times 10^{-34}$ J.s	Boltzmann constant $\kappa = 1.38 \times 10^{-23}$J.K^{-1}
Electron mass $m_e = 9.11 \times 10^{-31}$kg	Proton mass $m_p = 1.00758$amu	Neutron mass $m_n = 1.00897$amu
Wien's constant $b = 2.9 \times 10^{-3}$m.K	Stefans constant $\sigma = 5.67 \times 10^{-8}$Wm^{-2}K^{-4}	Rydberg constant $R = 1.0974 \times 10^7$m^{-1}

Below is a list of formulas that might be helpful.

Faraday's law: $\epsilon = -N\frac{d\Phi_m}{dt}$

Magnetic flux: $\Phi_m = \int \mathbf{B} \cdot d\mathbf{A}$

Motional emf: $\epsilon = -Blv$

Magnetic field inside a solenoid : $B = \frac{\mu_0 NI}{l}$

Magnetic energy density : $U^* = \frac{U}{V} = \frac{1}{2\mu_0}B^2$

Decay law: $N = N_0 e^{-\lambda t}$. The decay rate or activity $A = \frac{dN}{dt} = -\lambda N$

Energy of a photon $E = \frac{hc}{\lambda}$, and momentum of a photon $p = \frac{h}{\lambda}$

Transmitted intensity $I = I_0 e^{-\mu x}$

Planck's radiation law:

$$E(\lambda, T) = \frac{2\pi^2 c^2 h}{\lambda^5} \frac{1}{e^{\frac{ch}{\lambda \kappa T}} - 1}$$

Photoelectric equation: $\frac{1}{2}mv^2 = h\nu - \varphi$

Compton scattering equation: $\Delta\lambda = \lambda' - \lambda = \frac{h}{m_0 c}(1 - \cos\theta)$

Moseley's law: $\sqrt{\nu} = a(Z - b)$

Wien's displacement law: $\lambda_{max} T = 0.2898 \times 10^{-2}$ m.K

Stefan's law $E(T) = \sigma T^4$

De Broglie wavelength: $\lambda = \frac{h}{mv}$

Total energy of a planetary electron

$$E_n = E_k + E_p = \frac{1}{2}mv^2 - \frac{Ze^2}{4\pi\epsilon_0 r}$$

Permitted radii in Bohr atom:

$$r = \frac{\epsilon_0 h^2 n^2}{\pi m_e Z e^2}$$

Q1 (a) The hydrogen Balmer series reciprocal wavelengths are given by

$$\frac{1}{\lambda_{mn}} = R\left(\frac{1}{m^2} - \frac{1}{n^2}\right) \qquad \text{for} \qquad n > m$$

with $m = 2$ and $n = 3, 4, 5, \cdots$.
Other series of hydrogen spectral lines were found for $m = 1$ (by Theodore Lyman) and $m = 3$ (by Friedrich Paschen). Compute the wavelengths of the first lines of the Lyman and Paschen series. [5]

(b) (i) Using the Bohr relation for one the electron atom, the frequency of emitted radiation is given by

$$\nu = \frac{\Delta E}{h} = \frac{E_0 Z^2}{h}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

Using $(Z - 1)$ in place of Z by Moseley as was done and $R = \frac{E_0}{hc}$ as in the Bohr's prediction of the Rydberg constant, show that the frequency of the K series is given by

$$\nu = cR(Z-1)^2\left(1 - \frac{1}{n_i^2}\right)$$

[2]

(ii) Calculate the wavelength of the K_α line of Molybdenum. [3]

(c) (i) In Bohr's original theory of the hydrogen atom (circular orbits), what postulate led to the choice of the allowed energy levels? [3]

(ii) Later de Broglie pointed out a most interesting relationship between the Bohr postulate and the de Broglie wavelength of the electron. State and derive this relationship. [3]

(iii) Compute the de Broglie wavelength of an electron whose kinetic energy is 10 eV [4]

[Total 20 Marks]

Q2 (a) (i) Derive Bohr's formula

$$E_n = -\frac{me^4}{8\epsilon_0^2 n^2 h^2}$$

for the allowed total energies of the hydrogen atom, discussing the assumptions made in your derivation. [8]

(ii) A photon incident upon a hydrogen atom ejects an electron with a kinetic energy of 10.7eV. If the ejected electron was in the first excited state, calculate the energy of the photon [5]

(iii) What kinetic energy would have been imparted to an electron in the ground state if the incident photon had energy as in (ii) [2]

(b) What is the kinetic energy and the speed of an electron ejected from a sodium surface whose work function is $W_0 = 2.28$ eV when illuminated by light of wavelength (a) 410 nm and (ii) 550 nm? [5]

[Total 20 Marks]

Q3 (a) Differentiate between natural and artificial radioactivity. [3]

(b) Write short notes on the three processes through which X-rays are mainly absorbed by matter. [6]

(c) The activity of a certain radioactive nuclide decreases by 15% of its original value in 10 days. Find its disintegration constant λ and its half-life $T_{\frac{1}{2}}$ [5]

(d) Study the part of the uranium decay series given below, and answer the questions that follow:

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th \longrightarrow {}^{234}_{91}Pa \longrightarrow {}^{234}_{92}U \longrightarrow {}^{230}_{90}Th \longrightarrow {}^{226}_{88}Ra \longrightarrow \cdots$$

(i) Name the particle emitted in each decay,

(ii) List the pairs of isotopes occurring in this part of the series,

(iii) If the stable end product of the complete uranium series is $^{206}_{82}Pb$, how many alpha particles are emitted between $^{226}_{88}Ra$ and the end of the series?

[6]

[Total 20 Marks]

Q4 (a) (i) What is the relationship between the most intense radiation and its temperature? [2]

(ii) The temperature of a blackbody is increased from 900K to 1900K. By what factor does the total power radiated per unit area increase. (Hint: use Stefan's law) [4]

(iii) Show that at long wavelength, Plank's radiation law reduces to

$$E(\lambda, T) = 2\pi^2 \frac{c}{\lambda^4} \kappa T \qquad \text{with} \quad \lambda \to \infty$$

[5]

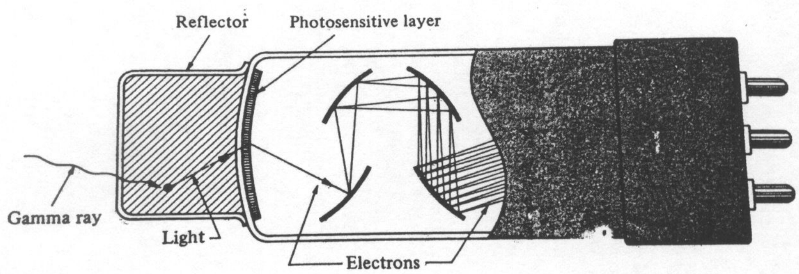
(b) (i) When X-rays traverse a material of a certain thickness, the transmitted intensity can be computed using the relation $I = I_0 e^{-\mu x}$. Define all the symbols appearing in this equation. [2]

(ii) Find the linear attenuation coefficient when the intensity of a narrow gamma ray beam is reduced to $\frac{1}{4}$ of its original intensity upon passing through a 5 cm thickness of a substance. [3]

(iii) What percentage of the X-ray beam is absorbed when it passes through 0.1 mm of liquid mercury for which the linear absorption coefficient is $\mu = 0.22\ \text{mm}^{-1}$. [4]

[Total 20 marks]

Q5 (a) The figure below shows the essential features of the scintillation radiation detector. Study it carefully and answer the questions that follow:



(i) Explain why the voltages attached to the electrodes are graded in increasing positive values [3]

(ii) Explain the function of the photosensitive layer [1]

(iii) The assembly starting with the photosensitive layer is called the "photomultiplier tube". Explain why it is called so. [2]

(b) Write three characteristics of the blackbody radiation spectrum. Explain the Stefan- Boltzmann law and the Wien displacement law. [9]

(c) Use the Bohr model to

(i) determine the ionization energy of the He^+ ion, which has a single electron, [2]

(ii) calculate the maximum wavelength a photon can have to cause ionization. [3]

[Total 20 Marks]

Q6 (a) (i) How are X-rays produced? [2]

(ii) State four properties of X-rays. [2]

(b) X-rays from a certain cobalt target tube are composed of the strong K-series of cobalt (Z=27) and two weak K- lines due to impurities. The wavelength of the K_α lines is $1.785\dot{A}$ for cobalt and for the impurities are $2.285\dot{A}$ and $1.537\dot{A}$. Using Moseley's law, calculate the atomic number of each of the two impurities. (NOTE: for K series $b = 1$) [7]

(c) Explain with the aid of a well-labelled diagram the mechanism of Compton scattering. [4]

(d) X-rays of wavelength 0.140nm are scattered from a very thin slice of carbon. What will be the wavelength of X-rays scattered at (i) 0°, (ii) 90° and (iii) 180°? [5]

Q7 (a) Briefly discuss the implication of the equation $\oint \mathbf{B}.d\mathbf{S} = 0$, Gausss law for magnetic flux. [2]

(b) Distinguish between free currents and Amperian currents. [2]

(c) Show that the magnetic field intensity **B**, the magnetization **M** and the magnetic field strength **H** are related by $\mathbf{B} = \mu_0 (\mathbf{H} + \mathbf{M})$ [7]

(d) A flat loop of wire A is placed in a region where the magnetic field is perpendicular to the plane of the loop. The magnitude of **B** varies with time according to the expression $B = B_0 e^{-at}$, where a is some constant. Find the induced emf in the loop as a function of time. [3]

(e) An ideal air-core solenoid has a radius 2.0 cm, length 12 cm and 9000 turns. The solenoid carries a current of 2.0 A.

(i) Find the magnetic field inside the solenoid. [2]

(ii) Determine how much energy U is stored in the solenoid. [4]

[Total 20 Marks]

==End of PHY2112 Examination==

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF PHYSICS
2015/16 ACADEMIC YEAR EXAMINATIONS

PHY-2522: ANALYTICAL MECHANICS AND SPECIAL THEORY OF RELATIVITY

Time allowed: **3 Hours**

Instructions

- **This examination paper contains 7 questions. Each question carries 20 marks. Attempt any 5 questions out of the 7 questions given.**
- **This paper has a total of 100 marks. All questions carry equal marks.**
- **Show all your working clearly. Omission of essential work will result in loss of marks.**
- **Write your computer number clearly on the answer sheet.**

Where necessary, you may use the following:

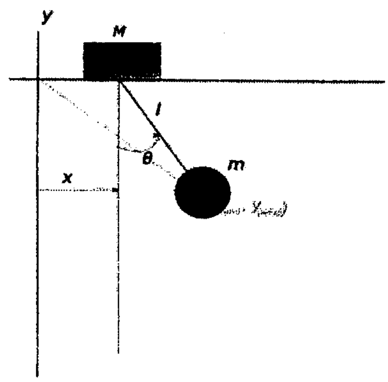
$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_k}\right)-\frac{\partial L}{\partial q_k}=Q_k,\quad \dot{q}_k=\frac{\partial H}{\partial p_k},\quad \frac{\partial H}{\partial t}=-\frac{\partial L}{\partial t},\quad -\dot{p}_k=\frac{\partial H}{\partial q_k},\quad p_k=\frac{\partial H}{\partial \dot{q}_k},\quad x'=\gamma(x-vt),$$

$$t'=\gamma\left(t-\frac{Vx}{c^2}\right),\quad y'=y,\quad z'=z,\quad \gamma=\frac{1}{\sqrt{1-\frac{v^2}{c^2}}},\quad \text{speed of light } c=3\times10^8\,\text{m/s}$$

$$\frac{\partial^2 u(x,t)}{\partial t^2}=\frac{T}{\mu}\frac{\partial^2 u(x,t)}{\partial x^2},\quad \gamma L=L_0,\quad I_{sphere}=\frac{2}{5}Ma^2$$

$$A_n=\frac{2}{L}\int_0^L u_0(x)\sin\left(\frac{n\pi x}{L}\right)dx,\quad B_n=\int_0^L \dot{u}_0(x)\sin\left(\frac{n\pi x}{L}\right)dx,$$

Q1 Consider a pendulum of mass m and length ℓ, which is attached to a support with mass M, which can move along a line in the x-direction as shown in the figure below. Let x be the coordinate along the line of the support, and let the position of the pendulum be denoted by the angle θ measured from the vertical.



(a) How many degrees of freedom does the system have? **[2 marks]**

(b) Show that the Lagrangian of the system is

$$L = \frac{1}{2}(M+m)\dot{x}^2 + m\dot{x}l\dot{\theta}\cos\theta + \frac{1}{2}ml^2\dot{\theta}^2 + mgl\cos\theta \qquad \textbf{[8 marks]}$$

(c) Identify the ignorable coordinate in the system and state its physical significance. **[2 marks]**

(d) Show that the equations of motion arising from the Lagrangian formalism are:

$$ml^2\ddot{\theta} + ml(\ddot{x}\cos\theta + g\sin\theta) = 0 \text{ and} \qquad \textbf{[4marks]}$$

$$(M+m)\ddot{x} + ml\ddot{\theta}\cos\theta - ml\dot{\theta}^2\sin\theta = 0 \qquad \textbf{[4 marks]}$$

Q2 The solution for the motion of a particle undergoing simple harmonic motion is $x = A\sin(\omega_0 t + \delta)$. The particle has a velocity v_1 when the displacement is x_1 and a velocity v_2 when the displacement is x_2. Find the

(i) angular frequency ω_0 in terms of x_1, x_2, $\dot{x}_1$, $\dot{x}_2$ and **[10 marks]**

(ii) amplitude of the motion in terms of x_1, x_2, $\dot{x}_1$, $\dot{x}_2$. **[10 marks]**

Q3 A block of mass m attached to a spring of spring constant k is moving on a horizontal table which provides a frictional force given by mbv, where v is the velocity of the block.

(a) Write down the equation governing the motion of the system. **[2 marks]**

(b) By assuming that the solution to your equation in (a) above is given by

$$x(t) = ae^{-\gamma t}\cos(\omega_1 t - \phi),$$

obtain the expression for the velocity of the system and **[3 marks]**

(c) the expression for the acceleration of the system. **[3 marks]**

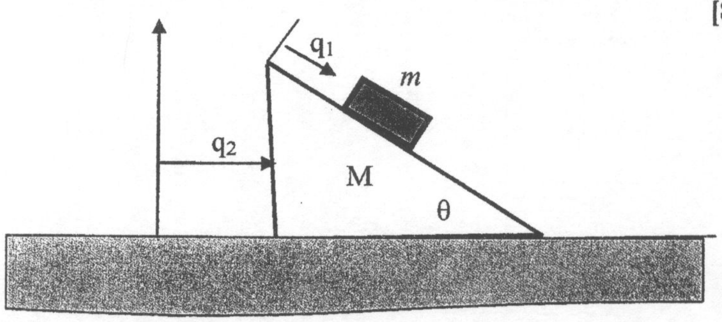
(d) Show that

(i) $\gamma = b/2$ and **[6 marks]**

(ii) $\omega_1 = \left(\omega_0^2 - \frac{b}{4}\right)^{\frac{1}{2}}$ **[6 marks]**

Q4(a) A block of mass m is held motionless on a frictionless plane of mass M and angle of inclination θ (see Fig. below). The plane rests on a frictionless horizontal surface. The block is released. Using the Euler-Lagrange equations, find the expression for the Lagrangian of the system. [Hint: use the generalized coordinates shown in the figure]

[8 marks]



(b) Show that the resulting two equations of motion are:

$$(M + m)\ddot{q}_2 + m\ddot{q}_1\cos\theta = 0$$ **[6 marks]**

and

$$\ddot{q}_1 = \frac{g\sin\theta}{1 - \frac{m}{M+m}\cos^2\theta}$$ **[6 marks]**

Q5 A projectile is launched near the surface of the earth at an angle of θ^0 to the horizontal with a velocity of $v\,\text{ms}^{-1}$.

(a) Obtain the Hamiltonian of the projectile. **[6 marks]**

(b) Using the Hamilton formalism, deduce the conserved quantity. **[6 marks]**

(c) Find the equations of motion of the projectile. **[8 marks]**

Q6 A string of length L and linear mass density μ is fixed tight at both ends. The string is set into vibration and the differential equation of motion of the wave in the string is given by

$$\frac{\partial^2 u(x,t)}{\partial x^2} - \frac{1}{v^2}\frac{\partial^2 u(x,t)}{\partial t^2} = 0.$$

(a) Using the method of separation of variables, obtain the two equations for x and t.

[6 marks]

(b) By choosing the constant of separation as $-\omega^2$, obtain the general expression for the solution of the wave equation with all the unknown four constants of integration.

[8 marks].

(c) Explain how you would go about eliminating any of the constants of integration and determining the Fourier coefficients in your final expression of the solution.

[6 marks]

Q7 The trajectory of a particle moving parallel to O_x with a uniform velocity v in the stationary inertial reference frame S is given by

$$x = x_0 + vt.$$

(a) Show that in the reference frame S' in standard configuration with S and moving with a velocity V relative to S the trajectory of the particle is given by

$$x' = \frac{x_0}{\gamma\left(1-\frac{vV}{c^2}\right)} + \frac{(v-V)\,t'}{\left(1-\frac{vV}{c^2}\right)}$$ **[5 marks]**

(b) Explain the physical effect of $V \ll c$ in the equation of the trajectory of the particle in the S' obtained in (a) above. **[5 marks]**

(c) The relativistic expression for the kinetic energy of a moving particle is given by

$$T = mc^2 - m_0 c^2$$

Show that for velocities v much lower than the speed of light c, this expression reduces to the Newtonian one, that is

$$T = \frac{1}{2} m_0 v^2$$ **[5 marks]**

(d) Starting from the equation of motion for the one dimensional damped harmonic oscillator of mass m given by

$$m\ddot{X} + C\dot{X} + kX = 0.$$

Show that the characteristic equation is

$$m\alpha^2 + \alpha C + k = 0$$

if a solution of the form $X = e^{\alpha t}$ is assumed. **[5 marks]**

***************END OF PHY 2522 EXAMINATION******************

The University of Zambia

School of Natural Sciences

Department of Physics

2015/2016 Academic Year

End of Year Examinations

PHY 2712 – Optics

Duration : 3 hours **Max Marks : 100**

Instructions

- This examination paper contains 7 questions. Attempt any 5 questions.
- Each question carries 20 marks. Marks allocated for each question are indicated in brackets [ ].
- Show all your working clearly. Omission of essential work will result in loss of marks.
- Write your computer number clearly on the answer booklets.

CONSTANTS THAT MAY BE USEFUL

$e = 1.602 \times 10^{-19}\, C$

$m_e = 1.6 \times 10^{-27}\, kg$

$m_p = 9.11 \times 10^{-31}\, kg$

$\varepsilon_o = 8.85 \times 10^{-12}\, C^2\, N^{-1}\, m^{-2}$

$\mu_o = 4\pi \times 10^{-7}\, N\, s^2\, C^{-2}$

$c \approx 3 \times 10^8\, m/s$

$1\, A^o = 0.1\, nm$

$n_{water} = 1.33$

$n_{glass} = 1.50$

$n_{air} = 1$

FORMULAE THAT MAY BE USEFUL

$n_1 \sin\theta_1 = n_2 \sin\theta_2$	$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$	$\frac{n_1}{u} + \frac{n_2}{v} = \frac{n_2 - n_1}{R}$
$\frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$	$m = -\frac{v}{m}$	$P = \frac{1}{f}$
$u_E = \frac{1}{2}\varepsilon_o E^2$	$u_B = \frac{1}{2\mu_o} B^2$	$u_{total} = \varepsilon_o E^2 = c\varepsilon_o EB$
$I = \langle S \rangle = \frac{E_o^2}{2\mu_o c}$	$v = \frac{1}{\sqrt{\mu_o \varepsilon_o}}$	$n(\lambda) = a + \frac{b}{\lambda^2} + \frac{c}{\lambda^4}$
$\theta_i = \frac{(\delta_m + A)}{2}$	$n = \frac{\sin\theta_i}{\sin\theta_r}$	$\sin\theta_i = \sin\left[\frac{(\delta_m + A)}{2}\right]$
$\sin\theta_r = \frac{A}{2}$	$\delta_m = A(n-1)$	$\delta_V - \delta_R = A(n_V - n_R)$
$\omega = \frac{n_V - n_R}{n-1}$	$k = \frac{2\pi}{\lambda}$	$\nu = \frac{1}{\lambda}$
$v = f\lambda$	$\omega = kv = ck = 2\pi f$	$\frac{1}{v^2}\frac{\partial^2\psi(x,t)}{\partial t^2} = \frac{\partial^2\psi(x,t)}{\partial t^2}$
$\psi(x,t) = A\sin(kx \pm \omega t)$	$v = \frac{1}{\sqrt{\mu_o \varepsilon_o}}$	$E_o = \frac{1}{\sqrt{\mu_o \varepsilon_o}} B_o$
$\frac{\partial E_z}{\partial y} = -\frac{\partial B_x}{\partial t}$	$\frac{\partial B_x}{\partial y} = -\mu_o \varepsilon_o \frac{\partial E_z}{\partial t}$	$\mu_o \varepsilon_o \frac{\partial^2 E_z}{\partial t^2} = \frac{\partial^2 E_z}{\partial y^2}$
$\mu_o \varepsilon_o \frac{\partial^2 B_x}{\partial t^2} = \frac{\partial^2 B_x}{\partial y^2}$	$E_z(y,t) = E_o \sin(ky \pm \omega t)$	$B_x(y,t) = B_o \sin(ky \pm \omega t)$
$I_n = I_o \cos^2\theta$	$\tan\theta_{Br} = \frac{n_2}{n_1}$	$R = \frac{\left(D_{n+m}^2 - D_n^2\right)}{4m\lambda}$
$\psi_1(r,t) = A\cos(kr - \omega t)$	$\psi_2(r+\delta,t) = A\cos(kr - \omega t + k\delta)$	$\cos\alpha + \cos\beta = 2\cos\left(\frac{\alpha+\beta}{2}\right)\cos\left(\frac{\alpha-\beta}{2}\right)$

$\psi(r,t)=\tilde{A}\cos\left(kr-\omega t+\frac{k\delta}{2}\right)$	$\tilde{A}=2A\cos\left(\frac{k\delta}{2}\right)$	$\delta=d\sin\theta_n$
$\delta=n\lambda$	$\delta=(2n+1)\left(\frac{\lambda}{2}\right)$	$\sin\theta_n=\frac{x_n}{L}=\frac{D_n}{2L}$

Question 1

(a) The solutions to Maxwell's equations for electromagnetic theory of light in free space for an oscillating electric field in the $yz-$plane and an oscillating magnetic field in the $xy-$plane satisfy the following two equations

$$\frac{\partial E_z}{\partial y} = -\frac{\partial B_x}{\partial t} \quad , \quad \frac{\partial B_x}{\partial y} = -\mu_o \varepsilon_o \frac{\partial E_z}{\partial t} \ .$$

(i) Use these equations to derive the wave equations for the electric and magnetic fields.

$$\mu_o \varepsilon_o \frac{\partial^2 E_z}{\partial t^2} = \frac{\partial^2 E_z}{\partial y^2} \quad , \quad \mu_o \varepsilon_o \frac{\partial^2 B_x}{\partial t^2} = \frac{\partial^2 B_x}{\partial y^2}$$ [8]

(ii) Show that $E_z(y, t) = E_o \sin(ky - \omega t)$ and $B_x(y, t) = B_o \sin(ky - \omega t)$ are solutions to the wave equations for the electric and magnetic fields. [6]

(iii) Show that the amplitude of the electric field and the magnetic field are related by $E_o = \frac{1}{\sqrt{\mu_o \varepsilon_o}} B_o$. [4]

(iv) Show that the velocity of an electromagnetic wave is equal to the speed of light. [2]

Question 2

(a) State Fermat's principle of least time [1]

(b) With the aid of a suitable diagrams and by using calculus to minimize the transit times of light as required by Fermat's principle, derive the following laws.

(i) Law of reflection of light [6]

(ii) Snell's law of refraction of light [6]

(c) An object is placed 50 cm in front of a concave parabolic reflector with a focal length $f = 25$ cm . Describe the type, orientation and magnification of the image formed. [5]

(d) Define the following terms

(i) Dispersion of white light [1]

(ii) Polarization of light [1]

Question 3

(a) Derive the expression for the Gaussian lens formula for a:

i. concave parabolic reflector [6]

ii. thin lens [6]

(b) Write an expression of the form $E(y,t) = E_o \sin(ky \pm \omega t + \phi)$ for an oscillating electric field vector of amplitude 10^3 V/m, period 2.2×10^{-15} s, and speed 3×10^8 m/s. The electric field is propagating in the positive $y-$ direction and has a value of 10^3 V/m at $t = 0$ and $x = 0$. Calculate the mean value of the Poynting vector of the electric field. [4]

(c) In a Newton's rings experiment, the diameter of the 15^{th} ring was found to be 0.590 cm and that of the 5^{th} ring was 0.336 cm. If the radius of curvature of the plano-convex lens is 100 cm, calculate the wavelength of the light used. [4]

Question 4

(a) Two positive lenses with focal lengths of $f_1 = 0.30$ m and $f_2 = 0.50$ m are separated by a distance of $d = 0.20$ m . A small frog rests on the central (or principal) axis 0.50 m in front of the first lens. Locate the resulting final image with respect to the first lens and describe its type, orientation and magnification. [6]

(b) Find the polarizing angle and the angle of refraction for light incident from

(i) glass to water [3]

(ii) water to glass [3]

(c) If a convex lens having a refractive index of 1.5 has a focal length of 20 cm in air, what will be the focal length when it is immersed in water? [4]

(d) Show that the electric field energy density $u_E = \frac{1}{2}\varepsilon_o E^2$ is equal to the magnetic field energy density $u_B = \frac{1}{2\mu_o} B^2$ for an electromagnetic wave. [4]

Question 5

(a) Starting with the formula for refraction on a curved surface , derive the lensmaker's formula

$$\frac{1}{f}=\left(\frac{n_2}{n_1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$ [6]

(b) A thin biconvex lens ($n_2 = 1.50$) in air has radii of curvatures $R_1 = 20$ cm and $R_2 = 40$ cm. Locate and describe the nature of the image formed by an object placed 40 cm in front of the lens. [6]

(c) A glass prism has an angle $A = 60^o$ and a refractive index of 1.5. Calculate the angle of incidence for a minimum deviation, and the value of the minimum deviation, assuming the ray passes symmetrically through the prism. [4]

(d) With the aid of the table given below and use of Cauchy's formula for refractive index for transparent media, discuss the formation of dispersion spectrums resulting from a beam of white light incident on a prism. [4]

Color	Wavelength, λ (nm)
Red	622 – 780
Orange	597 – 622
Yellow	577 – 597
Green	492 – 577
Blue	455 – 492
Violet	390 – 455

Question 6

(a) Show that the superposition of wave functions originating from the two slits separated a distance d in Young's double slit experiment onto any point located a distance x from the center on a screen is given by

$$\psi(r,t) = 2A\cos\left(\frac{k\delta}{2}\right)\cos\left(kr - \omega t + \frac{k\delta}{2}\right) \qquad [8]$$

(b) Derive the path difference equations for superposing waves producing constructive and destructive interference. [8]

(c) Young's double slit experiment is performed with light of the green mercury line. The double slit separation distance d is $800\ \mu m$. When the fringes are measured with a micrometer eyepiece $80\,\text{cm}$ behind the double slit, it is found that 20 bright fringes occupy a distance of 10.92 mm from the centre of the slits. Find the wavelength of the light. [4]

Question 7

(a) State Malus' law of linearly polarized light. [2]

(b) Unpolarized light with electric filed vector of amplitude $10^3\ \text{V/m}$ is incident on a linear polarizer. Three other linear polarizers are placed at equal distances behind the first linear polarizer with each of their polarization axes oriented 30^o with respect to the polarizer in front. Calculate the intensity of the polarized light that exits. [4]

(c) With the aid of suitable diagrams, explain and discuss polarization of light by

(i) Transmission [3]

(ii) Reflection [3]

(iii) Scattering [3]

(d) The dispersion powers of crown and flint glasses are 0.03 and 0.05 respectively. If the difference in the refractive indices of violent and red colors is 0.014 for crown glass and 0.023 for flint glass, calculate the angles of the two prisms for a deviation of $10°$ (without dispersion). [5]

End of PHY 2712 Examination

The University of Zambia
School of Natural Sciences
Department of Physics
University Examinations 2016
PHY4132: Theoretical Nuclear Physics

Attempt any four questions. All questions carry equal marks. The marks are shown in brackets. Clearly indicate on the answer script cover page which questions you have attempted.

Time: Three hours. **Maximum marks = 100.**

Write your computer number clearly on the answer book.

Wherever necessary use:

$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N.m^2	$m_{hydrogen\ atom} = 1.007825$ a.m.u.
$m_{neutron} = 1.008665$ a.m.u. $= 939.551$ MeV	$m_{alpha} = 4.002603$ a.m.u.
1 a.m.u. $= 931.5$ MeV $= 1.6604 \times 10^{-27}$ kg	$m_p = 1.67 \times 10^{-27}$ kg $= 938.28$ MeV
$c = 3 \times 10^8$ m/s	$m_e = 9.11 \times 10^{-31}$ kg $= 0.511$ MeV
$h = 6.63 \times 10^{-34}$ J-s	$e = 1.6 \times 10^{-19}$ C
$\hbar = 6.58 \times 10^{-22}$ MeV-s $= 1.05 \times 10^{-34}$ J-s	1eV $= 1.6 \times 10^{-19}$ J
1 fermi $= 10^{-15}$ m	1 barn $= 10^{-28}$ m^2
Avogadro's constant $= 6 \times 10^{23}$ per mole	Velocity of light $= 3 \times 10^8$ m.sec^{-1}.
$\left(e^2/4\pi\varepsilon_0\right) = 1.44$ MeV-fermi	$m = \left(m_0c^2/c^2\right) \equiv \left(MeV/c^2\right)$
$\tan(A+B) = \dfrac{\tan A + \tan B}{1 - \tan A \tan B}$	$e^2/\hbar c = (1/137)$ $\hbar c = 197.33$ MeV-fermi

$$(1s_{1/2})^2, (1p_{3/2})^4, (1p_{1/2})^2, (1d_{5/2})^6, (2s_{1/2})^2, (1d_{3/2})^4, (1f_{7/2})^8, (2p_{3/2})^4, (1f_{5/2})^6, (2p_{1/2})^2, (1g_{9/2})^{10}, [50]$$

$$E = \frac{\hbar^2}{2\Im}\left[J(J+1) - BJ^2(J+1)^2\right]. \qquad \Delta E_C = \frac{3}{5}\frac{e^2}{R}\left[Z^2 - (Z+1)^2\right] \qquad Z_0 = \frac{\beta}{2\gamma}$$

Q1(a) It is said that "everything in the universe, including light and gravity, can be described in terms of *particles*" using the wave-particle duality. These particles have a property called *spin*.

(i) Write short notes on particles of spin 0, ½ , 1, and 2.

(ii) How can the particles in the universe be grouped? What do these groups of particles represent?

(iii) Which group of particles obey Pauli exclusion principle? [Total marks 12]

(b) To study the nuclear size, shape and density distribution one employs electrons, protons and neutrons as probes.

i) What are the criteria in selecting the probe? Explain.

ii) Compare the advantages and disadvantages of the probes mentioned above.

iii) Are photons suitable for this purpose? Explain. [8]

(c) Write down the expression for the density distribution of nuclear matter, explaining the parameters that appear in it. [5]

Q 2. (a) The semi-empirical mass formula for the mass of a neutral atom is

$$M(A,Z) = Z M_H + (A-Z)\, M_n - c_v\, A + c_s\, A^{2/3} + c_c \frac{Z(Z-1)}{A^{1/3}} + c_{symm} \frac{(A-2Z)^2}{A} \pm \delta,$$

where M_H and M_n are the masses of the hydrogen atom and the neutron respectively in atomic mass units.

(i) Show that it can be written for a given A as $M(A,Z) = \alpha A + \beta Z + \gamma Z^2 \pm \delta$ where α, β, and γ are appropriately defined constants and δ is the pairing energy contribution. [4]

(ii) Hence show that the reaction energy Q for beta decay $Z \rightarrow (Z \pm 1)$ at constant even A becomes $Q = 2\gamma\left(\pm(Z_0 - Z) - \frac{1}{2}\right) \pm 2\delta$ where Z_0 is the charge of the most stable isobar. [6]

(b) Use the mass formula to estimate the energy released in the symmetric fission of a ${}^{238}_{92}U_{146}$ nucleus. (Hint: consider only the Coulomb and the surface terms).

Given, $a_C = 0.59, a_s = 14$ MeV [6]

(c) Show that the electrostatic energy of a uniformly charged sphere of radius R is $\frac{3}{5}\frac{q^2}{R}$ where q is the total charge of the sphere. [9]

Q3 (a) How does the inclusion of a strong spin-orbit coupling in the single-particle shell model of the nucleus lead to the splitting of a state of given l?
Show that the splitting is proportional to $(2l + 1)$. [11]

(b) From the shell model predictions find the ground state spin and parity of the following nuclides:

$${}^{3}_{2}He, {}^{20}_{10}Ne, {}^{27}_{13}Al, \text{and } {}^{41}_{21}Sc.$$ [8]

(c) Predict the spin-parity of the *first excited state* of the nuclei ${}^{31}_{14}Si$, ${}^{41}_{19}K$, ${}^{49}_{21}Sc$. [6]

Comment on the fact that the observed values are $\frac{1}{2}^+, \frac{1}{2}^+$, and $\frac{3}{2}^+$.

Given the filling scheme: $(1s_{1/2})^2$, $(1p_{3/2})^4$, $(1p_{1/2})^2$, $(1d_{5/2})^6$, $(2s_{1/2})^2$, $(1d_{3/2})^4$, $(1f_{7/2})^8$, $(2p_{3/2})^4$, $(1f_{5/2})^6$, $(2p_{1/2})^2$, $(1g_{9/2})^{10}$, [50 nucleons].

Q4(a) (i) Show that an alpha particle with total energy E_o incident on a potential barrier of energy V ($V > E_o$) and of thickness b has a quantum probability of penetrating it.
(ii) Sketch the energy diagram showing the incident and transmitted waves of the particle. [10+2]

(b) In the experimentally determined ground state rotational band of ${}^{166}_{70}Yb$, the first excited state with $J^{\pi} = 2^+$ has an excitation energy of 0.102 MeV, and a higher-lying state with $J^{\pi} = 12^+$ is found to have an excitation energy of 2.17 MeV.
Obtain the angular momenta, parity, and the expected excitation energies of the second and third excited states of this rotational band. [13]

Q5(a). Give short explanations of the terms *super allowed, allowed, first forbidden,* and *second forbidden* in beta transitions in terms of (i) the nuclear matrix element $|M_{if}|$, (ii) log- fT values and (iii) the nuclear shell model. [12]

(b) Distinguish between the Fermi and the Gamow-Teller selection rules in beta decay of nuclei. [7]

(c) On the basis of these selection rules, deduce:

(i) the degree of forbiddenness, and

(ii) the type (Fermi, G-T, or mixed) of the following beta transitions :

$0^+ \rightarrow 1^+ \quad \frac{5}{2}^+ \rightarrow \frac{7}{2}^+ \quad \frac{1}{2}^+ \rightarrow \frac{1}{2}^+ \quad 0^+ \rightarrow 0^+$ [6]

Q6(a) Explain the origin of electric and magnetic multipole transitions in gamma decay of a nucleus. [6]

(b) Explain *nuclear isomerism.* Under what conditions can this effect manifest itself? Given an example of nuclear isomerism. [5]

(c) Explain why the $0^+ \rightarrow 0^+$ transition will not allow any gamma radiation to be emitted. [6]

(d) What multipole types of gamma ray transitions are likely to be predominant if the J^{π} of the initial and final nuclei are given as below:

(i) $\frac{1}{2}^+ \rightarrow \frac{1}{2}^+$ (ii) $\frac{3}{2}^- \rightarrow \frac{5}{2}^+$ (iii) $1^+ \rightarrow 0^+$ (iv) $\frac{3}{2}^- \rightarrow \frac{1}{2}^+$ [8]

==End of PHY 4132 Exam==

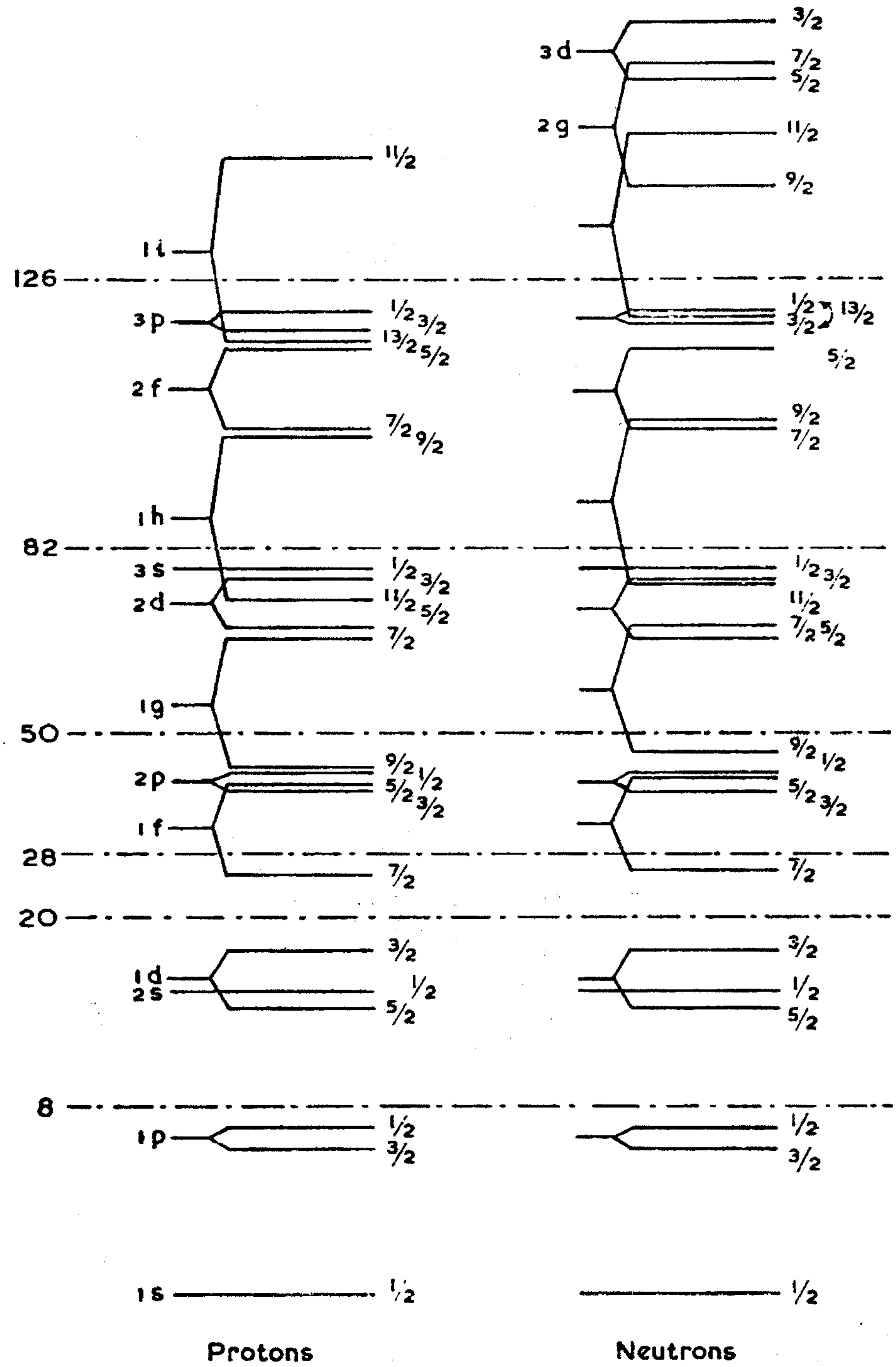


FIG. 5.6. PROTON AND NEUTRON LEVEL SCHEMES
[After Klinkenberg, P. F. A., *Revs. Mod. Phys.*, **24**, p. 63 (1952), Fig. 1.]

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Physics

2015/2016 ACADEMIC YEAR

Mid Year University Examinations

PHY 4221 - Solid State Physics I

Time Allowed: 3 Hours | Maximum Marks : 100

Instructions:

The paper contains 6 questions each carrying 25 marks.

Answer any 4 questions.

Show all your working to earn credit.

Write your computer number clearly on all the answer sheets.

Additional information can be found on the last page.

Question One

(a) Explain why polycrystalline materials are mostly isotropic. **[3]**

(b) Sketch two simple cubic lattices and show the $(1\bar{1}2)$ and (002)planes respectively. **[3]**

(c) Powder specimens of three monatomic cubic crystals are analysed with a Debye Scherrer camera. It is known that one sample is FCC, one is BCC and one has a diamond structure. The approximate positions of the first four diffraction rings in each case are shown in the table.

θ values for the samples

A	**B**	**C**
42.2	28.8	42.8
49.2	41.0	73.2
72.0	50.8	89.0
87.3	59.6	115.0

(i) Identify the crystal structures of A, B and C . **[8]**

(ii) If the wavelength of the incident X-ray beam is 0.15 nm, what is the length of the side of the conventional FCC and BCC? **[4]**

(d) In a van der Waals bonded solid where the equilibrium atomic spacing is $r_o = 4.5$Å, the binding energy is given by

$$U = -\frac{A}{r^6} + B\exp\left(\frac{-r}{\rho}\right)$$

where A, B and ρ are constants. If the attractive van der Waals energy has a magnitude ten times larger than the repulsive overlap energy at the equilibrium spacing r_o, find the value of the characteristic length ρ. **[7]**

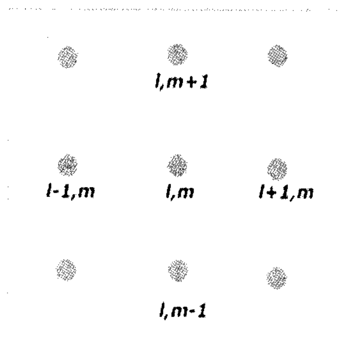
Question Two

(a) Define a phonon and draw the symbol. **[2]**

(b) What are normal and Umklapp processes? Explain with the help of vector diagrams. **[4]**

(c) Visible light of wavelength 400 nm undergoes scattering from a diamond crystal of refractive index 2.42. Calculate the maximum frequency of the phonon generated and the fractional change in the frequency of the incident radiation, given that the velocity of sound in diamond is 1.2 x 10^4 m/s. **[5]**

(d) Consider transverse vibrations of a planar lattice of rows and columns of identical atoms shown in the figure below, and let u_{lm} denote the displacement normal to the plane of the lattice of the atom in the l^{th} column and m^{th} row. The mass of each atom is M and C is the force constant for the nearest neighbour (N-N) atoms.



(i) Show that the equation of motion is

$$M\frac{d^2u_{l,m}}{dt^2} = C\left[(u_{l+1,m} + u_{l-1,m} - 2u_{lm}) + (u_{l,m+1} + u_{l,m-1} - 2u_{lm})\right]$$

[4]

(ii) Assume solutions of the form $u_{lm} = u\exp\left[i\left(lk_xa + mk_ya - \omega t\right)\right]$ where a is the spacing between the N-N atoms. Show that the equation of motion is satisfied if

$$\omega^2 M = 2C\left(2 - \cos k_xa - \cos k_ya\right)$$

[7]

(iii) For $ka \ll 1$, show that $\omega = \left(Ca^2/M\right)^{\frac{1}{2}} k^2$ **[3]**

Question Three

(a) What is the Fermi level? What does it signify? How does the Fermi level change with temperature? **[3]**

(b) How does a free electron gas differ from an ordinary gas? **[2]**

(c) Given that the energy of a free electron gas at the Fermi surface is $\epsilon_F = \frac{\hbar^2}{2m}k_F^2$, where m and k are the electron mass and wave vector, respectively:

(i) Derive an expression for the density of states $D(\epsilon)$ of the gas in three dimensions. **[7]**

(ii) Find an expression for the velocity and energy of electrons at the Fermi surface in terms of the concentration density ($n = \frac{N}{V}$). **[4]**

(d) For NaCl, the Na atom has an ionisation energy of 5.14 eV and the Cl atom has an electron affinity of of 3.61 eV. The equilibrium separation between the ion-pair is 0.282 nm:

(i) What is the total energy (cohesive energy) required to transfer an electron from Na to Cl? **[4]**

(ii) Given a NaCl crystal, what is the total energy (cohesive energy) required to separate it into neutral atoms? The Madelung constant is $\alpha = 1.75$. **[5]**

Question Four

(a) In reference to the electronic contribution to specific heat capacity in metals, only a small fraction of the total number of electrons are capable of being thermally excited. Why is it so? **[4]**

(b) At low temperatures, the Debye temperature of NaCl and KCl, which have the same crystal structure, are 300 K and 250 K respectively. The lattice heat capacity of KCl at 4 K is 4×10^{-2} J/mol.K. Estimate the lattice heat capacity of NaCl at 4 K. **[4]**

(c) Using the Debye approximation for a monatomic linear lattice,

(i) Derive an expression for the density of states and hence the total thermal energy of the system. **[4]**

(ii) Show that the heat capacity at a temperature $T \ll \theta_D$ (low temperature range) is proportional to T/θ_D. **[7]**

(ii) Show that for the high temperature range, the heat capacity is independent of temperature. **[6]**

Question Five

(a) What is the origin of metallic bonding and how does it differ from ionic bonding? **[2]**

(b) In the prediction of specific heat capacity of materials, what were the basic assumptions of the following models:

(i) The Dulong and Petit model. [2]

(ii) The Einstein model. [2]

(iii) The Debye model. [2]

(c) For Copper, the Debye temperature is 315 K, the Fermi energy is 7 eV and the number of valence electrons per atom is 1. At what temperature are the contributions from the lattice and electronic specific heats equal? [3]

(d) The primitive translation vectors of the hexagonal space lattice may be taken as $\mathbf{a}_1 = (3^{\frac{1}{2}}a/2)\hat{x} + (a/2)\hat{y}$; $\mathbf{a}_2 = -(3^{\frac{1}{2}}a/2)\hat{x} + (a/2)\hat{y}$ and $\mathbf{a}_3 = c\hat{z}$:

(i) Show that the volume of the primitive cell is $(3^{\frac{1}{2}}/2)a^2c$. [5]

(ii) Show that the primitive translations of the reciprocal lattice are $\mathbf{b}_1 = (2\pi/3^{\frac{1}{2}}a)\hat{x} + (2\pi/a)\hat{y}$; $\mathbf{b}_2 = -(2\pi/3^{\frac{1}{2}}a)\hat{x} + (2\pi/a)\hat{y}$ and $\mathbf{b}_3 = (2\pi/c)\hat{z}$. [9]

Question Six

(a) What is the origin of repulsive forces in inert crystals? [3]

(b) Show that a simple cubic lattice is self reciprocal but with different cell dimensions. [9]

(c) Consider a model one-dimensional chain of N atoms, equally spaced with separation a, and each with the same mass m. The force constant coupling each atom to its nearest neighbour is C. The dispersion relation arising from this is $m\omega^2 = 4C\sin^2(\frac{ka}{2})$ for $-\frac{\pi}{a} \leq k \leq \frac{\pi}{a}$.

(i) Derive an expression for the group velocity v_g as a function of the wave vector k. **[7]**

(ii) Using the results in (i), evaluate v_g at very small values of k $(k \to 0)$. Briefly discuss the physical significance of this low k group velocity. **[3]**

(iii) Using the results in (i) evaluate v_g for k at the Brillouin zone (BZ) boundary $(k = \frac{\pi}{a})$. Briefly discuss the physical significance of this BZ group velocity. **[3]**

Additional Information

Electron charge $e = 1.602 \times 10^{-19}$ C ; Planck's constant $h = 6.626 \times 10^{-34}$ J/s ; Boltzmann constant $k_B = 1.381 \times 10^{-23}$ J/K ; Avogadro's number $N_A = 6.022 \times 10^{23}$ /gmol

Ratios of $h^2 + k^2 + l^2$ values for allowed reflections from cubic crystals as obtained from extinction rules are:

SC: 1:2:3:4:5:6:8 : BCC: 2:4:6:8:10:12 or 1:2:3:4:5:6 : FCC: 3:4:8:11:12:16:19;: DC: 3:8:11:16:19

Direct lattice to reciprocal lattice: $\vec{b}_1 = 2\pi \frac{\vec{a}_2 \times \vec{a}_3}{\vec{a}_1 \cdot \vec{a}_2 \times \vec{a}_3}$; $\vec{b}_2 = 2\pi \frac{\vec{a}_3 \times \vec{a}_1}{\vec{a}_1 \cdot \vec{a}_2 \times \vec{a}_3}$; $\vec{b}_3 = 2\pi \frac{\vec{a}_1 \times \vec{a}_2}{\vec{a}_1 \cdot \vec{a}_2 \times \vec{a}_3}$

$\int_0^{+\infty} \frac{x}{e^x - 1}\, dx = 1.51$; $\int_0^{+\infty} \frac{x^3}{e^x - 1}\, dx = \frac{\pi^4}{15}$; $\int_{-\infty}^{+\infty} \frac{x^2 e^x}{(e^x + 1)^2}\, dx = \frac{\pi^2}{3}$;

Total phonon energy, $E = \frac{3}{5}\pi^4 N k_B \frac{T^4}{\theta_D^3}$; electron contribution to heat capacity, $C_e = \frac{\pi^2 k^2 N T}{2E_F}$

Density of states, $D(\omega) = \frac{L}{\pi}\frac{dk}{d\omega}$ in 1 dimension ; $D(\omega) = \frac{Vk^2}{2\pi^2}\frac{dk}{d\omega}$ in 3 dimensions

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Physics

2015/2016 ACADEMIC YEAR

University Examinations

PHY 4222 - Solid State Physics II

21 September 2016

Time Allowed: 3 Hours   Maximum Marks : 100

Instructions:

The paper contains 6 questions each carrying 25 marks.

Answer any 4 questions.

Show all your working to earn credit.

Write your computer number clearly on all the answer sheets.

Additional information can be found on the last page.

Question One

(a) In superconductivity, what is meant by the terms upper critical field and lower critical field and what is the condition for a superconductor to exhibit these critical fields, rather than one single critical field. **[6]**

(b) The transition from the normal to the superconducting state results in a discontinuity in specific heat capacity. The change is given by

$$c_n - c_s = \frac{T_c}{4\pi}\left[\left(\frac{dH_c}{dT}\right)^2 + \left(\frac{d^2H_c}{dT^2}\right)\right]$$

If $T_c = 1.18K$, $H_c(0) = 99$ Gauss and $\gamma = 1.35 \times 10^{-3}$ joules/mol.K^2. Calculate the fractional change in specific heat capacity for Aluminum at T_c. **[10]**

(c) The resistivity of an intrinsic semiconductor is 4.5 ohm-m at 293 K and 2.0 ohm-m at 305 K. What is the energy band gap? . **[9]**

Question Two

(a)

(i) What is spontaneous magnetization? **[2]**

(ii) According to the Weiss field theory what is the cause of the macroscopic magnetic properties of materials? **[3]**

(b) The total exchange energy of a system of atoms when the applied field is directed in the z-axis is $U_i = -\frac{2J_e z M S_{zi}}{g\mu_B N}$ or $U_i = -\mu_B g S_{zi} B_E$ for contributions from nearest neighbour atoms only. Here J_e is the exchange integral, z is the number of nearest neighbour atoms, M is the magnetization, B_E is the exchange field, N is the number of atoms per unit volume, g is the *Lande's* g-factor and S_{zi} is the instantaneous value of a neighbouring spin.

(i) Show that the exchange integral (coefficient) J_e is given by

$$Je = \frac{3kT_C}{2zS(S+1)}$$

for a ferromagnet with Curie temperature T_C. Each atom has z identical nearest neighbours and each has spin S. **[8]**

(ii) Calculate the exchange integral for nickel (Ni^{28}) which has a face centred cubic structure (with lattice constant 3.52 Angstroms) and a Curie temperature of 631 K. **[5]**

(ii) Calculate the internal field. **[3]**

(c) Discuss the difference between direct and indirect band gaps. You can draw the pertinent diagrams. **[4]**

Question Three

(a) What is the difference between a conductor cooled to 0 K and a superconductor? Explain in terms of the Meissner effect and the disappearance of resistivity. **[5]**

(b) What are the differences between an *Antiferromagnet* and a *Ferrimagnet?* Supplement your brief answer with pertinent diagrams. **[4]**

(c) Nickel has an atomic number of 28. Compute the effective number of Bohr magnetons for the nickel ion Ni^{2+} if the orbital angular momentum

(i) is not quenched. **[5]**

(ii) is quenched. **[3]**

(d) The London penetration depths for a superconductor at 3K and at 7 K are 39.6 nm and 173 nm respectively. Show that the superconducting transition temperature is 7.19 K. **[8]**

Question Four

(a) How is the Josephson effect applied in quantum computing? **[4]**

(b) What is diamagnetism and explain why it has a negative susceptibility? Derive it mathematically if necessary. **[4]**

(c)

(i) Show that for the tightly bound electron approximation, the energy dispersion $E(k) = E_o - \gamma_o - \gamma\sum_j \exp\{i\vec{k} \bullet \vec{r_j}\}$ for a simple cubic system of lattice constant a reduces to

$E(\vec{k}) = E_o - \gamma - 2\gamma(\cos k_x a + \cos k_y a + \cos k_z a)$ where $\vec{r}_j$ is the vector from one atom to the jth nearest neighbour atom. **[9]**

(ii) Show that for small values of k the energy varies as k^2 and hence find the expression for the effective mass of the electron. **[4]**

(iii) Determine the maximum energy range for this dispersion. **[4]**

Question Five

(a)

(i) Explain the difference between the terms *Curie* temperature and *Neel* temperature. **[4]**

(ii) Why are metallic bodies opaque? **[6]**

(b) Show that for an electron revolving around the nucleus with frequency, ω_o, the frequency of an electron changes by a factor of $\frac{eB}{2m}$when a magnetic induction **B** is applied perpendicular to the orbit of radius r, i.e

$$\omega = -\frac{eB}{2m} \pm \omega_o$$

[9]

(c) In the tight binding approximation the wave function, $\Psi_k(\vec{r})$, for an electron in a crystal lattice is obtained by taking a linear combination of atomic wave functions $\varphi(\vec{r})$. Show that the form

$$\Psi_k(\vec{r}) = \sum_j C_{kj}\varphi(\vec{r} - \vec{r_j})$$

where $C_{kj} = N^{\frac{1}{2}}e^{i\vec{k}\cdot\vec{r}}$ for a crystal of, N, atoms satisfies the Bloch law

$$\Psi_k(\vec{r} + \vec{T}) = e^{i\vec{k}\cdot\vec{r}}\psi_k(\vec{r})$$

where, $\vec{T}$, is the lattice translation vector. **[6]**

Question Six

(a) Unlike in normal magnetic materials where two magnets will either repel or attract when brought into proximity, a superconductor when brought near a magnet will **attract and repel** at the same time. Describe the respective phenomena responsible for repulsion and attraction. **[4]**

(b) For a lightly doped semiconductor

(i) Show that the conductivity is minimum when the impurity is p-type such that

$$p_o = n_i\sqrt{\frac{\mu_n}{\mu_p}}$$

where p_o is the hole concentration which gives minimum conductivity. **[4]**

(ii) Show that the minimum conductivity is $2n_ie\sqrt{\mu_n\mu_p}$. **[4]**

(iii) If the electron mobilities in a silicon sample are 0.135 and 0.048 m^2/V-s respectively and $n_i = 1.5 \times 10^{16}$atoms/m^3 at 300 K, determine the minimum conductivity of silicon and compare it with the intrinsic conductivity. **[4]**

(c) The critical fields at 14 K and 13 K for a superconductor are 0.14 MA/m and 0.42M A/m respectively. Determine the transition temperature and the critical field at 0 K. **[5]**

– END OF EXAMINATION–

Additional Information

1. Electron charge $e = 1.602 \times 10^{-19}$ C ;
2. Planck's constant $h = 6.626 \times 10^{-34}$ J/s ;
3. Boltzmann constant $k_B = 1.381 \times 10^{-23}$ J/K ;
4. Avogadro's number $N_A = 6.022 \times 10^{23}$ /gmol
5. electrical conductivity, $\sigma = e\,[n\mu_n + p\mu_p]$,
6. superconducting critical field, $H_C = H_C(0)\left[1 - \frac{T^2}{T_C^2}\right]$,
7. flux penetration at the surface of a superconductor, $H(x) = H(o)\exp(-\frac{x}{\lambda_L})$,
8. $\lambda_L(T) = \lambda_L(0)\left[1 - \frac{T^4}{T_C^4}\right]^{-0.5}$,
9. Change in specific heat capacity from normal to superconducting state, $c_n - c_s = \frac{T_c}{4\pi}\left[\left(\frac{dH_c}{dT}\right)^2 + H_c\left(\frac{d^2H_c}{dT^2}\right)\right]$
10. Maxwell equation, $\nabla \times E = -\frac{\partial B}{\partial t}$,
11. *Lande's* g factor, $g = 1 + \frac{J(J+1)+S(S+1)-L(L+1)}{2J(J+1)}$,
12. Specific heat, $C = \gamma T + \beta T^3$
13. Effective number of Borh magnetons, $P_{eff} = g\sqrt{J(J+1)}$,
14. Internal Field, $B_E = \lambda M$.
15. Magnetisation, $M = \frac{Ng\mu_B x(J+1)}{3}$, $x = \frac{g\mu_B J(B+\lambda M)}{kT}$,
16. Susceptibility, $\chi = \frac{C}{T-T_C}$, $C = \frac{\mu_o T_C}{\lambda}$,
17. Curie temperature, $T_C = \frac{\lambda N g^2 \mu_B^2 J(J+1)}{3k}$

18. Effective mass of an electron, $m^{\star} = \frac{\hbar}{\frac{\partial^2 E}{\partial k^2}}$,

19. Lorentz force, $\vec{F} = e(\vec{v} \times \vec{B})$

The University of Zambia

Department of Physics

Final Examination PHY 4242, September 2016

All questions carry equal marks. The marks are shown in brackets.

Time: 3 hours. **Maximum marks = 100**

Instructions:

Attempt any 5 questions, all questions carry equal marks

Useful Equations:

$$\mathrm{SI}=\frac{4500}{\left(v/c\right)^2} \quad : \quad \frac{\text{Radiation energy loss}}{\text{Ionisation energy loss}}=\frac{E_kZ}{820} \quad : \quad I=I_oe^{-\mu x} \quad : \quad \mathrm{HVL}=\frac{\ln 2}{\mu}$$

$$\mu_{\mathrm{en}}=\mu\frac{E_a}{h\nu} \quad : \quad \lambda=\frac{1.24}{h\nu} \quad : \quad \Delta\lambda=0.00243(1-\cos\phi) \quad : E_{\max}=h\nu_{\max}=\frac{hc}{\lambda_{\min}}$$

$$\Phi=\frac{N}{A} \quad : \quad \phi=\frac{\Phi}{t}=\frac{N}{A.t} \quad : \quad \Psi=\Phi E=\frac{NE}{A} \quad : \quad I=\psi=\phi E=\frac{NE}{At}$$

$$I=\psi=\sum_{i=1}^{m} f_i\phi E_i \quad : \quad X=\frac{Q}{m} : \quad \frac{\Phi}{X}=\frac{2.11\times10^{14}}{h\nu\left(\mu_{en}\right)_m} \quad : \quad D(\mathrm{Gy})=\frac{E/m}{1\mathrm{J/kg}}$$

$$\mathrm{DE}(\mathrm{Sv})=D(\mathrm{Gy})\times\mathrm{QF} \quad : \quad \mathrm{ED}(\mathrm{mSv})=D(\mathrm{mGy})\times W_R \quad : \quad E=JW$$

$$\Psi=\frac{JW}{\rho\left(\mu_{en}\right)_m} \quad : \quad \frac{V}{X}=\frac{1.29v}{C+C_e}$$

Constants:

$W=33.85\mathrm{eV}$ **:** Avagadro's number = 6.023 10^{23} : 1R = 2.58 x 10^{-4}C/kg-air
1 R = 1electrostatic unit (ESU)/0.001293 g air = 1 ESU/cm^3 air at STP

1Gy = 1 J/kg : 1 R = 0.869 rad in air : 1C/kg = 33.85 J/kg

Q 1 **a)** Draw a well labeled schematic diagram of a simple self-rectified x-ray circuit showing how the tube voltage and current may be controlled. [10]

b) Explain the functioning of each component in the above diagram in producing x-rays. [10]

Q 2 **a)** Explain with the aid of a diagram how you would measure the apparent focal spot of an x-ray tube with a pin-hole camera; take into consideration the dimensions of the actual focal spot in the x-ray tube. [10]

b) An apparent focal spot of 1 mm is projected from an x-ray tube. The true focal is 5 mm.

i) What is the target angle? [5]

ii) Why is the heel effect greater in an x-ray beam from a target with a small angle? [3]

iii) Explain why x-ray tube target material affects the efficiency of x-ray production [2]

Q 3 **a)** A chest x-ray uses 10^{15} photons to expose film with an area of 30 cm x 40 cm during an exposure of 0.15 second. Assume all photons have energy of 70 keV. Find:

i) The photon fluence
ii) The photon flux.
iii) The energy fluence, and
iv) The intensity I. [9]

b) A dose of 60 Gy is delivered uniformly to a 150 g mass of soft tissue. How much energy in joules is absorbed by each gram of tissue and by the entire tissue mass? [5]

c) Give a brief explanation of the principles on which the following dosimetry systems are based:

i) Calorimetric;

ii) chemical; and

iii) thermoluminescence. [6]

Q 4 **a).**Copper has a density of 8.9 g/cm^3 and a molecular mass of 63.56. The total attenuation of copper is 8.5 x 10^{-24} cm^2/atom for 450 keV photons. What thickness (in cm) of copper is required to attenuate 40 keV photons to a quarter of the original number? [7]

b) A thimble chamber with an air-equivalent wall receives an exposure of 0.015 C/kg in one minute. The volume of the chamber is 0.46 cm^3.What is the ionization current from the chamber? [5]

c) i) Perspex is normally used as tissue equivalent material to make measurements and it has a density of 1.19 g/cm^3.The composition of Perspex is given below, calculate the approximate effective atomic number of this material. [5]

Atomic number	**Fraction by weight**
1	0.080538
6	0.599848
8	0.319614

ii) Name any three corrections that are usually applied to measurements with a free-air ionization chamber. [3]

Q 5 **a)** Draw a well labeled diagram of a free air-ionization chamber and explain its operation. [10]

b) A Condenser ionisation chamber has a sensitivity of 7750 v/C-kg. The volume of the chamber is 0.46 cm^3. The capacitance is six times the capacitance of the charger-reader. What is the capacitance of the chamber? [10]

Q 6 **a)** A 200 keV photon is scattered at an angle of 75^0 during a Compton interaction. What are the energies of the scattered photon and the Compton electron? [10]

b) The tenth-value layer is the thickness of slab of matter necessary to attenuate the beam of x or γ rays to one tenth of the intensity with no attenuation present. Assuming good geometry and mono-energetic photons, show that the tenth value layer equals 2.30/μ, where μ is the total linear attenuation coefficient. [5]

c) Attenuation measurements for an x-ray beam from 120 kVp x-ray generator yield the following results:

Added filtration (mmAl)	Percent transimission
1.0	60.2
2.0	41.4
3.0	30.0
4.0	22.4
5.0	16.9

Plot the data on a semi-log graph paper and determine the following:

i) The first HVL.

ii) The second HVL.

iii) The homogeneity coefficient of the x-ray beam. [5]

End of Exam

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF PHYSICS

2015/16 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATION

PHY4422: DIGITAL ELECTRONICS II

TIME: THREE HOURS MAXIMUM MARKS : 100

Attempt ANY FOUR questions
All questions carry equal marks.
The marks are shown in brackets.

Q1. (a) What are the internal data operations of a microprocessor? [5]

(b) Explain the various flags in the flag register of a microprocessor, giving examples of each. Show the bit positions of each flag in the flag register. [12]

(c) Explain the functions of the following signals of a microprocessor. [8]

(i) RESET (ii) INTERRUPT (iii) READY (iv) HOLD

Q2. (a) (i) Explain what is meant by "don't care conditions" in Karnaugh map techniques. [3]

(ii) Reduce the following expression using the Karnaugh map. [10]

$$F= \Sigma m\ (3,4,7,9,10,11) + d(0,1,2,13,14,15)$$

(b) Find the minimum Product-Of-Sums (POS) expression for the following function. [8]

$$F= \prod M\ (3,5,7,8,10,11,12,13)$$

(c) Write short notes on

(i) Minterm and (ii) Maxterm [4]

Give an example of each.

Q3 (a) Explain the differences between a compiler and an interpreter? [6]

(b) Explain the differences between the instructions MOV R, M and LDAX Rp with an example. [8]

(c) (i) Write the instruction and machine code to rotate the contents of the accumulator left through carry, assuming that the accumulator has A7H and the carry flag is reset. Which instruction is used to restore the original contents of the accumulator? Illustrate using figures. [7]

(ii) Write short notes on cache memory. [4]

Q4. (a) (i) Define memory map of a computer. Explain the memory map of a (32K ×8) memory chip. Illustrate using a figure. [13]

(ii) Explain how the memory map can be changed by modifying the hardware of the chip select $\overline{CS}$ line. [7]

(b) What do you understand by "word length" of a computer? Explain with examples. [5]

Q5 (a) The design of a function generator of three inputs should implement the following logic functions using AND, OR, NAND, NOR, XOR, and XNOR.

Using connection abbreviations, show how these functions can be programmed on a Field Programmable Logic Array (FPLA) circuit. [11]

$$F_1 = ABC$$
$$F_2 = A + B + C$$
$$F_3 = \overline{ABC}$$
$$F_4 = \overline{A + B + C}$$
$$F_5 = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$$
$$F_6 = AB\bar{C} + \bar{A}BC + A\bar{B}C + A\bar{B}\bar{C}$$

(b) Simplify the Sum-Of-Product expression below, providing a result in Product-Of-Sums (POS) form. Draw the logic circuit for the simplified expression using basic logic gates. [10+4]

$$X = \bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}CD + \bar{A}B\bar{C}\bar{D} + \bar{A}B\bar{C}D + \bar{A}BCD + AB\bar{C}\bar{D} + AB\bar{C}D + ABCD$$

Q6. A system is designed to monitor the voltage of a circuit. A set of voltage readings are stored in memory locations starting at 8040H. The end of data string is indicated by the data byte 00H. The readings are expected to be positive. Draw a flowchart and write a program to

(i) check each reading to determine whether it is positive or negative
(ii) reject all negative readings
(iii) add all positive readings
(iv) store FFH in memory location when the sum exceeds 8-bits to indicate "ERROR"; otherwise store the sum

Use the instruction set of 8085 microprocessor for writing the assembly language program.

END OF PHY4422 EXAMINATION

8085 / 8080A Instruction summary by Functional Groups

DATA TRANSFER (COPY)

Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic
40	MOV B,B	58	MOV E,B	70	MOV M,B	1A	LDAX D
41	MOV B,C	59	MOV E,C	71	MOV M,C	2A	LHLD
42	MOV B,D	5A	MOV E,D	72	MOV M,D	3A	LDA
43	MOV B,E	5B	MOV E,E	73	MOV M,E	02	STAX B
44	MOV B,H	5C	MOV E,H	74	MOV M,H	12	STAX D
45	MOV B,L	5D	MOV E,L	75	MOV M,L	22	SHLD
46	MOV B,M	5E	MOV E,M	77	MOV M,A	32	STA
47	MOV B,A	5F	MOV E,A	78	MOV A,B	01	LXI B
48	MOV C,B	60	MOV H,B	79	MOV A,C	11	LXI D
49	MOV C,C	61	MOV H,C	7A	MOV A,D	21	LXI H
4A	MOV C,D	62	MOV H,D	7B	MOV A,E	31	LXI SP
4B	MOV C,E	63	MOV H,E	7C	MOV A,H	F9	SPHL
4C	MOV C,H	64	MOV H,H	7D	MOV A,L	E3	XTHL
4D	MOV C,L	65	MOV H,L	7E	MOV A,M	EB	XCHG
4E	MOV C,M	66	MOV H,M	7F	MOV A,A	D3	OUT
4F	MOV C,A	67	MOV H,A	06	MVI B	DB	IN
50	MOV D,B	68	MOV L,B	0E	MVI C	C5	PUSH B
51	MOV D,C	69	MOV L,C	16	MVI D	D5	PUSH D
52	MOV D,D	6A	MOV L,D	1E	MVI E	E5	PUSH H
53	MOV D,E	6B	MOV L,E	26	MVI H	F5	PUSH PSW
54	MOV D,H	6C	MOV L,H	2E	MVI L	C1	POP B
55	MOV D,L	6D	MOV L,L	36	MVI M	D1	POP D
56	MOV D,M	6E	MOV L,M	3E	MVI A	E1	POP H
57	MOV D,A	6F	MOV L,A	0A	LDAX B	F1	POP PSW

ARITHMETIC

Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic
80	ADD B	CE	ACI	D6	SUI	23	INX H
81	ADD C	90	SUB B	DE	SBI	33	INX SP
82	ADD D	91	SUB C	09	DAD B	05	DCR B
83	ADD E	92	SUB D	19	DAD D	0D	DCRC
84	ADD H	93	SUB E	29	DAD H	15	DCR D
85	ADD L	94	SUB H	39	DAD SP	1D	DCR E
86	ADD M	95	SUB L	27	DAA	25	DCR H
87	ADD A	96	SUB M	04	INR B	2D	DCR L
88	ADC B	97	SUB A	0C	INR C	35	DCR M
89	ADC C	98	SBB B	14	INR D	3D	DCR A
8A	ADC D	99	SBB C	1C	INR E	0B	DCX B
8B	ADC E	9A	SBB D	24	INR H	1B	DCX D
8C	ADC H	9B	SBB E	2C	INR L	2B	DCX H
8D	ADC L	9C	SBB H	34	INR M	3B	DCX SP
8E	ADC M	9D	SBB L	3C	INR A		
8F	ADC A	9E	SBB M	03	INX B		
C6	ADI	9F	SBB A	13	INX D		

LOGICAL

Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic
37	STC	A9	XRA C	B3	ORA E	BD	CMP L
A0	ANA B	AA	XRA D	B4	ORA H	BE	CMP M
A1	ANA C	AB	XRA E	B5	ORA L	BF	CMP A
A2	ANA D	AC	XRA H	B6	ORA M	FE	CPI
A3	ANA E	AD	XRA L	B7	ORA A	07	RLC
A4	ANA H	AE	XRA M	F6	ORI	0F	RRC
A5	ANA L	AF	XRA A	B8	CMP B	17	RAL
A6	ANA M	EE	XRI	B9	CMP C	1F	RAR
A7	ANA A	B0	ORA B	BA	CMP D	2F	CMA
E6	ANI	B1	ORA C	BB	CMP E	3F	CMC
A8	XRA B	B2	ORA D	BC	CMP H		

BRANCHING

Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic
C3	JMP	D7	RST 2	EC	CPE
C2	JNZ	DF	RST 3	F4	CP
CA	JZ	E7	RST 4	FC	CM
D2	JNC	EF	RST 5	C9	RET
DA	JC	F7	RST 6	C0	RNZ
E2	JPO	FF	RST 7	C8	RZ
EA	JPE	CD	CALL	D0	RNC
F2	JP	C4	CNZ	D8	RC
FA	JM	CC	CZ	E0	RPO
E9	PCHL	D4	CNC	E8	RPE
C7	RST 0	DC	CC	F0	RP
CF	RST 1	E4	CPO	F8	RM

CONTROL

Hex	Mnemonic
00	NOP
76	HLT
F3	DI
FB	EI
20	RIM
30	SIM

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS – 2015/16
PHY4815 - PHYSICS OF RENEWABLE ENERGY RESOURCES AND ENVIRONMENT

TIME: 3 HOURS MAX MARKS: 100

ATTEMPT ANY **FOUR** (4) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS. THE MARKS ARE SHOWN IN SQUARE BRACKETS.

You may use the following information:

Boltzmann constant k	$= 1.38 \times 10^{-23}$ JK^{-1}
Gas constant R	= 8314 J/kmol.K
1 electron volt	$= 1.6 \times 10^{-19}$ J
Stefan's constant σ	$= 5.67 \times 10^{-8}$ W/m^{2}K^4
Sun's radius R_s	$= 6.96\times10^8$m
Mean Earth-Sun distance r_0	$= 1.496\times10^{11}$m
Solar constant I_{sc}	= 1367 Wm^{-2}
Earth's radius R_e	$= 6.37\times10^6$m
Planck's constant h	$= 6.6 \times 10^{-34}$J.s
Speed of light c	$= 3.0 \times 10^8$m.s^{-1}

In the usual notation

$$E_0 = \left(\frac{r_0}{r}\right)^2 = 1 + 0.033\cos\left(\frac{360\, d_n}{365}\right)$$

$$\delta = 23.45° \sin\left[\frac{360}{365}(d_n + 284)\right]$$

$$\cos\theta_z = \sin\delta\sin\phi + \cos\delta\cos\phi\cos\omega$$

$$\tan\psi = \frac{\cos\delta\sin\omega}{\cos\delta\sin\phi\cos\omega - \sin\delta\cos\phi}$$

$$\cos\psi = \frac{\sin\alpha\ \sin\varphi - \sin\delta}{\cos\alpha\ \cos\varphi}$$

$$\begin{aligned}\cos\theta = {} & (\sin\varphi\cos\beta - \cos\varphi\sin\beta\cos\gamma)\sin\delta \\ & + (\cos\varphi\cos\beta + \sin\varphi\sin\beta\cos\gamma)\cos\delta\cos\omega \\ & + \cos\delta\sin\beta\sin\gamma\sin\omega\end{aligned}$$

$$\omega = 15^{\circ}(12 - t); \quad \omega_s = \cos^{-1}(-\tan\phi\tan\delta)$$

Solar time = clock time + $4(L_l - L_s)$ min + EOT

Wien's Law: $\lambda_{max} T = 2898$ μm.K

The emissive power of a black body $B_\lambda(T)$ (in W/m^2 per unit wavelength range) is

$$B_\lambda(T) = \frac{2\pi hc^2}{\lambda^5\left(e^{\frac{hc}{\lambda kT}} - 1\right)}$$

Direct flux on an inclined surface

$$F^{dir} = I_{sc}\cos\theta\exp\left(-\frac{\tau}{\cos\theta_z}\right)$$

The convective heat flux from a plate to a glazing

$$J = h_d(T_2 - T_1)$$

In a single heat exchanger the exit temperature is

$$T_{f,e} = T_B - (T_B - T_{f,i})\exp\left(-\frac{U_L L}{\dot{m} C_f}\right),$$

and the heat extraction rate is

$$\dot{Q} = \dot{m} C_f (T_B - T_{f,i})\left[1 - \exp\left(-\frac{U_L L}{\dot{m} C_f}\right)\right].$$

Fresnel's equations

$$r_{\parallel} = \left[\frac{n_r^2 \cos\theta_i - n_i\sqrt{n_r^2 - n_i^2 \sin^2\theta_i}}{n_r^2 \cos\theta_i + n_i\sqrt{n_r^2 - n_i^2 \sin^2\theta_i}}\right]^2$$

$$r_{\perp} = \left[\frac{n_i \cos\theta_i - \sqrt{n_r^2 - n_i^2 \sin^2\theta_i}}{n_i \cos\theta_i + \sqrt{n_r^2 - n_i^2 \sin^2\theta_i}}\right]^2$$

Overall reflectance and transmittance of a single glazing are

$$R = r\left[1 + \frac{\alpha^2(1-r)^2}{1-\alpha^2 r^2}\right]$$

$$T = \frac{\alpha(1-r)^2}{1-\alpha^2 r^2}$$

The carrier concentration in an intrinsic semiconductor is

$$n_i = p_i = AT^{3/2} exp\left(-\frac{\varepsilon_g}{2kT}\right)$$

The resistivity of an extrinsic material is

$$\rho = \frac{1}{e(n\mu_n + p\mu_p)}$$

The reverse saturation current density is

$$J_0 = DT^3 \exp\left(-\frac{\varepsilon_g}{kT}\right)$$

The forward current density is

$$J = J_0\left[\exp\left(\frac{eV}{kT}\right) - 1\right]$$

The J-V characteristic equation for a single cell is

$$J = \overline{K}\,F - J_0\left(e^{\frac{eV}{kT}} - 1\right)$$

Yearly variation of the equation of time

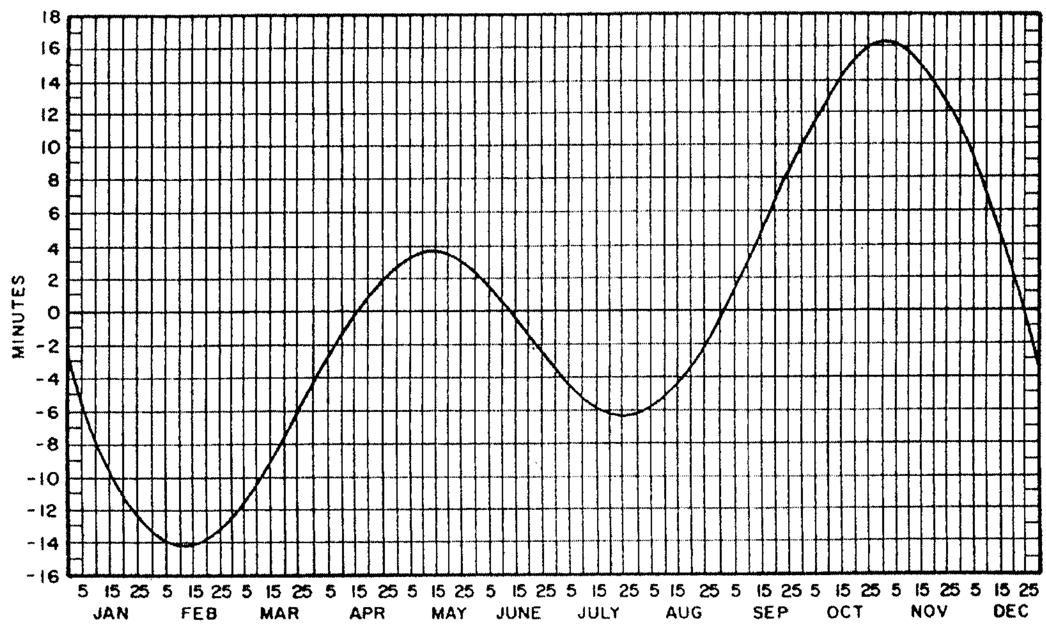


TABLE *The function $f(x)$*

$x(\mu m\text{-}K)$	$f(x)$	$x(\mu m\text{-}K)$	$f(x)$	$x(\mu m\text{-}K)$	$f(x)$
1100	0.001	4600	0.580	8100	0.860
1200	0.002	4700	0.594	8200	0.864
1300	0.004	4800	0.608	8300	0.868
1400	0.008	4900	0.621	8400	0.871
1500	0.013	5000	0.634	8500	0.875
1600	0.020	5100	0.646	8600	0.878
1700	0.029	5200	0.658	8700	0.881
1800	0.040	5300	0.669	8800	0.884
1900	0.052	5400	0.680	8900	0.887
2000	0.067	5500	0.691	9000	0.890
2100	0.083	5600	0.701	9100	0.893
2200	0.101	5700	0.711	9200	0.895
2300	0.120	5800	0.720	9300	0.898
2400	0.140	5900	0.730	9400	0.901
2500	0.161	6000	0.738	9500	0.903
2600	0.183	6100	0.746	9600	0.905
2700	0.205	6200	0.754	9700	0.908
2800	0.228	6300	0.762	9800	0.910
2900	0.251	6400	0.770	9900	0.912
3000	0.273	6500	0.776	10000	0.914
3100	0.296	6600	0.783	11000	0.932
3200	0.318	6700	0.790	12000	0.945
3300	0.340	6800	0.796	13000	0.955
3400	0.362	6900	0.802	14000	0.963
3500	0.383	7000	0.808	15000	0.969
3600	0.404	7100	0.814	16000	0.974
3700	0.424	7200	0.819	17000	0.978
3800	0.443	7300	0.824	18000	0.981
3900	0.462	7400	0.830	19000	0.983
4000	0.483	7500	0.834	20000	0.986
4100	0.499	7600	0.840	30000	0.995
4200	0.516	7700	0.844	40000	0.998
4300	0.533	7800	0.848	50000	0.999
4400	0.549	7900	0.852		
4500	0.564	8000	0.856		

Q.1.

(a)

(i) Define the solar constant. [2]

(ii) Given the value of the solar constant on the Earth to be 1367 W/m^2, find its value on Jupiter, which is at a distance from the Sun five (5) times the average Earth-Sun distance. [3]

(iii) Define equatorial plane, ecliptic plane, and angle of declination [3]

(iv) Using the given analytical expression and average value of the Earth-Sun distance, calculate the Earth-Sun distance on 12th September. [3]

(v) If the Earth's orbit round the Sun were perfectly circular and the Earth's axis normal to the ecliptic plane, what changes will happen? [2]

(b) For Lusaka, the latitude is 15°S, the longitude 28°30' E and the standard meridien is 30° East of the Greenwich. Calculate the following at 11 a.m. clock time on 12th September.

(i) the solar declination [3]
(ii) solar time [3]
(iii) hour angle [2]
(iv) the sun-rise hour angle [2]
(v) the day length [2]

Q.2

(a) (i) What do you understand by "stagnant condition" as referred to a collector? [2]

(ii) Write down the equation of energy balance under non-steady conditions of such a collector and solve it to show that

$$T_p - T_a = \frac{F_{abs}}{U_c}\left[1 - \exp\left(-\frac{U_c t}{C_A}\right)\right],$$

[10]

(iii) What will be the value of $T_p - T_a$ under steady-state stagnant conditions? [2]

(iv) What is the time constant of the collector and what is its physical significance? [4]

(b) An absorber plate of a collector is made of copper ($C = 389$ J/kg-°C) and has an area of 3 m^2 and a mass of 30 kg. The overall heat transfer coefficient to the surroundings is U_c=8 W/m^2.

(i) Find the time constant of the collector. [3]

(ii) If the insolation suddenly changes from zero to some constant value, how much time will it take for (T_p-T_a) to reach 80% of the stagnant limit? [4]

Q.3 A flat-plate solar heating panel contains two glazings with T_p=80°C and T_{sky}=T_a=30°C. The coefficients for heat transfer from the plate to the inner glazings are $U_{d,1}^{(c)}$= 3 W/m^2-°C and $U_{d,1}^{(r)}$=5W/m^2-°C. Those for heat transfer from one glazing to the other are $U_{d,2}^{(c)}$= 2.5 W/m^2-°C and $U_{d,2}^{(r)}$= 6 W/m^2-°C. The coefficients for heat transfer from the outer glazing are $U_\infty^{(c)}$= 8 W/m^2-°C and $U_\infty^{(r)}$= 7 W/m^2-°C.

(i) Draw the equivalent resistor network to represent the system, clearly showing the values of the heat transfer coefficients on each of the resistors. [5]

(ii) Find the overall heat transfer coefficient for the system, [6]

(iii) Find the flux loss from the absorber [2]

(iv) Find the temperature of each glazing [4]

(v) Find the flux loss from the absorber if the space between the two glazings as well as space between the inner glazing and the plate has vacuum. [8]

Q.4

(a) A pipe carrying water passes through a tank containing fluid at a given constant temperature. Describing the physics involved, obtain, in terms of the rate of flow of water, the inlet temperature of water, the length of the tank and the heat transfer coefficient for the pipe, steady state expressions for

(i) the exit temperature of the water, and [13]

(ii) the rate of heat extracted. [3]

(b) Water (C=4186J/Kg-°C) enters a long convoluted pipe at a temperature of 10°C. The walls of the pipe are maintained at 50°C by a heat bath. The pipe is 3m long and carries water at a rate of 10g/s. The flow is laminar and the average heat transfer coefficient is U_L=6W/m-°C. Find

(i) the temperature of the water when it exits, and [5]

(ii) the heat extraction rate. [4]

Q. 5 (a) Show that the optical efficiency of a single glazing absorber system is given by

$$\eta_{opt} = \frac{A_p T_g}{1-(1-A_p)R_g}$$

[8]

(b) A single glazing panel has the following specifications

thermal efficiency of the panel = 0.7
plate absorptance = 0.9
extinction coefficient k for the glazing = 0.1 cm^{-1}
thickness of the glazing = 0.5 cm
refractive index of the glazing = 1.5
surface reflectance r of the glazing = 0.04

If a direct solar beam is incident at an angle of 30° on the panel, calculate

(i) the bulk transmittivity of the glazing [5]
(ii) the overall transmittance of the glazing [3]
(iii) the overall reflectance of the glazing [3]
(iv) the optical efficiency of the glazing-absorber system [3]
(v) the overall efficiency of the heating panel [3]

Q. 6 (a) Consider a semiconductor with band gap $\varepsilon_g = 0.75$ eV.

(i) Find the cut off wavelength λ_c for the semiconductor. [3]

(ii) Find the maximum fraction of the solar spectrum (6000K) that can possibly be harnessed by the semiconductor photovoltaic. [3]

(iii) If the spectral responsivity is equal to $K_\lambda = 0.1$ A/W for $0 < \lambda < 1$ μm and $K_\lambda = 0.3$ A/W for 1 μm $< \lambda < \lambda_c$, find the average responsivity for the solar spectrum and calculate the photocurrent density at a flux of 1 Sun. [6]

(b) A PV array has 200 circular cells each with diameter of 10 cm. The array has 10 parallel strings each with 20 cells in series. If $\overline{K}$ =25mA.cm^{-2}.Sun^{-1}, $J_0 = 5\text{x}10^{-10}$ mA.cm^{-2} and $T = 300$ K,

(i) Using the J-V characteristic equation for a single cell, obtain the I-V characteristic equation for the array [6]
(ii) Find the open circuit voltage of the array for a radiation of 1 Sun. [5]
(iii) Find the short circuit current for a radiation of 1 Sun. [2]

------------------- END OF THE EXAMINATION -------------------