

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2009 FIRST SEMESTER EXAMINATIONS

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|---------------|---|
| 1. BS 349 | - MICROBIOLOGY (THEORY PAPER) |
| 2. BS 411 | -INSECT BEHAVIOUR AND ECOLOGY (THEORY PAPER 1&2) |
| 3. BS 491 | -FRESH WATER BIOLOGY (THEORY PAPER) |
| 4. BIO 1011 ✓ | -CELLS AND BIOMOLECULES (THEORY PAPER) |
| 5. BIO2051 | -DIVERSITY OF PLANTS (THEORY PAPER) |
| 6. BIO2041 | -BASIC PHYSIOLOGY (THEORY PAPER) |
| 7. BIO2075 | -ECOSYSTEMS AND DIVERSITY (THEORY PAPER) |
| 8. C 101 | -INTRODUCTION TO CHEMISTRY 1 |
| 9. C 205 | -ANALYTICAL AND INORGANIC CHEMISTRY |
| 10. C 225 | -ANATICAL CHEMISTRY 1 |
| 11. C 245 | -INORGANIC CHEMISTRY 1 |
| 12. C 251 | -ORGANIC CHEMISTRY |
| 13. CAV251 | -AGRICULTURE AND VETERINARY CHEMISTRY |
| 14. C 341 | -INORGANIC CHEMISTRY 2 |
| 15. C 351 | -ORGANIC CHEMISTRY 1 |
| 16. C 361 | -CHEMICAL KINETICS AND NUCLEAR CHEMISTRY |
| 17. C 411 | -ADVANCED BIOCHEMISTRY 1 |
| 18. C 451 | -ADVANCED ORGANIC CHEMISTRY |
| 19. C 461 | -QUANTUM MECHANICS AND MOLECULAR SPECTROSCOPY |
| 20. C 481 | -INORGANIC INDUSTRIAL CHEMISTRY |
| 21. C 491 | -ORGANIC INDUSTRIAL CHEMISTRY 1 |
| 22. CS 3061 | -COMPUTER NETWORKS & DATA COMMUNICATION SYSTEMS |
| 23. CS 4251 | -ELECTRONICS FOR COMPUTING 3 |
| 24. CST 2011 | -AN INTRODUCTION TO OBJECT ORIENTED PROGRAMMING
USING DATA |

25. CST 2041 -INTRODUCTION TO OPERATING SYSTEMS
26. CST 3031 -INTRODUCTION TO SOFTWARE ENGINEERING
27. CST 3251 -ELECTRONICS FOR COMPUTERS 1
28. CST 4131 -ADVANCED OBJECT ORIENTED PROGRAMMING WITH JAVA
29. CST 4252 -ELECTRONICS FOR COMPUTING 4
30. GEO 111 -INTRODUCTION TO HUMAN GEOGRAPHY
31. GEO 155 -INTRODUCTION TO PHYSICAL GEOGRAPHY
32. GEO 175 -INTRODUCTION TO MAPPING TECHNIQUES IN GEOGRAPHY
33. GEO 211 -THE GEOGRAPHY OF AFRICA
34. GEO 271 -QUANTITATIVE TECHNIQUES IN GEOGRAPHY 1
35. GEO 381 -ENVIRONMENT AND DEVELOPMENT 1
36. GEO 451 -LAND RESOURCES SURVEY
37. GEO 481 -ENVIRONMENTAL AND DEVELOPMENT 2
38. GEO 495 -ENVIRONMENTAL HAZARDS AND DISASTERS
39. GEO 911 -POPULATION GROWTH
40. GEO 951 -CLIMATOLOGY
41. GEO 961 -SOILS GEOGRAPHY
42. GEO 971 -AERIAL PHOTOGRAPHY & AERIAL PHOTO INTERPRETATION
(PAPER 1)
43. GEO 971 -AERIAL PHOTOGRAPHY & AERIAL PHOTO INTERPRETATION
(PAPER 2)
44. M 111 -MATHEMATICS METHODS 1
45. M 161 -INTRODUCTION TO MATHEMATICS, PROBABILITY &
STATISTICS
46. EM 211 -ENGINEERING MATHEMATICS 1
47. EM 311 -ENGINEERING MATHEMATICS 3
48. M 211 -MATHEMATICS METHODS 3
49. M 221 -LINEAR ALGEBRA 1
50. M 231 -REAL ANALYSIS 1
51. M 261 -INTRODUCTION TO STATISTICS
52. M 331 -REAL ANALYSIS 3

53. M	361	-MATHEMATICAL STATISTICS
54. M	411	-FUNCTIONS OF A COMPLEX VARIABLES 1
55. M	415	-MATHEMATICAL METHODS FOR PHYSICS
56. M	421	-STRUCTURES AND PRESENTATIONS OF GRAPHS Groups
57. M	431	-REAL ANALYSIS 5
58. M	462	-BAYESIAN INFERENCE AND DISCRETE ANALYSIS
59. M	911	-MATHEMATICAL METHODS 5
60. M	912	-MATHEMATICAL METHODS 6
✓61. P	191	-INTRODUCTION TO PHYSICS 1
62. P	251	-INTRODUCTION TO CLASSICAL MECHANICS 1
63. P	261	-ELECTRICITY AND MAGNETISM
64. P	341	-ANALOGUE ELECTRONICS 1
65. P	351	-INTRODUCTION TO QUANTUM MECHANICS
66. P	361	-ELECTROMAGNETIC THEORY
67. P	401	-COMPUTATIONAL PHYSICS 2
68. P	411	-NUCLEAR EXPERIMENTAL TECHNIQUES
69. P	421	-SOLID STATE PHYSICS 1
70. P	422	-SOLID STATE PHYSICS 2
71. P	441	-ANALOGUE ELECTRONICS 3

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

FIRST
2009-2010 ACADEMIC YEAR ~~SECOND~~ SEMESTER
FINAL EXAMINATIONS

BS 411: INSECT BEHAVIOUR AND ECOLOGY
THEORY PAPER II

TIME: THREE HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS. USE ILLUSTRATIONS
WHERE NECESSARY.

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1. Discuss individual and population attributes in insects.
 2. Discuss how insect populations are regulated in nature.
 3. Compare and contrast K and r strategies. Give examples of insects which are K and r - selected respectively.
 4. A typical female of the bubble gum maggot (*Bubblicious blowhardi* Meyer) lays 250 eggs. On average, 32 of these eggs are infertile and 64 are killed by parasites. Of the survivors, 64 die as larvae due to habitat destruction and 87 die as pupae because the gum gets too hard. Construct a life table for this species.
 5. Summarise the following concepts:
 - (a) Cohort.
 - (b) Deme.
 - (c) Insect outbreaks.
 - (d) Exclusion principle.
 6. Discuss Key factor analysis in mortality of insects following Varley and Gradwell's method.
 7. Describe the logistic population growth curve in insects. Illustrate your answer with graphs, equations and symbols.
 8. Distinguish between ecosystems and agroecosystems giving examples.
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END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

**2009-2010 ACADEMIC YEAR FIRST SEMESTER
DEFERRED EXAMINATIONS**

**BS 411: INSECT BEHAVIOUR AND ECOLOGY
THEORY PAPER I**

TIME: THREE HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS. USE ILLUSTRATIONS WHERE POSSIBLE.

1. Discuss four mechanisms of orientation behaviour in named insects.
 2. Discuss behavioural steps that are involved in feeding by herbivorous insects.
 3. Describe the major chemical and passive defensive mechanisms in named insects.
 4. Explain the mechanisms involved in thermoregulation in both endothermic and ectothermic insects.
 5. Explain the common mode of communication in the forager honey bee (*Apis mellifera* L.).
 6. Discuss the biological functions of insect sounds in different insect groups.
 7. Explain how mate location and courtship are attained in various insect groups.
 8. Compare and contrast the major characteristics between the social termites and the highly eusocial hymenoptera.
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END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009-2010 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

BS 491: FRESHWATER BIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS. QUESTIONS 1 AND 2 IN SECTION A ARE COMPULSORY AND ANSWER ANY THREE QUESTIONS IN SECTION B

SECTION A

1. Briefly discuss the following in relation to productivity of freshwater ecosystems:

- (a) Lake mean depth.
- (b) Secchi depth.
- (c) Orthograde oxygen profile.
- (d) Diatom bloom.
- (e) Salinity.

2. A well known limnologist, G. E. Hutchinson (1956) is reported to have suggested that 'perceptive freshwater ecologist can assess the relative productivity of any lake by measuring the oxygen concentration throughout a depth profile in summer under thermal stratification.

Assess the validity of this statement and explain in detail the rationale for such an observation.

SECTION B

3. Compare and contrast characteristics, distribution and abundance of organisms in lentic and lotic aquatic ecosystems.

TURN OVER

4. Discuss the factors that limit phytoplankton productivity in eutrophic monomictic lakes.
5. Lake Kivu is a very large rift valley lake in East Africa with an area of $2,060 \text{ km}^2$ compared to 370 km^2 for Lake Itzhi-tezhi. Lake Kivu also holds about $8,000 \text{ km}^3$ of Carbon dioxide (CO_2) in its hypolimnion compared to the 3.5 km^3 held by Lake Itzhi-tezhi.

Discuss important physical and chemical factors that allow the CO_2 to remain in Lake Kivu and would have to change in order for the gas to be released.

6. Discuss potential effects of global warming on the productivity of tropical lakes.
7. Discuss the dynamics of silicon compounds in freshwater ecosystems and evaluate the role and contribution of silicates in the vertical and seasonal succession of the phytoplankton populations in temperate monomictic lakes.
8. Provide a detailed description of factors responsible for the vertical distribution and seasonal abundance of pelagic zooplankton in freshwater ecosystems.

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF BIOLOGICAL SCIENCES

2009-2010 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 1011: CELLS AND BIOMOLECULES
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS:

1. Answer **all** questions
2. Choose the best answer to the questions
3. Use the answer sheet provided to record the answers
4. Use a pen (not a pencil) to record the answers
5. One box should have only one answer
6. If you change an answer, cross it out and write the fresh one by the side
7. All questions carry equal marks
8. A wrong answer carries -1 mark
9. "I do not know" carries 0 mark
10. Copying of any kind will lead to disqualification
11. Fill in the computer number on your answer sheet in the provided space

1. Determine which cell would be more successful if environmental conditions became limiting for survival.
 1. Onion cells
 2. Cell of the cheek
 3. Cells with an average size of 1.0 μ m
 4. Cells with a size range of 2.5 – 5.0 μ m
 5. Eukaryotic cells
 6. I do not know

2. Identify the false statement.
 1. Respiration in prokaryotes takes place in the plasma membrane
 2. Hereditary materials are found in both prokaryotes and eukaryotes.
 3. Ribosomes perform the same functions in all cells.
 4. A nucleotide is a feature found in all cells.
 5. Bacterial cell walls are more complex than plant cell walls.
 6. I do not know

3. Gram staining technique is useful in determining a drug to be used on a patient. Non reaction after treating cells with crystal violet and washing them in ethanol indicates that ...
 1. cells are Gram negative.
 2. cells walls are made of cellulose and protein.
 3. cells are Gram positive.
 4. cells are eukaryotic in nature.
 5. the bacterial cells are not virulent.
 6. I do not know

4. 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.

5. The stalked particles are the structures where respiratory enzymes are located. Where are the stalked particles themselves located?
 1. Stroma
 2. Mitochondrial matrix
 3. Inner membrane
 4. In the intracristal space
 5. Granum
 6. I do not know.

6. Identify the statement that is **correct** about chloroplasts.
 1. Chloroplasts are capable of synthesizing their own proteins.
 2. DNA is absent in all eukaryotic organelles including chloroplasts.
 3. Ribosomes are absent in chloroplasts.
 4. Chlorophyll is located in the stroma of chloroplasts.
 5. Chloroplasts are the site for intense respiratory activities of a cell.
 6. I do not know.

7. The first amino acid to get transcribed when forming a protein is ...
 1. Alanine.
 2. Valine.
 3. Guanine.
 4. Methionine.
 5. Cysteine. /
 6. I do not know.

8. The stop codon for mRNA is ...
 1. UAA.
 2. TUA
 3. CTU
 4. CUU
 5. CTC
 6. I do not know.

9. The first peptide bond formed between two amino acids occurs when ... is in the ... chamber of ...
 1. mRNA, amino acyl, ribosome.
 2. tRNA, amino acyl, ribosome.
 3. rRNA, peptidyl, ribosome.
 4. tRNA, peptidyl, ribosome.
 5. ribosomes, cytosol, tRNA.
 6. Peptidyl, ribosome, the cytosol.

10. Two examples of pyrimidines are ...
 1. Guanine and Cytosine.
 2. Adenine and Guanine. ✓
 3. Thymine and Uracil.
 4. Uracil and Cytosine.
 5. Thymine and Cytosine
 6. I do not know.

11. Determine the number of tRNAs that translate mRNA with a base sequence of - AAUCGA
1. 2
 2. 3
 3. 4
 4. 5
 5. 6
 6. I do not know
12. The polymers used as sensor receptors on the surface of cell membranes are called ...
1. lipoproteins. *transposition*
 2. glycolipids.
 3. proteins.
 4. lipids.
 5. glycoproteins. *glycolipids*
 6. I do not know.
- receptors are glycolipids*
13. The ester bonds in the DNA back bone are found ...
1. between organic bases
 2. between phosphate groups
 3. at the 3' and 6' carbons of a pentose sugar.
 4. at the 3' and 5' carbons of a pentose sugar. ✓
 5. at the 2' and 3' carbons of furanose ring
 6. I do not know
14. The formation of peptide bonds is between two ...
1. glucose molecules.
 2. amino acids.
 3. alcohol molecules.
 4. Glycerol molecules.
 5. Phosphate groups.
 6. I do not know
15. The formation of a glycosidic bond arises by ...
1. the removal of a water molecule from two reacting substances.
 2. a condensation process.
 3. addition of a water molecule.
 4. the removal of protons from the reacting substances.
 5. The addition of a hydroxide molecule as two substances react.
 6. I do not know.

16. The formation of a covalent bond between a pentose sugar and an organic base leads to the synthesis of a ...
1. nucleotide.
 2. nucleosome.
 3. disaccharide
 4. nucleoside.
 5. dipeptide
 6. I do not know.
17. Which of the following substances would cross the plasma membrane without resistance?
(a) CH_4 (b) Oxygen (c) Carbon dioxide
1. (a)
 2. (a) and (b)
 3. (a), (b) and (c)
 4. (a) and (c)
 5. (b) and (c)
 6. I do not know.
18. When a cell wall is removed from a plant cell, the protoplasm rounds up. This demonstrates that ...
1. a cell wall is responsible for turgor pressure.
 2. a cell wall helps to protect a cell from injury.
 3. a cell needs a cell wall for movement of substances into the cytoplasm.
 4. a cell needs a cell wall to maintain its shape.
 5. a cell wall is not tightly bound to the plasma membrane.
 6. I do not know.
19. Identify a secondary structure protein from the following list of proteins.
(a) Collagen (b) Insulin (c) Beta pleated sheet
1. (a)
 2. (a) and (b)
 3. (a), (b) and (c)
 4. (a) and (c)
 5. (b) and (c)
 6. I do not know.
20. Which protein is responsible for the characteristics of animal hair?
1. Collagen
 2. β - Pleated sheet
 3. Haemoglobin
 4. Keratin
 5. Haem-group
 6. I do not know

21. Define "energy of activation".
1. The energy required to start a biochemical reaction. ✓
 2. The energy required to activate an enzyme.
 3. The energy required to bring two reacting substances together.
 4. The energy given out during a chemical reaction.
 5. The energy required to inhibit a chemical reaction.
 6. I do not know.
22. Water is a polar molecule because...
1. more of the protons are in the hydrogen nucleus.
 2. more of the electrons are near the hydrogen nucleus.
 3. of the equal numbers of protons in hydrogen and oxygen.
 4. of the relative positions of hydrogen atoms to the oxygen atom.
 5. of the unequal sharing of electrons between hydrogen and oxygen. ✓
 6. I do not know
23. Blood pH is approximately 7.4 and organisms maintain this pH at a constant level partially through the use of ...
1. salts.
 2. water.
 3. proteins. ✓
 4. carbohydrates.
 5. lipids
 6. I do not know
24. Which of the following molecules is a carbohydrate?
1. $C_3H_7O_2N$
 2. $C_{12}H_{24}O_{12}$
 3. $C_{13}H_{26}O_2$
 4. $C_{20}H_{40}O_2$
 5. $C_nCH=CHC_n$
 6. I do not know
25. The unit molecule of a ribonucleic acid is ...
1. glucose.
 2. glycerol.
 3. a nucleotide ✓
 4. an amino acid.
 5. an organic base.
 6. I do not know

26. The hydrolysis of lipids may produce
1. glucose.
 2. glycerol.
 3. fatty acids.
 4. amino acids.
 5. (2) and (3) above
 6. I do not know.
27. Which of the following are components of a phospholipid?
1. Cholesterol, glycerol, fatty acids
 2. Phosphate group and a hydrocarbon chain,
 3. Glycerol, amino acids, phosphate group
 4. Phosphate group, cholesterol, monosaccharides
 - ✓ 5. Fatty acids, phosphate group, glycerol
 6. I do not know.
28. An unsaturated fat could be converted to a saturated fat by doing one of the following things;
1. Breaking some peptide bonds.
 2. Removal of hydrogen atoms.
 3. Addition of hydrogen atoms.
 4. Increasing the hydrocarbon chain.
 5. Removal of Glycerol molecules.
 6. I do not know.
29. Which of the following base pairing is impossible?
1. A-U
 2. U-T
 3. G-C
 4. C-G
 5. A-T
 - 6 I do not know.
30. Transfer RNA (tRNA) is for the purpose of ...
1. staying in the nucleus and to be copied by DNA.
 2. carrying amino acids to the growing polypeptide chain.
 3. copying DNA and carrying the information to the ribosome.
 - ✓ 4. reading the codons and providing the site for protein synthesis.
 5. guiding mRNA to the ribosome.
 6. I do not know

31. A polypeptide found in the cytoplasm of a cell contains 18 amino acids. How many nucleotides would be required in the mRNA for this polypeptide to be translated?
1. 9
 2. 18
 3. 54
 4. 36
 5. 24
 6. I do not know.
32. A function of smooth endoplasmic reticulum is to ...
1. form ribonucleic acid.
 2. synthesise ribosomes
 3. store nucleic acid.
 4. synthesise lipids ✓
 5. breakdown carbohydrates.
 6. I do not know.
33. During the development of a tadpole into a frog, an organelle called a ... is responsible for the digestion of the cells of the tail of a tadpole.
1. ribosomes
 2. microtubules
 3. lysosome
 4. endoplasmic reticulum
 5. golgi bodies
 6. I do not know
34. What would happen to the plasma membrane in alcohol?
1. The membrane would be destroyed
 2. The membrane functional efficiency would improve.
 3. The membrane status would remain the same.
 4. It would allow the passage of polar molecules only.
 5. It would allow the passage of non-polar substances only.
 6. I do not know.
35. Identify the correct statement.
1. A covalent bond is characteristic of all ionic compounds.
 2. An ionic bond is what holds water molecules together.
 3. Hydrogen bonding involves the movement of electrons between atoms.
 4. An ionic bond is non polar. ✓
 5. A covalent bond is the strongest chemical bond.
 6. I do not know

40. Explain the fact that water is able to wet surfaces of its container.
1. The polarity of water helps it to adhere to polar surfaces
 2. Water is dipolar and therefore easily mixes with non polar surfaces.
 3. The dipolar water combines readily with surface molecules without a charge on them
 4. Because water is a liquid at ordinary temperature and pressure
 5. Hydrogen bond in water breaks when it comes in contact with dry surfaces
 6. I do not know
41. Identify the compound that will **not** dissolve in water.
1. Amino acids✓
 2. Proteins
 3. Glucose✓
 4. lactose
 5. Formaldehyde
 6. I do not know
42. Determine the effect of water on chemical reactions in a cell at 3°C.
1. The chemical reactions would proceed much faster than at 1°C. ✓
 2. Chemical reactions in the cell would stop.
 3. Cells would become smaller and the rate of reactions would improve.
 4. Water would lose its hydrogen bonds and become a liquid.
 5. Chemical reactions would not be affected at all.
 6. I do not know.
43. Explain why water is less dense at 1°C.
1. Water molecules occupy more space because hydrogen bonds are stretched out.
 2. There are more water molecules per unit volume because water has less than four hydrogen bonds around it.
 3. Solid water contains more water molecules to make it compact.
 4. The kinetic energy of water is low and therefore there are fewer water molecules per unit volume.
 5. Because some of the water molecules evaporate leaving a solid behind.
 6. I do not know

44. Identify the molecules that are not polar.
1. Sodium Chloride ✓
 2. Proteins
 3. Carbohydrates ✓
 4. Carbon dioxide ✓
 5. Phospholipids
 6. I do not know
45. State the functions of organic compounds in a cell.
1. They manufacture enzymes and salts for a cell.
 2. They make up most of the structural components of cells.
 3. They determine the characteristics of eukaryotic and prokaryotic cells
 4. Organic compounds are responsible for the manufacture of carbohydrates
 5. They are responsible for mutations in a cell.
 6. I do not know.
46. Identify the **wrong** statement from the items given below.
1. Water is an example of an organic compound.
 2. Organic compounds carry cellular information.
 3. Respiration is controlled by organic compounds
 4. Osmosis is under the direct control of organic compounds.
 5. Organic compounds are a source of energy in cells.
 6. I do not know.
47. Identify the molecule that is least reduced from the following list of compounds.
1. CH_2OH
 2. $\text{C}_3\text{H}_6\text{O}_3$
 3. $\text{C}_5\text{H}_{10}\text{O}_5$
 4. $\text{C}_4\text{H}_8\text{O}_4$
 5. $\text{C}_6\text{H}_{12}\text{O}_6$ ~
 6. I do not know

48. The following is a hypothetical chemical reaction.



Identify the correct statement from the following:

1. AH_2 has been reduced.
2. AH has been oxidised.
3. BH is an oxidising agent. ✓
4. BH_2 has been oxidised.
5. BH_2 has lost electrons.
6. I do not know.

49. Identify the molecule that has polar covalent bonds from the list of items given below.

1. $-\text{CH}_3$
2. CH_4
3. C_3CH_3
4. CH_3COOH ✓
5. C_5H_{12}
6. I do not know.

50. Identify the molecule with a furanose structure in its ring formation.

Aldose sugar ($\text{C}_6\text{H}_{12}\text{O}_6$) (b) Ketose sugar ($\text{C}_6\text{H}_{12}\text{O}_6$) (c) Dextrose ($\text{C}_6\text{H}_{12}\text{O}_6$) sugar

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

51. In an aldehyde, a carbonyl group is found at carbon ...

1. one ✓
2. two
3. three
4. five
5. six
6. I do not know

52. The asymmetric carbon in fructose is found at carbon ...
1. one
 2. two —
 3. three
 4. five
 5. six
 6. I do not know
53. Optical isomerism has to do with the...
1. orientation of hydrogen atoms around carbon five in a molecule.
 2. number of bonds around carbon atoms in an organic compound
 3. number of bonds and type of atoms around a carbon atom
 4. structural isomers in the open chain.
 5. the orientation of hydroxyl groups around a carbon atom.
 6. I do not know.
54. When carbon five of a hexose sugar has a hydroxyl group oriented to the right, the sugar is ...
1. laevorotatory.
 2. a beta dextrose form.
 3. dextrorotatory.
 4. an alpha levulose form.
 5. alpha laevurotary.
 6. I do not know
55. Identify the structural isomer of galactose.
1. Fructose
 2. Glyceraldehyde
 3. Dihydroxyacetone
 4. D – ribose
 5. All carbohydrates
 6. I do not know
56. Glucose shares the same chemical formula with ...
1. β – L glucose
 2. Galactose
 3. α - D glucose
 4. Fructose
 5. All the four organic molecules given in 1 – 4.
 6. I do not know

62. Chemical reactions that involve a breakdown of organic molecules ...

1. Are oxidation reactions.
2. Are reduction reactions.
3. Are synthetic reactions.
4. Require a supply of hydrogen atoms.
5. Are both oxidative and reductive reactions. reduct
6. I do not know.

63. A temperature above 50 °C ...


1. Increases the energy of activation.
2. Makes cells less susceptible to diseases.
3. Can affect the shape of an enzyme.
4. Is the required warmth for chemical reactions in a cell.
5. Is too low for normal chemical reactions.
6. I do not know.

64. Lipids are normally broken down to ...

1. Amino acids and alcohol.
2. Glycerol.
3. Fatty acids and glycerol.
4. Cholesterol and hydrocarbons.
5. Saturated and unsaturated fats
6. I do not know.

65. How does a prokaryotic chromosome differ from a eukaryotic one?

A prokaryotic chromosome ...

1. Is shorter and thicker. ✓
2. Is a single loop of DNA. 
3. Contains either DNA or RNA.
4. Never replicates.
5. Is a double stranded nucleic acid.
6. I do not know.

66. If 30% of an organism's DNA is thymine, then ...

1. 70% is purine
2. 70% is adenine
3. 20% is guanine
4. 30% is adenine
5. Both 3 and 4 are correct
6. I do not know.

A - T
30% → 30% ✓
A → T
30 → 70 X

57. Identify the reactive centre of dihydroxyacetone.
1. The hydroxyl groups bonded to carbon atoms.
 2. The oxygen atom attached to the second carbon.
 3. The hydroxyl group on the fifth carbon of the molecule.
 4. The carbon to carbon bond of the first two carbon atoms.
 5. The double bond of the oxygen atom on the first carbon.
 6. I do not know.
58. The function of a lysosome is for ...
1. Protein synthesis.
 2. ATP production.
 3. Intracellular digestion.
 4. Lipid synthesis.
 5. Processing and repackaging of cellular products.
 6. I do not know.
59. Mitochondria ...
1. Are involved in cellular respiration.
 2. Used for removal of wastes from a cell.
 3. Contain grana
 4. Contain vesicles from the golgi apparatus.
 5. Produce energy for microbes.
 6. I do not know.
60. Which organelle releases oxygen?
1. Ribosome
 2. Golgi apparatus
 3. Mitochondrion
 4. Vacuole
 5. Chloroplast.
 6. I do not know.
61. Which of the following is **not** true?
1. Actin filaments are in the muscle cells.
 2. Microtubules arise from the ER.
 3. Microtubules are made of a globular protein called tubulin.
 4. Intermediate filaments sometimes contain keratin.
 5. There is no cytoskeleton in bacteria.
 6. I do not know.

67. Which of the following is true of prokaryotic cells? They ...

1. Are not living cells.
2. Are all parasitic.
3. Have hereditary materials that are not in a membrane.
4. Do not have a cell wall.
5. Cannot reproduce independently.
6. I do not know.

68. Which feature is best associated with cell walls?

1. Impermeability
2. Support and protection. ✓
3. Rapid growth of cells.
4. Provide a large surface area for diffusion of substances.
5. Presence of carbohydrates and proteins.
6. I do not know.

69. Which of the following is not a characteristic of prokaryotes?

1. Peptidoglycan cell wall ✓ bacteria
2. Lacking a nuclear pores
3. Generate energy using mitochondria •
4. Grow by binary fission
5. They are capable of motion
6. I do not know.

70. Phosphorus would be found in all of the following molecules of the cell except ...

1. ATP.
2. DNA.
3. Nuclear envelope.
4. Cell wall. ✓
5. RNA.
6. I do not know.

71. Identify from the following molecules the molecule that has the highest amount of energy for a cell.

1. Carbon dioxide ✓
2. Adenine triosephosphate ✓
3. Glucose ✓
4. Amino acids ✓
5. Oxygen ✓
6. I do not know.

72. A triple bond holding two bases together in a DNA helix are found between ... and ...
1. Two purines.
 2. Guanine and Cytosine. ✓
 3. Pyrimidines and a purines.
 4. Cytosine and adenine.
 5. Thymine and adenine.
 6. I do not know.
73. Which of the following would be solid at 2 °C?
1. Oxygen
 2. Nitrogen
 3. Carbon monoxide
 4. Water ✓
 5. Methane.
 6. I do not know.
- 0 → 100
liquid
74. Which of the following chemical compounds would dissolve in water?
1. $C_3H_8O_3$ *glycerol*
 2. C_6H_{14}
 3. $(CH_3)_2.C_4H_8$
 4. C_6H_6
 5. CH_4
 6. I do not know.
75. Which of the following expressions represents the correct order for electronegativity?
1. $N > S > C > P > O$
 2. $S > N > C > P > O$
 3. $O > N > S > C > P$ ✓
 4. $P > O > N > S > C$
 5. $O > S > N > P > C$
 6. I do not know.
76. The growth of cells is limited by the ...
1. Cellulose cell wall.
 2. Surface area to volume ratio. ✓
 3. Size of a nucleus.
 4. Number of organelles in a cytoplasm.
 5. Number of proteins synthesised by a cell. ✓
 6. I do not know.

77. Two cells lying side by side are connected through microscopic openings called ...

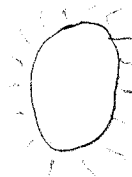
1. Receptors .
2. Markers.
- ③ 3. Plasmodesmata. ✓
4. Microvilli
5. Channels
6. I do not know.

78. Lipids and proteins are transported within cells by ...

1. Ribosomes.
2. Golgi apparatus. ✓ — *proteins*
3. Microtubules.
4. A cytoskeleton.
5. Endoplasmic reticulum. — *transport*
6. I do not know.

79. Which part of a cytoskeleton is responsible for locomotion in cells?

- ① 1. Microtubules..
2. Microtraberculae
3. Cilia ✓
4. Microfilaments
5. Flagella ✓
- × 6. I do not know.



80. The following are characteristics of plant cells.

1. Cell wall, centrioles and chloroplasts
2. Vacuole, cilia and chloroplasts
3. Cell wall, vacuole and thylakoids — *characteristic of plant cells*
4. Cytoskeleton, flagella and mitochondria
5. DNA, mitochondria and a nucleoid.
6. I do not know.

81. Disaccharides have ...

- × 1. One type of glycosidic bond (1 → 4) ✓
- ② 2. Two types of glycosidic bond (1 → 4 and 1 → 2)
- × 3. Three types of glycosidic bonds (1 → 4, 1 → 2 and 1 → 6)
4. Two types of glycosidic bond (1 → 4 and 1 → 6)
5. Two types of glycosidic bond (1 → 2 and 1 → 6)
6. I do not know.

82. Which of the following statements is **not** correct?

1. Carbohydrates, proteins and lipids are made up of carbon, hydrogen and oxygen only.
2. Ribosomes are present in mitochondria.
3. Rough endoplasmic reticula have ribosomes.
4. Vacuoles in plants are larger than those of animal cells.
5. Vacuoles serve different functions in plant and animal cells.
6. I do not know.

83. Lipids store more energy than carbohydrates because they have ...

1. More oxygen atoms. ✓
2. More double bonds. ✓
3. More hydrogen atoms. ✓
4. More hydroxyl groups.
5. Glycerol in the molecule.
6. I do not know.

84. The empirical formula for saturated fatty acids is ...

1. $C_nH_{2n-8}O_2$
2. $C_{2n}H_{2n}O_2$
3. $C_nH_{4n}O_2$
4. $C_nH_{2n}O_2$
5. $C_nH_{2n-2}O_2$
6. I do not know.

85. Proteins function as ...

1. Structural molecules. ✓
2. A source of energy for cells. ✓
3. Units of heredity. ✓
4. Insulation substances.
5. Growth promoter hormones.
6. I do not know.

86. A bond that forms between a fatty acid molecule and an alcohol is called ...
1. A Diester bond.
 2. A Phosphodiester bond.
 3. A Peptide bond.
 4. An Ester bond. ✓
 5. A Disulphide bridge.
 6. I do not know.
87. Any molecule containing both a carboxylic group and long hydrocarbon chain is a/an ...
1. Amino acid.
 2. Cholesterol.
 3. Fatty acid. ✓
 4. Organic ion.
 5. Polymer
 6. I do not know.
88. Which of the following environmental factors **do not** affect general enzyme activity?
1. Humidity —
 2. Temperature
 3. Coenzymes ✓
 4. pH ✓
 5. Substrate concentration ✓
 6. I do not know.
89. All of the following factors are involved in transcription, except ...
1. The enzyme polymerase. ✓
 2. A primer
 3. A promoter.
 4. Sigma.
 5. Uracil ✓
 6. I do not know.

90. Using the DNA strand shown below as a template, what will be the sequence of the RNA transcript?

5' GCGTTAACGTAGGC 3'

1. 5' GCGUUAACGUAGGC 3' x
2. 5' CGGAUGCAAUUGCG 3'
3. 5' CGCAAUUGCAUCCG 3' ✓
4. 5' GCCUACGUUAACGC 3' ^
5. 5' CGCUUAAGCUTACCG 3' x
6. I do not know.

91. Collagen is a ...

1. Globular protein
2. Quaternary structure of a protein.
3. Fibrous protein.
4. Fibre from muscles.
5. The same as a beta-pleated sheet.
6. I do not know.

92. Bonds that hold the secondary and tertiary structures together are ...

1. Polar covalent bonds.
2. Hydrogen bonds.
3. Ionic bonds.
4. Peptide bonds.
5. Both ionic and hydrogen bonds. ✓
6. I do not know.

93. Polymerases ...

1. synthesize molecules in catabolic reactions. x
2. Catalyse hydrolytic reactions. x
3. Release nucleotides in the process of breaking down DNA. ✓
4. Are involved in the synthesis of DNA and RNA molecules. ✓
5. Breakdown proteins by hydrolysing bonds between amino acids. ✓
6. I do not know.

94. The Golgi apparatus ...
1. Is linked to mRNA molecule during protein synthesis.
 2. Digests only substances that have been taken up by cells by endocytosis.
 3. Oxidises food molecules to generate energy.
 4. Modifies and repackages protein material received. ✓
 5. Manufactures most of the cell's lipids and many of its proteins.
 6. I do not know.
95. The two layers of phospholipid molecules are packed with their tails pointing ... and their heads
1. Outward, inward.
 2. Inward, outward. ✓
 3. Inward, inward.
 4. Outward, outward.
 5. Downward, outward.
 6. I do not know.
96. The main constituents of triacylglycerol in animal tissues are ...
1. glycerol ester of both saturated and unsaturated fatty acids.
 2. glycerol ester of unsaturated fatty acids.
 3. glycerol and phospholipids.
 4. ~~fats~~
 5. glycerol esters of saturated fatty acids.
 - ✓6. I do not know.
97. The parts of an amino acid that do not take part in making peptide bonds are ...
(a) amino group (b) carboxylic group (c) alkyl group (d) hydrogen
1. (a)
 2. (b)
 - ✓3. (c) and (d).
 4. (d) only
 5. (c) only
 6. I do not know.

98. One example of a pyrimidine is ...
1. Adenine.
 2. Uracil.
 3. Proline.
 4. Theonine.
 5. Pectin.
 6. I do not know.
99. What is the functional group of glycerol?
1. Amino group
 2. Carboxylic group
 3. Hydrogen
 4. Hydroxyl group
 5. Carbonyl group
 6. I do not know
100. Which of the following substrates is correctly matched with its enzyme?
1. Sucrose – lactase
 2. Starch – maltase
 3. Mannose – sucrose
 4. Galactose – kinase
 5. Fructose – Phosphofructokinase
 6. I do not know.

END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

**2009 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS**

C101: INTRODUCTION TO CHEMISTRY I

TIME: THREE (3) HOURS

INSTRUCTIONS:

1. Indicate your **student ID number** (computer 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 (Total marks = 40).
ANSWER ALL QUESTIONS. Questions carry equal marks.
4. Section **B** has five (5) long answer questions. (Total marks = 60).
ANSWER QUESTION B1 and ANY THREE QUESTIONS, EACH IN A SEPARATE ANSWER BOOKLET. Questions carry equal marks.
5. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORKING CLEARLY AND LOGICALLY.**

Information to the candidates:

1. **Useful data** is printed on **page 2**.
2. **Periodic Table** is printed on the **page 3** of this question paper.

DATA

Avogadro's constant, N_A	$6.022 \times 10^{23} \text{ mol}^{-1}$
Molar volume of gas at S.T.P	$22.4 \text{ dm}^3 \text{ mol}^{-1}$
Universal gas constant, R	$8.314 \text{ J K}^{-1} \text{ mol}^{-1}$
	$0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1}$
	$8.314 \text{ k Pa L K}^{-1} \text{ mol}^{-1}$
Planck's constant, h	$6.63 \times 10^{-34} \text{ J s}$
Rydberg constant, R_H	109678 cm^{-1}
Velocity of light, c	$3.00 \times 10^8 \text{ ms}^{-1}$
Electron volt, 1 eV	$1.602 \times 10^{-19} \text{ J}$
Faraday, 1 F	96485 C mol^{-1}
Joule, 1 J	$1 \text{ kg m}^2 \text{ s}^{-2}$
Mass of proton, m_p	1.00727 amu
Mass of Neutron, m_n	1.008665 amu
Mass of electron, m_e	0.000548593 amu

Standard Electrode Potentials:

$\text{MnO}_2(\text{s}) + 4\text{H}^+(\text{aq}) + 2\text{e}^- \leftrightarrow \text{Mn}^{2+}(\text{aq}) + 2\text{H}_2\text{O}(\text{l});$	$E^\circ = 1.21 \text{ V}$
$\text{Br}_2(\text{g}) + 2\text{e}^- \leftrightarrow 2\text{Br}^-(\text{aq});$	$E^\circ = 1.07 \text{ V}$
$\text{Ag}^+(\text{aq}) + \text{e}^- \leftrightarrow \text{Ag}(\text{s});$	$E^\circ = 0.80 \text{ V}$
$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \leftrightarrow \text{Cu}(\text{s});$	$E^\circ = 0.34 \text{ V}$
$\text{AgCl}(\text{s}) + \text{e}^- \leftrightarrow \text{Ag}(\text{s}) + \text{Cl}^-(\text{aq});$	$E^\circ = 0.22 \text{ V}$
$\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \leftrightarrow \text{Pb}(\text{s});$	$E^\circ = -0.13 \text{ V}$
$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \leftrightarrow \text{Zn}(\text{s});$	$E^\circ = -0.76 \text{ V}$
$\text{Al}^{3+}(\text{aq}) + 3\text{e}^- \leftrightarrow \text{Al}(\text{s});$	$E^\circ = -1.66 \text{ V}$

PERIODIC TABLE OF THE ELEMENTS

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

KEY

Atomic number
X
Atomic mass
Name of the element X

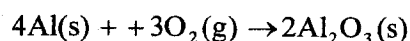
1 H Hydrogen 1.01	2 He Helium 4.00																	3 Li Lithium 6.94	4 Be Beryllium 9.01	5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18																																																																																																																																																																																																																																																																																																																																																																																																																																																													
11 Na Sodium 23.00	12 Mg magnesium 24.31	13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.99	16 S Sulphur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95	19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.88	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 71.61	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80	37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium 97.91	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29	55 Cs Caesium 132.91	56 Ba Barium 137.33	57-71 Lanthanum 140.12	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium 208.98	85 At Astatine 209.99	86 Rn Radon 222.02	87 Fr Francium (223.02)	88 Ra Radium 226.03	89 - 103 Actinium 227.03	104 Uuq 261.11	105 Uup 262.11	106 Uuh 263.12	107 Uus 262.12	108 Uuo 265.00	109 Uue 265	110 Uub 265	111 Uut 265	112 Uuq 265	113 Uuh 265	114 Uus 265	115 Uuo 265	116 Uue 265	117 Uub 265	118 Uut 265	119 Uuq 265	120 Uuh 265	121 Uus 265	122 Uuo 265	123 Uue 265	124 Uub 265	125 Uut 265	126 Uuq 265	127 Uuh 265	128 Uus 265	129 Uuo 265	130 Uue 265	131 Uub 265	132 Uut 265	133 Uuq 265	134 Uuh 265	135 Uus 265	136 Uuo 265	137 Uue 265	138 Uub 265	139 Uut 265	140 Uuq 265	141 Uuh 265	142 Uus 265	143 Uuo 265	144 Uue 265	145 Uub 265	146 Uut 265	147 Uuq 265	148 Uuh 265	149 Uus 265	150 Uuo 265	151 Uue 265	152 Uub 265	153 Uut 265	154 Uuq 265	155 Uuh 265	156 Uus 265	157 Uuo 265	158 Uue 265	159 Uub 265	160 Uut 265	161 Uuq 265	162 Uuh 265	163 Uus 265	164 Uuo 265	165 Uue 265	166 Uub 265	167 Uut 265	168 Uuq 265	169 Uuh 265	170 Uus 265	171 Uuo 265	172 Uue 265	173 Uub 265	174 Uut 265	175 Uuq 265	176 Uuh 265	177 Uus 265	178 Uuo 265	179 Uue 265	180 Uub 265	181 Uut 265	182 Uuq 265	183 Uuh 265	184 Uus 265	185 Uuo 265	186 Uue 265	187 Uub 265	188 Uut 265	189 Uuq 265	190 Uuh 265	191 Uus 265	192 Uuo 265	193 Uue 265	194 Uub 265	195 Uut 265	196 Uuq 265	197 Uuh 265	198 Uus 265	199 Uuo 265	200 Uue 265	201 Uub 265	202 Uut 265	203 Uuq 265	204 Uuh 265	205 Uus 265	206 Uuo 265	207 Uue 265	208 Uub 265	209 Uut 265	210 Uuq 265	211 Uuh 265	212 Uus 265	213 Uuo 265	214 Uue 265	215 Uub 265	216 Uut 265	217 Uuq 265	218 Uuh 265	219 Uus 265	220 Uuo 265	221 Uue 265	222 Uub 265	223 Uut 265	224 Uuq 265	225 Uuh 265	226 Uus 265	227 Uuo 265	228 Uue 265	229 Uub 265	230 Uut 265	231 Uuq 265	232 Uuh 265	233 Uus 265	234 Uuo 265	235 Uue 265	236 Uub 265	237 Uut 265	238 Uuq 265	239 Uuh 265	240 Uus 265	241 Uuo 265	242 Uue 265	243 Uub 265	244 Uut 265	245 Uuq 265	246 Uuh 265	247 Uus 265	248 Uuo 265	249 Uue 265	250 Uub 265	251 Uut 265	252 Uuq 265	253 Uuh 265	254 Uus 265	255 Uuo 265	256 Uue 265	257 Uub 265	258 Uut 265	259 Uuq 265	260 Uuh 265	261 Uus 265	262 Uuo 265	263 Uue 265	264 Uub 265	265 Uut 265	266 Uuq 265	267 Uuh 265	268 Uus 265	269 Uuo 265	270 Uue 265	271 Uub 265	272 Uut 265	273 Uuq 265	274 Uuh 265	275 Uus 265	276 Uuo 265	277 Uue 265	278 Uub 265	279 Uut 265	280 Uuq 265	281 Uuh 265	282 Uus 265	283 Uuo 265	284 Uue 265	285 Uub 265	286 Uut 265	287 Uuq 265	288 Uuh 265	289 Uus 265	290 Uuo 265	291 Uue 265	292 Uub 265	293 Uut 265	294 Uuq 265	295 Uuh 265	296 Uus 265	297 Uuo 265	298 Uue 265	299 Uub 265	300 Uut 265	301 Uuq 265	302 Uuh 265	303 Uus 265	304 Uuo 265	305 Uue 265	306 Uub 265	307 Uut 265	308 Uuq 265	309 Uuh 265	310 Uus 265	311 Uuo 265	312 Uue 265	313 Uub 265	314 Uut 265	315 Uuq 265	316 Uuh 265	317 Uus 265	318 Uuo 265	319 Uue 265	320 Uub 265	321 Uut 265	322 Uuq 265	323 Uuh 265	324 Uus 265	325 Uuo 265	326 Uue 265	327 Uub 265	328 Uut 265	329 Uuq 265	330 Uuh 265	331 Uus 265	332 Uuo 265	333 Uue 265	334 Uub 265	335 Uut 265	336 Uuq 265	337 Uuh 265	338 Uus 265	339 Uuo 265	340 Uue 265	341 Uub 265	342 Uut 265	343 Uuq 265	344 Uuh 265	345 Uus 265	346 Uuo 265	347 Uue 265	348 Uub 265	349 Uut 265	350 Uuq 265	351 Uuh 265	352 Uus 265	353 Uuo 265	354 Uue 265	355 Uub 265	356 Uut 265	357 Uuq 265	358 Uuh 265	359 Uus 265	360 Uuo 265	361 Uue 265	362 Uub 265	363 Uut 265	364 Uuq 265	365 Uuh 265	366 Uus 265	367 Uuo 265	368 Uue 265	369 Uub 265	370 Uut 265	371 Uuq 265	372 Uuh 265	373 Uus 265	374 Uuo 265	375 Uue 265	376 Uub 265	377 Uut 265	378 Uuq 265	379 Uuh 265	380 Uus 265	381 Uuo 265	382 Uue 265	383 Uub 265	384 Uut 265	385 Uuq 265	386 Uuh 265	387 Uus 265	388 Uuo 265	389 Uue 265	390 Uub 265	391 Uut 265	392 Uuq 265	393 Uuh 265	394 Uus 265	395 Uuo 265	396 Uue 265	397 Uub 265	398 Uut 265	399 Uuq 265	400 Uuh 265	401 Uus 265	402 Uuo 265	403 Uue 265	404 Uub 265	405 Uut 265	406 Uuq 265	407 Uuh 265	408 Uus 265	409 Uuo 265	410 Uue 265	411 Uub 265	412 Uut 265	413 Uuq 265	414 Uuh 265	415 Uus 265	416 Uuo 265	417 Uue 265	418 Uub 265	419 Uut 265	420 Uuq 265	421 Uuh 265	422 Uus 265	423 Uuo 265	424 Uue 265	425 Uub 265	426 Uut 265	427 Uuq 265	428 Uuh 265	429 Uus 265	430 Uuo 265	431 Uue 265	432 Uub 265	433 Uut 265	434 Uuq 265	435 Uuh 265	436 Uus 265	437 Uuo 265	438 Uue 265	439 Uub 265	440 Uut 265	441 Uuq 265	442 Uuh 265	443 Uus 265	444 Uuo 265	445 Uue 265	446 Uub 265	447 Uut 265	448 Uuq 265	449 Uuh 265	450 Uus 265	451 Uuo 265	452 Uue 265	453 Uub 265	454 Uut 265	455 Uuq 265	456 Uuh 265	457 Uus 265	458 Uuo 265	459 Uue 265	460 Uub 265	461 Uut 265	462 Uuq 265	463 Uuh 265	464 Uus 265	465 Uuo 265	466 Uue 265	467 Uub 265	468 Uut 265	469 Uuq 265	470 Uuh 265	471 Uus 265	472 Uuo 265	473 Uue 265	474 Uub 265	475 Uut 265	476 Uuq 265	477 Uuh 265	478 Uus 265	479 Uuo 265	480 Uue 265	481 Uub 265	482 Uut 265	483 Uuq 265	484 Uuh 265	485 Uus 265	486 Uuo 265	487 Uue 265	488 Uub 265	489 Uut 265	490 Uuq 265	491 Uuh 265	492 Uus 265	493 Uuo 265	494 Uue 265	495 Uub 265	496 Uut 265	497 Uuq 265	498 Uuh 265	499 Uus 265	500 Uuo 265	501 Uue 265	502 Uub 265	503 Uut 265	504 Uuq 265	505 Uuh 265	506 Uus 265	507 Uuo 265	508 Uue 265	

SECTION A**ANSWER ALL QUESTIONS****QUESTION A 1**

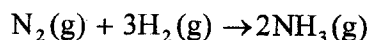
The insecticide DDT, $C_{14}H_9Cl_5$, has molar mass of 345.15 g/mol. Calculate the number of moles and mass of Cl in 3.4515 g of white crystalline powder of DDT.

[4 Marks]**QUESTION A 2**

Calculate the mass of oxygen required to react completely with 5.3960 grams of aluminum according to the reaction:

**[4 Marks]****QUESTION A 3**

How many liters of ammonia at 0.00 °C and 25 atmospheres are produced when 10.00 g of hydrogen is combined with nitrogen according to the reaction:

**[4 Marks]****QUESTION A 4**

In an effusion experiment, 2.00 moles of fluorine gas at a pressure of 2 atmospheres was found to effuse through a pinhole into an evacuated chamber in 26.5 seconds. Under the same experimental condition how long would it take for 2.00 moles of NH_3 gas to effuse?

[4 Marks]**QUESTION A 5**

- (a) The Balmer series of lines in the hydrogen spectrum represent transition of the type $n_1 = 2$ and $n_2 = 3, 4, 5, 6, \dots$

Calculate the wavelength and energy associated with the series limit.

- (b) What is the significance of the *continuum* in an energy diagram showing electron transitions in the hydrogen atom?

[4 Marks]**QUESTION A 6**

- (a) Cu and Cr are typical examples of elements that show unusual configurations. Use *spdf* notation to show their unusual configurations.
- (b) Explain, in brief, these unusual configurations.

[4 Marks]

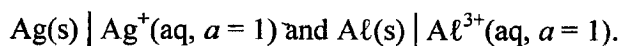
QUESTION A 7

- (a) Define the term electron *affinity*
- (b) For each of the following pairs, state the atom with a more exothermic affinity: (i) Cl or Br
(ii) Se or Br. Give reasons.

[4 Marks]

QUESTION A 8

A voltaic cell is set up to utilize the reactions of the following two half-cells:

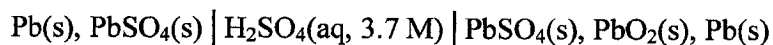


- (a) Calculate the E° of the cell.
- (b) Write the cell reaction occurring under standard state conditions.

[4 mks]

QUESTION A 9

Consider the following cell:

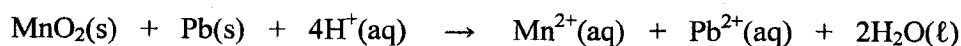


- (a) What is the class of this cell?
- (b) What distinguishes this class of cell from the other classes?
- (c) State two ideal properties that this class of cell should have.
- (d) State one disadvantage of this particular cell.

[4 mks]

QUESTION A 10

The reaction



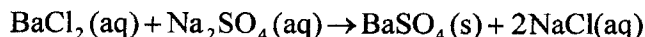
has a standard cell potential of 1.34 V. Calculate the Gibbs free energy ΔG° for the reaction.

[4 mks]

SECTION B
QUESTION B1

ANSWER B1 AND ANY THREE QUESTIONS

- (a) In Experiment III: Stoichiometry of Chemical reaction involving the reaction below you measured the height of the precipitate.

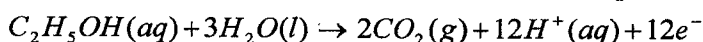
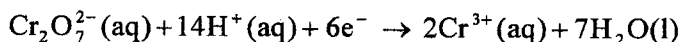


- (i) What physical quantity important in stoichiometry you should have measured instead of the height of the precipitate. Give two reasons why you did not measure that quantity.
- (ii) Write the ion reaction for the above reaction and identify the spectator ions in the reaction. Explain why they are called spectators ions.
- (b) In the C101 Laboratory you did two titration experiments.
- (i) Explain in less than three sentences what is meant by the term titration and name the two types of titrations you did?
- (ii) In two sentences explain why standardization of the secondary standard is important in titration? Use standardization of HCl using sodium carbonate and determination of ammonia using the standardized HCl to illustrate your answer.

[TOTAL = 15 mks]

QUESTION B 2

Laws passed in many countries define a drunk driver as the one who drives with blood alcohol, $\text{C}_2\text{H}_5\text{OH}$, level of 0.1000 % by mass or higher. The level of alcohol in the blood plasma is determined by redox titration involving the following half reactions in an acidic media:



Titration of 50.00 g of the driver's blood plasma required 38.94 mL of 0.0723 M of potassium dichromate solution to reach the endpoint.

- (a) Of the two half reactions above, identify the oxidation and reduction half reactions. Explain your answer.
- (b) From the half-reactions above, show that the **balanced redox reaction** is:
- $$2\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + \text{C}_2\text{H}_5\text{OH}(\text{aq}) + 16\text{H}^+(\text{aq}) \rightarrow 4\text{Cr}^{3+}(\text{aq}) + 2\text{CO}_2(\text{g}) + 11\text{H}_2\text{O}(\text{l})$$
- (c) Determine the percent alcohol level in the driver's blood plasma.
- (d) Did the driver exceed the legal limit?

[TOTAL = 15 mks]

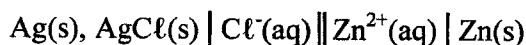
QUESTION B 3

- (a) (i) Give the equation that shows that radiation has both properties of waves as well as energy. Identify which parameters relate to energy and those to waves.
- (ii) Calculate the wavelength of radiation associated with the transition from $n = 1$ to $n = 5$. Is energy emitted or absorbed in this transition?
- (b) (i) Using spdf notation show the formation of magnesium chloride from magnesium and chlorine.
- (ii) Indicate whether Mg^{2+} is paramagnetic or diamagnetic. Justify your answer.
- (c) (i) Write Lewis structure (s) for the NCO^- molecule.
- (ii) What are the three resonance structures that are possible for the molecule shown in (c) (i) above
- (iii) Use the VSEPR theory to predict the molecular geometry of NCO^- .

[TOTAL = 15 mks]

QUESTION B 4

In an electrochemistry experiment requiring about 1.00 V, a third year chemistry student set up the following cell:



The cell operated under standard state conditions.

- (a) Was the cell set up in the conventional manner? Briefly explain your answer.
- (b) What is the balanced cell reaction that would provide the required voltage?
- (c) Calculate the E_{cell}° generated by the reaction.
- (d) What type of electrode is the cathode in the cell that generated the required E_{cell}° ?

[TOTAL = 15 Marks]

QUESTION B5

- (a) A half-cell consisting of a zinc electrode dipping into a 0.001 M $\text{Zn}^{2+}(\text{aq})$ ion solution at 298.15 K is connected to the standard hydrogen electrode. Calculate its voltage relative to the SHE.

- (b) The zinc half-cell in part (a) of this QUESTION is then connected to a standard bromine half-cell. What voltage would be generated?
- (c) Write the short-hand notation of the cell in part (b) of this QUESTION.
- (d) Write the reaction that occurs at the cathode.
- (e) Write the reaction that occurs at the anode.

END OF EXAMINATION

[TOTAL = 15 mks]

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

**2009 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS**

C 205: ANALYTICAL AND INORGANIC CHEMISTRY

TIME: 3 HOURS.

INSTRUCTIONS:

1. THIS PAPER CONTAINS SIX (06) QUESTIONS.
 2. ANSWER ONLY ONE (01) QUESTION FROM SECTION A; AND ANY THREE (03) QUESTIONS FROM SECTION B.
 3. EACH QUESTION CARRIES 15 MARKS.
 4. READ ALL INSTRUCTIONS CAREFULLY, BEFORE YOU START WORK.
-

Section A.

Question 1.

a).

Calculate the short and long wave length limits of Lyman series in the spectrum of Hydrogen atom. Given Rydberg constant $R_H = 109677 \text{ cm}^{-1}$

b).

A cricket ball weighing 100 g is to be located within 0.1 \AA . What is the uncertainty in its velocity? Comment on your result. [Planck's constant $h = 6.626 \times 10^{-34} \text{ Js}$].

c).

Calculate in units of Δ_o the difference in CFSE between complexes (a) and (b) assuming that the ligands are strong field ligands. (i). $d^6 (\text{oh})$ (ii) $d^6 (\text{td})$.

Question 2.

a).

Draw the molecular orbital diagrams of NO^- and NO^+ . Compare the bond orders and magnetic properties.

b.

Describe the nature of bonding in SO_2 and ClO_3^- using any theory of your choice. Predict the hybridization state, geometry and bond angle.

c.

Complete the following reactions

- i). $2\text{Li} + \text{H}_{2(\text{g})} \rightarrow$
- ii). $\text{LiAlH}_4 + \text{SiCl}_4 \rightarrow$
- iii). $4\text{BCl}_3 + 3\text{Li}[\text{AlH}_4] \rightarrow$

Section B.

Question 1.

a).

The first and second acidity constants of the weak acid, H_2S , are 10^{-7} and 10^{-15} respectively.

Calculate:

- the equilibrium constant (K_a) for the reaction $\text{H}_2\text{S} + 2\text{H}_2\text{O} \rightarrow 2\text{H}_3\text{O}^+ + \text{S}^{2-}$
- the concentration of S^{2-} ion in a 0.1 M H_2S solution at pH 2.

b).

When 10.0 cm³ of 0.100 M KNO_3 and 20.0 cm³ of 0.100 M K_2SO_4 are mixed, what would be the final concentration of each of the ionic species:

- K^+ in the resulting solution
- NO_3^- in the resulting solution.

c).

A new gravimetric method of analysis for iron (III) based on precipitation using a new organoboron 'cage' compound was developed. To test the accuracy of the new method, another established method based on iron precipitation with ammonia was used. Given the data below, establish whether there is significant difference between the two methods.

%Fe (cage method): 20.10; 20.50; 18.65; 19.25; 19.40 and 19.99
%Fe (ammonia method): 19.89; 19.20; 19.00; 19.70 and 19.40

Question 2.

a).

Write balanced equations, and decide which of the following may be regarded as redox reactions:

- $\text{BaCl}_2 + \text{H}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + \text{HCl}$
- $\text{Ag} + \text{Cl}_2 \rightarrow \text{AgCl}$

b).

Calcium in blood is determined by two methods (AAS and Colorimetry). Use F-test to determine whether there is significant difference in the precision of the AAS method and the new colorimetric method. The data is:

AAS (mg/dL): 10.9; 10.1; 10.6; 11.2; 9.6; 10.0
Colorimetry (mg/dL): 9.2; 10.5; 9.7; 11.5; 11.6; 9.3; 10.1; 11.2

c).

Orthoarsenic acid, H_3AsO_4 , is a triprotic acid with $\text{p}K_{a1} = 2.22$, $\text{p}K_{a2} = 6.98$ and $\text{p}K_{a3} = 11.53$. What is the equilibrium concentration of the conjugate base of arsenic acid in a 0.200 M H_3AsO_4 solution at pH 3?

Question 3.

a).

What concentrations should be used to prepare a cyanic acid-cyanate (HCNO/CNO^-) buffer solution of $\text{pH} = 3.50$? ($K_a = 1.2 \times 10^{-4}$ for HCNO)

b).

A solution contains $2.50 \times 10^{-4} \text{ M Pb(NO}_3)_2$. Calculate the following:

- the concentration of $\text{Pb(NO}_3)_2$ expressed as ppm
- the concentration of NO_3^- ions in this solution given that $\text{Pb(NO}_3)_2$ is a strong electrolyte.

c).

A batch of cough mixture bottles was weighed to determine if they fell within acceptable standard control guidelines. The individual weights were: 127.2; 128.4; 127.1; 129.0 and 131.1 g.

- Calculate the mean
- Determine whether the last weight is an outlier datum at 99% CL

Question 4.

a).

Calculate the pH of a solution obtained by dissolving 50ml of 0.15 M ammonia solution (17.0g/mol; density 0.90 g/mL; 28.0% w/w) and 2.00 g ammonium chloride in water and diluting to exactly 250 mL (for ammonia, $\text{p}K_b = 4.756$).

b).

A sample was analysed several times using two different methods. The following two sets of results for % ethanol content were obtained:

Method I (%ethanol): 13.5; 13.3; 12.9; 13.0;

Method II (%ethanol): 12.7; 12.6; 13.3; 13.3

Use the F test to determine whether Method I give the same results as Method II at 95% confidence level?

c).

A company trading in chemicals discovered that it had 1.435 kg of expired alkali in stock (0.6125 kg of NaOH and 0.8225 kg of KOH) which they wished to dispose of. To ensure safe disposal, they decided to neutralize an aqueous solution (1.00 L) of the alkalis with acid. What volume of 0.5 M H_2SO_4 would be required to neutralize the mixture?

.....**END OF EXAMINATION**.....

Universal Statistical Tables:

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	19.5
	3	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.70	8.66	8.62
	4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.86	5.80	5.75
	5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.62	4.56	4.50
	6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	3.94	3.87	3.81
	7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.51	3.44	3.38
	8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.22	3.15	3.08
	9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.01	2.94	2.86
	10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.85	2.77	2.70
	15	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.40	2.33	2.25
	20	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.20	2.12	2.04
	30	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.01	1.93	1.84

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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KEY

Atomic number X	Atomic mass	Name of the element X
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1 H 1.01 Hydrogen	4 Be 9.01 Beryllium
3 Li 6.94 Lithium	
11 Na 23.00 Sodium	12 Mg 24.31 Magnesium
19 K 39.10 Potassium	20 Ca 40.08 Calcium
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium
55 Cs 132.91 Cesium	56 Ba 137.33 Barium
87 Fr (223.02)	88 Ra 226.03 Radium

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 63.65 Copper	30 Zn 65.39 Zinc
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
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
89-103	104 Uuq 261.11	105 Uup 262.11	106 Uuh 263.12	107 Uus 262.12	108 Uuo 265.00	109 Uue 265			

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
13 Al 27.99 Aluminum	14 Si 28.09 Silicon	15 P 30.99 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
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
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
81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po 209 Polonium	85 At 210 Astatine	86 Rn 222 Radon

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**

**2009 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS**

C 225: ANALYTICAL CHEMISTRY 1.

TIME: 3 HOURS.

INSTRUCTIONS:

- 1. THIS PAPER CONTAINS FIVE (05) QUESTIONS.**
 - 2. ANSWER ANY THREE (03) QUESTIONS.**
 - 3. EACH QUESTION CARRIES 20 MARKS.**
 - 4. READ ALL INSTRUCTIONS CAREFULLY, BEFORE YOU START WORK.**
-

Question 1.

a).

- i). What is a standard solution?
- ii). What is meant by the equivalence point of a titration?
- iii). How much 0.1 N NaOH would have been added to 30 mL of 0.1N H₂SO₄, at the equivalence point?

b).

Will a precipitate form if 10ml of 0.01 M NaCl and 10ml of 0.0001 M AgNO₃ are mixed? Assume that the final volume of the solution is 20 ml. ($K_{sp} = 1.7 \times 10^{-10}$ for AgCl).

c). Phosphorus was determined in urine by phosphomolybdate method, and the results were as follows:

Phosphorus (ppm): 1.0; 2.0; 3.0; 4.0; 5.0

Absorbance (A): 0.205; 0.410; 0.615; 0.820; 1.025

From the data given above, determine the regression line equation.

Question 2.

a).

Phthalic acid is an acid (generally represented as H₂A) with its equilibrium dissociation constants given as $K_{a1} = 1.13 \times 10^{-3}$, and $K_{a2} = 3.90 \times 10^{-6}$. Determine the following:

- i). equilibrium concentration of the phthalate ion (A²⁻) at pH 1 in 0.05 M acid.
- ii). value of K_a for phthalic acid

b).

If 5.82 g of KHC₂O₄·H₂C₂O₄ (three ionisable protons) having 10% inert impurities, and 3.02 g of KHC₈H₄O₄ (one ionisable proton) are dissolved in water and diluted to 500 cm³, what is the normality of the solution assuming complete ionisation.

c).

Riboflavin (vitamin B₂) is determined in cereal samples by measuring fluorescence intensity in a 5% acetic acid solution.

Data: Standards concentration (ppm): 0.000; 0.100; 0.200; 0.400; 0.800

Fluorescence intensities (I): 0.000; 5.8; 12.2; 22.3; 43.3

From analytical data given above, determine the equation for the best-fit line for the calibration curve.

Question 3.

a).

A solution contains 2.50×10^{-4} M $\text{Cu}(\text{NO}_3)_2$. What is this copper nitrate concentration of the solution, expressed in ppm; and, what is the concentration of NO_3^- ions in this solution given that $\text{Cu}(\text{NO}_3)_2$ is a strong electrolyte.

b).

i). A solution of potassium permanganate (KMnO_4) prepared by dissolving 0.04568 kg in water, and making up to 750 cm^3 in a volumetric flask. Calculate the normality of the solution.

ii). What is the pH; and, the degree of hydrolysis of a 0.10 M solution of sodium acetate, $\text{NaC}_2\text{H}_3\text{O}_2$? For acetic acid, $K_a = 1.75 \times 10^{-5}$.

c).

i). Distinguish between the major and minor constituents of a sample.

ii). The following concentrations were determined from replicate analyses of a sample containing arsenic. Calculate the mean, median, standard deviation; and, the RSD as % and ppt.

Trial No.	Concentration, M
1.	2.35
2.	2.17
3.	2.24
4.	2.40
5.	2.29
6.	2.25

Question 4.

a).

The following results were obtained with a single air sample of an air pollution-monitoring programme. Determine the following parameters: the mean, median, standard deviation; and, RSD of the result.

Trial	SO_2 concentration, $\mu\text{g}/\text{m}^3$
1	80
2	77
3.	84
4.	86
5.	84
6.	79
7.	83
8.	82

b).

i). What is meant by the term 'triprotic'?

ii). What is the equilibrium concentration of the undissociated acid in a 0.2 M solution of orthoarsenic acid, H_3AsO_4 , ($K_{a1} = 5.65 \times 10^{-3}$; $K_{a2} = 1.75 \times 10^{-7}$ and $K_{a3} = 2.54 \times 10^{-12}$) at pH 3

c).

Calculate the mass of potassium permanganate, KMnO_4 , that should be dissolved in $1\,000 \text{ cm}^3$ of water to produce a solution of 0.500 N.

Question 5.

a).

i). Determinate errors may be attributed to three main causes, namely: instrumental errors, operative errors, and errors of the method. Describe each type of error; and, give an example of each type.

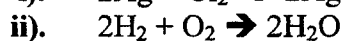
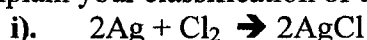
ii). A sample containing phosphorus was analysed five times using the phosphomolybdate method, and the results were as follows:

Sample No.:	1;	2;	3;	4;	5
ppm (P):	1.005;	1.006;	1.056;	1.061;	1.057

From the data obtained, calculate the results range; and, the standard deviation of the results obtained during the analysis.

b).

Explain your classification of the following reactions as either redox or not redox:



c).

i). To 40.0 mL of 1.00 M AgNO_3 is added 20.0 mL of 0.500 M AlCl_3 . What is the molarity of silver ion in the resulting solution?

ii). Determine whether a precipitate will form if 2 mg of solid $\text{Ca}(\text{NO}_3)_2$ and 2 mg of solid NaF were equilibrated at 25°C in 500 cm^3 of water (K_{sp} for $\text{CaF}_2 = 4.0 \times 10^{-11}$)

.....END OF EXAMINATION.....

Universal Statistical Tables:

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
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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
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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	19.5
	3	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.70	8.62
	4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.86	5.75
	5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.62	4.50
	6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	3.94	3.81
	7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.51	3.38
	8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.22	3.08
	9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.01	2.86
	10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.85	2.70
	15	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.40	2.25
	20	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.20	2.04
	30	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.01	1.84

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number X	Atomic mass Name of the element X
--------------------	---

1 H 1.01 Hydrogen	4 Be 9.01 Beryllium
3 Li 6.94 Lithium	
11 Na 23.00 Sodium	12 Mg 24.31 magnesium
19 K 39.10 Potassium	20 Ca 40.08 Calcium
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium
55 Cs 132.91 Cesium	56 Ba 137.33 Barium
87 Fr (223.02) Francium	88 Ra 226.03 Radium

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 63.65 Copper	30 Zn 65.39 Zinc
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
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
104 Uuq 261.11	105 Uup 262.11	106 Uuh 263.12	107 Uus 262.12	108 Uuo 265.00	109 Uue 265				

57 - 71									
89 - 103									

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
13 Al 27.99 Aluminum	14 Si 28.09 Silicon	15 P 30.99 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
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
81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po 209 Polonium	85 At 210 Astatine	86 Rn 222 Radon

1 H 1.01 Hydrogen	2 He 4.00 Helium
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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**

**2009 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS**

C245: INORGANIC CHEMISTRY 1

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	$6.022 \times 10^{23} \text{ mol}^{-1}$
Electron mass	m_e	$9.109 \times 10^{-31} \text{ kg}$
Electron charge	$-e$	$1.602 \times 10^{-19} \text{ C}$
Planck's constant	h	$6.626 \times 10^{-34} \text{ Js}$
Permittivity of free space	ϵ_0	$8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$
Speed of light	c	$2.998 \times 10^8 \text{ ms}^{-1}$

Question 1.

- a) Using PF_3 and PCl_3 , explain the meaning of basicity of a ligand.
- b) Draw, on the same graph, the Radial Distribution Function (RDF) of the following orbitals for which
 - i) $n = 2$ and $l = 1$
 - ii) $n = 3$ and $l = 2$
 - iii) What is the main distinguishing feature of the RDFs in (i) and (ii)
- c) The wave function for a 1s orbital in the hydrogen atom is given by

$$\Psi_{1s} = \frac{1}{\sqrt{\pi}} \left(\frac{Z}{a_0} \right)^{3/2} e^{-Zr/a_0}$$

- i) Re-write this expression in atomic units.
- ii) Identify the radial function in (i)
- ii) Show where the electron in hydrogen atom is most likely to reside

Question 2

- a) By considering an electron in a 1-D box
 - i) State the Hamiltonian for this system in classical terms. (i.e. using p as momentum)
 - ii) Derive expression for the Broglie Wavelength
- b)
 - i) Define the Hamiltonian for a stationary ${}_3\text{Li}^{2+}$ ion (neglecting the electron-electron repulsion term)
 - ii) State the expression for the Schrodinger equation.
- c) Name the complexes
 - a) $[\text{Ni}(\text{en})_3]^{2+}$
 - b) $[\text{Cu}(\text{EDTA})]^{2-}$

Question 3

- (a) Using Molecular Orbital Theory concepts explain why bond length of N_2^+ is 0.02 greater than that of N_2 whereas that of NO^+ is 0.09 less than that of NO ?
- (b) What is the product obtained when I_2 is dissolved in aqueous KI ? Describe the nature and structure of bonds formed.
- (c) Describe the bonding in CH_4 using Molecular Orbital diagram.

Question 4

- (a) The aqueous ions Zn^{2+} and Ag^+ form complexes with NH_3 that have similar stabilities, yet zinc and silver are in different groups in periodic table. Suggest a reason for this similar chemistry.
- (b) How can you synthesize ionic hydrides. Give some examples.
- (c) The complex $K_2[Ni(CN)_4]$ has a magnetic moment $\mu_s = 0.01 \mu_B$. Using crystal field theory discuss the shape and bonding in this molecule.

Question 5

- (a) Using Valence bond Theory explain the bonding in $[Fe(H_2O)_6]^{2+}$. Predict the hybridization, geometry and compute the spin only magnetic moment of the complex.
- (b) Make a list of factors that can influence the atomic or ionic radius of an element.
- (c) Calculate the electronegativity of carbon from the data given as $E_{H-H} = 104.2 \text{ Kcal/mol}$, $E_{C-C} = 83.1 \text{ Kcal/mol}$, $E_{C-H} = 98.0 \text{ Kcal/mol}$, and $X_H = 2.1$. [Where E is the bond energy and X is the electronegativity.]

Question 6

- (a) Ionic radius (\AA) of Na^+ is 1.02 and ionic mobility at infinite dilution is $43.5 \text{ m}^2\text{s}^{-1}\text{V}^{-1}$. Ionic radius of Cs^+ is 1.67 and ionic mobility at infinite dilution is $68.00 \text{ m}^2\text{s}^{-1}\text{V}^{-1}$. Account for this.
- (b) Lattice enthalpies can be used to explain the non - existence of some compounds. Elaborate the above statement using suitable example.
- (c) Construct a Born Haber cycle and use it and the data below to calculate the 2nd electron affinity of oxygen.

Enthalpy of atomization of Mg	150 (KJ/mol)
Bond energy of O=O in O_2	496
1 st ionization energy of Mg	736
2 nd ionization energy of Mg	1450
1 st electron affinity of O_2	-142
Lattice enthalpy of MgO	-3889
Enthalpy of formation of MgO	-602

END OF EXAMINATION

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number X
Atomic mass Name of the element X

KEY									
1	2	3	4	5	6	7	8	9	10
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THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C251: ORGANIC CHEMISTRY I

TIME: THREE HOURS

INSTRUCTIONS:

1. Answer any four questions.
2. Marks allocation for questions is shown [x]

Max.marks: 120

Question 1

- (a) Hydrogen-hydrogen eclipsing interaction in the eclipsed conformation of ethane costs 1.0 kcal/mol.
- (i) How many such eclipsing interactions are present in cyclopropane?
 - (ii) What fraction or percentage of the overall 27.6 kcal/mol strain energy of cyclopropane is due to torsional strain?

[10 Marks]

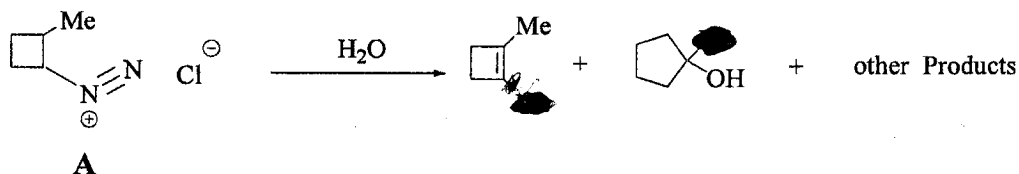
- (b) Optically pure (*S*)-2-methylbutanoic acid has a specific rotation of $+23.1^\circ$ and (*R*)-2-methylbutanoic acid has a specific rotation of -23.1° . In an attempt to prepare (*R*)-2-methylbutanoic acid, a C251 student obtained 24g of a mixture of (*R*)- and (*S*)-2-methylbutanoic acids whose specific rotation was -15° .

- (i) What was the optical purity of the mixture?
- (ii) How much of each isomer was present in the mixture?
- (iii) Outline a route for the resolution of (*R*)- and (*S*)-2-methylbutanoic acids using (*R*)-1-Phenylethylamine.

[20 Marks]

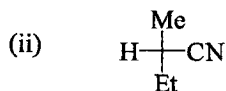
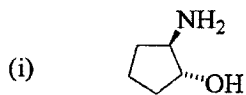
Question 2

- (a) The aliphatic diazonium salts are highly reactive and the nitrogen is an excellent leaving group. In aqueous solutions, the diazonium species, $\text{RRCHN}^+\equiv\text{N}$, is rapidly hydrolysed by $\text{S}_{\text{N}}1$ mechanism to give a mixture of products. Based on your understanding of the $\text{S}_{\text{N}}1$ and $\text{E}1$ reactions, suggest plausible reaction mechanisms to account for the products of the hydrolysis of the diazonium salt **A** shown below.



[14 Marks]

- (b) Propose a synthesis of the following compounds from any alcohols containing **not** more than five carbon atoms and any other readily available reagents. Show all steps of your synthesis clearly and give the reagents, the solvents (if any) and the reaction conditions for each step of your proposed synthesis. *Pay attention to the stereochemistry of the molecules. Do not show any reaction mechanisms.*

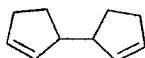


[16Marks]

Question 3

- (a) Bromination of cyclopentene with bromine in carbon tetrachloride in the presence of tert.-butyl peroxide (t-Bu-O-O-t-Bu) gave the expected product, 3-bromocyclopentene, in good yield. However, small amounts of the compound **B**, structure shown below, and tert.-butanol were also isolated from the reaction mixture. Suggest a mechanism for the formation of the compound **B** and tert.-butanol in this reaction.

Compound **B**:



[12 Marks]

(b) A compound **C**, $C_7H_{11}Br$ reacts with hydrogen bromide to give a mixture of two isomeric products, **D** and **E**, both of molecular formula $C_7H_{12}Br_2$. Treating **C** with potassium tert-butoxide yields a compound **F**, C_7H_{10} . Subjecting one mole of **F** to ozonolysis followed by treatment with zinc and acetic acid yields two moles of formaldehyde (HCHO) and one mole of 1,3-cyclopentanedione.

(i) Deduce the stereochemical structures of the compounds **C**, **D**, **E**, and **F** from the following experimental results.

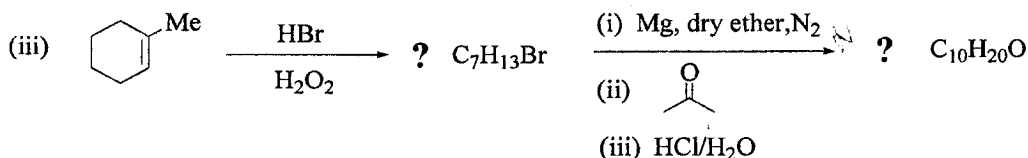
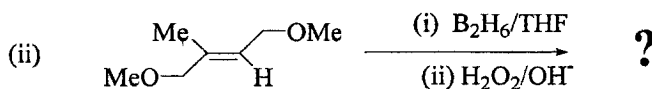
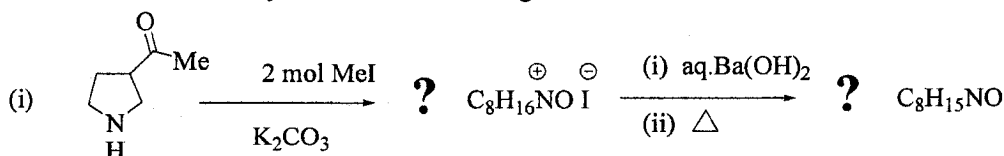
(ii) Outline the reactions involved in these transformations.

(iii) In addition to **D** and **E**, other products could be formed in the reaction of **C** with hydrogen bromide. Give the structure of any one other product that could be formed in the reaction of **C** with hydrogen bromide.

[18 Marks]

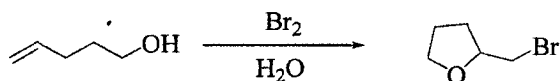
Question 4

(a) Give the structures of the major organic products, including stereochemistry where relevant, and the mechanisms of **any two** of the following reactions:



[20 Marks]

(b) When 4-penten-1-ol is treated with aqueous bromine, a cyclic bromoether is formed rather than the expected bromohydrin:

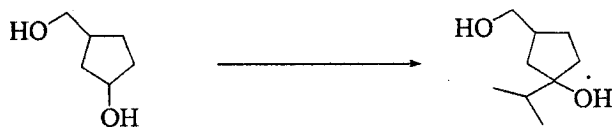


- (i) Propose a mechanism for this transformation.
(ii) Explain why the bromohydrin was not formed.

[10 Marks]

Question 5

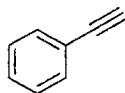
- (a) Propose how you would carry out the following transformation:



Show clearly all the steps, the reagents used, and provide mechanisms of the reactions involved in your proposal.

[14 Marks]

- (b) (i) What product(s) you would obtain by treating benzoacetylene, structure shown below, with mercuric sulphate followed by the subsequent removal of the inorganic mercuric compound.



- (ii) If the benzoacetylene shown in 5 (b) (i) above were treated with ozone followed by hydrolysis, what product(s) would you expect to obtain? Show clearly the steps and the intermediate products of this reaction.

[16 Marks]

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY
2009 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS
CAV 251: AGRICUTURAL AND VETERINARY CHEMISTRY

TIME ALLOWED: THREE HOURS

INTRUCTIONS: ANSWER ANY FOUR FROM THE FIVE QUESTIONS

- 1 (a) (i) How would you obtain a maize sample from a truck full of shelled maize for the determination of moisture content?
- (ii) What are determinate errors? Name three sources of these errors. Define the standard deviation of a set of data.
- (b) (i) 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.
- (ii) Draw the necessary criteria for a compound to be aromatic. Describe Huckel's rule of aromaticity with special reference to benzene and naphthalene.
- (c) A commercial farmer purchased a track load of stock feed from a Manufacturer. The analysis certificate made out while the track was being loaded showed 46.70% protein with a standard deviation of 0.07% for five measurements. When the stock feed arrived at the farm, it was analyzed with the following results, %protein: 45.58, 45.61, 45.69, 45.64 and 48.92. Should the farmer accept the stock feed?
- (d) (i) Three possible products can be formed in the bromination of methylbenzene (Toluene). Draw the three structures.
- (ii) Give an account of the mechanism of nitration and Friedel Craft's akylation reaction of benzene.
- (e) (i) What is an α -amino acid?
- (ii) Write equations to show the reactions of the amino acid alanine, $\text{CH}_3\text{CH}(\text{NH}_2)\text{COOH}$, with HCl and NaOH .
- (f) 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)

- 2 (a) One mole of an ideal gas at 20°C is compressed adiabatically so that the temperature rises to 50°C . Calculate the ΔU , w , and ΔH . C_v for the gas is $1.5R$. (4marks)
- (b) The hydrolysis of adenosine triphosphate (ATP) which liberates its terminal phosphate group is a reaction of considerable biochemical significance, and many attempts have been made to measure the values of ΔH , ΔS and ΔG for this reaction at 'physiological' temperature and pH values. In one such determination at 36°C and pH 7 in the presence of Mg^{2+} ions, it was calculated that when ΔH was -20.68kJ/mol , ΔS was 35.68J/K-mol .
- (i) Calculate the corresponding value of ΔG of the reaction.
- (ii) Deduce whether or not the reaction will be spontaneous at 36°C .
- (c) Cl^- ions are added to a solution that contains 0.03M Ag^+ and 0.010M Pb^{2+} . Carry out the necessary calculations to show if fractional precipitate as chlorides is a feasible method of effecting an analytical separation of Ag^+ from Pb^{2+} . K_{sp} for $\text{AgCl} = 1.80 \times 10^{-10}$ and K_{sp} for $\text{PbCl}_2 = 1.60 \times 10^{-5}$
- (d) A new method of determining oxyphen butazone gave 99.35% recovery (variance 0.185). The standard method gave 99.53% recovery (variance 0.152). In each case three replicate measurements were made. Test whether the two means differ significantly at the 95% confidence level. (12marks)
- (e) 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 (10marks).
- 3 (a) The solubility product of the compound P_2X was found equal to 3.58×10^{-13} on the basis of solubility measurements and the assumption of quantitative ionisation to P^+ and X^{2-} ions. Later it was found that the compound is quantitatively ionised to P_2^{2+} ions. Calculate the real solubility product of P_2X . (10marks)
- (b) Three moles of an ideal gas at 300K expands isothermally and reversibly from 20dm^3 to 60dm^3 . Compute w , q , ΔU and ΔH . (10marks)
- (c) Mr. Mwauluka was able to determine the rate at which bird flu (H_5N_1) depletes vitamin C in the body of a human being. He found that at 40°C the rate was four times faster than at 15°C . Calculate the approximate energy of activation for the reaction (5marks)

- (d) What is meant by the terms S_N1 and S_N2 ? Give the mechanism for the S_N1 reaction between optically active 2-bromobutane and anhydrous NaOH and explain why the product is optically inactive. (4marks)
- (e) Compound A ($C_5H_{12}O$) does not give a yellow precipitate with 2, 4-dinitrophenylhydrazine. Oxidation of A with potassium dichromate gives B ($C_5H_{10}O$). Compound B reacts with 2,4-dinitrophenylhydrazine but does not give a precipitate with silver nitrate in ammonia. Acid-catalyzed dehydration of compound A gives hydrocarbon C (C_5H_{10}). Ozonolysis of hydrocarbon C gives propanone (acetone) and ethanal (acetaldehyde). Propose structural formulas for compound A, B and C (15marks)
- 4 (a) The Director of Mount Makulu was trying to decide whether or not to keep a young, recently hired CAV 251 student. The Director decided to see if the student's work was of the same quality as that of the other staff. He asked both a Senior Technician and the student to analyze the same sample using the same procedure, reagents, and instruments. They obtained the following results:

<u>Senior Technician</u>	<u>CAV 251 Student</u>
1.38	1.28
1.33	1.36
1.34	1.35
1.35	1.40
1.30	1.31

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

- (b) The Mohr method was used to determine the concentration of sodium chloride in a 1.004g sample. The sample was dissolved in water and titrated to the end point with 32.36ml of 0.1012M silver nitrate. Calculate the percent of sodium chloride in the sample (10marks) (MM NaCl == 58.44)
- (c) An organic compound X has the formula C_3H_6O .
- Write four structural formulae for the compound (4marks)
 - Classify each according to its functional group (4marks).
 - Give the systematic IUPAC names for each compound (4marks).
- (d) Draw the structure of the product formed when benzene is reacted exhaustively with chlorine gas in the presence of UV light. Give the name of the product formed and its pharmaceutical use. (4marks)
- (e) (i) Starting with 1-propanol how could one prepare propene and 1-bromopropane (3marks)

- (ii) Draw both E- and Z-1-methyl cycloheptene. Which would you expect to be more stable? Explain (4marks)
- 5
- (a) What is the minimum required concentration of Na_2CO_3 in solution A so that by shaking 2.00g of BaSO_4 in 20ml solution A is converted quantitatively to BaCO_3 . K_{sp} for BaSO_4 is 1.5×10^{-9} ; K_{sp} for BaCO_3 is 1.6×10^{-9} .
- (b) Calculate the pH and pOH of a solution obtained by mixing equal volumes of 0.1M H_2SO_4 and 0.3M NaOH (5marks)
- (c) You are given a sample of 2, 3- dibromobutane, a compound that contains two chiral carbons. It fails to rotate the plane polarized light. Give two possible explanations (2marks)
- (d) Draw structural formulas for all compounds of molecular formula C_5H_{10} that are:
- (i) Alkenes that do not show cis-trans isomerism (2marks)
 - (ii) Alkenes that do show cis-trans isomerism (2marks)
 - (iii) Cycloalkanes that do not show cis-trans isomerism (4marks)
 - (iv) Cycloalkanes that do show cis-trans isomerism (2marks)
- (e) (i) The ionisation constant of the weak acid, HCN , is 4.00×10^{-10} . A solution is prepared by dissolving 9.802g of NaCN in enough water to make 1.00dm^3 of solution. Calculate the pH of the solution. MM of $\text{NaCN} = 49.02$ amu. (5marks)
- (ii) Give the stereo chemical structure (s) of the product (s) that would be obtained when 2-butyne is hydrogenated in the presence of Lindlar's catalyst and Na/NH_3 . (2marks)

END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

**2009 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS**

C 341: INORGANIC CHEMISTRY II

TIME: THREE HOURS

INSTRUCTIONS: ANSWER ANY FOUR QUESTIONS

- Question 1. (a) Name the complex cation $K_3[Fe(CN)_5NO]$.
(b) Draw the structure of the complex bis(ethylenediamine)Cobalt(III)- μ -imido- μ -hydroxobis(en)cobalt(III).
(c) Give the structural formulas for all the possible isomers of each of the following:
(i) $[Co(en)_2(NH_3)Cl]^{2+}$
(ii) $[Co(en)(NH_3)_2Cl_2]^{2+}$

- Question 2. (a) Cr^{3+} in emerald shows 3 peaks at 16260 cm^{-1} , 23700 cm^{-1} and 23740 cm^{-1} . Assign the bands.
(b) Derive the ground state term symbol of d^{10} configuration.
(c) The isoelectronic ions VO_4^{3-} , CrO_4^{2-} , MnO_4^- all have intense charge transfer transitions. The wavelength of these transitions increase in this series, with MnO_4^- having its absorption at the longest wavelength. Suggest a reason for this trend.

- Question 3. (a) Explain temperature dependent paramagnetism (TDP) and temperature independent paramagnetism (TIP).
(b) Calculate the wave number and wavelength of the fundamental absorption peak due to stretching vibration of a carbonyl group. The force constant is 1×10^6 dynes/cm. The masses of Carbon and Oxygen are 2.0×10^{-23} and 2.7×10^{-23} g/atom.
(c) Select from the following list:
NO, Br₂, O₂, H₂C=O, CCl₄, CH₃-CH₂-Cl, CH₃CH₂OH
(1) Those, which give more than one NMR band.
(2) Those with no dipole moments.

Question 4. The Halogen group VII contains F, Cl, Br, I, and At. Write down the reactions:

- (a) Preparation of elements.
- (b) Of elements with metals and alkalis.
- (c) Preparations of oxides of halogens and their reactions with water and alkalis.

Question 5. The Noble gases group contains He, Ne, Ar, Kr, Xe, and Rn.

- (a) How do they obtain the Noble gases?
- (b) Describe the main properties of each of them: Density, melting and boiling points.
- (b) Write down the reactions production of Xenon trioxide and tetra oxide and their reactions with water and concentrated and dilute alkalis.

Question 6. Discuss the production processes of H_2 , CO and CO_2 from:

- (a) Coal.
- (b) Natural gases.
- (c) Coke-oven gases.

END OF EXAMINATIONS

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number	X
Atomic mass	
Name of the element X	

PERIODIC TABLE OF THE ELEMENTS																														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18													
KEY																														
Atomic number X Atomic mass Name of the element X																														
1 H 1.01 Hydrogen	2 He 4.00 Helium															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 27.99 Aluminum	14 Si 28.09 Silicon	15 P 30.99 Phosphorus	16 S 32.07 Sulfur	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													
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 131.2 Xenon													
55 Cs 132.91 Cesium	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 209.99 Polonium	85 At 209.99 Astatine	86 Rn 222.0 Radon
87 Fr 226.03 Francium	88 Ra 226.03 Radium	89-103														104 Unq 261.11	105 Unp 262.11	106 unh 263.12	107 unl 262.12	108 Uue 265.00	109 Uuh 265	110 Uub 265	111 Uut 265	112 Uuq 265	113 Uup 265	114 Uuh 265	115 Uus 265	116 Uuq 265	117 Uus 265	118 Uuo 265

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C351: ORGANIC CHEMISTRY I

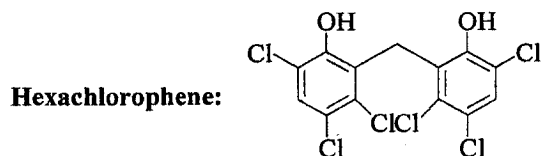
TIME: THREE HOURS

INSTRUCTIONS:

1. Answer any four questions.
2. Marks allocation for questions is shown [x] Max. marks: 120

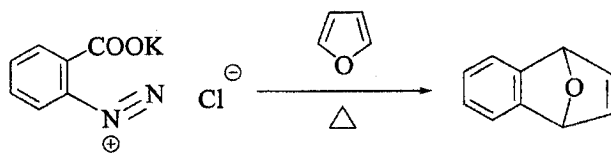
Question 1

- (a) Hexachlorophene, a substance used in the manufacture of germicidal soaps, is prepared by reaction of 2,4,5-trichlorophenol with formaldehyde in the presence of concentrated sulphuric acid. Propose a mechanism to account for the reaction.



[12 marks]

- (b) Upon heating, benzene diazonium carboxylate decomposes to yield a reactive intermediate, **A**, (MS: m/z : 76) and two other substances - **B** (MS: m/z : 28) and **C** (MS: m/z : 44).
When benzenediazonium carboxylate is heated in presence of furan, the following reaction is observed:



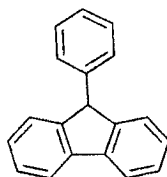
- (i) Identify **A**, **B** and **C**.
- (ii) Propose a mechanism for the reaction shown above.

[18 marks]

Question 2

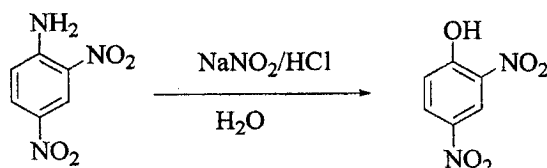
- (a) Hydrolysis of 1,1,1-triphenylmethylbromide, $((\text{C}_6\text{H}_5)_3\text{CBr})$, in aqueous sulphuric acid at 25°C unexpectedly gave a tricyclic compound **D** instead of 1,1,1-triphenylmethanol. Propose a mechanistic explanation to account for this observation.

Compound **D**:



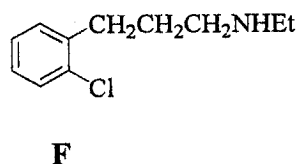
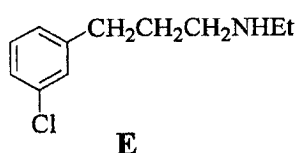
[10 marks]

- (b) (i) Diazotisation of 2, 4-dinitroaniline in aqueous solution is accompanied by some conversion into phenols in which a nitro group is replaced by a hydroxyl group.



Show all steps including mechanisms of the reactions involved in the above transformation

- (ii) When treated with $\text{Et}_2\text{NK}/\text{Et}_2\text{NH}$, both **E** and **F** give the same product **G**, $\text{C}_9\text{H}_{11}\text{N}$, in good yield.

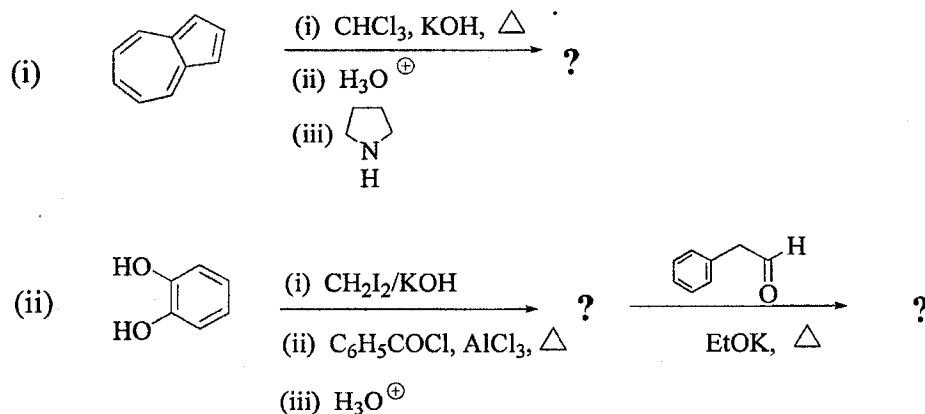


- (a) What is the product **G**?
 (b) Provide a mechanistic explanation to account for these experimental results.

[20 Marks]

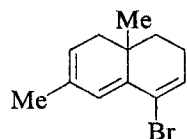
Question 3

(a) Predict the major organic products and give mechanisms of the following reactions:

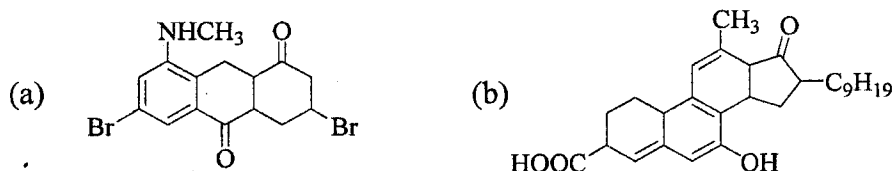


[18 Marks]

(b) (i) Partial hydrogenation of the triene, structure shown below, results in two compounds, **H** and **I**, both of molecular formula $C_{10}H_{14}$. Compound **H** shows a $\lambda_{\max} = 235$ and **I** at 278 nm. Assign the structures:



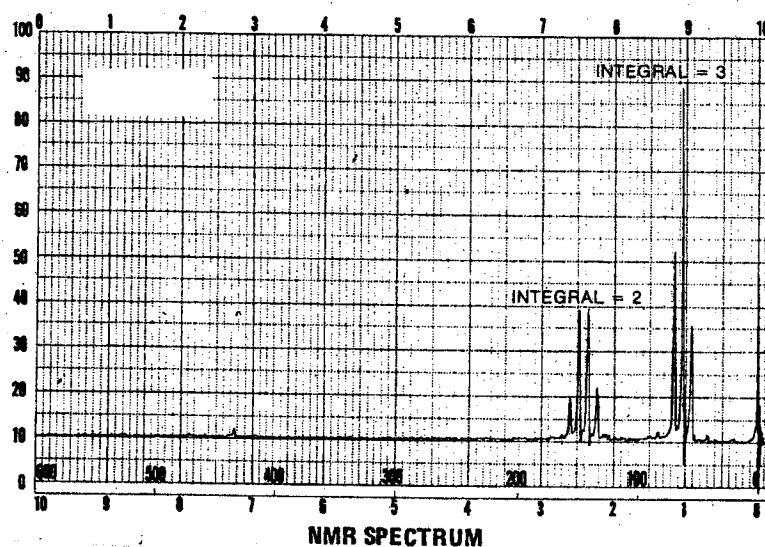
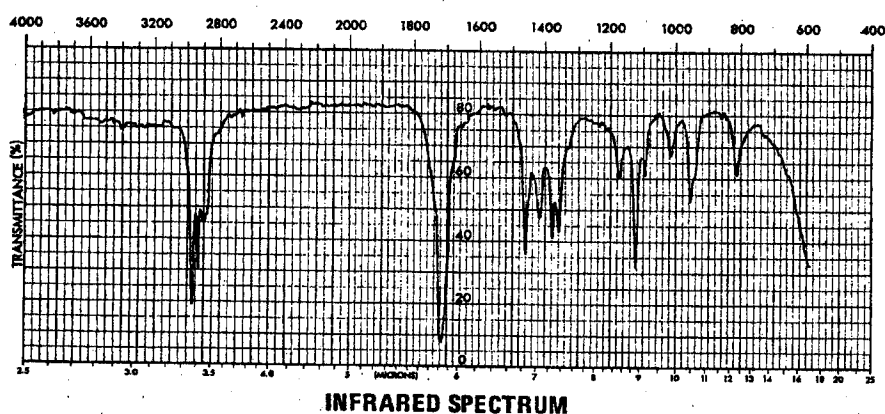
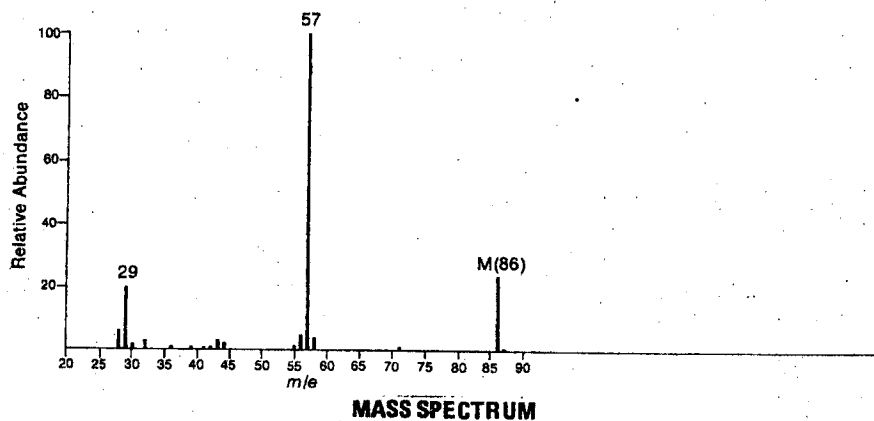
(ii) Predict the UV maximum for the following compounds shown below:



[12 Marks]

Question 4

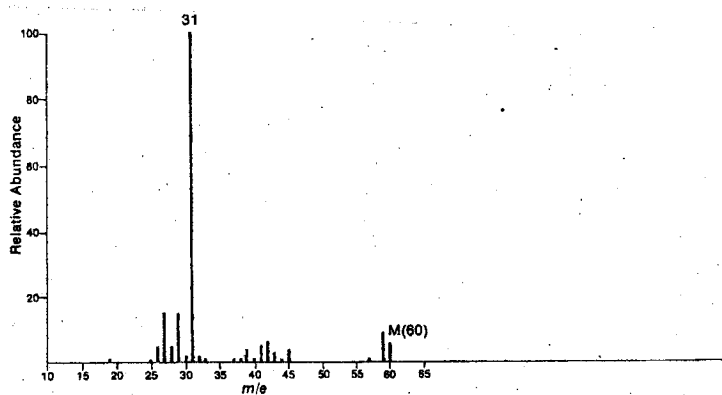
Deduce the structure of a compound **J**, whose MS, IR and ^1H NMR are given below.



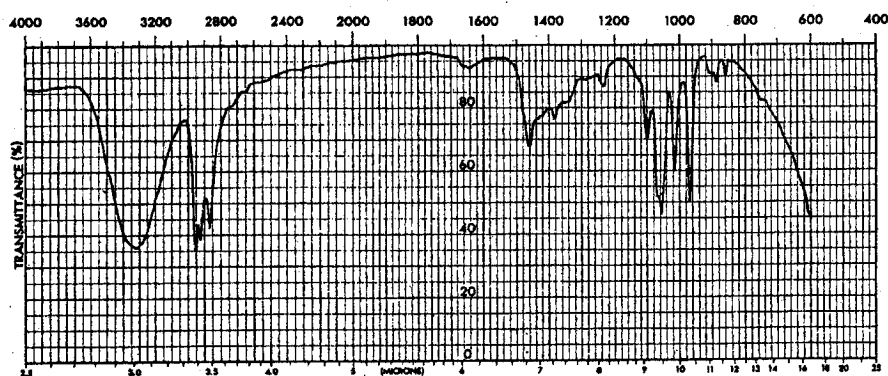
[30 Marks]

Question 5

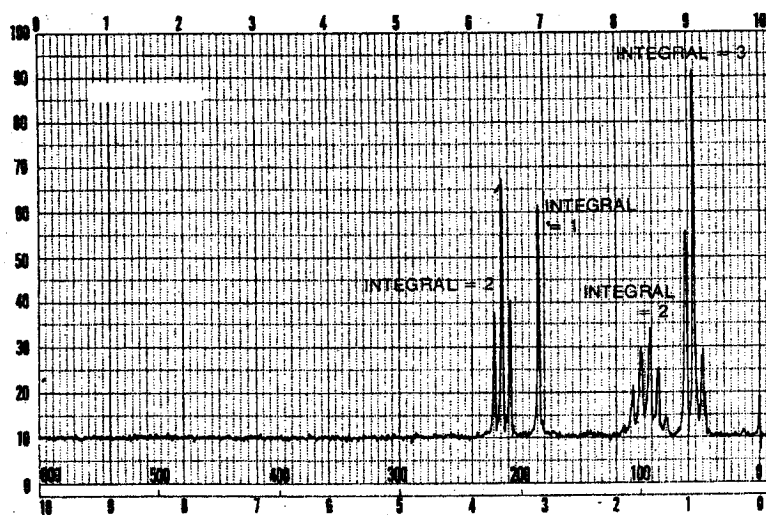
Deduce the structure of a compound K, whose MS, IR and ^1H NMR are given below.



MASS SPECTRUM



INFRARED SPECTRUM



NMR SPECTRUM

[30 Marks]

END OF THE EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

UNIVERSITY SEMESTER I SESSIONAL EXAMINATIONS 2009

C361 CHEMICAL KINETICS AND NUCLEAR CHEMISTRY

2 NOVEMBER 2009

TIME: THREE HOURS

INSTRUCTIONS: ANSWER QUESTION, 1 AND ANY FOUR OTHERS.

DATA

Boltzmann constant $k_B = 1.38 \times 10^{-23} \text{ J K}^{-1}$; $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$

Avogadro number $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

Planck constant $h = 6.63 \times 10^{-34} \text{ J s} = 4.136 \times 10^{-21} \text{ MeV s}$

Atomic masses in u

${}_0^1\text{n} = 1.0141$; ${}_2^4\text{He} = 4.002603$; ${}_{90}^{231}\text{Th} = 231.03630$; ${}_{92}^{235}\text{U} = 235.04392$

Mass excess in Mev

${}_0^1\text{n} = 8.07143$; ${}_2^4\text{He} = 2.42468$; ${}_{39}^{102}\text{Y} = -63.63$; ${}_{53}^{131}\text{I} = -87.451$; ${}_{90}^{231}\text{Th} = 33.81276$;

${}_{92}^{235}\text{U} = 40.9164$; ${}_{92}^{236}\text{U} = 42.4420$

QUESTION 1 (40 MARKS)

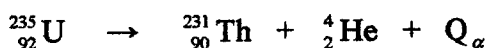
- a) Catalase is an enzyme that promotes the conversion of hydrogen peroxide into water and oxygen. For catalase the diffusion constant = $6.0 \times 10^{-7} \text{ cm}^2 \text{ s}^{-1}$ and radius = 5.12 nm. For hydrogen peroxide the diffusion constant is $1.5 \times 10^{-5} \text{ cm}^2 \text{ s}^{-1}$ and the radius = 0.2 nm.

- (i) Calculate the rate constant for the reaction.
- (ii) The experimentally determined rate constant for the conversion of hydrogen peroxide by catalase is $5 \times 10^6 \text{ M}^{-1} \text{ s}^{-1}$. Is this a diffusion controlled reaction?

- b) Determine the ground state spin and parity of $^{33}_{16}\text{S}$ and $^{41}_{21}\text{Sc}$ using data in the Table below.

State	ℓ	Nucleons = $2j + 1$	Total nucleons
$1f_{\frac{7}{2}}$	3	8	
$1d_{\frac{3}{2}}$	2	4	20
$2s_{\frac{1}{2}}$	0	2	
$1d_{\frac{5}{2}}$	2	6	
$1p_{\frac{1}{2}}$	1	2	8
$1p_{\frac{3}{2}}$	1	4	
$1s_{\frac{1}{2}}$	0	2	2

- c) Consider the reaction:

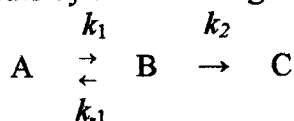


- (i) Calculate the energy of the reaction, Q_{α} .
 - (ii) Determine the kinetic energy of the alpha particle, E_{α} .
- d) The rate constant for the gas phase decomposition of N_2O_5 in the reaction:
- $$2\text{N}_2\text{O}_5 \rightarrow 4\text{NO}_2 + \text{O}_2$$

is $k = 3.38 \times 10^{-5} \text{ s}^{-1}$ at 298.15 K

- (i) What is the half life of N_2O_5 ?
- (ii) How long would it take for N_2O_5 to decrease to 10 % of its initial value?

- e) A reaction occurs by the following mechanism:



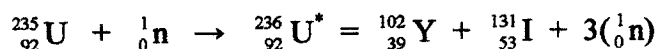
- (i) What type of reaction follows this mechanism?
- (ii) Write kinetic expressions such as $\frac{d[B]}{dt}$ for all reactants and products.

QUESTION 2 (15 MARKS)

- a) $^{235}_{92}\text{U}$ is an important nuclide that is used in fission reaction in nuclear research reactors and nuclear power reactors. The ground state of $^{235}_{92}\text{U}$ has spin and parity of $\frac{7}{2}^{-}$ and next energy of 0.046347 MeV has spin and parity of $\frac{9}{2}^{-}$.

- (i) Calculate the rotational constant, B, for this rotational band.
- (ii) Determine the energy of the $\frac{11}{2}^{-}$ state.

- b) One of the fission reactions of $^{235}_{92}\text{U}$ with 0.0253 eV thermal neutron is shown below:



- (i) The nuclide that fission is $^{236}_{92}\text{U}$ with a critical energy, $E_{\text{crit}} = 5.5$ MeV, calculate the binding energy of the last neutron in $^{236}_{92}\text{U}$ and show that spontaneous fission of this nuclide is possible with thermal neutrons of essentially zero kinetic energy.
- (ii) Calculate the energy released in the fission reaction above.

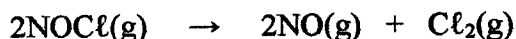
QUESTION 3 (15 MARKS)

- a) The following is a key equation in physical chemistry: ✓

$$k = \frac{k_B T}{h} \frac{RT}{p^\circ} e^{\Delta S^\ddagger / R} e^{-\Delta H^\ddagger / RT}$$

- (i) Name the equation
- (ii) Identify each symbol in the equation

- b) The thermal decomposition of nitrosyl halides is important in tropospheric chemistry. For example consider the decomposition of NOCl :



The Arrhenius parameters for the reaction are $A = 1.00 \times 10^{13} \text{ M}^{-1} \text{ s}^{-1}$ and $E_a = 104 \text{ kJ mol}^{-1}$. Calculate ΔS^\ddagger and ΔH^\ddagger .

QUESTION 4 (15 MARKS)

Reciprocal plots provide a relatively straightforward way to determine if an enzyme demonstrates Michaelis Menten kinetics and to determine the corresponding kinetic parameters. An alternative to reciprocal plots is the Eadie-Hofstee plot where the reaction rate is plotted versus the rate divided by the substrate concentration and the data are fit to a straight line.

- a) Beginning with the general expression for the reaction rate given by the Michaelis Menten mechanism:

$$V = \frac{V_{\max} [S]_0}{[S]_0 + K_m}$$

Rearrange this equation to construct the following expression which is the basis for the Eadie-Hofstee plot:

$$V = V_{\max} - K_m \frac{V}{[S]_0}$$

- b) Using the Eadie-Hofstee plot, determine V_{\max} and K_m for the hydrolysis of sugar by the enzyme invertase using the following data:

[Sucrose] ₀ (M)	0.029	0.059	0.088	0.117	0.175	0.234
Rate(M s ⁻¹)	0.182	0.266	0.310	0.330	0.362	0.361

QUESTION 5 (15 MARKS)

- a) The hydrolysis of ethyl acetate



in aqueous solution is first order with respect to ethyl acetate. When the pH of the solution is varied, the first order constant varies as shown:

$[\text{H}^+]$ M	0.001	0.01	0.1
k_1	1.1	11	110

What is the order of the reaction with respect to H^+ and the value of the rate constant?

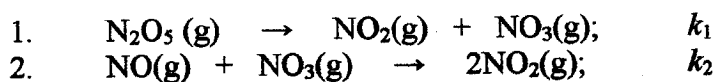
- b) Ortho and para hydrogen are two forms of the diatomic molecule H_2 in which the nuclear spins on the hydrogen nuclei are parallel and opposed respectively. The conversion occurs with the half lives given below at the corresponding initial pressure of para hydrogen:

p_o (Pa)	6650	13300	26600	53200
$t_{1/2}$ (s)	648	450	318	222

What is the order of the conversion reaction: ${}_p\text{-}H_2(g) \rightarrow {}_o\text{-}H_2(g)$

QUESTION 6 (15 MARKS)

The reaction between nitric oxide and dinitrogen pentoxide is believed to occur via a two step mechanism as follows:



- What is the net reaction?
- What is the net rate of production of $NO_2(g)$?
- Apply the steady state approximation to obtain the rate law for the production of $NO_2(g)$?

END OF C 361 EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATION

C 411: ADVANCED BIOCHEMISTRY I

TIME: THREE HOURS

INSTRUCTIONS:

- 1. There are six questions in this examination paper**
 - 2. All questions carry equal marks**
 - 3. Answer ANY five (5) Questions**
 - 4. Make sure you have TWO (2) printed pages**
-

Question 1 **Describe** the structure of actin. Where does the myosin bind? Explain in detail how actin and myosin interact resulting in muscle contraction (**highlight** the roles of ATP and calcium pump)?

[20 marks]

Question 2 i) **Describe** TWO precautionary measures taken when working with radioactive materials in a biochemistry laboratory.

ii) **Calculate:**

- a) the decay constant (λ) in terms of day^{-1} and sec^{-1} and
- b) the % of initial radioactivity remaining in a sample of ^{35}S after 50 days

$$^{35}\text{S } t_{1/2} = 84.7 \text{ days}$$

[20 marks]

PLEASE TURN OVER THE PAGE

- Question 3 (i) In molecular terms, **describe** in detail how voltage can result in conformation change of a protein. Use sodium channel as an example.
- (ii) Suppose you were conducting a research on a protein involved in transporting ions in and out of cells. **Would** you expect to find the non-polar amino acid residues in the interior of such a protein or on its exterior? **Why?** **Would** you expect to find the polar residues of such a protein in the interior or the exterior? **Why?**

[20 marks]

- Question 4 **Describe** in detail covalent regulation of glutamine synthetase.

[20 marks]

- Question 5 **Describe** the chemistry and functions of adenohipophyseal hormones.

[20 marks]

- Question 6 **What** is the mechanism of action for the following hormones:

- a) epinephrine
- b) corticosteroids

[20 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C451: ADVANCED ORGANIC CHEMISTRY

TIME: THREE HOURS

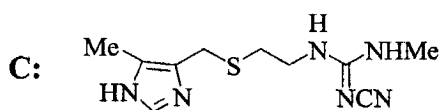
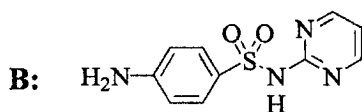
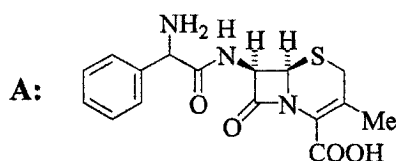
INSTRUCTIONS:

1. Answer any FOUR questions.
2. Marks allocation for questions is shown.

Max. marks: 120

QUESTION 1

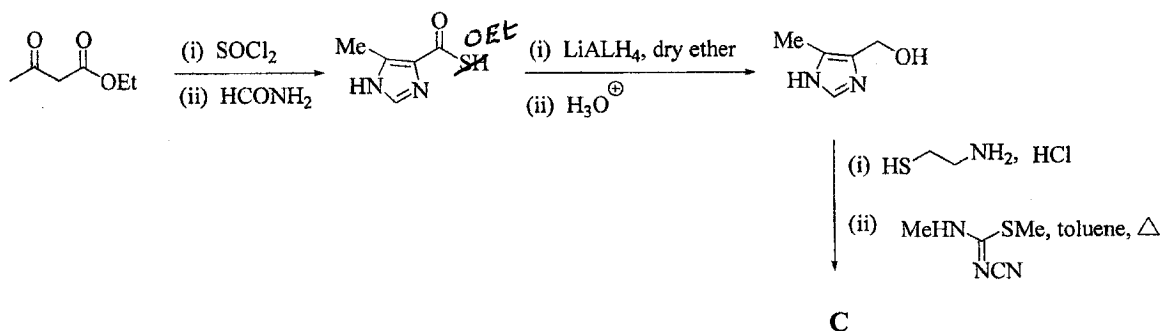
- (a) Consider the molecular structures of the following drugs, A, B and C.



- (i) Give the principal pharmacological actions of the drugs A, B and C.
- (ii) Identify the *pharmacophore* in the drug molecules A and B.

QUESTION 1 (contd. from page 1)

- (iii) Suggest the mechanisms for the reactions involved in the following synthesis of the drug **C**.



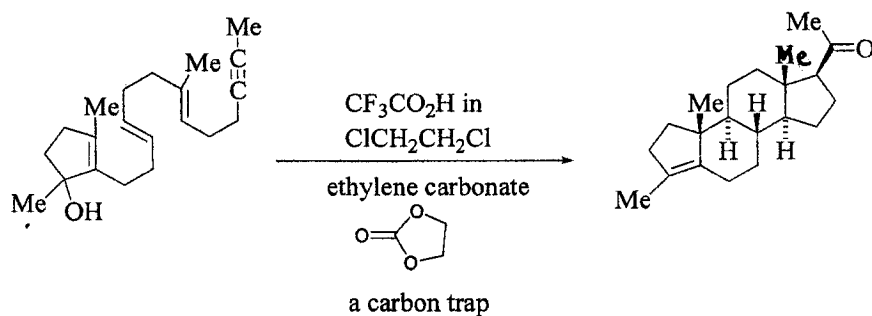
[22]

- (b) When administered orally, the naturally occurring penicillins are ineffective in the treatment of microbial infections. Provide an explanation for this observation. Illustrate your answer with a suitable example.

[8]

QUESTION 2

- (a) (i) List three observable characteristics that are usually associated with *anchimeric assistance*.
- (ii) Provide a mechanism for the following transformation:



[16]

QUESTION 2 (contd. from page 2)

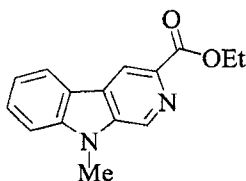
- (b) (i) The acetolysis of *trans*-C-hexyl tosylate gives *trans*-diacetate, with $K = 1.9 \times 10^{-4}$, while the acetolysis of *cis*-C-hexyl tosylate also gives the *trans*-diacetate with $K = 2.9 \times 10^{-7}$. Provide an explanation for this observation.
- (ii) Acetolysis of 4-methylpent-3-enyl tosylate proceeds about 1200 times as fast as that of ethyl tosylate. Give the products of these reactions and account for their formation.

[14]

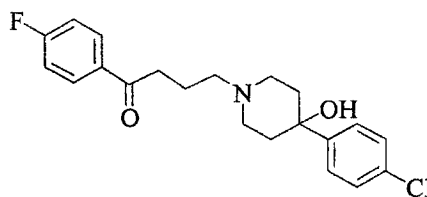
QUESTION 3

- (a) Discuss the structure-activity relationships in 8-aminoquinoline ant-malarial agents.
- (b) Propose a synthesis of the anti-psychotic drug **D** and the anti-protozoal drug **E**, structures shown below, from readily available non-heterocyclic starting materials. Show clearly each step of your proposed synthesis.

Compound D:



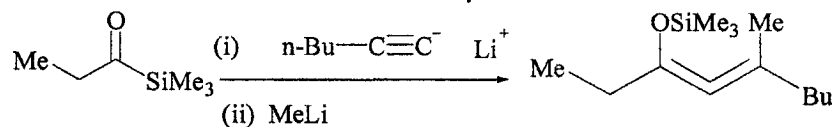
Compound E:



[24]

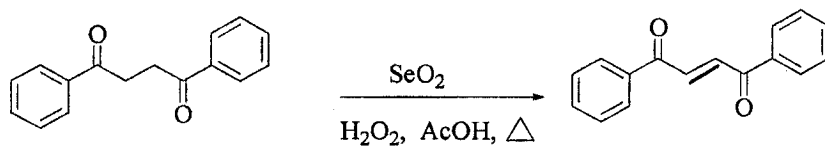
QUESTION 4

- (a) (i) Provide the structure of the major organic product and give mechanism of the following reaction.



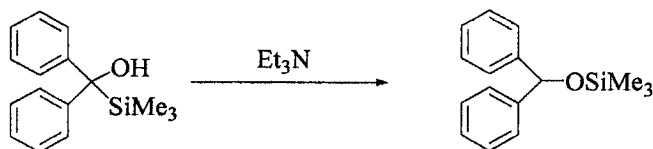
Using this information, propose a mechanism of the above reaction.

- (ii) Suggest plausible mechanisms of the reactions involved in the following transformation.



[20]

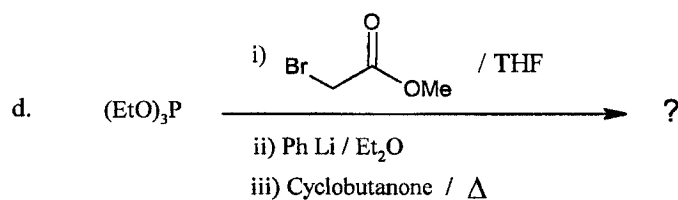
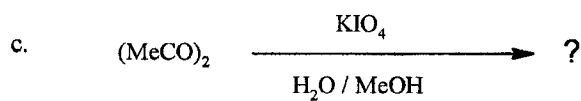
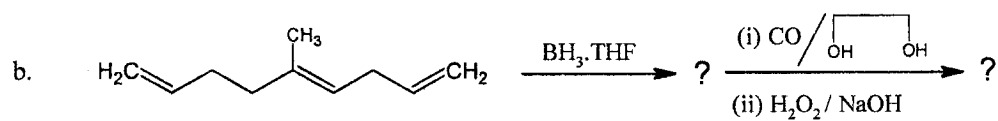
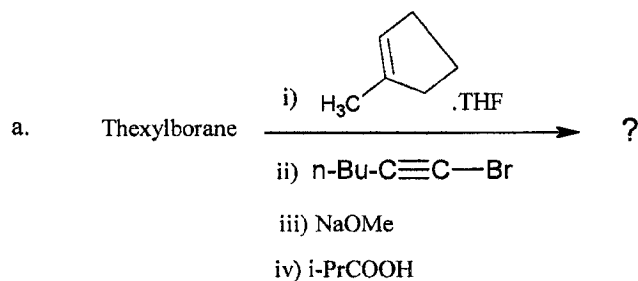
- (b) Provide a mechanistic explanation to account for the molecular rearrangement shown below:



[10]

QUESTION 5

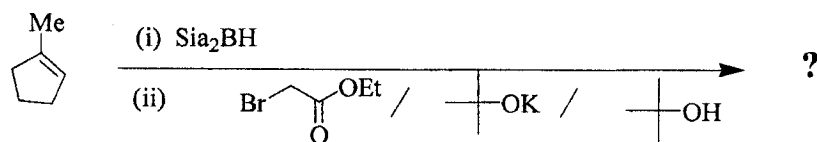
- (i) Predict the major organic products of the following reactions. Show the structures of the intermediate products, where applicable.



[18]

QUESTION 5 (contd. from page 4)

- (ii) Provide the structures of major organic product and show the mechanism of the following reaction.



[12]

END OF THE EXAMINATION

**THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF CHEMISTRY**

UNIVERSITY SEMESTER I SESSIONAL EXAMINATIONS

C 461: QUANTUM MECHANICS AND MOLECULAR SPECTROSCOPY

16 NOVEMBER 2009

TIME: THREE HOURS

**INSTRUCTIONS TO THE CANDIDATES:
ANSWER: QUESTION 1 AND ANY FOUR OTHERS.**

DATA

$$h = 6.626 \times 10^{-34} \text{ J s};$$

$$\text{eV} = 1.602 \times 10^{-19} \text{ J};$$

$$c = 3.00 \times 10^8 \text{ m s}^{-1};$$

$$1 \text{ u} = 1.6605 \times 10^{-27} \text{ kg};$$

$$1 \text{ J} = \text{kg m}^2 \text{ s}^{-2};$$

$$^{12}\text{C} = 12.00000 \text{ u};$$

$$^{16}\text{O} = 15.9949 \text{ u}$$

QUESTION 1 (40 MARKS)

- a) A Hermitian operator α has a set of eigenfunctions Ψ_i , i.e. $\alpha\Psi_i = a_i\Psi_i$ and the complex conjugate $\alpha^*\Psi_i^* = a_i^*\Psi_i^*$. Show that according to quantum mechanical postulate II, one indeed obtains *real* answers if the Hermitian operator α represents an observable.
- b) (i) From your knowledge of molecular spectroscopy explain how the increase in the emission of CO_2 (a green house gas) in the atmosphere is contributing to global warming.
- (ii) Calculate the moment of inertia for $^{12}\text{C}^{16}\text{O}_2$. $r_{\text{C=O}} = 116.156 \text{ pm}$ and oxygen $^{16}\text{O}_2$, $r_{\text{O=O}} = 120.752 \text{ pm}$.
- c) Naturally radioactive species can emit particles or photons. When they do, because of conservation of momentum, they recoil, i.e. they acquire a momentum equal and opposite to that of the emitted particle as in Mossbauer spectroscopy, a technique which yields information on chemical environment similar to that obtained by NMR.
- Suppose a nucleus of iron ^{57}Fe (mass = $9.45 \times 10^{-26} \text{ kg}$) emits a γ - ray of energy $2.31 \times 10^{-15} \text{ J}$.
- (i) Calculate the momentum of this photon.
- (ii) Calculate the kinetic energy acquired by the iron nucleus as a result of this process.
- d) (i) What is a Raman spectrum?
- (ii) What essentially criteria for a molecule to be both Raman active and infra-red active, Raman active but not infra-red active?
- e) Consider a diatomic molecule rotating in the ϕ plane with an eigenfunction
- $$\Phi_m(\phi) = A_m e^{im\phi}.$$
- a) Calculate the normalization constant A_m .
- b) Show that the normalized function is an eigenfunction of the angular momentum operator $\mathbf{J}_z = \frac{\hbar}{i} \frac{d}{d\phi}$. What is the eigenvalue?

**THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF CHEMISTRY**

UNIVERSITY SEMESTER I SESSIONAL EXAMINATIONS

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- e) Consider a diatomic molecule rotating in the ϕ plane with an eigenfunction
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- a) Calculate the normalization constant A_m .
- b) Show that the normalized function is an eigenfunction of the angular momentum operator $J_z = \frac{\hbar}{i} \frac{d}{d\phi}$. What is the eigenvalue?

QUESTION 2 (15 MARKS)

The Bohr Theory of the Atom, as applied to the hydrogen atom, was based on Rutherford's Planetary Model of the Atom.

- a) What three assumptions were used in Bohr's theory of the hydrogen atom?
- b) The principal result of Bohr's theory of the hydrogen atom is that

$$E_n = -\frac{Z^2 m e^4}{8 \epsilon_0^2 h^2} \frac{1}{n^2}$$

Explain the importance of this formula in the development of quantum mechanics.

- c) In spite of its successes, the Bohr's theory of the hydrogen atom had its share of failures. What were these failures of the Bohr's theory of the hydrogen atom? Explain them.

QUESTION 3 (15 MARKS)

The infra-red spectrum of $^{12}\text{C}^{16}\text{O}$ for the $v = 0$ to $v = 1$ transition is shown below. The spectral lines for the R-branch are given by:

$$\omega_R = \omega_e + (2B_e - 3\alpha_e) + (2B_e - 4\alpha_e)J'' - \alpha_e J''^2$$

R (J)	$\omega(\text{cm}^{-1})$
0	2147.19
1	2150.97
2	2154.71
3	2158.41
4	2162.08
5	2165.71
6	2169.31

- a) Use the above equation to obtain B_e and α_e .
- b) Determine the bond length of the molecule.

QUESTION 4 (15 MARKS)

- a) What is the lowest energy for each of the following?
- (i) a particle in a one-dimensional box;
 - (ii) harmonic oscillator; and
 - (iii) rigid rotator diatomic molecule.
- b) For each system, discuss whether or not the value of the lowest energy is consistent with the Heisenberg Uncertainty Principle.

QUESTION 5 (15 MARKS)

Pure rotational Raman spectrum of $^{16}\text{O}_2$ was observed at a pressure of one atmosphere in a flow cell which was mounted in a cavity of an argon ion laser giving 8 watts power at 4880.0 \AA with the slit width of 0.3 cm^{-1} . The first four lines of the Stokes lines are $20477.43, 20465.93, 20454.43, 20442.93 \text{ cm}^{-1}$ and the first four Antistokes lines are $20506.11, 20517.68, 20529.181, 20540.681 \text{ cm}^{-1}$. The Rayleigh line is at $20491.803 \text{ cm}^{-1}$.

The spectral lines for the Antistokes and Stokes lines are given as

$$\omega = \omega_{\text{laser}} \pm 2B(2J'' + 3)$$

Note that $^{16}\text{O}_2$ has ground state spectroscopic notation of $^3\Sigma_g^-$ and the nuclear spin of ^{16}O , $I = 0$

- Calculate B in the above equation using linear regression of the Antistokes lines.
- Calculate the moment of inertia of $^{16}\text{O}_2$
- Determine the bond length of $^{16}\text{O}_2$.

QUESTION 6 (15 MARKS)

Some data for the kinetic energy ejected as a function of wavelength of incident radiation for the photoelectric effect for sodium metal are

$\lambda \text{ (nm)}$	100	200	300	400	500
Kinetic energy $T \text{ (eV)}$	10.1	3.94	1.88	0.842	0.222

- Use these data to obtain Planck's constant h and the work function for sodium metal.
- The ionization potential of an atom of sodium in the gas phase is 5.14 eV . Try to explain why this is not the same as the work function of sodium metal.

_____ **END OF C 461 EXAMINATION** _____

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

**2009 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS**

**C 481: INORGANIC INDUSTRIAL CHEMISTRY
TIME: THREE HOURS**

INSTRUCTIONS: ANSWER ANY FOUR QUESTIONS

Question 1. Write down the reactions and ammonia technological process for manufacturing soda ash. In details describe the following processes:

- (a) Carbonization
- (b) Ammoniation
- (c) Recovery of ammonia.

Question 2. In production of organic and inorganic substances the mainly used absorbers and gas purification apparatus are: absorbers with sieve plates, bubble cap plates, packing and fluidized packing columns. Draw up sketches and briefly describe:

- (a) Absorbers with bubble cap plates,
- (b) Columns with sieve plates,
- (c) Fluidized packing columns.

Question 3. Describe composition and indicate formulas of:

- (a) The raw materials used for production of binding materials,
- (b) Air-setting binding materials,
- (c) Hydraulic-setting binding materials.

Question 4. Draw up sketches and describe the following apparatus and equipment:

- (a) For crushing and grinding – jaw and drum crushers and ball mills.
- (b) For the measurements of fluids and gas flows – orifices, rotameters and weirs.
- (c) Heat exchangers – single-pass tubular heater and double – pipe heat exchangers.

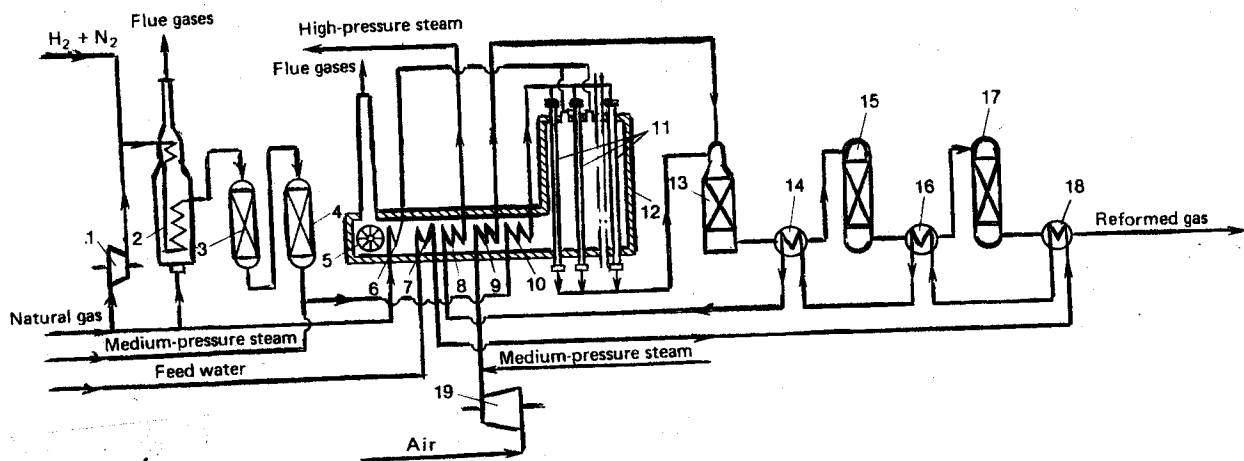
Question 5. Write down the reactions and briefly describe the technological processes of production of the following alkali compounds:

- a) Sodium sulphate, sulphite and thiosulphate,
- b) Sodium nitrite, peroxide and sodium Ferro cyanide,
- c) Sodium chloride production process by Frash method.

Question 6. Describe the flow-sheet diagramme for the production of H_2 , CO and CO_2 from natural gas (the diagram is attached).

- (a) Write down the natural gas desulphurization and H_2S adsorption reactions,
- (b) On the diagram indicate the temperatures and concentrations of the components of the gas mixture,
- (c) Name the composition of the catalysts used in the technological processes.

END OF EXAMINATION



Flowsheet of a two-stage gas reformer unit:

1, natural gas compressor; 2, direct-fired furnace-type heater; 3, desulphurizer; 4, adsorber; 5, smoke exhauster; 6, natural gas preheater; 7, feedwater preheater; 8, steam superheater; 9, steam-air preheater; 10, steam-gas preheater; 11, reaction tubes; 12, primary reformer; 13, secondary methanol reformer; 14, steam boiler; 15, primary CO shift converter; 16, steam boiler; 17, secondary CO shift converter; 18, heat exchanger; 19, air compressor.

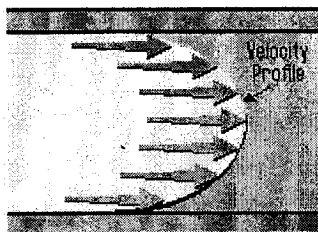
THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2009 ACADEMIC YEAR FIRST SEMESTER EXAMINATION

C491 : ORGANIC INDUSTRIAL CHEMISTRY I
TIME : THREE (3) HOURS

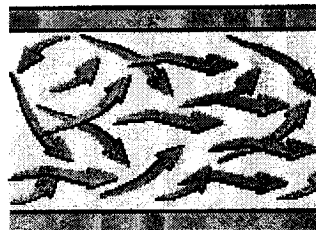
INSTRUCTIONS: Answer **Question 1** and any other three (3) Questions

QUESTION 1

- (a) (i) What are the main features associated with a batch and continuous process? Draw simple sketch diagrams to illustrate the answer.
- (ii) Explain in brief key advantages and disadvantages for each type of processing.
- (b) (i) Discuss in detail the purpose of size reduction by grinding.
- (ii) Crushers may be classified as follows: coarse, intermediate or fine. Outline the difference between the different classes and give one example of a crushing device in that category.
- (c) Movement of liquids in a chemical industry is often carried out using various types of pumps and sizes of pipes.
 - (i) What factors are responsible for resistance to flow of a liquid?
 - (ii) The diagrams below illustrate two (2) types of flow. Identify the two types labelled **A** and **B** and outline their key characteristics.



(A)



(B)

- (iii) The Reynolds number is used to give an indication or prediction of the type of flow that maybe taking place in a pipe. Use the Reynolds equation to show how you would change flow so as to facilitate mixing of chemicals in a pipe.

QUESTION 2

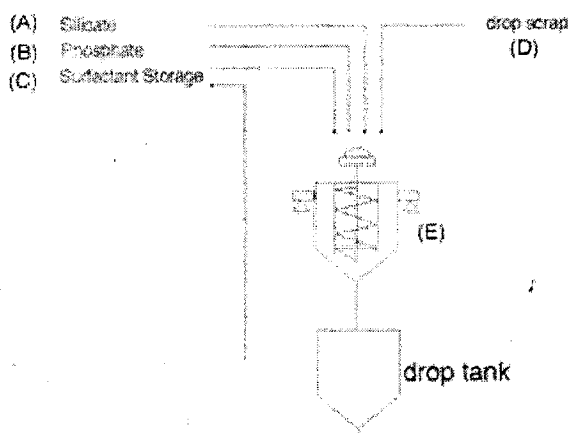
- (a) Pre-treatment of crude petroleum before fractionation involves removal of non-hydrocarbon components. Explain how each of these components affect the refining process and the end products.
- (b) What is the purpose of cracking in petroleum refining. Describe the process known as *fluid catalytic cracking*.
- (c) Define the *Octane Number* of a gasoline and explain factors that increase this characteristic.
- (d) Explain the rationale behind the phasing out of leaded petroleum. How does unleaded petroleum achieve the same performance as one that has just been phased out.

QUESTION 3

- (a) Wood the main raw material for the paper and pulp industry is classified as either hard or soft.
 - (i) Outline the characteristics associated with soft and hard woods.
 - (ii) How do the characteristics of the two types of wood affect the properties or quality of paper?
- (b) Draw a fully labelled chart that illustrates the chemical recovery process in the sulphate process.
- (c) What is the purpose of the beater and Jordan engine in paper manufacturing?

QUESTION 4

- (a) The diagram below shows part of detergent manufacturing plant.



- Describe in detail the function or purpose of each the items labelled A, B, C, D and E in the diagram.
- (b) Explain how the density of detergent powders maybe increased to enable smaller packaging.

Question 5

- (a) A common household insect killer indicated d-phenothrin (pyrethroid) as the active ingredient. Outline in brief the manufacture, mode of action and use of the active ingredient cited on the container.
- (b) What non-lethal methods can be used for control of pests?
- (c) Explain in detail environmental concerns associated with the use of pesticides and measures that may mitigate their impact on the environment.

END OF EXAMINATION

The University of Zambia

School of Natural Science

Department of Computer Studies

FINAL EXAM SEMESTER I – November 2009

Computer Networks and Data Communication Systems (CS3061)

Instructions

1. There are **two sections** and a total of **six questions** in this question paper.
2. Each question carries **20 marks** only
3. You are required to **answer a total of five questions**
4. **Section A** has **two** questions while **section B** has **four** questions
5. **Answer all** questions in **section A** and any **three** questions in **section B**

Date: Thursday 4th November 2009

Time: 09:00hrs – 12:00hrs

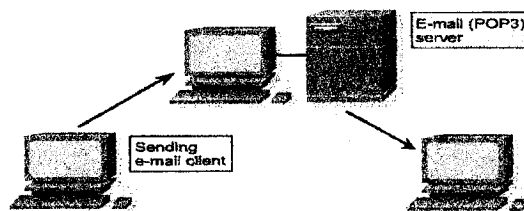
Venue: Library Basement

NOTE: Do not open this paper until you are told to do so

SECTION A – Answer all the questions in this section

1) Question One

- a) Define the following terms [2]
 - i) Intranet
 - ii) Multiplexing
- b) The 802.11 standard states that each conformant wireless LAN must provide nine services which are divided into two categories namely distribution services and station services. The distribution services relate to managing cell membership and interacting with stations outside the cell. In contrast, the station services relate to activity within a single cell. List any four (4) services that each 802.11 Standard Wireless LAN is supposed to provide [2]
- c) Convert the following numbers [2]
 - i) 228_{ten} from **base ten** to **base sixteen**
 - ii) $1011001000010101_{\text{two}}$ from **base two** to **ten**
- d) What is a networking device? List any four examples of networking devices. [3]
- e) What is a network topology? **Give two other examples of physical topology networks** and **two examples of logical topology networks**. [3]
- f) **Briefly** describe the differences between congestion control and flow control. [4]
- g) With reference to the diagram below and using a well labeled diagram, explain how the email system (Electronic Mail System) works. [4]



2) Question Two

a) Define the following terms [2]

- i) Protocol
- ii) A Packet

b) The diagram below shows the TCP/IP model. The Internet as it is today was built on this model. Give at least two protocols found at each layer. [4]



c) Identify the group where the following IP addresses belong and give the default subnet masks of each one of them. [2]

- i) 131.207.134.90
- ii) 222.16.214.189

d) Given the IP network address as **167.193.0.0** [12]

- i) In order to create twelve (12) Usable subnets,
 - (1) How many bits can you borrow from the host portion?
 - (2) How many usable IP addresses will be in each created subnet
- ii) Draw a table with four columns as shown below. The headings should be the Subnet, Network Address, Usable IP Range and Broadcast Address. Fill up the table with **all the possible subnets** that can be obtained using the computation in (i)(1) and (i)(2) above.

Subnet	Network Address	Usable IP Range	Broadcast Address
0			
1			
...			
n			

Section B – Answer any three questions in this section

3) Question Three

- a) Define the following terms [3]
 - i) Collision Domain
 - ii) Ethernet
 - iii) Virtual Private Network (VPN)
 - b) Recently Zamnet announced that Zambians will start enjoying cheap Internet connectivity via Fiber Optical Cable. In Zambia today, only two institutions or companies have installed the fiber backbone around the country. Name the two institutions. Draw a well labeled diagram showing the structure of a fiber optic cable. [5]
 - c) **Draw** a well labeled diagram of the **OSI model**. **Give** the function of each layer. [7]
 - d) The two primary duties of the transport layer are to provide flow control and reliability by defining end-to-end connectivity between host applications. **List** the five basic transport services provided by the transport layer [5]
-

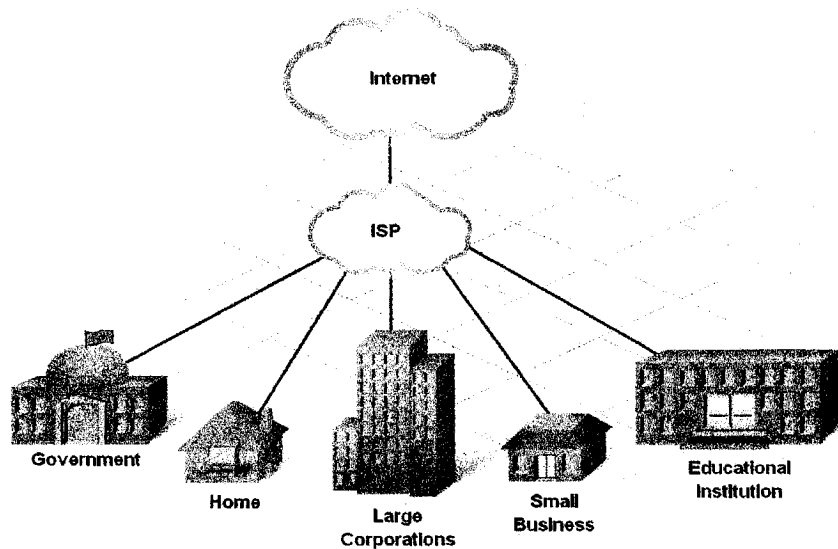
4) Question Four

- a) **List** the four Data Link Layer Design Issues [2]
- b) Draw a well labeled diagram showing the structure of the telephone system for a typical circuit route for a medium-distance call showing the local loops and trunks. [4]
- c) What is the difference between a routed and a routing algorithm? Give two examples of routing and two examples of routed algorithms. [3]
- d) Today Ethernet Technology is used to implement more than 95% of the Local Area Networks (LAN). The table below shows the Ethernet cabling. Complete the table by filling in the blanks[3]

#	Name	Cable	Max Segment	Maximum Bandwidth
1	10Base5			10Mbps
2	100Base-TX			100Mbps
3	100Base-FX			100Mbps

- e) Mobile phones have gone through three distinct generations, with different technologies. Name the generations and their respective technologies. [3]

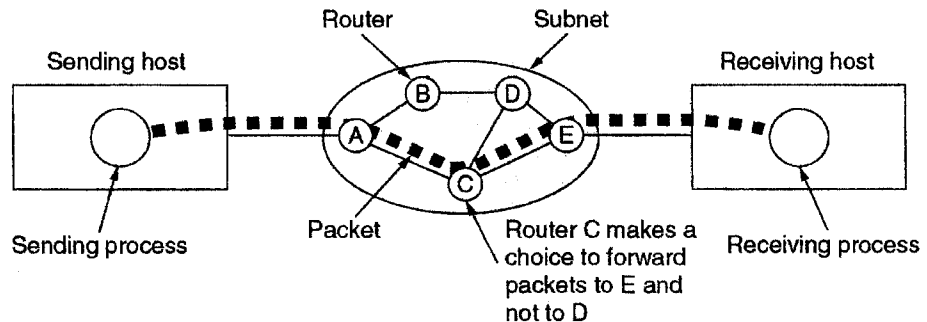
- f) The diagram below shows how various institutions connect to the Internet. UNZA is an example of an education institution as shown in the diagram below. However, we use private instead of public IP addresses to go to this Internet. Using the concept of Network Address Translation (NAT), explain how two students from Computer studies department will be able to access the Yahoo Home Page located in the Britain or USA. [5]



5) Question Five

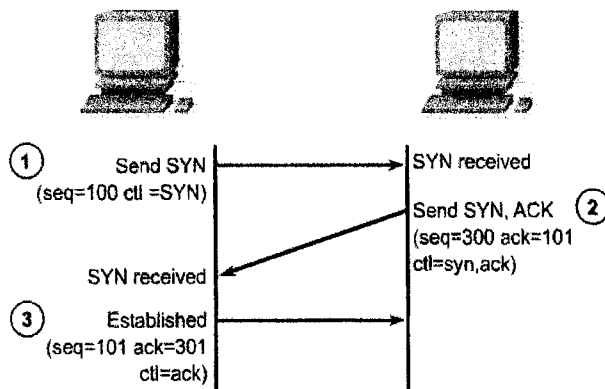
- There are four primary parameters that together determine the Quality of Service (QoS) of a given network list ant three parameters [3]
- The two primary duties of the transport layer are to provide flow control and reliability by defining end-to-end connectivity between host applications. **List** any four basic transport services provided by the transport layer that help to achieve the above primary duties[4]
- Draw a well labeled diagram showing the communication satellites and some of their properties, including altitude above the earth, round-trip delay time and number-of satellites needed for global coverage. [5]
- An alternative criterion for classifying networks is by using their scale. Usually we classify multiple processor systems by their physical size. At the top are the Personal Area Networks, networks that are meant for one person. List the other four classes [2]

- e) The diagram below shows the movement of a packet in an internetwork. With the help of the diagrams, compare the operation of the Connectionless Service and the Connection-Oriented Service at the network layer[6]



6) Question Six

- a) Identify and name the diagram below. Give a brief description of what is going on [3]



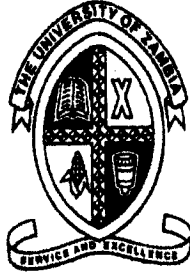
- b) IP addresses on a host device (Workstation) can either be assigned manually or automatically using DHCP. In either case each host device must be assigned an
- (1) IP address
 - (2) Subnet Mask
 - (3) DNS and the
 - (4) Default Gateway

Give a brief description and the function for each of the above addresses. [4]

- c) IPv4 addresses are slowly running out and to help avoid the problem of limited IP addresses, some IP addresses were set aside for private usage. These addresses allow hosts to communicate locally without each device needing a public IP

address. However, they cannot be routed on the Internet. List all the groups of the Reserved IP Addresses [3]

- d) With the help of a diagram, Give a brief description how each of the following functions [6]
 - ii) Frequency Division Multiplexing
 - iii) Wavelength Division Multiplexing
 - iv) Time Division Multiplexing
- f) The Network layer provides two basic services to the transport layer. Name the services. Draw a well labeled diagram showing the IPv4 (Internet Protocol) header. [4]



**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

CS4251: ELECTRONICS FOR COMPUTING III

SEMESTER 1 EXAM

11th NOVEMBER 2009

TIME: THREE HOURS

ANSWER: ALL QUESTIONS IN SECTION (A) AND ANY FOUR (4) FROM SECTION (B)

SECTION A (ANSWER ALL QUESTIONS)

QUESTION 1

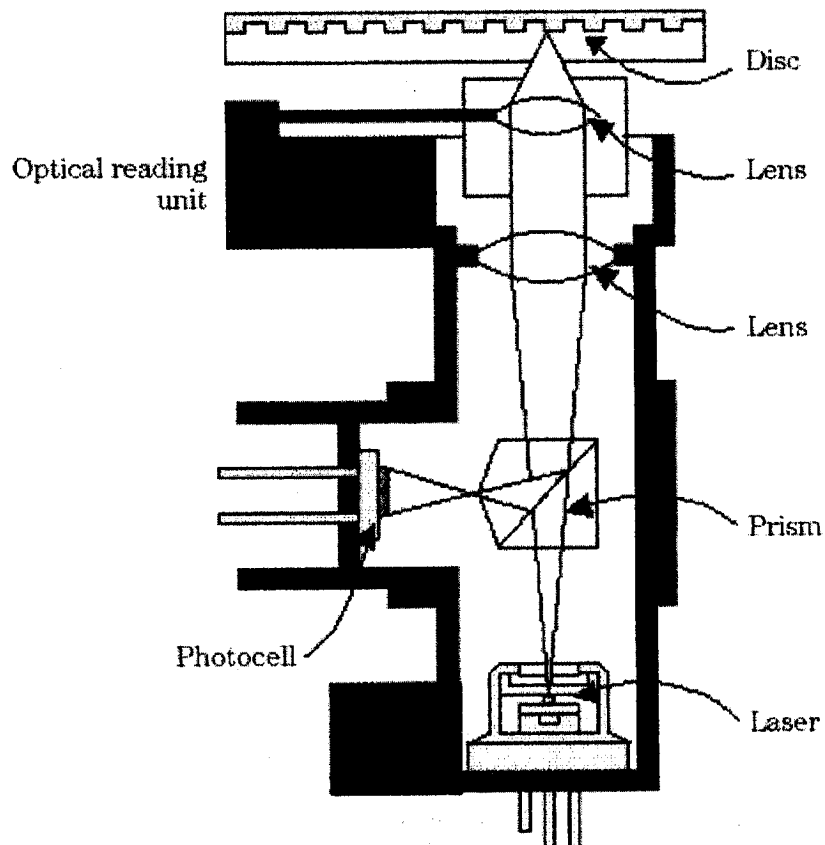
Using the sketch of CD ROM/Writer unit below, describe:

- (i) The focusing process of the optical unit
- (ii) The reading process
- (iii) The writing process

[4 Marks]

[4 Marks]

[4 Marks]

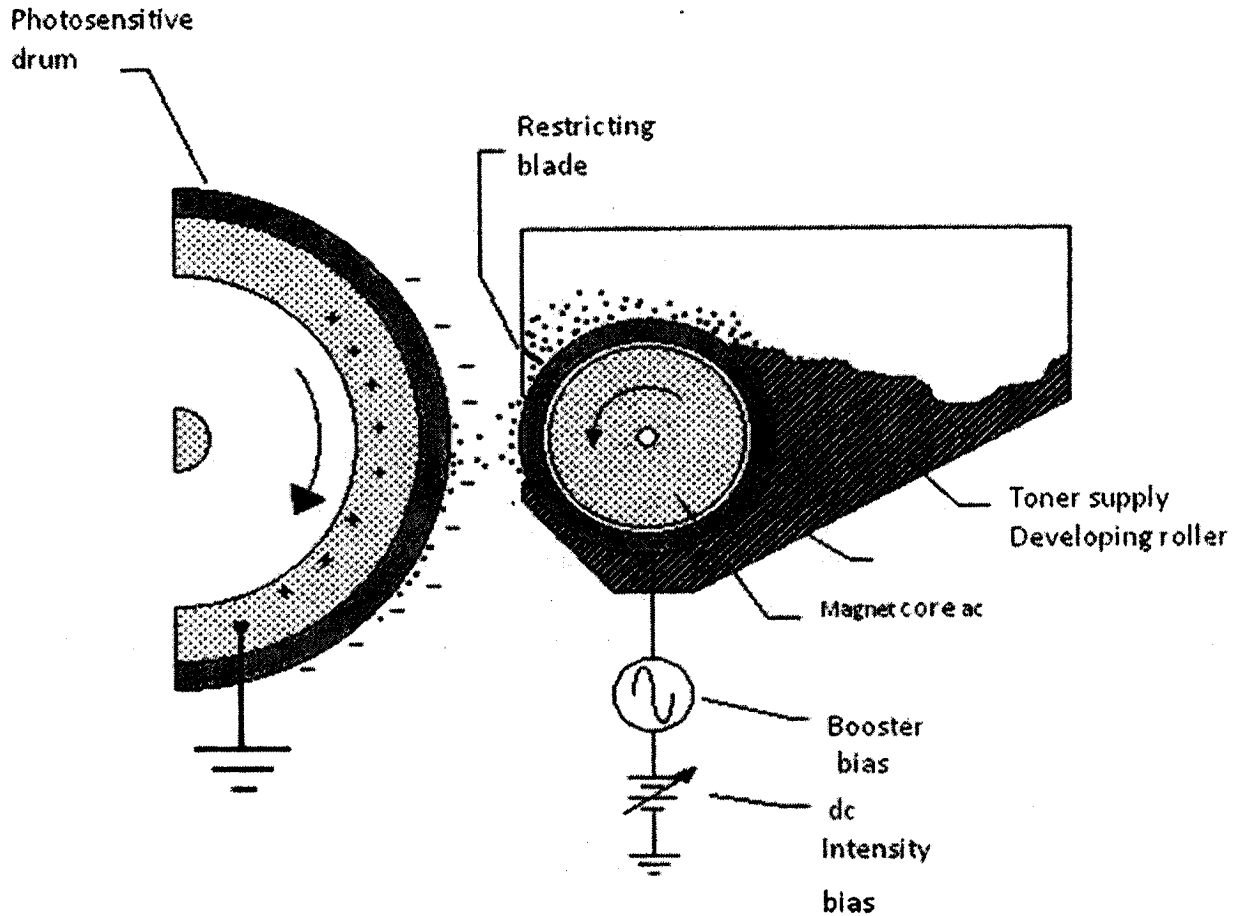


QUESTION 2

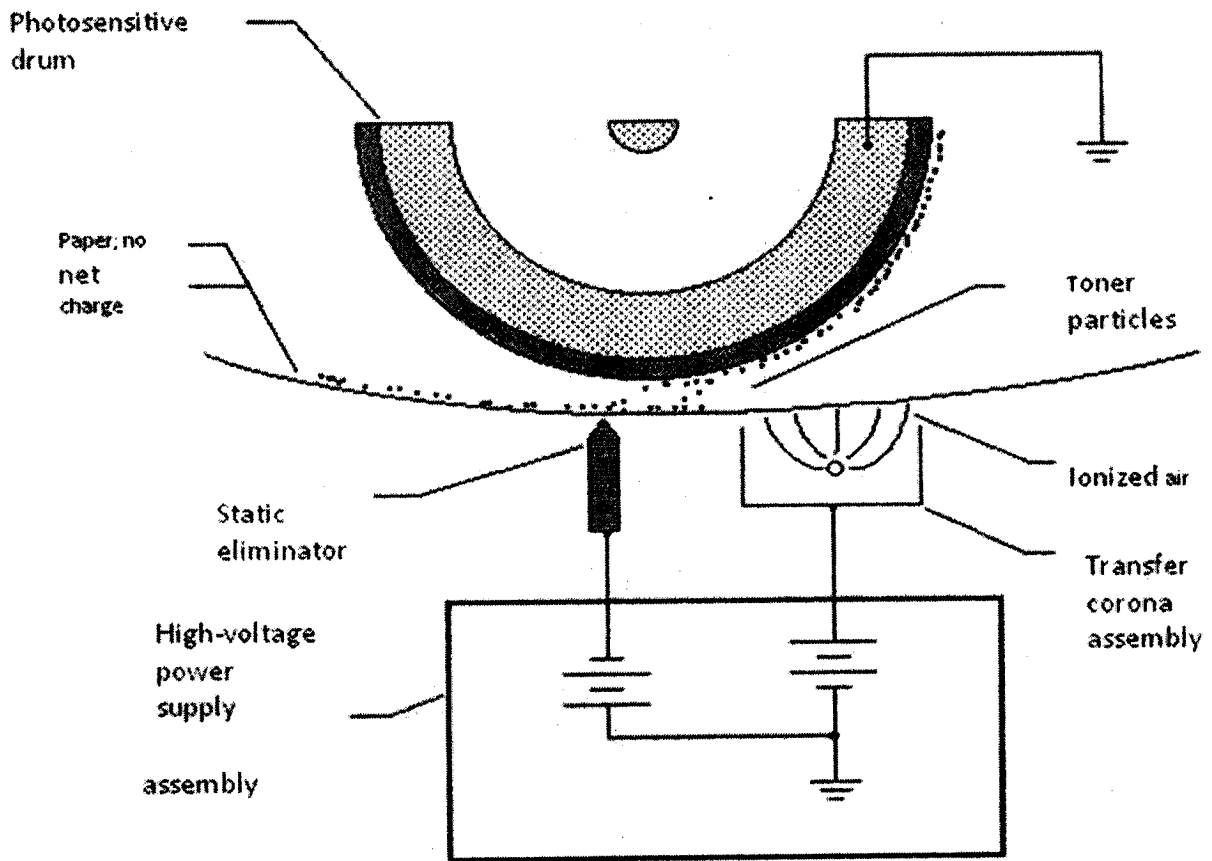
In a laser printer, printing is a process that involves 6-steps of image formation.

(i) List the 6 steps of image formation in order of their occurrence. [3 Marks]

(ii) With the help of the sketch below identify this step and describe the process taking place at this particular step in details. [5 Marks]

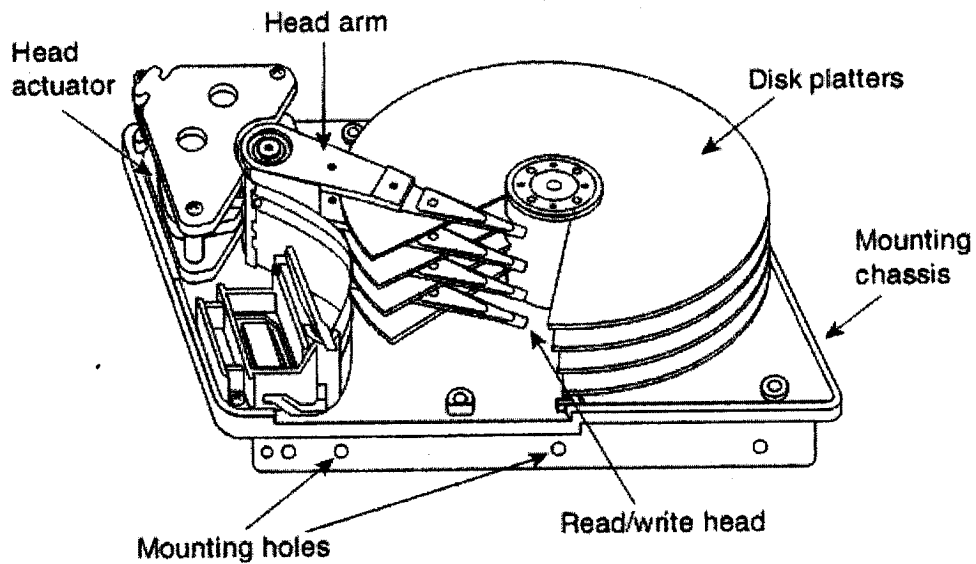


(iii) With the help of the sketch below identify this step and describe the process taking place at this particular step in details. [5 Marks]



QUESTION 3

A hard disk drive is a device that enables data storage in a PC. Below is the general architecture of a conventional hard disk drive.



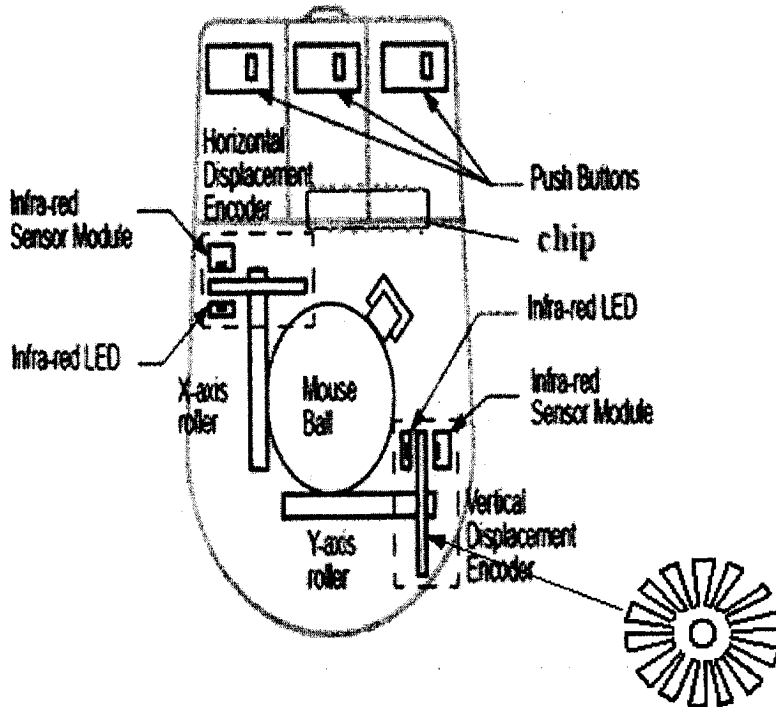
- (i) With the help of sketches, describe the writing process.
 (ii) Describe the reading process.

[6 Marks]

[6 Marks]

QUESTION 4

A conventional mechanical mouse works on a principle of mechanical – electrical signal transformation.



- (i) With the help of the schematic illustration above, describe the mechanism of encoding mechanical movement in a mouse. [4 Marks]
 (ii) If the mouse is moving forward at a constant speed how will the graphical digital output from the Y-axis infra-red sensor be (use sketches!) [2 Marks]

QUESTION 5

There are basically two categories of printers in accordance with the printing technology. These are impact and non-impact printers. An inkjet printer falls in the category of non-impact printers.

- (i) What are the two primary inkjet technologies?
 (ii) Describe the identified technologies in details

[2 Marks]

[6 Marks]

QUESTION 6

Describe the process of scanning, and the technology involved in capturing the image. [6 Marks]
 Explain the keyboard technology that makes it impossible to type 2 letters at once. [3 Marks]

SECTION B ANSWER ANY FOUR (4) QUESTIONS

QUESTION 1

A cache memory improves performance in a computer system.

- (i) What are the two predictable properties of memory references? [1 Marks]
- (ii) What are the three Causes for Cache Misses? [3 Marks]
- (iii) State the effects of the following cache Parameters on Performance;
 - (a) larger cache size, [2 Marks]
 - (b) higher associativity, [2 Marks]
 - (c) and larger block size. [2 Marks]

QUESTION 2

Using the data path diagrams, describe the stages of pipelining the following instructions.

- (i) sw \$20, \$10 [5 Marks]
- (ii) lw \$20, \$10 [5 Marks]

QUESTION 3

With the help of sketches, describe any three of the touch screen technologies. [10 Marks]

QUESTION 4

In a capacitive touch pad technology, how are the following processes achieved:

- (i) Sensing finger presence, [3 Marks]
- (ii) Filtering position data, [3 Marks]
- (iii) Sensing motion. [4 Marks]

QUESTION 5

With the help of detailed sketches, describe the process of image formation in a:

- (i) TFT-LCD monitor. [5 Marks]
- (i) CRT monitor. [5 Marks]

QUESTION 6

The EEPROM is a basic component of a flash drive. With the help of schematics describe the following EEPROM modes, giving details of the inputs and outputs of each associated wire {array ground, row(0), col(0), V_{ERASE}, I/O(0)..I/O(7)}.

- (i) Erase mode of the 1 byte array. [3 Marks]
- (i) Programming the 1 byte array to 01010101. [4 Marks]
- (i) Reading the 1 byte array. [3 Marks]

END OF EXAM



University of Zambia

School of Natural Sciences

Department of Computer Studies

CST2011 Final Exam

An Introduction to Object Oriented Programming using Java

This exam has four sections. Section A, B and C has compulsory questions and each carry 30, 30 and 10 points respectively. Section D has five questions and you are expected to answer any three of the five. Each question in Section D carries 10 points.

Section a [30 points] (True or False)

1. When an instance of a class, or object, is specified as a parameter to a method, a reference to the said object is passed to the method.
2. Declarations must appear at the start of the body of a Java method.
3. All interface methods must be declared as public when implemented in a class.
4. An overloaded method cannot throw exceptions not checked in the base class.
5. In Java, an abstract class cannot be sub-classed.
6. The modulus operator (%) in Java can be used only with variables of integer type.
7. A *static* method can refer to any instance variable of the class.
8. Whenever the "&&" operator is used, such as in: `exp1 && exp2` where `exp1` and `exp2` are boolean expressions, both the boolean expressions are not always evaluated.
9. The expression `(y >= z && a == b)` is evaluated by first evaluating the expression `y >= z`, and then evaluating `a == b` whatever the value of `y` and `z`.
10. The "switch" selection structure must end with the *default* case.
11. A *break* statement must always be present in the *default* case of a "switch" selection structure.
12. Consider the statement `"x = (a > b) ? a : b"`; then the value of `x` is 27, if `a = 18` and `b = 27`.
13. Variables declared inside a *for* loop are limited in scope to the loop.
14. An array in the Java programming language has the ability to store many different types
15. An individual array element from an array of type `int`, when passed to a method is passed by value.
16. Objects of a super class can always be assigned to a subclass reference.
17. Objects of a subclass can be assigned to a super class reference.
18. The `==` operator can be used to compare two *String* objects. The result is always true if the two strings are identical.
19. Methods can be overloaded with a difference only in the type of the return variable.
20. A method in a class declared as *static* can only access *static* class members.
21. A method in a class declared as *static* may be invoked simply by using the name of the method alone.
22. The constructor of a class must not have a return type.
23. Java does not allow a method with the same signature in a subclass, as a method in the super class.
24. When a method or a variable in a class is declared as *private*, it can only be accessed by the methods within the same class.
25. A method declaration must always contain the access level.
26. A method declared as *final* can be overridden by subclasses if it is also declared as *static*.
27. The return value from a method must always match the declared return type.
28. The access level of an overridden method cannot be changed in a subclass.
29. As the `toString` method is defined in the `Object` class, `System.out.println` can be used to print any object.
30. The java programming language supports pointers.

Section B [30 points]

1. What all gets printed when the following code is compiled and run? Select the three correct answers.

```
public class xyz {  
    public static void main(String args[]) {  
        for(int i = 0; i < 2; i++) {  
            for(int j = 2; j >= 0; j--) {  
                if(i == j) break;  
                System.out.println("i=" + i + " j="+j);  
            }  
        }  
    }  
}
```

- a) i=0 j=0
- b) i=0 j=1
- c) i=0 j=2
- d) i=1 j=0
- e) i=1 j=1
- f) i=1 j=2
- g) i=2 j=0
- h) i=2 j=1
- i) i=2 j=2

2. Which of the following are keywords or reserved words in Java?

- a) if
- b) then
- c) goto
- d) while
- e) case

3. What gets printed when the following code is compiled and run with the following command

java test 2

Select the one correct answer.

```
public class test {  
    public static void main(String args[]) {  
        Integer intObj=Integer.valueOf(args[args.length-1]);  
        int i = intObj.intValue();  
  
        if(args.length > 1)
```

```

        System.out.println(i);
    if (args.length > 0)
        System.out.println(i - 1);
    else
        System.out.println(i - 2);
    }
}

```

- a) test
- b) test -1
- c) 0
- d) 1
- e) 2

4. What will happen if you try to compile and run the following code?

```

public class Q {
    public static void main(String argv[]){
        int anar[]=new int[]{1,2,3};
        System.out.println(anar[1]);
    }
}

```

- a) 1
- b) Error anar is referenced before it is initialized
- c) 2
- d) Error: size of array must be defined

5. What will be printed out if you attempt to compile and run the following code ?

```

int i=1;
switch (i) {
    case 0:
        System.out.println("zero");
        break;
    case 1:
        System.out.println("one");
    case 2:
        System.out.println("two");
    default:
        System.out.println("default");
}

```

- a) one
- b) one, default
- c) one, two, default
- d) default

6. Which two of the following lines of code will compile without error

- a) `int i=0;`
`if(i) {`
`System.out.println("Hello");`
`}`
- b) `boolean b=true;`
`boolean b2=true;`
`if(b==b2) {`
`System.out.println("So true");`
`}`
- c) `int i=1;`
`int j=2;`
`if(i==1 || j==2)`
`System.out.println("OK");`
- d) `int i=1;`
`int j=2;`
`if(i==1 & | j==2)`
`System.out.println("OK");`

7. Which of these statements are legal? Select the three correct answers.

- a) `int arr[][] = new int[5][5];`
- b) `int[] arr[] = new int[5][5];`
- c) `int[] arr = new int[5][];`
- d) `int[] arr = new int[][5];`

8. What is the output of this code fragment.

```
int X=3; int Y =10;  
System.out.println(y%x);
```

- a) 0
- b) 1
- c) 2
- d) 3

9. What is the output of the following code when compiled and run? Select two correct answers.

```
public class Question01 {  
    public static void main(String[] args){  
        int y=0; //line 1  
        int x=z=1; //line 2  
        System.out.println(y+" "+x+" "+z); //line 3  
    }  
}
```

- a) Prints 0,1,1
- b) Error during compilation at line 1
- c) Prints 0,0,1
- d) Error during compilation at line 3
- e) Error during compilation at line 2

10. What is the output of the following code when compiled and run? Select one correct answer.

```
public class Question10 {
    public static void main(String[] args) {
        try {
            int i = (int)(Math.random()*10);
            if(i<=5)
                System.out.println("i = "+i);
            else
                throw new Exception("i > 5");
        } catch (Exception e){
            System.err.println(e.getMessage()+" (i="+i+"")");
        }
    }
}
```

- a) The output cannot be determined.
- b) Compilation error.
- c) An exception is thrown at runtime.
- d) Output is i = 2
- e) Output is i > 5 (i=6)

11. Select one correct statement about the following code.

```
public class Question11 {
    public static void main(String[] args){
        while(false);           //line 1
        if(false);               //line 2
        do{}while(false);       //line 3
        for(;;false;);           //line 4
    }
}
```

- a) Compilation error on lines 1,2 and 4.
- b) Compilation error on lines 2,3 and 4.
- c) Compilation error on lines 1,2 and 3.
- d) Compilation error on lines 1 and 4.
- e) The code compiles and runs fine.

12. Which declaration of the main method below would allow a class to be started as a standalone program. Select the one correct answer.

- a) public static int main(char args[])
- b) public static void main(String args[])
- c) public static void MAIN(String args[])
- d) public static void main(String args)
- e) public static void main(char args[])

13. What all gets printed when the following program is compiled and run. Select the two correct answers.

```
public class test {
    public static void main(String args[]) {
        int i, j=1;
        i = (j>1)?2:1;
        switch(i) {
            case 0: System.out.println(0); break;
            case 1: System.out.println(1);
            case 2: System.out.println(2); break;
            case 3: System.out.println(3); break;
        }
    }
}
```

- a) 0
- b) 1
- c) 2
- d) 3

14. What all gets printed when the following program is compiled and run. Select the one correct answer.

```
public class test {
    public static void main(String args[]) {
        int i=0, j=2;
        do {
            i=++i;
            j--;
        } while(j>0);
        System.out.println(i);
    }
}
```

- a) 0
- b) 1
- c) 2
- d) The program does not compile because of statement "i=++i;"

15. What is the value of a?

```
int a = 7;
    int b = 4;
    a = b;
    a = a + 1;
```

- a) 4
- b) 5
- c) 7
- d) 8

16. What output will the following line produce? `System.out.println("The answer is: "+17+3);`

- a) The answer is: 20
- b) The answer is: 17+3
- c) The answer is: 173
- d) The answer is:

17. What is the number of bytes used by Java primitive long. Select the one correct answer.

- a) The number of bytes is compiler dependent.
- b) 2
- c) 4
- d) 8
- e) 64

18. `int j;`

```
for(int i=0;i<14;i++) {
    if(i<10) {
        j = 2 + i;
    }
    System.out.println("j: " + j + " i: " + i);
}
```

What is WRONG with the above code?

- a) Integer "j" is not initialized.
- b) Nothing.
- c) You cannot declare integer i inside the for-loop declaration.
- d) The syntax of the "if" statement is incorrect.
- e) You cannot print integer values without converting them to strings.

19. For a constant which key word do we use in java?

- a) static
- b) final
- c) private
- d) unchangeable

20. Which of the following are legal identifier names in Java? Select the two correct answers.

- e) %abcd
- f) \$abcd
- g) 1abcd
- h) package
- i) _a_long_name

21. What is the result of compiling and running the following program.

```
public class test {  
    public static void main(String args[]) {  
        String str1="abc";  
        String str2="def";  
        String str3=str1.concat(str2);  
  
        str1.concat(str2);  
        System.out.println(str1);  
    }  
}
```

- j) abc
- k) def
- l) abcabc
- m) abcdef
- n) defabc
- o) abcdefdef

22. Select the one correct answer. The number of characters in an object of a class String is given by

- p) The member variable called size
- q) The member variable called length
- r) The method size() returns the number of characters.
- s) The method length() returns the number of characters.

23. Select the one correct answer. Which method defined in Integer class can be used to convert an Integer object to primitive int type.

- t) valueOf
- u) intValue .
- v) getInt
- w) getInteger

24. Which of the following are correct? Select the one correct answer.

- x) An import statement, if defined, must always be the first non-comment statement of the file.

- y) private members are accessible to all classes in the same package.
- z) An abstract class can be declared as final.
- aa) Local variables cannot be declared as static.

25. Which of these classes defined in java.io and used for file-handling are abstract. Select the two correct answers.

- bb) InputStream
- cc) PrintStream
- dd) Reader
- ee) FileInputStream
- ff) FileWriter

26. Name the keyword that makes a variable belong to a class, rather than being defined for each instance of the class. Select the one correct answer.

- gg) static
- hh) final
- ii) abstract
- jj) native
- kk) volatile
- ll) transient

27. Which of these statements are true? Select the two correct answers.

- mm) For each try block there must be at least one catch block defined.
- nn) A try block may be followed by any number of finally blocks.
- oo) A try block must be followed by at least one finally or catch block.
- pp) If both catch and finally blocks are defined, catch block must precede the finally block.

28. What gets printed when the following code is compiled and run. Select the one correct answer.

```
public class test {  
    public static void main(String args[]) {  
        int i = 1;  
        do {  
            i--;  
        } while (i > 2);  
        System.out.println(i);  
    }  
}
```

- qq) 0
- rr) 1
- ss) 2
- tt) -1

29. What all gets printed when the following gets compiled and run. Select the two correct answers.

```
public class test {  
    public static void main(String args[]) {  
        String s1 = "abc";  
        String s2 = "abc";  
        if(s1 == s2)  
            System.out.println(1);  
        else  
            System.out.println(2);  
        if(s1.equals(s2))  
            System.out.println(3);  
        else  
            System.out.println(4);  
    }  
}
```

uu) 1

vv) 2

ww) 3

xx) 4

30. What all gets printed when the following gets compiled and run. Select the two correct answers.

```
public class test {  
    public static void main(String args[]) {  
        int i=1, j=1;  
        try {  
            i++;  
            j--;  
            if(i == j)  
                i++;  
        }  
        catch(ArithmeticException e) {  
            System.out.println(0);  
        }  
        catch(ArrayIndexOutOfBoundsException e) {  
            System.out.println(1);  
        }  
        catch(Exception e) {  
            System.out.println(2);  
        }  
        finally {  
            System.out.println(3);  
        }  
    }  
}
```

```

    }
    System.out.println(4);
}
}
yy) 0
zz) 1
aaa)    2
bbb)    3

```

Section C [10 points]

Answer all questions in this section. Each question carries 1 point.

1. Explain the principle of multiple inheritances.
2. What is the difference between a "while" and "do....while" loop.
3. What is the java virtual machine?
4. What does it mean when we say Java is both interpreted and compiled?
5. Give an example of a package which is imported by default in java classes?
6. Which class is the ancestor of all classes?
7. What is the difference between a protected and public field?
8. What is the difference between declaring a variable and defining a variable?
9. Write the commands that you would use to compile and run a class called Final_Exam?
10. How can we pass parameters to a program from the commandline?

Section D [30 points]

There are five questions in this section. Answer any three questions. Each question carries 10 points.

1. Write a java program that manipulates Strings. It should have the following functionality
 - a) It should be able to input a line of text and output the text twice, once in all uppercase letters and once in all lowercase letters.
 - b) It should be able to input a line of text, and a character. It should then be able to search for the character in the text and determine the number of occurrences of the character in the text.
2. Write a program that asks the user for a range. Given the range the program should be able to print out Odd numbers and Even numbers in the given range. It should also be able to calculate the factorials of all the numbers in the range.
3. Write a menu driven game with the following options
 - a) Guess age
 - b) Guess Sex
 - c) Guess President

Enter a, b or c

When a player chooses "a" the program should prompt the player to guess an age for a celebrity. The game should then print out whether it's correct or not.

When a player chooses "b" the program should prompt the player to guess the Sex for a celebrity. The game should then print out whether it's correct or not.

When a player chooses "c" the program should prompt the player to guess the President of a given country. The game should then print out whether it's correct or not.

After each turn the game should take the player back to the main menu. A player has 3 lives and each wrong guess costs one life. The game should end when the player consumes all their lives.

4. Write a program that gets two numbers from a user, A and B. The program should be able to compute A/B , $A*B$, $A-B$ and $A+B$. The program should also be able to output the results of the arithmetic operations outlined above.
5. Write a class that allows a user to enter integers. The integers are to be stored in an array. Create a function to get the sum of the integers in the array (`int sumArray(int[])`). Use this function to output the sum of the integers the user entered.

UNVIRSIY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF COMPUTER STUDIES

CST 2041-Indrodcution to Operating Systems

EXAM –OCTOBER 2009

Instructions: Answer any 5 Questions. Each question carries equal marks

Time: 3 hours

Question 1.

- 1.1. What are basic functions of an operating system? **[5 MARKS]**
- 1.2. What are the main differences between Micro-Controller and Micro- Processor? **[5 MARKS]**
- 1.3. What is multi tasking, multi programming, multi threading? **[5 MARKS]**
- 1.4. Describe different job scheduling in operating systems. **[5 MARKS]**

Question 2.

Suppose that you were to design an advanced computer architecture that did process switching in hardware, instead of having interrupts. What information would the CPU need? Describe how the hardware process switching might work

[20 MARKS]

Question 3.

Why would a thread ever voluntarily give up the CPU by calling thread-yield? After all, since there is no periodic clock interrupt, it may never get the CPU back. Can a thread ever be preempted by a clock interrupt? if so, under what circumstance ?if not, why not?

[20 MARKS]

Question 4.

- a) Give 5 different path names for the file/etc/passwd .hint:think about the directory entries “.” and “...”.
- b) Some operating systems provide a system call rename to give a file anew name. Is there any difference at all between using this call to rename a file, and just copying the file to a new file with the new name, followed by deleting the old one?

[20 MARKS]

Question 5.

Define external and internal fragmentation (with respect to file systems)

[10 MARKS]

What are hard links?

[2 MARKS]

What problems do hard links create in terms of referential naming

And how does one solve it ? **[8 MARKS]**

Question 6.

Write a producer-consumer problem that uses threads and shares a common buffer. however, do not use semaphores or any other synchronization primitives to guard the shared data structure. Just let each thread access them when it wants to. Use **sleep** and **wakeup** to handle the full and empty conditions.

See how long it takes for a fatal race condition to occur

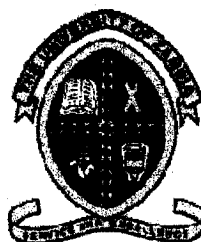
[20 MARKS]

Question 7.

A company is expanding rapidly, many new people are being employed and in addition the employees keep changing offices. The company wants to set up a networking system for the exchange of information among end user.

- a) List down the entire component needed and with the help of the diagram show how each computer will be connected
- b) What are the advantages of using the connection method you have chosen?
- c) Using a model show how information (data is been sent from workstation to workstation)
- d) How can you as the new administrator implement the security system in the entire system above
- e) What is the difference in use between a **Router** and **Hub**?

[20 marks]



THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
Department of Computer Studies

EXAM: 2009 - SEMESTER ONE FINAL
COURSE: CST3031 – INTRODUCTION TO SOFTWARE ENGINEERING
DURATION: 3 HOURS
DATE: 5th November, 2009

INSTRUCTIONS

- *Attempt any five(5) questions*
- *All questions carry equal marks(20 marks each)*
- *Clearly number your answers*
- *Use **the marks as a guide** to the detail required in your answers while keeping your answers concise and relevant.*

GOOD LUCK!!

QUESTION ONE

- (a) Why is Requirements engineering considered to be the most important part of software engineering? [2 marks]
- b) Requirements should state what a system should do, without stating how it should do it. Why is this distinction useful? [2 marks]
- c) Describe three different types of non-functional requirements which may be placed on a system. Give examples of each of these types of requirement. [6 marks]
- d) Explain why each of the following is an important property of a software specification, and explain how it can be achieved when writing specifications:
- i) Unambiguousness
 - ii) Traceability
 - iii) Verifiability. [6 marks]
- e) Project managers sometimes regard work put into writing high quality specifications as “gold plating”, and claim that it is unnecessary as it doesn’t contribute to producing program code. Under what circumstances is this view sensible, and under what circumstances is it foolish? In the latter case, how would you persuade such a manager that the specification does need to be high quality? [4 marks]

QUESTION TWO

- (a) A lift (elevator) in a building responds to users pressing the call button on different floor levels. Further, the lift will go to a particular floor either once it is called there from rest, or if a user enters the lift and presses a particular floor button. Once the door has been opened, it will wait 10 seconds before closing unless a call or floor button is pressed. If the lift has not been called for 5 minutes it returns to its rest position at the top of the building.
- Draw a state machine to show the possible states the lift can be in and the actions that move it from state to state. [5 marks]
- (b) Discuss the client-server model in the architectural design process;
- i. The role it plays
 - ii. Schematic representation (draw a diagram) of your choice to depict a sample model
 - iii. Mention two advantages and two disadvantages the model presents. [8 marks]
- (c) Control Models [7 marks]
- i. What is centralized based control?
 - ii. Describe the *nature of control* and *applicability* of the call-return and manager models.
-

QUESTION THREE

- (a) You are eliciting requirements for a new release of an existing product. For each of the elicitation problems described below, list a distinct elicitation technique that would best address that problem. [4 marks]
- i. You want to understand how users really use the existing system, as opposed to how they tell you they use the system.
 - ii. You want to invent new requirements or features to be added to the new release.
 - iii. You want to understand the original requirements of the existing system.
 - iv. You want to get a quick sense of the most popular features of the existing system.
- (b) Consider a system for administering the lending of books at a university library. A person must be a member of the university's community and must be in good standing— that is, not have any outstanding fines or overdue books – to borrow books. A book may be borrowed for up to two weeks at a time. A book loan may be renewed if the book is returned before the loan's due date and if no other library member has expressed an interest in borrowing the book. If a book is returned after the loan's due date, the borrower will be charged a fine of K500 for each late day. Fines are paid to the library staff at the circulation desk, where books are returned. Heavily-used books may be put on reserve, meaning that members can read them only in the library and cannot borrow them. The library has kiosks that members use to search for books, to determine the loan status of a book, or to express interest in borrowing a book that is currently out on loan. Members also use the kiosks to checkout books from the library and to renew book loans. The kiosks have scanners for scanning the member's library card and for scanning the barcodes on books. The kiosk will authenticate the member and check his or her standing before processing book loans or renewals.
- i. Provide a context diagram for the library lending system. [4 marks]
 - ii. Provide a use-case diagram that depicts only those use cases that are initiated by library members. [4 marks]
 - iii. Draw a data-flow diagram modelling the data processing involved when a member first steps up to the kiosk and ends when the kiosk issues a receipt (a slip of paper with the loan's due date) for the book loan. Assume that the use case applies to the loan of a single book. [8 marks]
-

QUESTION FOUR

- (a) Briefly explain the following terms;
- Black box testing
 - White box testing
- [4 marks]
- (b) Compare Top-down and Bottom-up integration testing under the following headings;
- Architectural validation
 - System demonstration
 - Test implementation
 - Test observation
- [8 marks]
- (c) Why is it important to partition the test space into *equivalence classes*? [2 marks]
- (d) For the following code fragment, describe 3 different test cases, and for each, describe the class of test cases it represents. [6 marks]

```
char * triangle (int x, y, z) {  
    /*
```

requires: The parameters are in ascending order (i.e. $x \leq y \leq z$)

effects: If x, y and z are the lengths of the sides of a triangle, this function classifies the triangle using one of the three strings, "scalene", "isosceles" or "equilateral". If x, y, and z do not form a triangle, the empty string is returned.

```
*/
```

```
    char *r;  
    r="scalene";  
    if (x==y || y==z)  
        r="equilateral";  
    if (x==z)  
        r="isosceles";  
    if (x <= 0 || (x+y) <= z)  
        r="";  
    return (r); }
```

QUESTION FIVE

(a) Given the following code fragment

```
public double calculate(int amount)
{
    double rushCharge = 0;

    if (nextday.equals("yes") )
    {
        rushCharge = 14.50;
    }

    double tax = amount * .0725;

    if (amount >= 1000)
    {
        shipcharge = amount * .06 + rushCharge;
    }

    else if (amount >= 200)
    {
        shipcharge = amount * .08 + rushCharge;
    }

    else if (amount >= 100)
    {
        shipcharge = 13.25 + rushCharge;
    }

    else if (amount >= 50)
    {
        shipcharge = 9.95 + rushCharge;
    }

    else if (amount >= 25)
    {
        shipcharge = 7.25 + rushCharge;
    }

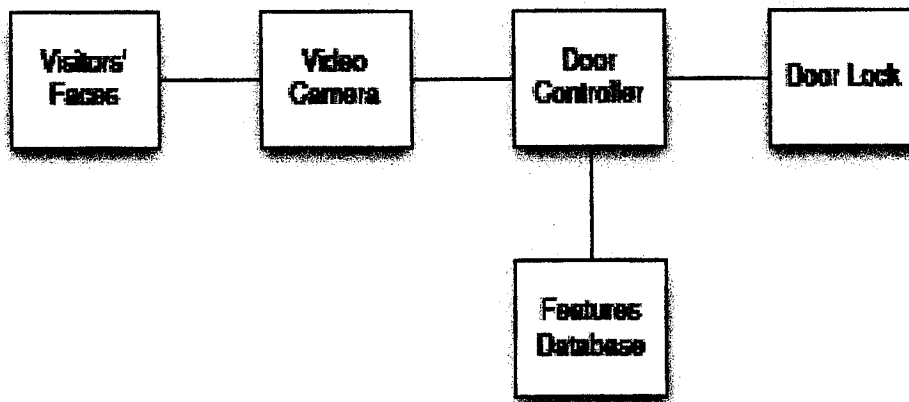
    else
    {
        shipcharge = 5.25 + rushCharge;
    }

    total = amount + tax + shipcharge;
    return total;
}
//end calculate
```

- i. Using the code, draw the corresponding flow graph. **[10 marks]**
 - ii. Determine the cyclomatic complexity of the flow graph. **[5 marks]**
 - iii. Determine a basis set of independent paths. **[5 marks]**
-

QUESTION SIX

- (a) Consider the following problem. A door to a secure area is to be controlled by a computer that recognizes facial features. The face of each person desiring admission is captured in a video stream, and the features are compared with entries in a database of the features of people who have been cleared for entry. A modeller has attempted to capture the above problem in the following context diagram:



- i. Should Visitors' Faces be a domain (box) in the context diagram? Defend your answer. [3 marks]
- ii. Should Video Camera be a domain in the context diagram? Defend your answer. [3 marks]
- (b) Draw a UML class diagram for software to represent the following associations. A Partnership has a husband who is a Male, a wife who is a Female and any number of children who are Persons. A Male is a Person. A Female is a Person. A Marriage is a type of Partnership. There is no need to show attributes and methods for the classes but do show aggregation, inheritance, roles and multiplicity. [6 marks]
- (c) Structured Analysis proceeds by modeling the current physical system, abstracting out a model of the current logical system, and then modeling the new logical system. What are the advantages and disadvantages of building these three separate models? What representations are used for each of these models? [8 marks]
-

THE END



**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF COMPUTER STUDIES**

2009 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

CST3251: ELECTRONICS FOR COMPUTING I

TIME: THREE HOURS

MAXIMUM MARKS - 100

Answer any FOUR questions.

All questions carry equal marks.

The marks are shown in brackets.

Wherever necessary use:

Electrical parameters of 714C operational amplifier

$A = 400,000$

$R_i = 33 \text{ M}\Omega$

$R_o = 60 \Omega$

Supply voltages = $\pm 15\text{V}$

Maximum output voltage swing = $\pm 13\text{V}$

$U_{GB} = 0.6 \text{ MHz}$

Q1. (a) Draw a full wave bridge rectifier circuit and explain its operation. Sketch the output waveform of the rectifier circuit. [14]

(b) The 714C is configured as a non-inverting amplifier with the following specifications. $R_1=100\Omega$ and $R_F=4.7k\Omega$

Compute the following closed loop parameters;

[5]

- (i) Voltage gain
- (ii) Input resistance
- (iii) Output resistance
- (iv) Bandwidth

(c) For the figure given below, write the Boolean expression. [6]

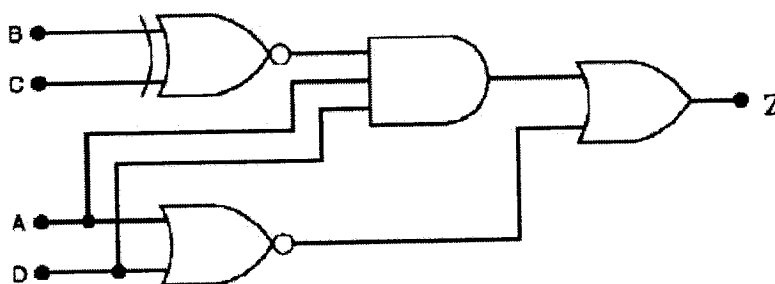


Figure 1

Q2. (a) Explain Miller's theorem. Draw the circuit diagram of a closed loop inverting amplifier for finding the input resistance and show how this theorem is useful in deriving the expression for input resistance. [4+6]

(b) Using Thevenin's theorem, find the current through 100Ω connected across terminals A and B in the circuit below. [12]

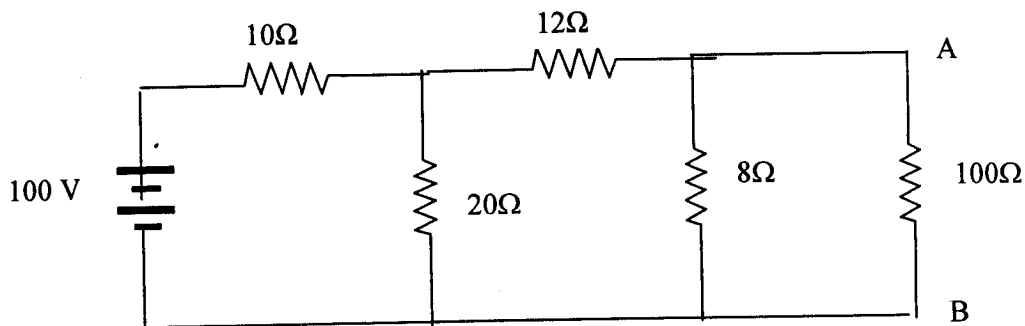


Figure 2

- (c) Write the complete expression for the minterm designation [3]

$$Y = \sum m (1,3,5,7)$$

- Q3. (a) Explain constant voltage and current sources. [8]

- (b) Find the donor concentration in a sample of n-type germanium crystal with resistivity $10^{-1} \Omega\text{m}$ at 303K. Given mobility of electron = $0.38 \text{ m}^2/\text{volt s}$ and charge of electron = $1.6 \times 10^{-19} \text{ C}$. [4]

- (c) Draw the logic circuit for the following equation

$$X = \overline{A \overline{B} \cdot (A + C)} + \overline{A} B \cdot (\overline{A + \overline{B} + \overline{C}})$$

Use De Morgan's theorem and Boolean algebra to simplify the equation. Draw the simplified circuit. [13]

- Q4. (a) (i) Add $(\text{AECF1})_{16}$ and $(15\text{ACD})_{16}$. [2]

- (ii) Subtract $(3\text{A7})_{16}$ from $(1274)_{16}$. [2]

- (iii) Convert $(2\text{B6D.5A6B})_{16}$ into equivalent decimal number. [3]

- (b) If $A = -60$ and $B = -28$

- (i) represent A and B in 8-bit two's complement. [4]

- (ii) find $B + A$ and $B - A$. [4]

- (c) Explain the action of a JFET as an amplifier [10]

- Q5. (a) Find the value of the current when an alternating e.m.f. of 220V at 50 Hz is applied to

- (i) an inductance of 0.5H [3]

- (ii) a capacitor of $10\mu\text{F}$ [3]

- (b) Explain what do you understand by **don't care conditions**. [3]

- (c) Find the simplified Boolean function in (i) sum of products form and (ii) in product of sums form for the Karnaugh Map represented by [8+8]

$$F(A,B,C,D) = \sum m(0,5,7,8,15) + \sum d(2,3,6,10,14)$$

- Q6. (a) Explain positive voltage feedback with figure. Derive an expression for the gain of a positive voltage feedback amplifier. [8]
- (b) Group the 1's in each of the Karnaugh maps in the figure below and write the resulting minimum SOP expression. [8]

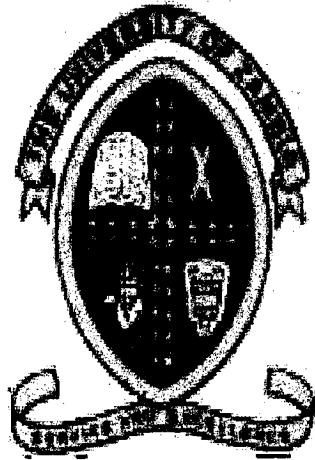
AB \ C	0	1
00	1	1
01	1	
11		1
10	1	1

AB \ CD	00	01	11	10
00	1			1
01	1	1		1
11	1	1		1
10	1		1	1

Figure 3

- (c) Write short notes on [9]
- (i) operating point
 - (ii) drift mobility
 - (iii) series induction filter

END OF CST3251 EXAMINATION



University of Zambia

School of Natural Sciences

Department of Computer Studies

CST4131 Final Exam

Advanced Object Oriented Programming with Java

This exam has four sections. Section A, B and C has compulsory questions and each carry 10, 30 and 15 points respectively. Section D has five questions and you are expected to answer any three of the five. Each question in Section D carries 15 points.

SECTION A (True or False) [10 points]

Answer all questions.

1. Any class that implements the Runnable interface has to provide the implementation for the following methods
public void start();
public void run();
2. A thread that has called the wait() method of an object still owns the lock of the object.
3. If you call the interrupted() method of a thread object twice the second call will always return false.
4. If you call the isInterrupted() method of a thread object twice the second call will always return false.
5. Consider the following class
public class Test implements Runnable{
public void run(){}
}
Creating an instance of this class and calling its run() method will spawn a new thread.
6. A Thread object has a method called notify().
7. This code compiles without error.
class MyButton extends Button implements MouseListener{
public MyButton(String lbl) {
super(lbl);
addMouseListener(this);
}
public void mousePressed(MouseEvent e){
//do something
}
}
}
8. A Dialog is a subclass of Frame.
9. When using the GridBagLayout manager, each new component requires a new instance of the GridBagConstraints class.
10. You can only obtain a mutually exclusive lock on methods in a class that extends Thread or implements runnable.
11. You can obtain a mutually exclusive lock on any object.

12. A thread can obtain a mutually exclusive lock on an object by calling a synchronized method on that object.
13. Thread scheduling algorithms are platform dependent.
14. Adding more classes via import statements will cause a performance overhead; only import classes you actually use.
15. Under no circumstances can a class be defined with the *private* modifier
16. A inner class may under some circumstances be defined with the *protected* modifier
17. An interface cannot be instantiated
18. At the root of the collection hierarchy is a class called Collection
19. The collection interface contains a method called enumerator
20. The Set interface is designed for unique elements

SECTION B (Multiple choice questions) [30 points]

Answer all questions.

1. A number of threads of the same priority have relinquished the lock on a monitor and are in a waiting state after having called the wait() method of the object. A new thread enters the monitor and calls the notifyAll() method of the monitor. Which of these threads will be the first one to resume?
 - a) The thread that has been waiting the longest.
 - b) The thread that was the last one to exit the monitor.
 - c) You can never be sure which thread will get to run first.
 - d) The first thread that called the wait() method
2. Which three of these are valid constructors of a Thread object?
 - a) public Thread(Object obj)
 - b) public Thread(String name)
 - c) public Thread(Runnable trgt)
 - d) public Thread(ThreadGroup grp, Runnable trgt, String name)
 - e) public Thread(ThreadGroup grp, Object ob)
3. Which four of the following are methods of the Thread class?
 - a) public void run()
 - b) public void start()
 - c) public void exit()
 - d) public final void setAccess()
 - e) public final void setPriority(int priNbr)

f) `public final int getPriority()`

4. What is the result of attempting to compile and run the following code?

```
public class Test1{
    public static void main(String[] args)
    {
        Integer int1 = new Integer(10);
        Vector vec1 = new Vector();
        LinkedList list = new LinkedList();
        vec1.add(int1);
        list.add(int1);
        if(vec1.equals(list)) System.out.println("equal");
        else System.out.println("not equal");
    }
}
```

- a) The code will fail to compile.
- b) Runtime error due to incompatible object comparison
- c) Will run and print "equal".
- d) Will run and print "not equal".

5. What is the result of attempting to compile and run the following code?

```
public class Test {

    public static void main(String[] args){
        Integer a = new Integer(4);
        Integer b = new Integer(8);
        Integer c = new Integer(4);
        HashSet hs = new HashSet();
        sh.add(a);
        sh.add(b);
        hs.add(c);
        System.out.println(hs);
    }
}
```

- a) Will print [8, 4]
- b) Will print [4, 8, 4]
- c) Will print [8, 4, 4]
- d) It will not compile

6. Which two of these statements are true?

- a) Hashtable is a sub class of Dictionary
- b) ArrayList is a sub class of Vector
- c) LinkedList is a subclass of ArrayList

d) Stack is a subclass of Vector

7. Which two of these statements are true?

- a) LinkedList extends List
- b) AbstractSet extends Set
- c) HashSet extends AbstractSet
- d) WeakHashMap extends HashMap
- e) TreeSet extends AbstractSet

8. Which two of these statements are not true?

- a) A HashSet does not permit duplicates
- b) A Vector permits duplicates
- c) A TreeSet is an ordered Set
- d) A LinkedList is sorted in descending order
- e) A LinkedList is sorted in ascending order

9. What will be the result of compiling and running the following code?

```
import java.awt.*;
import java.applet.*;
public class AppletTest extends Applet {
    Label lbl = new Label("hello");
    public void init()
    {
        setSize(200,100);
        setVisible(true);
        lbl.setBackground(new Color(0,100,180));
        setLayout(new GridLayout(1,1));
        add(lbl);
        setLayout(new FlowLayout());
        lbl.setBounds(0,0,100,24);
    }
}
```

- a) The label will fill half the display area of the applet.
- b) The label will be wide enough to display the text "hello"
- c) The label will not be visible.
- d) The label will fill the entire display area of the applet
- e) The code will throw a run time error because of the second setLayout() call.

10. What will be the result of compiling and running the following applet?

```
import java.awt.*;
import java.applet.*;
public class AppletTest extends Applet {
    public void init()
    {
```

```

super.init();
PanelTest p = new PanelTest();
p.init();
setVisible(true);
setSize(200,100);
add(p);
}

class PanelTest extends Panel{
    Button b1 = new Button("Press me");
    public PanelTest()
    {
        setSize(200,100);
        setVisible(true);
    }
    public void init(){
        super.init();
        add(b1);
    }
}

```

- a) The button will fill the entire display area of the applet.
- b) The code will fail to compile.
- c) The button will be just big enough to encompass its label.
- d) The applet's display area will be blank.

11. Which two of the following are valid constructors for a TextField .

- a) TextField();
- b) TextField(int rows , int cols);
- c) TextField(int cols , String txt);
- d) TextField(int cols);
- e) TextField(String txt , boolean scrollBars);

12. What is the result of attempting to compile and run the following?

```

import java.awt.*;
import java.awt.event.*;
class FrameTest extends Frame{
    Label lblTest = new Label("TEST");
    Button btnTest = new Button(" TEST ");
    public static void main(String[] args){
        FrameTest ft = new FrameTest();
        ft.setLayout(new FlowLayout());
        ft.add(ft.lblTest);
        ft.add(ft.btnTest);
        ft.setSize(200,100);
    }
}

```

```

        ft.setVisible(true);
        ft.enableEvents(AWTEvent.ACTION_EVENT_MASK);
    }
    public void processActionEvent(ActionEvent event){
        super.processActionEvent(event);
        if(event.getID() == AWTEvent.ACTION_EVENT_MASK){
            if(event.getSource() instanceof Button){
                lblTest.setText("OK");
            }
        }
    }
}

```

- a) The code will not compile
- b) There will be a runtime error
- c) The frame will not be visible
- d) Nothing happens when you click the button
- e) The label's caption changes to "OK" when you click the button

13. What is the default layout for a Dialog?

- a) FlowLayout
- b) GridLayout
- c) CardLayout
- d) BorderLayout
- e) GridBagLayout

14. What will this draw ?

```

public class AppletTest extends Applet{
    public void init(){
        setVisible(true);
        setSize(200,200);
    }
    public void paint(Graphics g){
        g.setColor(new Color(0,0,255));
        g.drawRect(50, 100 , 100, 50);
    }
}

```

- a) A rectangle 50 pixels wide with top left corner at 100, 50.
- b) A rectangle 50 pixels wide with top left corner at 50,100.
- c) A rectangle 100 pixels wide with top left corner at 50,100.
- d) A rectangle 100 pixels high with top left corner at 50,100.
- e) A rectangle 100 pixels high with top left corner at 100,50.

15. What is the result of compiling and running this program?

```

class Mammal{
    void eat(Mammal m){
        System.out.println("Mammal eats food");
    }
}
class Cattle extends Mammal{
    void eat(Cattle c){
        System.out.println("Cattle eats hay");
    }
}

class Horse extends Cattle{
    void eat(Horse h){
        System.out.println("Horse eats hay");
    }
}

public class Test{
    public static void main(String[] args){
        Mammal h = new Horse();
        Cattle c = new Horse();
        c.eat(h);
    }
}

```

- a) prints "Mammal eats food"
- b) prints "Cattle eats hay"
- c) prints "Horse eats hay"
- d) Class cast Exception at runtime.

16. Consider the following class hierarchy.

```

interface A{
    public void method1();
}
class One implements A{
    public void method1(){
        System.out.println("hello");
    }
}
class Two extends One{}
public class Test extends Two{
    public static void main(String[] args)
    {
        A a;
        Two t = new Two();
        a = t;
        a.method1();
    }
}

```

}

What will be the outcome on attempting to compile and run this ?

- a) Compiles and runs printing out "hello".
- b) Compilation error at line 16.
- c) The compiler raises an objection to the assignment at line 15.
- d) Throws a NoSuchMethodException at runtime.

17. What will happen if you try to compile and run this ?

```
interface A{
    public void innerMeth();
}
public class Test {
    A a;
    int memVar = 1;
    void aMethod(){
        a = new A(){
            public void innerMeth(){
                System.out.println(memVar);
            }
        };
    }

    public static void main(String[] args){
        Test t = new Test();
        t.a.innerMeth();
    }
}
```

- a) Compiler error.
- b) NoSuchMethodException at runtime.
- c) Compiles and runs printing 1
- d) Throws a NullPointerException at runtime.

18. What will happen if you try to compile and run this code?

```
class Rectangle{
    public int area(int length , int width) {
        return length * width;
    }
}

class Square extends Rectangle{
    public int area(long length , long width) {
        return (int) Math.pow(length ,2);
    }
}
```



```

    }
    class Test{
        public static void main(String args[]) {
            Square r = new Square();
            System.out.println(r.area(5 , 4));
        }
    }

```

- a) Will not compile.
- b) Will compile and run printing out 20
- c) Runtime error
- d) Will compile and run printing out 25

19. What will be the result of attempting to compile and run this?

```

class Base{}
class Derived extends Base{}
public class Test {
    public static void main(String[] args){
        Derived d = (Derived) new Base();
    }
}

```

- a) Will not compile
- b) Compiles and runs without error.
- c) Runtime error

20. What will this program print out?

```

class Base{
    int value = 0;
    Base(){
        addValue();
    }
    void addValue(){
        value += 10;
    }
    int getValue(){
        return value;
    }
}

class Derived extends Base{
    Derived(){
        addValue();
    }
    void addValue(){
        value += 20;
    }
}

```

```

    }
    public class Test {
        public static void main(String[] args){
            Base b = new Derived();
            System.out.println(b.getValue());
        }
    }

```

- a) 10
- b) 20
- c) 30
- d) 40

21. What will it print now?

```

class Base{
    static int value = 0;
    Base(){
        addValue();
    }
    static void addValue(){
        value += 10;
    }
    int getValue(){
        return value;
    }
}
class Derived extends Base{
    Derived(){
        addValue();
    }
    static void addValue(){
        value += 20;
    }
}
public class Test {
    public static void main(String[] args){
        Base b = new Derived();
        System.out.println(b.getValue());
    }
}

```

- a) 10
- b) 20
- c) 30
- d) 40

22. What is the result of attempting to compile and run this?

```
interface ITest{
    public void setVal();
}

public class Test {
    private String a;
    void aMethod(){
        final String b;
        ITest it = new ITest() {
            public void setVal(){
                a = "Hello";
                b = " World";
            };
        };
        it.setVal();
        System.out.println(a + b);
    }
    public static void main(String[] args) {
        Test t = new Test();
        t.aMethod();
    }
}
```

- a) Code will not compile
- b) Run time error
- c) Will compile and run printing "Hello"
- d) Will compile and run without any output

23. What is the result of attempting to compile and run this?

```
class Base{
    String s = "Base";
    String show(){
        return s;
    }
}

class Derived extends Base{
    String s = "Derived";
}

public class Test {
    void print(Base b){
        System.out.println(b.show());
    }
    void print(Derived d){
        System.out.println(d.show());
    }
    public static void main(String[] args){
        Test t = new Test();
        Base b = new Derived();
    }
}
```

```

        t.print(b);
    }
}

```

- a) Code will not compile
- b) Run time error
- c) Will compile and run printing "Derived"
- d) Will compile and run printing "Base"

24. What is the result of attempting to compile and run this?

```

interface ITest{
    public void setVal();
}
public class Test {
    private String a;
    void aMethod(){
        final String b = " World";
        ITest it = new ITest() {
            public void setVal(){
                a = "Hello" + b;
            };
        };
        it.setVal();
        System.out.println(a);
    }
    public static void main(String[] args) {
        Test t = new Test();
        t.aMethod();
    }
}

```

- a) Code will not compile
- b) Run time error
- c) Will compile and run printing "Hello World"
- d) Will compile and run printing "Hello"

25. What will happen when you attempt to compile and run this code

```

//Demonstration of event handling
import java.awt.*;
import java.awt.event.*;
public class MyWc extends Frame implements WindowListener{
    public static void main(String argv[]){
        MyWc mwc = new MyWc();
    }
    public void windowClosing(WindowEvent we){
        System.exit(0);
    } //End of windowClosing
}

```

```

public void MyWc(){
    setSize(300,300);
    setVisible(true);
}
} //End of class

```

- a) Error at compile time
- b) Visible Frame created that that can be closed
- c) Compilation but no output at run time
- d) Error at compile time because of comment before *import* statements

26. Which of the following best describes the use of the synchronized keyword?

- a) Allows two process to run in parallel but to communicate with each other
- b) Ensures only one thread at a time may access a method or object
- c) Ensures that two or more processes will start and end at the same time
- d) Ensures that two or more Threads will start and end at the same time

27. Which most closely matches a description of a Java Map?

- a) A vector of arrays for a 2D geographic representation
- b) A class for containing unique array elements
- c) A class for containing unique vector elements
- d) An interface that ensures that implementing classes cannot contain duplicate keys

28. How does the set collection deal with duplicate elements?

- a) An exception is thrown if you attempt to add an element with a duplicate value
- b) The *add* method returns false if you attempt to add an element with a duplicate value
- c) A set may contain elements that return duplicate values from a call to the *equals* method
- d) Duplicate values will cause an error at compile time

29. Which of the following cannot cause a thread to stop executing?

- a) The program exits via a call to *System.exit(0)*;
- b) Another thread is given a higher priority
- c) A call to the thread's *stop* method.
- d) A call to the *halt* method of the *Thread* class?

30. Given the following code

```

class Base{
public class MyCast extends Base{
    static boolean b1=false;
    static int i = -1;
    static double d = 10.1;
}
}

```

```

    public static void main(String argv[]){
        MyCast m = new MyCast();
        Base b = new Base();
        //Here
    }
}

```

Which of the following, if inserted at the comment //Here will allow the code to compile and run without error.

- a) b = m;
- b) m = b;
- c) d = i;
- d) b1 = i;

SECTION C (Answer all questions) [15 points]

1. Briefly explain how java supports distributed applications using rmi.
2. How does Java implement security in Applets with relation to Sockets?
3. Outline the life cycle of an applet.
4. Outline the life cycle of a thread.
5. What is the java collections interface?
6. Elaborate on the execution of a Java application, applet and Servlet.
7. What are the salient features of a Java Socket?
8. Outline the three thread processing models with diagrams.
9. How does Java try to support multiple inheritances?
10. What makes a class abstract?

SECTION D (Answer any 3 questions) [45 points]

1. Write an applet to draw a circle whose radius is given as a PARAM field in the HTML file. The centre of the circle is at (300,300). Give the HTML file also.
2. Write a client application that connects to a server on port 3134 and uses a string "Hello Echo Server" to test the echo server. Write a threaded echo server that echoes back the client's request. The server should listen on port 3134.
3. Most transactions will have results that differ depending on the order of execution. Write a threaded application that allows for withdrawing, depositing and checking of an account balance. The results should be the same regardless of order of execution.
4. Search engines are tools that are becoming popular on the internet. The main challenge is data records updating and modification. Write a simple program that reads in content from a file and stores it in a data structure that allows for quick searches.
5. Quadrilaterals are four sided shapes. Write a java application that uses the principle of inheritance. It should support setting and getting properties of a Square and Rectangle.

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF COMPUTER STUDIES
SECOND SEMESTER EXAMINATION 2009

CST 4252: ELECTRONICS FOR COMPUTING IV

TIME: 3 HOURS

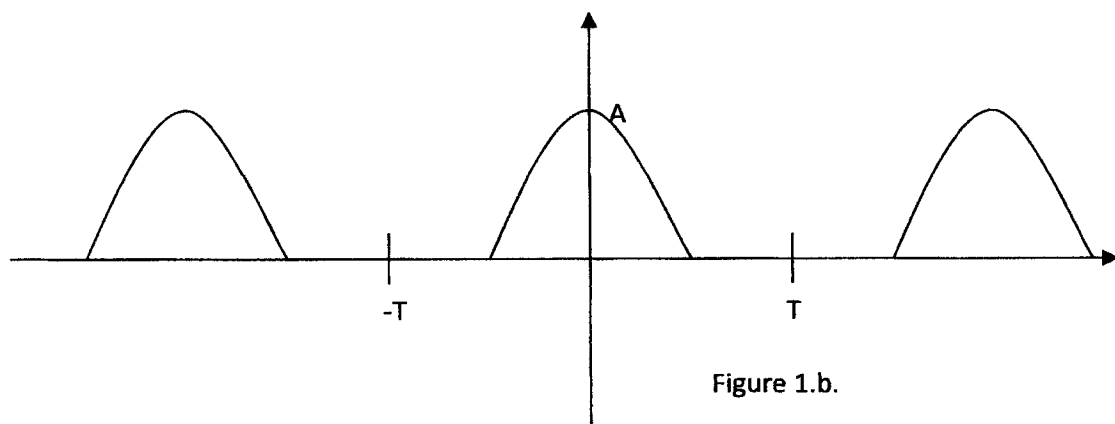
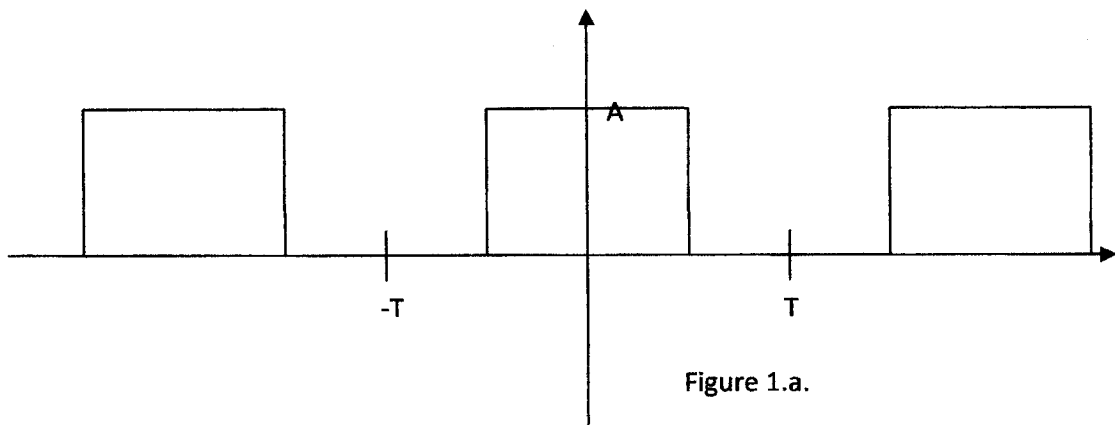
INSTRUCTIONS: ANSWER ANY FOUR QUESTIONS

TOTAL MARKS 100

ALL QUESTIONS CARRY EQUAL MARKS

- Q.1. Synchronization binary signals can be sent by a square wave pulse train as in figure 1(a). Unfortunately, undesirable high frequency terms are included in the signal, which tend to introduce noise and require more energy for transmission. To mitigate this, a high pass filter is introduced in the transmitter to produce a signal as in figure 1.b. (**cosine shape**). Show, using Fourier analysis, that the high frequency terms for figure 1.b. are attenuated after filtering.

[25]



Q.2.

- i) Give two reasons why multilevel signalling is used as a signalling strategy. [4]

- ii) What is the limiting factor on the number of levels that can be used in a multilevel signalling scheme? [2]

- a) A communications link is sending data at 28000 bps by using sixteen different voltage levels, each representing 4 bits, so that the voltage levels on the line only change at a quarter the required data rate. What is the minimum bandwidth required to pass the fundamental of this waveform? [8]

b) Two routers use binary signalling are connected by a serial cable. The cable has a flat frequency response up to 24 kHz, with negligible group delay distortion. [5][6]

- i) What is the maximum information transfer rate that can be accommodated by the cable, assuming a noise-free environment?
- ii) If the noise introduced by the cable is -80 dB with respect to the signal power, what is the resulting maximum information transfer rate?

Q.3.

a) A cable is measured to have a flat gain response with frequency over the band of interest, but is found to have a phase response that changes proportionally with frequency, with a measured phase increase of 10° for every 4 MHz of bandwidth. What is the group delay response for the cable? [6]

b) A twisted pair cable that use binary signalling is used in a serial communication channel. The cable has a flat frequency response of 3kHz. [19]

- i. What is the maximum data transfer rate of the cable assuming a noise free environment?
- ii. If the noise introduced to the cable is -20 dB with respect to the signal power, what is the maximum information rate for error free communication?
- iii. What is the power efficiency $[E_b/N_0]$ of the cable under the circumstances.

Given:

$$S/N = E_b C / N_0 B$$

- iv. If it is required to double the information rate for the same bandwidth how many symbol states would be required?

Q.4.

a) What is the significance of the signal spectrum when evaluating an encoding scheme? [6]

b) The waveform given below is received by a digital receiver, in a communication system using Differential Manchester encoding. An error check circuit determines that the fourth bit has an error in that it has been flipped. Determine the waveform of the original signal? Assume that there is no change at the start of the signal. [10]



c) Draw the waveform for the sent signal in a) if

[5+4]

- i) Bipolar-AMI is used.
- ii) NRZ-L is used.

Q.5.

a) A link has an average thermal noise power of -120 dBm at a temperature of -25°C . At what temperature would thermal noise power double? Given $k = 1.23 \times 10^{-23}$ W/K/Hz.

[5]

b) If the bandwidth B for the link is 30 kHz and the channel capacity is 600 kbps for the link in part a) at the temperature -25°C , by what factor does the channel capacity reduce at the new temperature?

[8]

c) Draw the waveform for the digital signal 101101 if the following modulation method is used:

[12]

i) FSK

ii) ASK

iii) PSK

END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

**2009/10 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS**

GEO 111: INTRODUCTION TO HUMAN GEOGRAPHY

TIME: THREE HOURS

INSTRUCTIONS: QUESTION 1(40%) AND ANY OTHER 3 (20% EACH)

1. Using Figure 1 showing selected settlements in Zimbabwe;
 - a) Determine the settlement pattern given that the total area is 44,625 square kilometres,
 - b) Comment on the settlement pattern of the area.
 2. Using any three examples assess whether diffusion has its own advantages and disadvantages.
 3. Discuss the four urban land use models highlighting the various similarities.
 4. The concept of 'environmental determinism' is not totally applicable in the world today. Elucidate.
 5. Examine the chronological way of defining 'Geography'.
 6. Discuss contributions of geographers in antiquity and at least two explorers to the field of geography.
-

END OF EXAMINATION

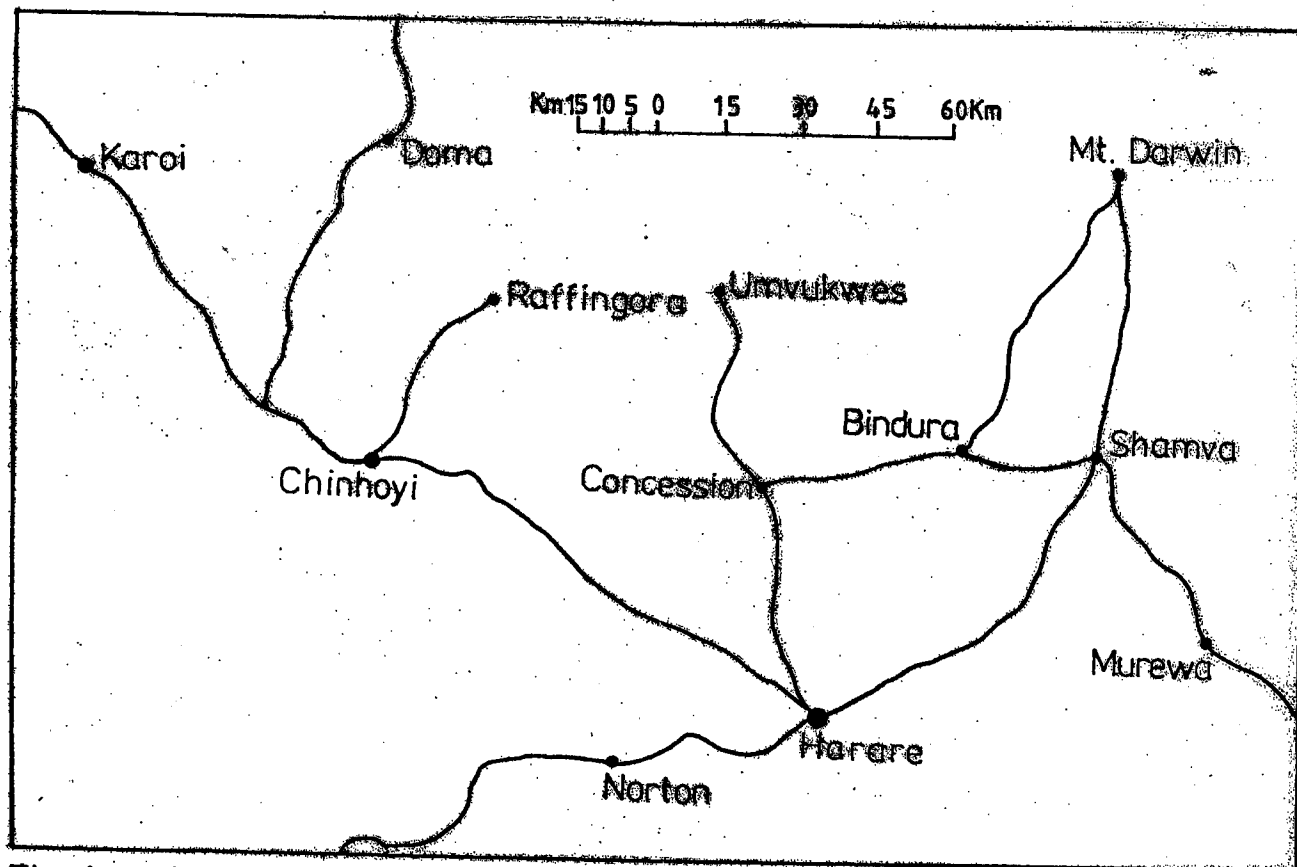


Fig.1 Map showing selected settlements in Zimbabwe.

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

2009 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 155: INTRODUCTION TO PHYSICAL GEOGRAPHY

TIME: **Three hours**

INSTRUCTIONS: Answer any **FOUR** questions.

All questions carry equal marks. Candidates are advised to make use of illustrations and examples wherever appropriate.

-
1. Compare and contrast the theories of precipitation formation.
 2. With the aid of a diagram describe the forces that influence air movement in the earth-atmosphere system.
 3. Explain the relationship between minerals and rocks and how the rock cycle enhances the understanding of rock formation and destruction on earth.
 4. Discuss the weathering and mass wasting processes on earth.
 5. Describe the major forms of water in soil and their importance to plant use.
 6. Explain the factors which influence the distribution patterns of plants and animals in the world.
-

END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

2008 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 175: INTRODUCTION TO MAPPING TECHNIQUES IN GEOGRAPHY

**PAPER II: THEORY
CLASSIFICATION OF NUMERICAL DATA, CONSTRUCTION OF TABLES,
STATISTICAL MAPS AND DIAGRAMS**

TIME: Three Hours

INSTRUCTIONS: Answer any four questions. The use of a Philip's University Atlas and a calculator is allowed. Candidates are encouraged to make use of illustrations wherever appropriate.

1. Write short explanatory notes on the distinction between all of the following pairs.
 - (a) Statistical diagrams and statistical maps
 - (b) Continuous and discrete variables
 - (c) Parameters and statistics
 - (d) Nominal and ordinal scales of measurement
 - (e) Comparative and divergence bar graphs

2. Study Figure 1 showing an outline base map of densities at various points and then answer the questions that follow.
 - (a) On Figure 1 provided, interpolate the 250; 300; 350; 400 and 450 isolines.
 - (b) Shade your diagram accordingly.
 - (c) Provide an appropriate legend to your diagram.
 - (d) What are the merits of the technique that you have used?
 - (e) Outline and describe any two methods of selecting isoline values.

3. Examine the data given in Table 1 and then answer the questions that follow.

Table 1: Time spent watching television during a period of one week

Class	Hours of TV	Frequency
1	1.0 – 1.3	3
2	1.4 – 1.7	4
3	1.8 – 2.1	5
4	2.2 – 2.5	8
5	2.6 – 2.9	11
6	3.0 – 3.3	5
7	3.4 – 3.7	6
8	3.8 – 4.1	8
Total Frequency		50

Source: Adapted from Hennessy L. 1989 *Quantitative Analysis*, Charles Letts & Co. London, P29

- (a) What are the class limits of the sixth class?
- (b) Calculate the class mark of the fourth class.
- (c) Determine the class boundaries of the second class.
- (d) What is the size of the fifth class interval?
- (e) Calculate the relative frequency of the eighth class.
- (f) Construct the frequency distributions of the data in Table 1.
- (g) How many people watched less than 1.8 hours of television that week?
- (h) How many people watched 1.4 hours of television or more that week?
- (i) Calculate the percentage of people who watched more than 1.8 hours but less than 3.0 hours of television that week.
- (j) How should the first class be written so that it becomes an open class?

4. Table 2 shows the area and populations of the standard administrative regions of the British Isles (Figure 2a) in 1981.

Table 2: Administrative regions of the British Isles in 1981

Standard Region	Area (Km ²)	Population ('000)
Northern	11,953.4	3,570
Yorkshire & Humberside	8,770.9	5,213
North-West	4,933.5	7,401
East Midlands	7,521.8	3,860
West Midlands	8,039.0	5,699
East Anglia	7,762.6	2,008
South East	16,935.7	18,585
South West	14,615.8	4,134
Wales	12,825.3	2,923
Scotland	47,673.8	5,314
Northern Ireland	8,722.9	1,664
British Isles	149,754.7	60,371

Source: Truran H. C. 1975 *A Practical Guide to Statistical Maps & Diagrams*, Heinemann Educational Books Ltd. London, P55

Study the data given in Table 2 and then answer the following questions:

- Using the most appropriate statistical mapping technique, graphically display the data in Table 2 on the outline base map of the British Isles (Figure 2 b) provided?
- What are the merits and demerits of the technique that you have used?

5. Examine the data given in Table 3 showing forest standing volume by province and then answer the questions that follow.

Table 3: Forest Standing Volume by Province

Province	Standing Volume (Million m ³)
Central	463.438
Copperbelt	286.314
Eastern	401.619
Luapula	351.101
Lusaka	982.946
Northern	-
Northwestern	982.946
Southern	126.602
Western	304.913
Zambia	3,092.078

Source: Mbindo K. 2003 *Forest Cover Crisis in the Sub-tropics: A case study from Zambia* (WWW.fao.org/Document) Accessed 18th August 2008, P7

- (a) Use the most appropriate statistical mapping technique to show the forest standing volume on the outline base map (figure 3) provided.
- (b) What are the merits and demerits of the technique that you have used?
6. A group of researchers have just completed reconstructing an imagined land use map of the Netherlands for the year 1969 and their findings are presented in Table 4.

Table 4: Land use in the Netherlands in 1969

Land use type	Percent Cover (%)
Grassland	46
Arable land	26
Woodland heaths & Dunes	13
Buildings & Roads	10
Horticulture	5
Total	100

Source: *Hypothetical*

Critically, examine the data in table 3 and then answer the following questions.

- (a) Use the most appropriate visual display to show the data in Table 4 as a graphic device for displaying values as a proportion of a rectangular graph.
- (b) What are the merits and demerits of the visual display that you have used?
- (c) Identify and describe another technique that could be used to visually display the data in Table 4.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 211 : THE GEOGRAPHY OF AFRICA

TIME: THREE HOURS

INSTRUCTIONS : **Answer any four questions.**
Candidates are advised to make use of
illustrations and examples wherever appropriate.

1. Write short explanatory notes on ALL of the following:
 - (a) Coral reef
 - (b) Basins and divides of Africa
 - (c) Harmattan winds
 - (d) Major pests in Africa.
 - (e) Desert landscapes
2. With the aid of sketch maps and diagrams, describe the extent of the Rift Valley of Africa and discuss the theories advanced on its origins.
3. Describe the main vegetation regions of Africa, and relate these to climatic conditions.
4. How can Africa's natural resource endowment be the basis for sustainable socio-economic development in the 21st century?
5. What are the explanations for the socio-economic crises in sub-Saharan Africa according to Griffiths and Binns (1988)?
6. 'Tanzania has made a successful transition from Ujamaa to a market economy' Discuss.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2009 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 271: QUANTITATIVE TECHNIQUES IN GEOGRAPHY 1

Time: Three hours

Instructions: Answer any **four** questions. All questions carry equal marks.

Candidates are encouraged to use illustrations wherever appropriate.

-
1. Write brief explanatory notes on all of the following ethical considerations in research:
 - (a) Requirement of informed consent.
 - (b) Principle of anonymity.
 - (c) Confidentiality.
 - (d) Right to service.
 - (e) Voluntary participation.
 2. Discuss the advantages and disadvantages of using a 'Focus Group Discussion' (FGD) as a method of data collection.
 3. Discuss the statement that *'a research problem is the situation that causes the researcher to feel apprehensive, and uncertain.'*
 4. Why is it important to process the data once it has been collected from the field?
 5. Outline the purpose of literature review in geographic research and the assessment criteria used to validate its significance.
 6. Mr. Nkisu has been assigned by a Non Governmental Organisation (NGO) to undertake a study on the 'impact of microfinance project on households in Chainda Compound'. What evaluation methodology would you recommend? Justify your choice.
-

END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

2008/2009 ACADEMIC YEAR ^{FIRST} SECOND SEMESTER FINAL EXAMINATION

GEO 381: ENVIRONMENT AND DEVELOPMENT I

TIME : Three hours

INSTRUCTIONS: Answer four questions. all questions carry equal marks. Candidates are advised to make use of illustrations and examples wherever appropriate

1. Why would applying ecological, social and economic pillars of sustainable development be ideal to achieving Millennium Development Goals (MDG's) in Zambia?
 2. The human induced or cultural pollution (eutrophication) of water increases algae growth. What are the likely impacts of the plant growth in relation to dissolved oxygen (DO) and general social and economic effects? Use the Kafue River weed (water hyacinth) as a case example.
 3. Climate change has become a contemporary defining issue not only for the rich but even more so for the poor as they are more affected. Discuss.
 4. Globalization has induced ecological, social and even political pressures on most developing countries. Discuss using Zambia as an example.
 5. Provide an elaborate exposition on the factors of environmental planning and their significance.
 6. Explain and discuss the three main stages involved in Environmental Impact Statement (EIS).
-

END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

2009 ACADEMIC YEAR FIRST SEMESTER EXAMINATIONS

GEO 451: LAND RESOURCES SURVEY

Time: Three hours

Instructions: Answer any four questions. All questions carry equal marks. The use of electronic calculators is allowed wherever appropriate.

1. Write short explanatory notes on ALL of the following:
 - a. The land use system of Zambia.
 - b. Detailed and semi detailed surveys.
 - c. Attributes of Land Utilization Types.
 - d. Productive Available Moisture of a soil.
 - e. Length of the growing period.
2. Describe the application of the two stage approach in land evaluation
3. Outline and explain the principles of land evaluation.
4. Describe the matching process in the land evaluation exercise.
5. You have been hired as a consultant to recommend to a team of experts how they can carry out an integrated resource management project in an area where there is a chronic shortage fuelwood and recurring food insecurity. The donor strongly recommends that the projects that they will support should be locally developed and administered. Answer the that follow:
 - a. Identify the method you will recommend and outline the stages involved?
 - b. What are the benefits and challenges of the suggested method you have recommended?
6. Describe the procedure for carrying out a Gross Margin Analysis.

End of Examination

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

2009 ACADEMIC YEAR FIRST SEMESTER

FINAL EXAMINATIONS

GEO 481

ENVIRONMENT AND DEVELOPMENT II

TIME : THREE HOURS

**INSTRUCTIONS : ANSWER ANY FOUR QUESTIONS. ALL QUESTIONS
CARRY EQUAL MARKS.**

1. 'Property can be defined as a social convention about the security of future benefit or income gains'. Using this statement, assess the significance of definition of property rights and their enforcement in achieving sustainable urban environments.
 2. Outline the components that Angelsen and Kaimowitz (2001) argue to be important in understanding the effects of agricultural technology on tropical deforestation.
 3. Compare and contrast the subsistence hypothesis and the environmental resource curse hypothesis.
 4. 'Natural resource management is closely linked to the rules and conventions that determine access to a resource'. Elucidate this statement with respect to pastoral livelihoods and rangeland utilisation in semi-arid environments in Africa.
 5. Using the Borlaug hypothesis evaluate the statement that 'the only ways to keep more land in forest are to increase agricultural yields, reduce population growth or depress incomes'.
 6. Outline the root causes of the environmental impacts of agricultural activities, and explain why the impacts are not as debatable as the root causes.
-

END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

2009 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 495: ENVIRONMENTAL HAZARDS AND DISASTERS

Time: Three hours

Instructions: Answer any four 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) Voluntary risk
 - (b) The radical (structural) paradigm of hazard
 - (c) Tangible and intangible effects of disaster
 - (d) A descriptive event tree technique
 - (e) Human vulnerability
 2. "The world disaster trend is probably towards more disaster related deaths and damages, even if the frequency of events is not growing and despite the many positive steps being taken to reduce disasters" (Smith, 1992:38). Elucidate.
 3. With the help of an annotated diagram, explain the statement that "environmental hazards exist at the interface between the natural events system (extreme events) and the human use system (technological failures)" (Smith, 2004:7).
 4. Using an example, explain the sensitivity to environmental hazard expressed as a function of the variability of geophysical elements and the degree of socio-economic tolerance.
 5. With the aid of a table, explain the major differences between risk assessment and risk perception.
 6. Using a tree diagram, explain how people react to irregular natural hazards like floods.
-

END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

**2009 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS**

GEO 911: POPULATION GEOGRAPHY

TIME: Three hours

INSTRUCTIONS: Answer any **four** questions.

All questions carry **equal** marks. Use of an approved calculator is allowed. Candidates are encouraged to use illustrations wherever appropriate.

1. Study Table 1 and answer the questions that follow:

Table 1: Population Size of Zambia in 1963, 1969, 1980, 1990 and 2000 Censuses

Census Year	Population Size
1963	3,490,170
1969	4,056,995
1980	5,661,801
1990	7,818,447
2000	9,885,591

- a. Assuming that fertility and mortality trends were like those between 1963 and 1969, find the population size of the country in 1950.
 - b. Estimate the population size of Zambia in 1987.
 - c. Find the doubling time for Zambia (use the 1990 and 2000 census figures).
 - d. Assuming that the average growth rate of Zambia's population will remain constant for the next 10 years from 2000, project Zambia's population size in 2030.
 - e. Considering your findings in c and d, discuss their implications on the government's plans for social service provision in the country.
2. Discuss any four of the developments which led to Mortality Transition in Europe in the eighteenth and nineteenth centuries and show how the changes helped the Less Developed Countries (LDCs) move to the early expanding stage of the Demographic Transition Theory.
3. 'There is a lot that Zambia can learn from Tunisia's 'far-sighted' population policy'. Discuss.
4. Examine the assertion that Malthusian Theory of population is far more sophisticated than that of the Classical School'.

- 5 Outline Bongaarts' (1978) four most important proximate determinants of fertility and show how these largely account for the differences in fertility from one population to another.
 - 6 Discuss the seven demographic indices which population geographers are concerned with when handling issues related to development planning.
-

END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

2009 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 951: CLIMATOLOGY

TIME: **Three hours**

INSTRUCTIONS: Answer any **FOUR** questions.

All questions carry equal marks. Candidates are advised to make use of illustrations and examples wherever appropriate.

1. Write short explanatory notes on ALL of the following:
 - a) Climate change and Climate variability
 - b) ENSO and Walker Circulation System
 - c) Air mass and Front
 - d) Scales of motion
 - e) Ozone depletion
 2. Discuss the importance of the study of climatology to sustainable national development and provide a general overview and detailed application of climate data and information to three socio-economic sectors.
 - 3 i). Discuss the importance of boundary layer climate processes.
ii). Describe the urban heat island phenomenon and state its implications on urban precipitation patterns.
 4. With the aid of a diagram, provide a detailed description of the global circulation system both in terms of wind regimes and transport cells.
 5. What do you understand by climate classification? Describe the simplified Köppen climate classification scheme and clearly state its advantages.
 6. Describe the air pollution dilution processes and assess the implications of air pollution on urban climate and ecosystems.
-

END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

2009 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 961: SOILS GEOGRAPHY

Time: Three hours

Instructions: Answer any four 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) The pH value of soils
 - (b) The exchange of bases within a soil
 - (c) Calcification
 - (d) The principal soil forming factors
 - (e) Forms of soil moisture
 2. Explain the important processes of soil formation in the genesis of a spodic horizon
 3. Explain the processes that are active during the formation of soil.
 4. Describe the factors in the Revised Universal Soil Loss Equation (RUSLE) and explain in detail those factors that a farmer can alter.
 5. With the help of a schematic vertical cross section from surface to bedrock, show the relationship between soil and regolith.
 6. Describe the differentiating criteria between a Mollisol and Alfisol and give the necessary limits.
-

END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

2009 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

**GEO 971 – AERIAL PHOTOGRAPHY AND AERIAL PHOTO
INTERPRETATION**

PAPER I

TIME: Three hours
INSTRUCTIONS: Answer any four questions
All questions carry equal marks

1. Write short explanatory notes on ALL of the following:
 - (a) Wave and particle theories
 - (b) The 'black body' concept and its relevance to remote sensing
 - (c) Specular versus diffuse reflectance
 - (d) Photographic data detection
 - (e) Relative orientation
 2. What innovations have contributed to the current status of aerial photography?
 3. Assume you have recently accepted a position as an employee of an aerial survey Company and your responsibilities include preparation of flight plans for the company's customers. What are the factors that you must consider as you plan each mission?
 4. Explain the likely disturbances that would occur, when electromagnetic energy is propagated through the atmosphere and how they would impact the aerial photographs.
 5. Describe the pattern of electromagnetic energy reflectance for soil, water, and Vegetation and emphasize on factors affecting the reflectance patterns.
 6. What are the advantages and disadvantages of using conventional aerial photographs over field observation?
-

END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

2009 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

**GEO 971 – AERIAL PHOTOGRAPHY AND AERIAL PHOTO
INTERPRETATION - PAPER II**

TIME: Three hours

INSTRUCTIONS: Answer all questions. Use of an approved calculator is allowed

1. (a) Aerial photographs of a plantation consisting of two classes of trees at different growth stages are undertaken at the scale of 1:20 000 using a narrow angle (300 mm) camera. The height difference between the two classes is found to be about 1.5 m. Explain if you would be able to make a distinction between the two classes, when the photographs are examined under a stereoscope. (5 Marks)
 - (b) A set of 1:15 000 vertical aerial photographs were acquired for an urban area at sea level. A camera with a wide angle lens of 83 mm was used. What would be the relief displacement of two-10m high buildings if their respective photo locations are 145 mm and 160 mm from the photo centre? (5 Marks)
 2. Explain the following (30 Marks):
 - (a) The types of flying errors that may occur during aerial photography acquisition.
 - (b) The impacts of flying errors on photo interpretation.
 - (c) The flying errors that may be corrected using a stereoplotter and photo rectifier.
 3. (a) What is meant by the term 'effective area' and why is it important in aerial photography? (10 Marks)
 - (b) Explain the procedure for establishing the 'effective area'. (15 Marks)
 - (c) Under what circumstances would the effective area vary? (5 Marks)
 4. The Disaster Management Unit (DMU) under the Office of the Vice President has two sets of aerial photographs (1980 and 2000) for Chibombo District. As an aerial photography expert, you have been requested by the DMU to provide some advice on the assessment of the magnitude of deforestation in the district. What key steps would you provide to the DMU so that the assessment is successfully undertaken? (30 Marks)
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Mathematics & Statistics

FIRST SEMESTER FINAL EXAMINATIONS

2nd November, 2009.

M111—MATHEMATICAL METHODS I

Time allowed : **THREE(3) HOURS**

Instructions : There are seven(7) questions. Answer **ANY FIVE (5)** questions. All questions carry equal marks. Show all your working to earn full marks.

CALCULATORS ARE NOT ALLOWED

1. (a) Consider the subsets $A = (-9, 0)$, $B = [-3, 6]$, and $C = [0, 6]$ of the universal set $(-9, 9]$. Find each of the following sets and display them on the number line:

- (i) $A \cap B$.
- (ii) $(A \cup B) \cap C$.
- (iii) $(A \cup B)' \cap C'$.

(b) Let X , Y and Z be subsets of the universal set U .

- (i) Simplify $X \cup (X \cup Y)'$.
- (ii) Display the set $(X \cap Z) \cap Y'$ on the Venn diagram.
- (iii) Given further that $X \cap Y = \emptyset$ and $X \cap Z = \emptyset$, show that $[X' \cap (Y \cup Z)]' = (Y \cup Z)'$.

- (c) An operator $*$ on the set \mathbb{R} of real numbers is defined by $a * b = a - 2^{a+b}$.

Answer the following with justification.

- (i) Is $*$ a binary operation on \mathbb{R} ?
 - (ii) Is $*$ commutative?
 - (iii) Is $*$ associative?
 - (iv) Evaluate $(-1 * 1) * 2$.
2. (a) (i) Express $2.07\overline{2}$ as a fraction in its simplest form.
- (ii) Given that k is irrational, prove that $\frac{1}{2+k}$ is also irrational.
- (iii) Give an example to show that addition is not a binary operation on the set of irrational numbers.
- (b) Rationalize the denominator of the following and leave your answer in the form $a + b\sqrt{c}$ where a and b are rational and c is a positive integer:

(i) $\frac{4 + \sqrt{2}}{-3 + \sqrt{2}}$ (ii) $\frac{(\sqrt{2})^3 + 1}{1 + \sqrt{2}}$ (iii) $-1 + \sqrt{5} + \frac{1}{1 - \sqrt{125}}$.

- (c) Given the function $f(x) = \sqrt{9 - x^2}$, find:

- (i) the domain of f .
- (ii) the range of f .
- (iii) the points at which $f(x) > \sqrt{5}$.

3. (a) Find the exact values of the following:

- (i) $\sec^2 \pi - \tan^2 \pi$.
- (ii) $\cos 510^\circ$.
- (iii) $\operatorname{cosec}^2 135^\circ - \cot^2 135^\circ$.

(b) Solve the following trigonometric equations for x in the interval

$$0 \leq x \leq 2\pi:$$

(i) $3 \tan^3 x = \tan x.$

(ii) $\sin^2 x - \sin x = \cos^2 x.$

(iii) $\sin x = \operatorname{cosec} x.$

(c) Let $f(x) = x^2 + 2x$ and $g(x) = x + 2.$

(i) Find $(f \circ g)(x)$ and $(g \circ f)(x).$

(ii) Sketch the graphs of $(f \circ g)(x)$ and $(g \circ f)(x)$ on the same cartesian axes.

(iii) Find the point of intersection of the graphs of $(f \circ g)(x)$ and $(g \circ f)(x).$

4. (a) (i) Given that $\sin \theta = \frac{3}{5}$ and θ is in the second quadrant, find the values of $\tan \theta$ and $\sec \theta.$

(ii) Sketch the graph of $y = 2 - 2 \sin x$ in the interval $[-180^\circ, 180^\circ],$ indicating all the intercepts.

(iii) Sketch the graph of $f(x) = \frac{2x-1}{x-1}$ indicating all the asymptotes and intercepts.

(b) Express the following in the form $a + ib$ where a and b are real numbers:

(i) i^{101} (ii) $\frac{1}{(1-i)^2}.$ (iii) $\frac{2}{3+i} + \frac{3}{2+i}.$

(c) Given that $f(x) = x^2 + kx + k + 5,$ find the solution set for k in each case of the following such that $f(x) = 0$ has:

(i) $x = k$ has one root.

(ii) identical roots (equal roots).

(iii) no real roots (complex numbers as roots).

5. (a) Solve the following equations for real values of x and y .

(i) $\frac{x+iy}{2+i} = 5-i$ (ii) $(x+iy)^2 = 3+4i$ (iii) $\frac{1}{x-iy} + \frac{2-i}{1+i} = 1$.

- (b) Prove the following identities.

(i) $\frac{1}{1-\sin^2 y} = 1 + \tan^2 y$.

(ii) $\frac{\cot \alpha + \tan \alpha}{\operatorname{cosec}^2 \alpha} = \tan \alpha$.

(iii) $(\sec x + \tan x)(1 - \sin x) = \cos x$.

- (c) (i) Let α and β be the roots of the equation $f(x) = 2 + 5x - 3x^2$. Find the value of

$$\frac{1}{\alpha^2 + 1} + \frac{1}{\beta^2 + 1}.$$

- (ii) Solve the equation $\sqrt{3x-2} = 3x-2$ for real values of x .

- (iii) Solve the inequality

$$\frac{x^2 + 2x + 2}{x^2 + 2x} > 0$$

for real values of x , and display your answer on a number line.

6. (a) (i) Factorise the polynomial $P(x) = x^3 - 7x^2 + 14x - 8$ completely.
(ii) Solve the equation $\sqrt{x+2} = -2$.
(iii) If one of the roots of the equation $2x^2 + kx - 8 = 0$ is the square of the other, find k .
- (b) (i) Redefine $3|x+1|$ and $|2x-1|$ without the modulus.
(ii) Hence sketch the graph of $f(x) = 3|x+1| - |2x-1|$.
(iii) Solve the inequality $|x-4| > 4$ for real values of x .

- (c) The effectiveness of a television commercial depends on how many times a viewer watches it. After some experiments, an advertising agency found that if the effectiveness E is measured on a scale of 0 to 10, then $E(n) = \frac{2}{3}n - \frac{1}{90}n^2$, where n is the number of times a viewer watches a given commercial. By completing the square of $E(n)$, find how many times a viewer should watch the commercial for a commercial to have maximum effectiveness?

7. (a) Explain which of the following functions are one-to-one, and find the inverse if it exists.

- (i) $f(x) = |x + 1|$.
- (ii) $f(x) = x^2, x \leq 0$.
- (iii) $f(x) = x^3$.

- (b) (i) Sketch the graphs of the functions $f(x) = |x| + |x - 2|$ and $g(x) = 2$ on the same cartesian axes.

- (ii) Find the intersection of $f(x)$ and $g(x)$ from part (i).
- (iii) Solve the equation $|3x - 5| = -7$ for real values of x .

- (c) (i) Show that the polynomial $P(x) = x^3 - x - 2$ does not have any rational roots.

- (ii) Find the quotient and remainder when $6x^3 + 2x^2 + 22x$ is divided by $2x^2 + 5$.

- (iii) Given that $z = a + ib \neq 0$, where a and b are real, show that

$$\frac{z}{\bar{z}} + \frac{\bar{z}}{z}$$

is real.

END.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF MATHEMATICS AND STATISTICS

2009 ACADEMIC YEAR
FIRST SEMESTER DEFERRED EXAMINATIONS

M161: INTRODUCTION TO MATHEMATICS, PROBABILITY AND STATISTICS I

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS:

1. Answer any **Five (5)** Questions
2. Show All Essential Working
3. Calculators are NOT allowed

1. (a) (i) ✓ Express $0.3\overline{34}$ in the form $\frac{a}{b}$ in its lowest terms where a and b ✓
are real numbers.
- (ii) ✓ Simplify $\frac{4x-4}{x^2-4} - \frac{3}{x+2}$
- (b) Solve the following equations:
- (i) $\left(\frac{1}{27}\right)^{3x} = 3^{2x-1}$
- (ii) $\log_2 x + \log_x 2 = 2$
- (c) (i) Find the range of values of x for which $2x^2 + 5x - 12$ is negative.
- (ii) Find the range of values of k for which the equation
 $x^2 + 2kx + 2 - k = 0$ has real roots.
2. (a) The roots of the equation $3x^2 - 6x + 1 = 0$ are α and β . Find the
- (i) value of $(\alpha - \beta)^2$
- (ii) equation whose roots are α^3 and β^3
- (b) Solve each of the following:
- (i) $2x - 11\sqrt{x} + 12 = 0$
- (ii) $|-2 - x| \leq 5$

- (c) Given that $f(x) = x^2 - 2$ and $g(x) = x + 4$, find
- $(f \circ g)(x)$ and state its domain.
 - $f^{-1}(x)$ stating its domain.
3. (a) Given the function $f(x) = 2x^2 - 4x - 1$
- find its vertex and axis of symmetry. ✓
 - graph the function.
- (b) Solve
- $\sin 2x + \cos x = 2 \sin x + 1$ for $0 \leq x < 2\pi$
 - $\cos 4\theta - \sin 2\theta = 0$ for $0^\circ \leq \theta < 360^\circ$
- (c) Given that $\log_2 3 = 1.585$ and $\log_2 7 = 2.8074$, find
- $\log_2 36$
 - $\frac{\ln 49}{\ln 16}$
4. (a) Given that $z_1 = -1 + 3i$, $z_2 = 4 - 3i$ and $z_3 = 2 - i$. Express the following in the form $a + ib$ where a and b are real numbers:
- $z_1 + z_2 - z_3$
 - $z_1^2 + |z_2|$
 - $\frac{1}{z_1} + \frac{1}{z_3}$
- (b) Express $\frac{9x}{(2x+1)^2(1-x)}$ into partial fractions.
- (c) If $\tan A = -\frac{2}{3}$ and $\tan B = \frac{3}{5}$, where A is an obtuse angle and B is a reflex angle, find
- $\tan(A - B)$
 - $\cos \frac{B}{2}$

5. (a) (i) Expand $(2+x)^4$ in ascending powers of x .
- (ii) Using the expansion in (i), find the value of $(2+\sqrt{3})^4 + (2-\sqrt{3})^4$
- (b) Given that $2x-1$ is a factor of $f(x) = ax^3 + 16x^2 - 5x - 4$.
- (i) Find the value of a .
- (ii) Hence or otherwise factorize $f(x)$ completely.
- (c) Prove that $(\csc \theta - \sec \theta)(\cos \theta + \sin \theta) = 2 \cot 2\theta$.
6. (a) Solve
- $$\begin{array}{rrcr} x & - & 2y & - & 3z & = & -6 \\ 3x & - & 5y & - & z & = & 4 \\ 2x & + & y & + & 2z & = & 2 \end{array}$$
- (b) Solve
- (i) $\left| \frac{x-2}{x+1} \right| > 2$
- (ii) $x^3 - 10x - 12 = 0$
- (c) Prove that $\tan \theta + \cot \theta = 2 \csc 2\theta$

END OF EXAMINATION

The University of Zambia

Department of Mathematics and Statistics

END OF SEMESTER I EXAMINATIONS 2009/2010

EM 211 - ENGINEERING MATHEMATICS I

Time allowed: Three (3) hrs

Instructions: (i) Answer any FIVE questions

(ii) All questions carry equal marks

(iii) Show all essential working to earn full marks

1.(a)(i) Sketch the region bounded by the graphs of

$$y = \frac{1}{\sqrt{1+x^2}}, x = 0 \text{ and } x = 1.$$

(ii) Determine the area of this region.

(iii) The region is revolved about the x-axis. Find the volume of the resulting solid.

(b) By removing the xy term using rotation of axes, determine the type of conic section represented by the equation

$$73x^2 - 72xy + 52y^2 + 30x + 40y - 75 = 0.$$

2. (a) Suppose that the position of a golf ball is given by

$$r(t) = 90\sqrt{2}ti + 90\sqrt{2}tj + (64t - 16t^2)k \text{ for } t \geq 0.$$

(i) Find the initial position and initial velocity of the golf ball.

(ii) Show that the golf ball strikes the ground at time $t = 4$, and determine the distance from its initial position.

(b) Find the interval of convergence of the series

(i) $\sum_{n=0}^{\infty} \frac{(-1)^n x^{2n+1}}{(2n+1)!}$

(ii) $\sum_{n=0}^{\infty} \frac{x^n}{2^n}$

(iii) $\sum_{n=0}^{\infty} \frac{x^n}{\sqrt{n} 3^n}$

3. (a) Find the values of x and y such that the point $(x, y, 1)$ lies on the line passing through $(2, 5, 7)$ and $(0, 3, 2)$.

(b) In mountainous areas, reception of radio and TV signals is sometimes poor. Consider an idealised case in which a hill is represented by the graph of the parabola $y = x - x^2$, a transmitter is located at the point $(-1, 1)$, and a receiver is located on the other side of the hill at the point $(x_0, 0)$. What is the nearest the receiver can be to the hill so that the reception is unobstructed?

(c) Determine whether the given series converges or diverges

(i) $\sum_{n=1}^{\infty} \frac{\sin n}{n^2 + 1}$

(ii) $\sum_{n=0}^{\infty} \frac{\ln n}{n}$

4. (a) (i) Find the Taylor series for the function $f(x) = \cos x$ about $x = 0$.

(ii) Determine the interval of convergence of the Taylor series.

(b) A circular helix is represented parametrically by

$$r(t) = 2\cos t i + 2\sin t j + 3tk.$$

(i) Determine the curvature of the helix.

(ii) Find the principal unit normal vector to the helix at the point corresponding to $t = \frac{\pi}{4}$.

5. (a) Find the arc length of the cycloid given parametrically by

$$x = 2(t - \sin t) \text{ and } y = 2(1 - \cos t)$$

over the interval $0 \leq t \leq 2\pi$.

(b) show that the curves parametrized by

$$r_1(t) = ti + 2tj + t^2k \text{ and } r_2(t) = t^2i + (1 - t)j + (2 - t^2)k,$$

(i) intersect at $(1, 2, 1)$ and that (ii) the vectors tangent to the two curves at $(1, 2, 1)$ are perpendicular.

6. (a)(i) Find the number d such that the line $x + y = d$ is tangent to the parabola $x^2 = 2y$.

(ii) Determine the point of tangency and sketch the graph of the parabola and the tangent.

(b) Determine whether the series converges or diverges

$$(i) \sum_{n=1}^{\infty} \frac{(-1)^{n+1} \sqrt{n}}{2n+1}$$

$$(ii) \sum_{n=3}^{\infty} \frac{\arctan n}{n^2+1}$$

$$(iii) \sum_{n=1}^{\infty} \frac{(-1)^n (\ln n)^p}{n}, \text{ where } p \text{ is any positive integer.}$$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2009 ACADEMIC YEAR
FIRST SEMESTER FINAL EXAMINATIONS

EM311: ENGINEERING MATHEMATICS III

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS : There are Seven (7) questions in this paper. They all carry 20 marks each.
Attempt any Five (5) questions from this paper.
Show all the essential working for full credit.

1. (a) Let $f(x) = x^3$ and $g(x) = |x|^3$ be two functions.
 - (i) Find the Wronskian of the functions.
 - (ii) Determine whether or not the functions are linearly independent on the interval $(-\infty, \infty)$
- (b) Consider the differential equation $x^2 \frac{d^2 y}{dx^2} - x \frac{dy}{dx} + y = \ln x$.
 - (i) By the substitution $t = \ln x$, use the chain rule of differentiation and show that the equation reduces to $\frac{d^2 y}{dt^2} - 2 \frac{dy}{dt} + y = t$
 - (ii) Use the method of Laplace transform to find the general solution of the equation in (i). (Take $y(0)$ and $y'(0)$ to be constants).
2. (a) A periodic function is defined in one period by $f(x) = 4 - x^2$, $-2 \leq x \leq 2$.
 - (i) Determine whether or not the function is an even function.
 - (ii) Find the Fourier series expansion of $f(x)$.
 - (iii) Use your series expansion in (ii) to find the sum $1 - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} + \frac{1}{5^2} - \dots$
- (b) Find the complex form of the Fourier series of the function defined in one period by $f(x) = x$, $-\pi \leq x \leq \pi$.

3. (a) (i) Find the general solution of the Euler equation $x^2 y'' + xy' + y = 0$
(ii) Hence use the method of variation of parameters to solve the initial value problem $x^2 y'' + xy' + y = 5x^2$, $y(1) = 1$, $y'(1) = 3$
- (b) Use the method of power series to find the general solution to the equation $y'' - 2xy = 0$.
4. (a) Let $f(x)$ be a function whose Fourier series $f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty} (a_n \cos \frac{n\pi x}{5} + b_n \sin \frac{n\pi x}{5})$ converges uniformly to the function $f(x)$ in the interval $-5 \leq x \leq 5$, show that $\frac{1}{5} \int_{-5}^5 [f(x)]^2 dx = \frac{a_0^2}{2} + \sum_{n=1}^{\infty} (a_n^2 + b_n^2)$.
- (b) Let f be defined by $f(x) = x^4$, $-\pi \leq x \leq \pi$.
(i) Find the cosine series expansion of the function.
(ii) Use your series in (i) and the fact that $\sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi^2}{6}$ to find the sum $\sum_{n=1}^{\infty} \frac{1}{n^4}$
5. (a) Find using the definition the Laplace transform of $f(t) = u(t-1)\cos t$ where $u(t-a) = \begin{cases} 0, & t < a \\ 1, & t \geq a \end{cases}$
- (b) Consider the initial value problem $y'' + 2ay' + a^2 y = f(t)$, $y(0) = y'(0) = 0$.
(i) Use the convolution theorem to find the particular integral of the equation.
(ii) Find the actual solution of the equation if $f(t) = t$
6. (a) Solve the partial differential equations $\frac{\partial^2 u}{\partial x \partial y} - \frac{\partial u}{\partial y} = 6xe^x$.
- (b) Consider the differential equation $x^2 y'' - x^2 y' + (x^2 - 2)y = 0$.
(i) Use the method of Frobenius to find the roots of the indicial equation to the differential equation.
(ii) Hence find two linearly independent solutions to the equation. (Write at least the first four terms in each bracket).

7. (a) Solve the system of differential equations $\frac{dx}{dt} = 2x + 3y$
 $\frac{dy}{dt} = 2x + y$
- (b) Consider the wave equation $\frac{\partial^2 u}{\partial t^2} = a^2 \frac{\partial^2 u}{\partial x^2}$.
- (i) Using the method of separation of variables determine possible solutions of the equation.
- (ii) Hence find a periodic solution of the equation which satisfies the boundary conditions $u(0, t) = 0$ and $\left. \frac{\partial u}{\partial x} \right|_{(L, t)} = 0$

**The University of Zambia
School of Natural Sciences
Department of Mathematics & Statistics**

**2009 ACADEMIC YEAR
FISRT SEMESTER FINAL EXAMINATIONS**

M211 – MATHEMATICAL METHODS III

18th November, 2009

INSTRUCTIONS: (1) Answer any **five (5)** questions only.
(2) Indicate the **question number** of each question attempted on the cover of the main answer book.

TIME ALLOWED: Three (3) hours.

1. (a) Sketch the graph of the conic whose equation is given by

$$4x^2 + 25y^2 - 90x - 150y + 225 = 0.$$

Hence, state its vertex (or vertices), focus (or foci) and directrix (or directices)

- (b) Discuss the graph of the curve

$$r = \frac{15}{4 - 4 \cos \theta},$$

stating the focus, the equation of directrix and the coordinates of points where the curve cuts the axes. Hence, sketch the curve.

- (c) Find the area of the region bounded by the ellipse whose major and minor axes have lengths $2a$ and $2b$ respectively.

2. (a) The equation of a conic section is given by

$$x^2 + 2xy + y^2 - 8x + 8y = 0.$$

- (i) Use a suitable rotation of axes to transform the equation in standard form. Hence, identify the conic.
- (ii) Find its vertex (or vertices), focus (or foci) and the directrix (or directrices) of the conic.
- (iii) Sketch the curve.

- (b) Find the polar equation of the conic with a focus at the pole, eccentricity $e = \frac{1}{2}$ and directrix $r = -3\sec\theta$.

3. (a) Use the definition of limits to prove that $\lim_{x \rightarrow \frac{3}{2}} \frac{4x^2 - 9}{2x - 3} = 6$.

Hence find the value of δ given that $\varepsilon = 0.01$.

- (b) Apply an appropriate test to determine whether each of the given series converges or diverges. If it converges find its sum.

(i) $\sum_{n=1}^{\infty} \left(\frac{e}{10}\right)^n$ (ii) $\sum_{n=1}^{\infty} \frac{1}{(2n-1)(2n+1)}$

(c) Evaluate the integral $\int_1^{10} \frac{3}{\sqrt{5x-1}} dx$

4. (a) State Rolle's theorem.

Hence, show that Rolle's theorem is satisfied by the function

$$f(x) = x^3 - 3x^2 + 4,$$

in the interval $[-1, 2]$.

(b) (i) Evaluate the integral $\int \frac{1}{x^2 + x + 4} dx$

- (ii) Find the unknown coefficients a_0, a_1, a_2, a_3, a_4 , given that

$$\int x^4 e^{3x} dx = e^{3x}(a_0 x^4 + a_1 x^3 + a_2 x^2 + a_3 x + a_4) + c.$$

- (c) Find the value of c such that $\lim_{x \rightarrow \infty} (1+x)^{\frac{c}{x}} = e^3$.

5. (a) (i) State the mean value theorem.

(ii) Show that the function $f(x) = \frac{1}{4}x^2 + 1$ satisfies the hypothesis of the mean value theorem on the interval $[-1, 4]$.

Hence, find the number c in the open interval $(-1, 4)$ that satisfies the conclusion of the theorem.

(b) Evaluate each of the following integrals

(i) $\int x e^{x^2-1} dx$ (ii) $\int x^4 \ln x dx$

(c) Find the interval of convergence of the series $\sum_{n=0}^{\infty} \frac{(-1)^n (x+1)^n}{2^n}$

6. (a) Express the function $f(x) = \ln x$ as a series in powers of $(x-1)$.

Hence, ignoring the term in $(x-1)^5$ and higher powers, find the approximate value for $\ln 0.9$, correct to 5 decimal places.

(b) Evaluate the integrals $\int \frac{dx}{(4-x^2)^{3/2}}$.

(c) Given the curve $f(x) = \sqrt{a^2 - x^2}$, where $-a \leq x \leq a$, find the volume generated when the area bounded by the curve and the x -axis is rotated about the x -axis.

7. (a) (i) Evaluate the integral $\int \sin^2 x \cos^3 x dx$

(ii) Given that $I_n = \int_0^{\pi/2} x^n \cos x dx$, where $n \geq 2$, show that

$$I_n = \left(\frac{\pi}{2}\right)^n - n(n-1)I_{n-2}.$$

Hence find I_4 .

(b) Find the length of the arc of the curve $x = 3y^{3/2} - 1$, from $y = 0$ to $y = 4$.

(c) Find the area of the surface of revolution generated by revolving about the x -axis the arc of the curve $y = \frac{1}{3}x^3$, from $x = 0$ to $x = 3$.

END OF EXAMINATION

The University of Zambia

Department of Mathematics and Statistics

END OF SEMESTER I EXAMINATIONS 2009/2010

M 221 - LINEAR ALGEBRA I

Time allowed: Three (3) hrs

Instructions: (i) Answer any FIVE questions.

(ii) All questions carry equal marks

(iii) Show all essential working to earn full marks

1.(a) Define the following terms

(i) The inverse of a function

(ii) An equivalence relation

(b) Prove the following;

(i) If $f : A \rightarrow B$ and $g : B \rightarrow C$ are both bijective functions, then $g \circ f$ is also bijective.

(ii) If $f : A \rightarrow B$ is a function from A to B and $X, Y \subset B$ then

$$f^{-1}(X \cup Y) = f^{-1}(X) \cup f^{-1}(Y).$$

(c)(i) If

$$f(x) = \begin{cases} |x| & (x < 0) \\ -3x^2 & (x \geq 0) \end{cases} \quad \text{and } g(x) = 2x,$$

find $(f \circ g)([-1, 1])$.

(ii) Prove that two equivalence classes of a set X under an equivalence relation \equiv are either disjoint or equal.

2.(a) Define the terms

- (i) Row reduced echelon matrix
- (ii) Normal form of a matrix

(b)(i) If A and B are invertible matrices, solve for X , the matrix equation

$$A^{-1}(BX)^{-1} = (A^{-1}B^3)^2$$

- (ii) Find the normal form of the matrix $A = \begin{bmatrix} -6 & 7 & 11 \\ 14 & 3 & -1 \\ -2 & -4 & 5 \\ \frac{1}{4} & -\frac{3}{7} & 8 \end{bmatrix}$

(c)(i) If A is a square matrix, prove that $\frac{1}{2}(A + A^t)$ is symmetric and $\frac{1}{2}(A - A^t)$ is skew-symmetric.

- (ii) Express the row reduced echelon matrix of $A = \begin{bmatrix} 1 & -2 & 1 \\ -1 & 6 & 1 \\ 2 & -2 & 4 \end{bmatrix}$ as a product of elementary matrices and the matrix A .

3.(a) Define the terms

- (i) Equivalent matrices A and B
- (ii) A consistent system of linear equations

(b) (i) Use determinants to prove that a quadratic equation can not have more than two distinct solutions.

(ii) Prove the following properties for determinants of 2×2 matrices.

$$(I) \det(kA) = k^2 \det(A) \text{ and } (II) \det(AB) = \det(A) \det(B)$$

where A and B are 2×2 matrices and k is a scalar.

(c) (i) Use elementary row operations to find the inverse of the matrix

$$A = \begin{bmatrix} 1 & - & 0 \\ 2 & -3 & 1 \\ 3 & 5 & -2 \end{bmatrix}$$

(ii) Find the values of t for which the system of linear equations has

$$\begin{bmatrix} -2 & -5 & 1 \\ 1 & -1 & t \\ 1 & 6 & -4 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} -1 \\ 3 \\ 0 \end{bmatrix}$$

(I) no solution (II) a unique solution.

4. (a) Define each of the following terms

- (i) A subspace U of a vector space V
- (ii) A basis of a subspace U of a vector space V

(b) Show that a subset U of $V_3(\mathbb{R})$ which is given by

$$U = \{(\alpha, \beta, \gamma) | \alpha + \beta - \gamma = 0\}$$

is a subspace of $V_3(\mathbb{R})$.

(c) Let U be a subspace of $V_4(\mathbb{R})$ generated by the set

$$\{(1, 1, 0, -1), (1, 2, 3, 0), (1, 2, 3, 1)\}.$$

Then find

- (i) a basis and dimension of U
- (ii) extend the basis of U to a basis for $V_4(\mathbb{R})$.

5. (a) Define each of the following terms

- (i) A linear transformation $T : U \rightarrow V$
- (ii) A matrix of a linear transformation

(b) Let $T : V_4(\mathbb{R}) \rightarrow V_3(\mathbb{R})$ be a map which is given by the rule:

$$T(x, y, z, w) = (x - y + z + w, x - 2y - z, x + y + 3z - 3w)$$

Then prove that T is a linear transformation.

(c) If T is defined as in 5(b), determine the matrix of T relative to the basis

$$\{(1, 0, 0), (0, 1, 0), (0, 0, 1)\}$$

6. (a) Let $T : U \rightarrow V$ be a linear transformation. Define

(i) The kernel $\ker T$ of T

(ii) The image $\text{im } T$ of T

(b) Prove that the kernel of T and the image of T are subspaces of U and V respectively

(c) If $T : V_4(\mathbb{R}) \rightarrow V_3(\mathbb{R})$ is defined by $T(x, y, z) = (x + z, x - z, y)$, show that T is non-singular and determine $\text{rank } T$.

END OF EXAMINATION

The University of Zambia
School of Natural Sciences
Department of Mathematics & Statistics

2009 ACADEMIC YEAR
FISRT SEMESTER FINAL EXAMINATIONS

M231 - REAL ANALYSIS I

INSTRUCTIONS: Answer any **five (5)** questions only.

TIME ALLOWED: Three (3) hours.

1. (a) Define the following:
- (i) A statement;
 - (ii) a truth functional form.
- (b) Let P and Q be frame variables. Give the truth-table for " P if and only if Q ".
- (c) Consider the English sentence: "For every positive real number x there is a real number y such that $2^y = x$ ".
- (i) Translate the sentence into a symbolic sentence with quantifiers.
 - (ii) Give the negation of the sentence both as a symbolic sentence and as an English sentence.

(d) Write the following symbolic sentence in ordinary English:

$$\forall x(x > 0 \Rightarrow \exists y \exists (y < 0 \ \& \ xy > 0)).$$

2. (a) Define the following:
- (i) A set;
 - (ii) a function from a set A to a set B ;
 - (iii) a sequence in a set A .
- (b) Let A and B be non-empty sets and f be a function from A to B . Prove that the function f^{-1} from B to A exists if and only if f is a bijection.
- (c) If A is a set of elements in a universal set U , then its complement $A' = \{x \in U : x \notin A\}$. Let A and B be sets of elements in a universal set U . Prove that $(A \cup B)' = A' \cap B'$.

3. (a) Define the following:
 - (i) A partially ordered set;
 - (ii) a totally ordered set;
 - (iii) a well ordered set;
 - (iv) order isomorphism.

(b) Let W_1 and W_2 be well ordered sets and $g : W_1 \rightarrow W_2$ be order preserving and injective. Denote the range of g by R_g . Prove that $g^{-1} : R_g \rightarrow W_1$ is order preserving.
4. (a) Define the following:
 - (i) A finite set;
 - (ii) an infinite set;
 - (iii) a countable set.

(b) Let A be a countable set. Let $f : A \rightarrow B$ be surjective. Prove that B is countable.
5. (a) (i) Define a totally ordered field.
 (ii) State the law of trichotomy.

(b) Let $(\mathbf{F}, +, \cdot, \mathbf{P})$ be a totally ordered field and $a, b \in \mathbf{P}$. Prove that

 - (i) $a < b \Leftrightarrow -a > -b$
 - (ii) if n is a nonnegative integer, then $a < b \Leftrightarrow a^n < b^n$.
6. (a) Define each of the following:
 - (i) A bounded set;
 - (ii) a lower bound of a set;
 - (iii) a least upper bound of a set

(b) (i) Let $(\mathbf{F}, +, \cdot)$ be an ordered field and S a non-empty subset of \mathbf{F} . Prove that a real number α is a least upper bound of S if and only if $\forall x \in S, x \leq \alpha$ and, for every $\varepsilon > 0$, there is some $x^* \in S$ such that $\alpha - \varepsilon < x^* \leq \alpha$.

(ii) Let $(\mathbf{F}, +, \cdot)$ be an ordered field and S a non-empty subset of \mathbf{F} . Prove that if $-S = \{-x : x \in S\}$ and if S has a supremum, then $-S$ has an infimum and $\inf(-S) = -\sup S$.

(c) Determine, for the set $S = \left\{ \frac{1}{m} + \frac{1}{n} : m, n \in \mathbf{N} \right\}$, if it exists,

 - (i) the greatest lower bound
 - (ii) the least upper bound.

7. (a) Give the definition of each of the following:

- (i) Neighbourhood of a point in \mathbf{R} ;
- (ii) an open set;
- (iii) a limit point of a set;
- (iv) a closed set.

(b) Prove each of the following:

- (i) Let the interior of a set $G \subset \mathbf{R}$ be denoted by G° . Then G is open if and only if $G = G^\circ$.
- (ii) The intersection of an arbitrary family of closed sets is closed.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS SEMESTER I - 2009

M261 – INTRODUCTION TO STATISTICS

INSTRUCTIONS:

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

Use of mathematical tables and calculators is allowed.

TIME ALLOWED:

Three (3) hours.

- 1a) The following data set shows a sample of marks obtained in test 1 by M261 students:

31 59 71 77 45 68 61 64 79 79 52 60 64 42 47 75 48 79

39 42 38 53 54 69 39 74 67 48 68 66 55 57 52 66 71 48

(i) Construct a stem- and -leaf plot for this data set

(ii) Determine the quartiles.

(iii) Construct a box-and-whisker diagram.

(iv) Identify if any, data values that may be considered to be outliers.

(iv) Comment on the performance of the marks of the students sampled.

- b) Define the following terms:

(i) point estimate

(ii) confidence-interval estimate

(iii) confidence level

A University lecturer wants to estimate the mean IQ of the students in attendance. Suppose that a random sample of ~~24~~ students gives the following data on IQs:

107 99 101 93 99 103 134 132 103 109 104 103
101 128 113 106 126 103 131 103 111 119 112 105

- c) Given that sum of the data is 3294,

(i) Obtain a point estimate for the mean IQ, μ of all students attending the university.

(ii) Is it likely that your point estimate in part (i) is exactly equal to μ ?

(iii) Assume that the standard deviation of IQs for all students attending university is $\sigma = 12$, find a 95% confidence interval for the mean μ

(iv) Interpret your result in part (iii) in words.

(v) Does the mean IQ, μ of all students attending the university lie in confidence interval that you obtained in (iv)? ~~(vi)?~~ ~~(iii)?~~

- 2 a) A normal distribution has $\mu = 27$ and $\sigma = 3$. For a random sample of size $n = 4$, determine the

- (i) Mean of \bar{X}
- (ii) Standard deviation of \bar{X}
- (iii) Distribution of \bar{X}

- b) On the basis of a random sample of size $n = 144$, someone proposes that

$$(\bar{x} - 0.13s, \bar{x} + 0.13s)$$

is a large sample confidence interval for μ .

Calculate the level of confidence associated with this interval.

- c) You are personnel manager for a company and you suspect a difference in the mean length of work time lost due to sickness for two types of employees: those who work at night versus those who work during the day. Particularly, you suspect that the mean time lost for the night shift exceeds the mean for the day shift. To check your theory, you randomly sample the records for ten employees for each shift category and record the number of days lost due to sickness within the past year. The data are shown in the table:

Night Shift I		Day Shift II	
21	2	13	18
10	19	5	17
14	6	16	3
33	4	0	24
7	12	7	1
$\bar{x}_1 = 12.8$		$\bar{x}_2 = 10.4$	
$\sum x_1^2 = 2,436$		$\sum x_2^2 = 1,698$	

- (i) Calculate S_1^2 and S_2^2 .

- (ii) Show that the pooled estimate of the common population standard deviation, σ , is 8.86

- (iii) If μ_1 and μ_2 represent the mean number of days per year lost due to sickness for the night and day shifts respectively, test at $\alpha = 0.05$,

$$H_0 : \mu_1 = \mu_2 \text{ against } H_a : \mu_1 > \mu_2.$$

- (iv) Do the data provide sufficient evidence to indicate that $\mu_1 > \mu_2$?

- (v) What assumptions must be satisfied so that the test statistic from part (iii) is valid?

3. a) The Ministry of Transport and Communication is responsible for the enforcement of airline safety regulations and has become concerned about an apparent increase in accidents and near mishaps involving commercial aircrafts. One area of concern is overloading due to passenger baggage exceeding regulated limits. Each passenger on overseas flights is allowed to carry 20kg of luggage on board. To check adherence to this regulation, Ministry officials conducted a spot check on passengers boarding both South African and British Airways flights from Lusaka International Airport.

The weight of luggage for each was recorded with the following results:

	AIRLINE	
	South African Airways	British Airways
Number of passengers	137	184
Mean Weight in Kg	29.48	32.67
Standard Deviation	9.45	8.03

- i) Construct a 95% confidence interval for the true mean weight of passenger luggage for each airline?
Is there reason to believe that either airline is violating luggage regulations?
- ii) Do the mean weights of luggage differ between the two airlines? (Test with $\alpha = 0.05$)
Support your conclusion statistically
- b) A post graduate student in the school of Education is studying the effect of alcohol on intellectual activity. The student devises two equivalent tests which entail a series of arithmetic operations. Eight undergraduate statistics students are selected to take the first test.
The following day the same eight students are each given three medium sized glasses of Mosi which they promptly consume. Immediately after consuming the beer, the students took the second test.

Although there were a great many volunteers to take the second test, only eight students were also willing to take the first test.
The test results are listed below:

STUDENT ID	A	B	C	D	E	F	G	H
FIRST TEST	72	84	67	73	78	53	69	64
SECOND TEST	61	52	74	68	60	66	64	59

- i) Test at 0.05 level of significance, whether alcohol affects mental performance.
ii) Construct a 95% confidence interval for the difference in test result.

c) Given the data set $n_1 = 100$ $\hat{p}_1 = \frac{45}{100} = 0.45$ $n_2 = 200$ $\hat{p}_2 = \frac{130}{200} = 0.65$

(i) Find a 95% confidence interval for $p_1 - p_2$

(ii) Perform a large sample Z test for testing the $H_0 : p_1 = p_2$ against $H_1 : p_1 < p_2$ at $\alpha = 0.05$.

4 a) A dog-food manufacturer sells 25kg bags of dog food. Seventy-five bags of this brand of dog food are randomly selected and carefully weighed. Using the weights obtained, a hypothesis test is to be performed in order to decide whether the mean weight of all bags of this dog food differs from the advertised weight of 25kg. The null and alternative hypotheses for the hypothesis test are:

$$H_0 : \mu = 25\text{kg}$$

$$H_a : \mu \neq 25\text{kg}$$

where μ is the actual mean weight of all 25kg bags of this dog food.

Explain what each of the following would mean in relation to the above:

i) A type I error

ii) A type II error

iii) A correct decision.

b) A soft-drink machine is regulated so that the amount of drink dispensed is approximately normally distributed with a standard deviation of 1.5mm.

i) Find a 95% confidence interval for the mean of all drinks dispensed if a random sample of 36 drinks has an average content of 22.5mm

ii) How large should our sample be if we wish to be 95% confident that our sample mean will be within 0.3 mm of the true mean.

c) A company operates four machines three shifts each day. From production records, the following data on the number of breakdowns are collected.

Shift	Machines				TOTAL
	A	B	C	D	
1	41	20	12	16	89
2	31	11	9	14	65
3	15	17	16	10	58
TOTAL	87	48	37	40	212

The company wishes to know whether machine breakdown is associated with the shift.

i) State the null and alternative hypothesis.

ii) State the test statistic.

iii) At 0.05 level of significance, test whether breakdowns are independent of shift.

- 5 The Living Conditions Monitoring Surveys conducted from 1991 to 2006 by the Central Statistical Office have shown that the incidence of poverty has reduced over the years. The data below show incidence of poverty by year.

YEAR (X)	1991	1993	1996	1998	2004	2006
Incidence of Poverty(Y)%	79	74	69	73	68	64

You decide to use a linear regression model:

$$y = \alpha + \beta x + \varepsilon$$

to model incidence of poverty using year as an independent variable.

- a) (i) Obtain the least squares estimates of α and β showing your working step by step
(ii) Write down the fitted line.
- b) (i) Predict the incidence of poverty for the year 2008.
(ii) Find the 95% confidence interval for the true incidence of poverty for the year 2008.
(iii) Calculate R^2 and hence, state the percentage of variation in Y explained by X.
- 6 Suppose that in a hope of attracting more visitors to Munda Wanga Botanical Garden the management decides to use four promotion plans. The amount earned in hundred of thousands of Kwacha for each plan are recorded as shown below. Let μ_i be the mean revenue for plan i, where $i = 1, 2, 3$ and 4.

Promotion Plan			
1	2	3	4
27	25	34	30
25	28	29	33
29	30	32	31
26	27	31	36

- a) (i) State the statistical design associated with this experiment.
(ii) Write down the ANOVA table using these data.
(iii) Test for the mean difference in the four plans at 5 % level of significance.
- b) (i) Find an estimate of the contrast $C(\mu) = \frac{\mu_1 + \mu_2}{2} - \frac{\mu_3 + \mu_4}{2}$
(ii) Test the hypothesis: $H_o : C(\mu) = 0$ versus $H_o : C(\mu) \neq 0$ for $C(\mu)$ in (i).
Assume common variance and use $S^2_p = MSW$.

END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF MATHEMATICS & STATISTICS**

**2009 ACADEMIC YEAR
FIRST SEMESTER FINAL EXAMINATIONS**

M331 : REAL ANALYSIS III

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: Attempt any Five (5) questions.

1. (a) Give the definition of the following:
 - (i) An open set in \mathbf{R} .
 - (ii) A limit point of a set in \mathbf{R} .
 - (iii) A closed set in \mathbf{R} .
- (b) Let $A \subset \mathbf{R}$. If A is both open and closed, prove that $A = \emptyset$ or $A = \mathbf{R}$.
2. (a) Let $A \subset \mathbf{R}$. Prove that l is a limit point of A if and only if there exists a sequence $\{x_n\}_{n=1}^{\infty}$ in A such that $\lim_{n \rightarrow \infty} x_n = l \in \mathbf{R}$ and for $n \in \mathbf{N}$, $x_n \neq l$.
- (b) Let $F \subset \mathbf{R}$. Prove that F is closed if and only if for every sequence $\{x_n\}_{n=1}^{\infty}$ in F such that $\lim_{n \rightarrow \infty} x_n$ exists and $\lim_{n \rightarrow \infty} x_n = l \in \mathbf{R}$, then $l \in F$.
3. (a) $\forall n \in \mathbf{Z}$, let A_n be the closed interval $[n, n+1]$. Show that the collection $\{A_n : n \in \mathbf{Z}\}$ is a covering of \mathbf{R} .
- (b) State the Heine – Borel theorem.
- (c) Let $S \subset \mathbf{R}$. If S is compact, prove that S is closed and bounded.

4. (a) Let $D \subset \mathbf{R}$. When is D said to be disconnected?
- (b) Let $D \subset \mathbf{R}$. Suppose D contains at least two distinct points. Prove that D is connected if and only if it is an interval.
5. (a) Give the definition of a continuous function with both range and domain contained in \mathbf{R} .
- (b) If H is a connected set in the domain of a continuous function f with domain and range in \mathbf{R} , prove that $f(H)$ is connected.
- (c) State and prove Bolzano's intermediate value theorem.
6. (a) Let f have domain \mathbf{D}_f , and range, \mathbf{R}_f , in \mathbf{R} . When is f uniformly continuous on $A \subset \mathbf{D}_f$?
- (b) Let f have domain \mathbf{D}_f , and range, \mathbf{R}_f , in \mathbf{R} . If f is continuous on \mathbf{D}_f and $K \subset \mathbf{D}_f$ is compact, prove that f is uniformly continuous on K .
7. (a) Let $f : [a, b] \rightarrow \mathbf{R}$.
 - (i) When is f said to be of bounded variation?
 - (ii) If f is of bounded variation, define the total variation of f on $[a, b]$.
- (b) Let $f : [a, b] \rightarrow \mathbf{R}$ be of bounded variation and $V_f(a, b)$ be the total variation of f on $[a, b]$. Define $V : [a, b] \rightarrow \mathbf{R}$ by $V(x) = V_f(a, x)$ if $a < x \leq b$ and $V(a) = 0$. Prove the following:
 - (i) V is an increasing function on $[a, b]$.
 - (ii) $V - f$ is an increasing function on $[a, b]$.

END OF EXAM.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
Department of Mathematics & Statistics
FIRST SEMESTER FINAL EXAMINATIONS

19th November, 2009.

M411—Functions of a Complex Variable I

Time allowed : THREE(3) HOURS

Instructions : There are six(6) questions. Answer **ANY FIVE (5)** questions. All questions carry equal marks. Show all your working to earn full marks.

1. (a) (i) For any complex numbers z and w , show that

$$|z + w|^2 + |z - w|^2 = 2(|z|^2 + |w|^2).$$

- (ii) Find the real and imaginary parts of

$$f(z) = \frac{2 + i}{4i + (1 + i)^2}.$$

- (b) Determine the radius and domain of convergence of the series

$$\sum_{n=0}^{\infty} \frac{n!}{n^n} z^n.$$

- (c) Prove that if $z = x + iy$, $f(z) = 2x + ixy^2$ is nowhere analytic.

2. (a) (i) Given a complex number z , prove that $|\operatorname{Im} z| + |\operatorname{Re} z| \leq \sqrt{2}|z|$.

- (ii) Show that if $z = x + iy$, the hyperbola $x^2 - y^2 = 1$ can be written as $z^2 + \bar{z}^2 = 2$.

- (b) Determine whether the following series is absolutely convergent, convergent, or divergent:

$$\sum_{n=0}^{\infty} \frac{n(n+3i)}{(n+2)(n+3)}.$$

- (c) Solve the equation $z^6 + 1 = i\sqrt{3}$ for all possible values of z .

3. (a) (i) Find all possible values of $z = (i)^{-3i}$ and also find the Principal value.
(ii) Shade the region or domain in the complex plane defined by

$$|z| \geq 1, -2 \leq \operatorname{Re} z \leq 3, -1 \leq \operatorname{Im} z \leq 2.$$

- (b) Let a function $f(z)$ be analytic in a domain D . Show that $f(z)$ is constant in D if $\overline{f(z)}$ is also analytic in D .

- (c) Prove that the function $f(z) = u(x, y) + iv(x, y)$ where

$$f(z) = \frac{x^3(1+i) - y^3(1-i)}{x^2 + y^2}$$

for $z \neq 0$, and $f(0) = 0$, satisfies the Cauchy-Riemann equations at the origin.

4. (a) (i) Show that $u(x, y) = 3x^2 + x - 3y^2 + 4$ is harmonic.
(ii) Find the most general conjugate harmonic function $v(x, y)$, of $u(x, y)$ from part (i) above.

- (b) Let

$$S(z) = \frac{az + b}{cz + d}$$

be a linear fractional transformation. Find conditions on a, b, c, d such that $S(z)$ has two non-infinite fixed points.

- (c) Find the linear fractional transformation that maps the points $z_1 = \infty$, $z_2 = i$, $z_3 = 0$ in the z -plane onto $w_1 = 0$, $w_2 = i$, $w_3 = \infty$ in the w -plane.

5. (a) Evaluate

$$\int_C f(z) dz$$

where $f(z) = y - x - 3x^2i$, $z = x + iy$ and C is the contour comprising two line segments, one from $z = 0$ to $z = i$ and the other from $z = i$ to $z = 1 + i$.

- (b) Let C be the arc of the circle $|z| = 2$ from $z = 2$ to $z = 2i$ that lies in the first quadrant. Without evaluating the integral, show that

$$\left| \int_C \frac{dz}{z^2 + 1} \right| \leq \frac{\pi}{3}.$$

- (c) Find the singular points of the following functions and determine if they are isolated or not.

(i)

$$f(z) = \frac{e^{\sec z}}{z^2 + 1}.$$

(ii)

$$\frac{3z^3 + 2}{e^z(z^2 + 9)}.$$

6. (a) Evaluate

$$\int_C \frac{dz}{z^{\frac{1}{2}}}$$

where C is the circle $|z| = \sqrt{2}$, the branch to be used is one for which $(1)^{\frac{1}{2}} = 1$, and the integration starts from $z = -1 + i$.

- (b) (i) State, without proof, the Cauchy-Goursat theorem for a simple region.
(ii) Evaluate

$$\int_C \tan z dz$$

when C is the circle $|z| = 1$ which is positively oriented.

- (c) Evaluate

$$\int_C \frac{z dz}{(9 - z^2)(z + i)},$$

where C is the circle $|z| = 2$ taken in the positive sense. **END.**



UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS
2009 FIRST SEMESTER UNIVERSITY EXAMINATIONS

MP415
MATHEMATICAL METHODS FOR PHYSICS

DURATION: Three hours.

INSTRUCTIONS: Answer any four questions from the six given.
Each question carries 25 marks with the division of marks within each question indicated by the numbers in parenthesis next to the question.

MAXIMUM MARKS: 100

DATE: Monday 2nd November 2009.

Formulae that may be needed:

1. The Cauchy-Riemann equations:

$$u_x = v_y, \quad u_y = -v_x$$

2. Integration by use of the path:

$$\int_C f(z) dz = \int_a^b f[z(t)] \dot{z}(t) dt.$$

3. Cauchy's integral formula:

$$\oint_C \frac{f(z)}{z - z_0} dz = 2\pi i f(z_0).$$

4. Derivative of an analytic function:

$$f^{(n)}(z_0) = \frac{n!}{2\pi i} \oint_C \frac{f(z)}{(z - z_0)^{n+1}} dz \quad (n = 1, 2, \dots).$$

5. The geometric series

$$\sum_{m=0}^{\infty} q^m = 1 + q + q^2 + \dots$$

converges with sum $1/(1 - q)$ when $|q| < 1$.

6. Ratio test 1: Series converges if $|\frac{z_{n+1}}{z_n}| \leq q < 1$, and diverges if $|\frac{z_{n+1}}{z_n}| \geq 1$ for n greater

than some N .

7. Ratio test 2:

$$\lim_{n \rightarrow \infty} \left| \frac{z_{n+1}}{z_n} \right| = L.$$

8. Root test 1: Series converges if $\sqrt[n]{|z_n|} \leq q < 1$, and diverges if $\sqrt[n]{|z_n|} \geq 1$.

9. Root test 2:

$$\lim_{n \rightarrow \infty} \sqrt[n]{|z_n|} = L.$$

10. Radius of convergence of a power series:

$$\begin{aligned} R &= \frac{1}{L^*}, & L^* &= \lim_{n \rightarrow \infty} \left| \frac{a_{n+1}}{a_n} \right| \\ R &= \frac{1}{\tilde{L}}, & \tilde{L} &= \lim_{n \rightarrow \infty} \sqrt[n]{|a_n|} \\ R &= \frac{1}{\tilde{l}}, & \tilde{l} &= \text{largest limit of } \lim_{n \rightarrow \infty} \sqrt[n]{|a_n|} \end{aligned}$$

11.

$$(\cosh z)' = \sinh z, \quad (\sinh z)' = \cosh z.$$

12. Formula 1 for residue at a simple pole:

$$\operatorname{Res}_{z=z_0} f(z) = \lim_{z \rightarrow z_0} (z - z_0) f(z).$$

13. Formula 2 for the residue at a simple pole:

$$\operatorname{Res}_{z=z_0} \frac{p(z)}{q(z)} = \frac{p(z_0)}{q'(z_0)}.$$

14. Formula for residues of any order:

$$\operatorname{Res}_{z=z_0} f(z) = \frac{1}{(m-1)!} \lim_{z \rightarrow z_0} \left\{ \frac{d^{m-1}}{dz^{m-1}} [(z - z_0)^m f(z)] \right\}.$$

15. Residue theorem:

$$\oint_C f(z) dz = 2\pi i \sum_{j=1}^k \operatorname{Res}_{z=z_j} f(z).$$

16. Improper integrals of rational functions of $\sin \theta$ and $\cos \theta$ (integration taken counter-clockwise)

$$\int_0^{2\pi} f(z) \frac{dz}{iz} = 2\pi i \sum \operatorname{Res} \left[\frac{f(z)}{iz} \right],$$

where $f(z)$ is obtained from $f(\cos \theta, \sin \theta)$ by the substitutions

$$\cos \theta = \frac{1}{2} \left(z + \frac{1}{z} \right), \quad \sin \theta = \frac{1}{2i} \left(z - \frac{1}{z} \right).$$

17. Improper integrals of rational functions:

$$\int_{-\infty}^{\infty} f(x) dx = 2\pi i \sum \operatorname{Res} f(z).$$

18.

$$e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \dots$$

QUESTION 1

- (a) Give the condition, with a diagram, for a complex function $f(z)$ to have a limit as z tends to a point z_0 . (5 marks)
- (b) Give the definition for the derivative of a complex function. (4 marks)
- (c) Test whether or not the following function is harmonic:

$$u = e^x \sin y$$

If it is find the conjugate harmonic, and go on to find the corresponding analytic function.

(16 marks)

QUESTION 2

- (a) Evaluate the integral

$$\int_C 3z^2 dz, \quad \text{where } C \text{ the line segment from } 3i \text{ to } 4 - i$$

by

- (i) the method of path, and (13 marks)
- (ii) by direct integration. (8 marks)
- (b) State the Principle of Deformation of Path. (4 marks)

QUESTION 3

- (a) Integrate

$$\oint_C \frac{\tan z}{z^2 - 1} dz$$

counterclockwise around the path C $|z| = \frac{3}{2}$:

- (i) By Cauchy's integral formula. Explain why Cauchy's integral theorem can be used. (9 marks)
- (ii) By the residue theorem. You must first determine the number and order of the poles. (9 marks)
- (b) Find the center and radius of convergence of the power series

$$\sum_{n=0}^{\infty} \frac{3n+4}{2^n} (z-2-i)^n.$$

(7 marks)

QUESTION 4

- (a) Expand the following Laurent series that converges for $\frac{1}{4} < |z - 1| < \frac{1}{2}$ in powers of $(z - 1)$ and determine the precise region of convergence:

$$\frac{1}{1 - z^2}.$$

(8 marks)

- (b) Determine the location and order of singularities of the function

$$\frac{z^3 + 3z}{z^2 + 1}.$$

(8 marks)

- (c) Evaluate the improper integral

$$\int_{-\infty}^{\infty} \frac{1}{x^2 + 16} dz.$$

(9 marks)

QUESTION 5

- (a) Use Gauss elimination to solve

$$\begin{aligned} -x + y + 2z &= 0 \\ 3x + 4y + z &= 0 \\ 2x + 5y + 3z &= 0 \end{aligned}$$

(8 marks)

- (b) Use Gauss-Jordan elimination to find the inverse of

$$A = \begin{bmatrix} 1 & 0 & 0 \\ \frac{1}{2} & 1 & 0 \\ 1 & 5 & 2 \end{bmatrix}.$$

Check your answer.

(9 marks)

- (c) Find the eigenvalues and eigenvectors of

$$A = \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix}.$$

(8 marks)

QUESTION 6

- (a) Solve the differential equation

$$(x + 1)y' - (2x + 3)y = 0$$

by the power series method.

(18 marks)

- (b) Prove that your series solution of part (a) can be written in the form

$$y = a_0(x + 1)e^{2x}.$$

(7 marks)

END

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF MATHEMATICS & STATISTICS**

**2009 ACADEMIC YEAR
FIRST SEMESTER FINAL EXAMINATIONS**

M421 : STRUCTURE AND REPRESENTATIONS OF GROUPS

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: Answer any **Four (4)** questions in all and at **least one** question from section B.

SECTION A : (STRUCTURE OF GROUPS)

1. (a) Define each of the following terms:
 - (i) the commutator subgroup G' of a group G .
 - (ii) a normal series of a finite group G .
 - (b) (i) Let G be a finite group with normal series
$$G = G_0 \geq G_1 \geq \dots \geq G_{n-1} \geq G_n = (e).$$
Then prove that every subgroup N of G possesses a normal series.
 - (ii) Let H be a subgroup of a group G such that $x^2 \in H$ for every $x \in G$. Then show that G/H is an abelian group. Hence deduce that $G' \subset H$. Is the converse true? Justify.
 - (c) (i) Let N be a normal subgroup of a group G such that $N \cap G' = (e)$. Then prove that $N \subset Z(G)$, where $Z(G)$ denotes the centre of the group G .
 - (ii) Determine a normal series for the dihedral group D_4 of order 8 where $D_4 = \langle a, b \mid a^4 = b^2 = 1 \rangle$.
-
2. (a) Define the following terms as applied to finite groups.
 - (i) solvable group
 - (ii) nilpotent group
 - (b) (i) Given that a nilpotent group G contains a normal subgroup H , prove that G/H is also nilpotent.

- (ii) Given that the solvable group G contains a normal subgroup H , prove that G/H is also solvable.
- (c) (i) Show that every finite p -group is nilpotent.
- (ii) Show that the symmetric group S_5 of degree 5 is not solvable.
3. (a) Define each of the following terms as applied to finite groups.
- (i) the commutator $[x, y]$ of the elements x, y in the group G .
- (ii) a composition series of a group G .
- (b) (i) Let N be normal subgroup of a group G and let G' denote the group generated by $[x, y]$. Then prove that the factor group G/N is abelian if and only if G' is contained in N .
- (c) Obtain a composition series for the group G which is generated by the permutations $T = (1\ 2\ 3\ 4)$ and $P = (2\ 4)$.
4. (a) Let G be a permutation group acting on the set Ω . Then give the meaning to each of the following terms;
- (i) the stabilizer G_α of $\alpha \in \Omega$ in G .
- (ii) G is a regular permutation group.
- (b) (i) Show that if G is transitive on Ω , then all the stabilizers G_α of $\alpha \in \Omega$ are conjugate in G .
- (ii) Prove that G is a regular permutation group on Ω if and only if for any $\alpha, \beta \in \Omega$, there exists one and only one $\sigma \in G$ such that $\alpha^\sigma = \beta$.
- (c) (i) Show that if a transitive permutation group G is imprimitive on Ω , then no stabilizer G_α is maximal in G for each $\alpha \in \Omega$.
- (ii) Show that if a primitive regular permutation group is of finite, then it has prime power order.

SECTION B : (REPRESENTATION THEORY OF GROUPS)

(Attempt at least one question from this section)

5. (a) Give the meaning of each of the following terms as applied to representations of finite groups;

(i) a completely reducible representation of a group G .

(ii) a group character χ of a group G .

(b) Prove that if K is a field whose characteristic does not divide the order of a group G , then all the K -representations of G are completely reducible.

(c) Show that the mapping $T: C_n \rightarrow \mathbb{C}$ given by $T(a^k) = \omega^j$, where $\omega = e^{2\pi i/n}$ and $j = 0, 1, \dots, n-1$, is a representation of $C_n = \langle a \mid a^n = e \rangle$. Hence use the fact that $N = \{ (1), (1\ 2)(3\ 4), (1\ 4)(2\ 3) \}$ is a subgroup of index 3 in the alternating group A_4 of degree 4 to determine the character table of A_4 . [Hint: use the fact that $A_4/N \cong C_3$].

6. (a) Give the meaning of each of the following terms as applied to representations of groups;

(i) the character table of a group G .

(ii) the first orthogonality relations for the group characters of a group G .

(b) (i) Prove that equivalent representations of a group G have the same character.

(ii) Let G be a finite group with k conjugacy classes, and let χ^α ($\alpha = 1, 2, \dots, k$) be the distinct irreducible group characters of G . Then use the first orthogonality relations to show that

$$\sum_{\alpha=1}^k h_i \chi_i^\alpha \chi_j^{\alpha*} = |G| \delta_{ij}, \quad i, j = 1, 2, \dots, k \quad \text{where } h_i \text{ is the order of the conjugacy class } C_i \text{ of } G, \chi_j^{\alpha*} = \chi^\alpha(g_j^{-1}) \text{ for } g_j^{-1} \in C_j, \text{ and } d_{st} = 1 \text{ if } s=t \text{ and } 0 \text{ otherwise.}$$

(c) (i) Keeping the notation and concepts in 6(b) above, deduce that the sum of the squares of the degrees of the characters of G equals the order of G .

(ii) Show that the map $\chi: S_3 \rightarrow \mathbb{C}_2$ given by

$$\chi(\sigma) = \begin{cases} 1 & \text{if } \sigma \text{ is even in } S_3 \\ -1 & \text{if } \sigma \text{ is odd in } S_3 \end{cases}$$

is a representation of the symmetric group of degree 3. Hence write down its character table.

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
Department of Mathematics & Statistics
FIRST SEMESTER FINAL EXAMINATIONS

13th November, 2009.

M431—REAL ANALYSIS V

Time allowed : THREE(3) HOURS

Instructions : There are seven(7) questions. Answer **ANY FIVE (5)** questions. All questions carry equal marks. Show all your working to earn full marks.

1. (a) Define a metric space.
(b) Let d be a metric on a non empty set X .
(i) Prove that

$$|d(x, z) - d(z, y)| \leq d(x, y),$$

for all $x, y, z \in X$.

- (ii) Let $\{x_n\}_{n=1}^{\infty}$ and $\{y_n\}_{n=1}^{\infty}$ be Cauchy sequences in X . Prove that $\{d(x_n, y_n)\}_{n=1}^{\infty}$ converges in \mathbb{R} .

2. (a) Let d be a metric on a non empty set X . Give the definition of each of the following:
(i) an open ball in X .
(ii) an open set in X .

- (b) Let $1 \leq p < \infty$ and $N \in \mathbb{N}$. Define

$$E_N = \{\{x_n\}_{n=1}^{\infty} \in l^p : x_m = 0 \quad \forall m > N\}.$$

Prove that the complement, $\sim E_N$, of E_N is an open set in l^p .

- (c) Let

$$C_0 = \{\{x_n\}_{n=1}^{\infty} \in l^{\infty} : \lim_{n \rightarrow \infty} x_n = 0\}.$$

Prove that the complement, $\sim C_0$, of C_0 is an open set in l^{∞} .

3. (a) Define the following:

(i) l^p and $\|x\|_p$, for $1 \leq p < \infty$ and $x \in l^p$.

(i) l^{∞} and $\|x\|_{\infty}$, for $x \in l^{\infty}$.

- (b) Using calculus it can be proved that for all $t \geq 0$ and $0 < \lambda < 1$, the inequality $t^{\lambda} \leq \lambda t + 1 - \lambda$ holds. Use this to prove that if $1 < p < \infty$ and $q \in \mathbb{R}$ is such that $\frac{1}{p} + \frac{1}{q} = 1$, then for $a \geq 0$ and $b \geq 0$ we have

$$ab \leq \frac{a^p}{p} + \frac{b^q}{q}.$$

- (c) Let $1 < p < \infty$ and $q \in \mathbb{R}$ such that $\frac{1}{p} + \frac{1}{q} = 1$. If $x = \{x_n\}_{n=1}^{\infty} \in l^p$ and $y = \{y_n\}_{n=1}^{\infty} \in l^q$ then $z = \{x_n y_n\}_{n=1}^{\infty} \in l^1$ and $\|z\|_1 \leq \|x\|_p \|y\|_q$. This is Hölder's inequality.

(i) Prove it.

(ii) Deduce the Cauchy-Schwartz inequality, that is if $\sum_{n=1}^{\infty} a_n^2 < \infty$ and

$\sum_{n=1}^{\infty} b_n^2 < \infty$ then

$$\sum_{n=1}^{\infty} |a_n b_n| \leq \left(\sum_{n=1}^{\infty} a_n^2 \right)^{\frac{1}{2}} \left(\sum_{n=1}^{\infty} b_n^2 \right)^{\frac{1}{2}}.$$

4. (a) Let (X, d) be a metric space and $A \subset X$. Define a point of closure of A .
 (b) Let

$$X = \{f : [0, 1] \rightarrow \mathbb{R} : f \text{ is a function}\}.$$

The metric $d(f, g) = \sup\{|f(x) - g(x)| : x \in [0, 1]\}$ is defined on X . Let $S[0, 1] = \{f : [0, 1] \rightarrow \mathbb{R} : f \text{ is a step function}\}$ and $C[0, 1] = \{f : [0, 1] \rightarrow \mathbb{R} : f \text{ is continuous}\}$. If $f \in C[0, 1]$, show that f is a point of closure of $S[0, 1]$.

5. (a) Let (X, d_x) and (Y, d_y) be metric spaces and $f : X \rightarrow Y$ be a function between them. Define the following:
- (i) f is Lipschitz continuous.
 - (ii) f is a contraction.
 - (iii) f is uniformly continuous on a compact subset A of X .
- (b) Let $X = Y = [1, \infty)$ and let X and Y both have the metric induced by the Euclidean metric on \mathbb{R} . For each fixed $k > \frac{1}{2}$, define the function $f_k : X \rightarrow Y$ by $f_k(x) = k(\frac{1}{x} + x)$.
- (i) Prove that f_k is uniformly continuous on X .
 - (ii) For what values of k is f_k a contraction?
- (c) Let $X = Y = (0, \infty)$, $d_x = d_y$ both be metrics induced by the usual metric on \mathbb{R} , and let $f(x) = \frac{1}{x}$ for $x \in X$. Prove that f is not uniformly continuous on X .
6. (a) Let (X, d_x) and (Y, d_y) be metric spaces. Define the following:
- (i) A subset B of X is sequentially compact.
 - (ii) A subset B of X is totally bounded.
- (b) Let $C([0, 1])$ have its usual supremum metric d and define the set A by

$$A = \{f \in C([0, 1]) : 0 \leq f(x) \leq 1 \text{ for every } x \in [0, 1]\}.$$

- (i) Show that A is bounded.

- (ii) Show that A is closed.
- (iii) Show that A is not sequentially compact.
- (c) Say, with reasons, if the set

$$A = \{(x, y) \in \mathbb{R}^2 : \frac{x^2}{4} + \frac{y^2}{9} = 4\}$$

is compact or not.

- 7. (a) Let (X, d_x) and (Y, d_y) be metric spaces and $f : X \rightarrow Y$ be a bijection. Define the following:
 - (i) f is a homeomorphism.
 - (ii) f is an isometry.
- (b) If X is a compact metric space, Y any metric space and $f : X \rightarrow Y$ a continuous bijection, prove that f is a homeomorphism.
- (c) Prove that every sequentially compact subset A of a metric space (X, d) is totally bounded.

END.

University of Zambia
School of Natural Sciences

2008/9 Academic year Second Semester Final Examinations

M462: Bayesian Inference and Discrete Analysis

Instructions:

1. Answer Any FIVE (5) questions.
2. Calculators may be used in this examination
3. You may use statistical tables provided
4. Show ALL your work to earn full marks

Time Allowed: THREE (3) Hours

- [1] (a) The failure times, T (in years), of a watch manufactured by a reputable company have an exponential distribution with a guarantee period G . Its density function is given by:

$$f(t/\theta) = \theta e^{-\theta(t-G)}, \quad 0 < G < t$$

- (i) Show that the survival function is equal to: $S(t) = \theta e^{-\theta(t-G)}$
- (ii) Obtain an expression for the hazard function $\lambda(t)$
- (iii) Find the cumulative hazard, $\Lambda(t)$, at time t .

- (b) Suppose t_1, t_2, \dots, t_n are observed times on study for n study units. Further, let

$$\delta_i = \begin{cases} 1 & \text{if the } i^{\text{th}} \text{ unit fails} \\ 0 & \text{if the } i^{\text{th}} \text{ unit is censored} \end{cases}$$

Let $f(t)$ be the density function for the survival times, $S(t)$ be the survival function and θ be a parameter of interest. Further, let the likelihood function be:

$$L(\theta/t, \delta) = \prod_{i=1}^n f(t_i)^{\delta_i} S(t_i +)^{1-\delta_i}$$

where $t_i +$ indicates that the i^{th} unit was censored at time t_i .
 $i = 1, 2, \dots, n$.

For the questions below, assume t_1, t_2, \dots, t_n are times on study and $\delta_1, \delta_2, \dots, \delta_n$ are indicators of censorship.

- (i) Using the given likelihood function, find an expression for the Maximum Likelihood Estimator for θ for the function given in (a) and $S(t)$ found in (a)(i).
- (ii) A sample of 10 watches such as described in (a) yielded the following times before failure, a plus indicates censored time:

8.2, 9, 9.4, 10+, 11, 8, 8.5+, 10, 12, and 11.7.

The watches had a guarantee period of $G=5$ years. Obtain an estimate of θ using your results in (b)(i).

- [2] (a) Suppose that the number of Short Message Service (SMS) texts that a front office clerk receives in a day has a Poisson distribution for which the mean, λ , is either 4 or 5, and that the prior probability function of λ is as follows:

$$P(4) = 0.75 \text{ and } P(5) = 0.25$$

If one day the clerk's cell phone shows 6 SMS's by the end of the day, what is the posterior probability function of λ ?

- (b) Suppose that X_1, X_2, \dots, X_n form a random sample from a distribution for which the probability density function, $f(x/\theta)$, is as follows:

$$f(x/\theta) = \begin{cases} \theta x^{\theta-1} & \text{for } 0 < x < 1 \\ 0 & \text{otherwise} \end{cases}$$

Suppose that the value of the parameter θ is unknown ($\theta > 0$) and that the prior distribution of θ is a gamma distribution shown below, with parameters α and β ($\alpha > 0$ and $\beta > 0$).

$$P(\theta) = \frac{\beta^\alpha \theta^{\alpha-1}}{\Gamma(\alpha)} e^{-\beta\theta}, \text{ where } \theta > 0.$$

- (i) Determine the posterior distribution of θ
- (ii) Determine the updating rules for α and β .
- (iii) Find the mean of θ for the prior distribution
- (iv) Using (ii) and results of (iii) determine the mean of the posterior distribution of θ

- [3] (a) A random variable Y has the probability density function (pdf) given by
- $$f(y/\theta) = \exp\left\{\frac{\omega}{\phi}(\theta y - b(\theta)) + C(\omega, \phi, y)\right\}, \quad \text{where } -\infty < y < +\infty, \omega, \phi \text{ are constants and } \theta \text{ is a parameter.}$$

- (i) State the general name of this family of distributions
- (ii) State the mean of Y in terms of ω, ϕ and $b(\theta)$
- (iii) State the variance of Y in terms of ω, ϕ and $b(\theta)$

- (b) Given that Y is a random variable with probability mass function

$$P(y) = \frac{\lambda^y}{y!} e^{-\lambda}, \quad y = 0, 1, 2, \dots$$

- (i) Show that $P(y)$ belongs to this family of distributions in (a)
- (ii) Identify ω, ϕ and $b(\theta)$ in (i)
- (iii) Derive the mean of Y using (b) (ii)
- (iv) Derive the variance of Y using (b) (ii)

- (c) Given that Y is a random variable with probability mass function

$$P(y) = \binom{n}{y} \pi^y (1-\pi)^{n-y}, \quad y = 0, 1, 2, \dots, n$$

- (i) Show that $P(y)$ belongs to this family of distributions in (a)
- (ii) Identify ω, ϕ and $b(\theta)$ in (i)
- (iii) Derive the mean of Y using (c) (ii)
- (iv) Derive the variance of Y using (c) (ii)

- [4] (a) Suppose Y is a binary response variable taking values 0 and 1. Further, suppose that X is an explanatory variable, continuous or categorical and that

$$\pi = \Pr(Y=1) = E(Y).$$

We desire to model Y on X given a random sample $(X_1, Y_1), (X_2, Y_2), \dots, (X_n, Y_n)$, via the model:

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i, \quad \text{where } \varepsilon_i \text{ has mean 0 and a nonzero variance.}$$

- (i) Given that $E(Y_i | X_i) = \pi_i = \beta_0 + \beta_1 X_i$, find the variance of ε_i .
- (ii) State three reasons why the suggested model is not often used for modeling a binary response variable, such as Y , on an explanatory variable X .
- (iii) State two reasons why the transformation: $\pi_i(x_i) = \frac{\exp(\beta_0 + \beta_1 X_i)}{1 + \exp(\beta_0 + \beta_1 X_i)}$ is often preferred in modeling Y on X .

- (b) The Living Conditions and Monitoring Survey carried out by The Central Statistical Office (CSO) in 1998 collected information on a number of things. Some of the information collected was on injury or illness experienced by people in both rural and urban areas. Let Y be a binary response variable (1 representing injury or illness and 0 represent no injury or illness). Further, let X be a binary explanatory variable (1 representing rural and 0 representing urban). The results below show the output of fitting a logistic model on Y versus X (region).

Variables in the Equation

		B	S.E.
Step	region	.295	.002
1	Constant	-2.196	.002

a. Variable(s) entered on step 1: region.

- (i) Write down the logistic model relating Y and X
- (ii) Find an estimate of odds of injury or illness for an individual in the rural area.
- (iii) Find an estimate of odds of injury or illness for an individual in the urban area.
- (iv) Find an estimate of the odds ratio of rural versus urban and interpret.
- (c) We would like to test the following hypotheses separately using the Wald statistic:
1. $H_0: \beta_0 = 0$ versus $H_1: \beta_0 \neq 0$
 2. $H_0: \beta_1 = 0$ versus $H_1: \beta_1 \neq 0$
- Given that the Wald statistic has a Chi-square distribution with 1 degree of freedom, carry out the two hypotheses separately, each at $\alpha = 0.05$

- [5] (a) Let $P(\theta)$ be a probability density function (pdf) which is defined as follows, for constants $\alpha > 0$ and $\beta > 0$.

$$P(\theta) = \begin{cases} \frac{\beta^\alpha \theta^{-(\alpha+1)}}{\Gamma(\alpha)} e^{-\beta/\theta}, & \text{for } \theta > 0 \\ 0 & \theta \leq 0 \end{cases}$$

- (i) Verify that $P(\theta)$ is actually a pdf.
- (ii) Let $f(x/\theta)$ be the normal distribution with a known value of the mean μ and an unknown value of the variance θ ($\theta = \sigma^2$).

Show that the family of prior distributions, $P(\theta)$, is a conjugate family for samples drawn from $f(x/\theta)$, where $f(x/\theta)$ is expressed as:

$$f(x/\theta) = \frac{1}{\theta^{\frac{1}{2}} \sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\theta}\right), \quad \theta > 0.$$

- (b) The performance of students taking a certain accounting exam is thought to have a normal distribution with mean 75 and variance 16, $N(75, 16)$. In a recent class, the following results (data), from a normal with mean μ and variance 15 were obtained:

59, 70, 67, 66, 48, 49, 66, 90, 68, and 66

- (i) State the posterior distribution of μ in full
- (ii) Find $\Pr(65 < \mu < 70)$ using the posterior density
- (iii) Find the 95% high density region for μ using the posterior density function.

- [6] Twelve cars with the same mechanical problem were randomly assigned two types of garages. The number of weeks it took for the problem to recur after repair are shown below:

Type of garage	Weeks to recurring of the problem					
Vendor	6	11	13	20+	22	18
Professional	5	14	23	31	39+	50

- (a) Estimate the survival functions for the two garages using the Product Limit Estimator.
- (b) Plot, on the same graph, the survival curves for the two garages. USE GRAPH ON PAGE 6
- (c) Compare the two survival curves using the Gehan test at $\alpha = 0.05$. PLEASE USE THE TABLE ON PAGE 7.

Graph for Problem 6 (b) ATTACHED THIS PAGE TO YOUR ANSWER BOOKLET

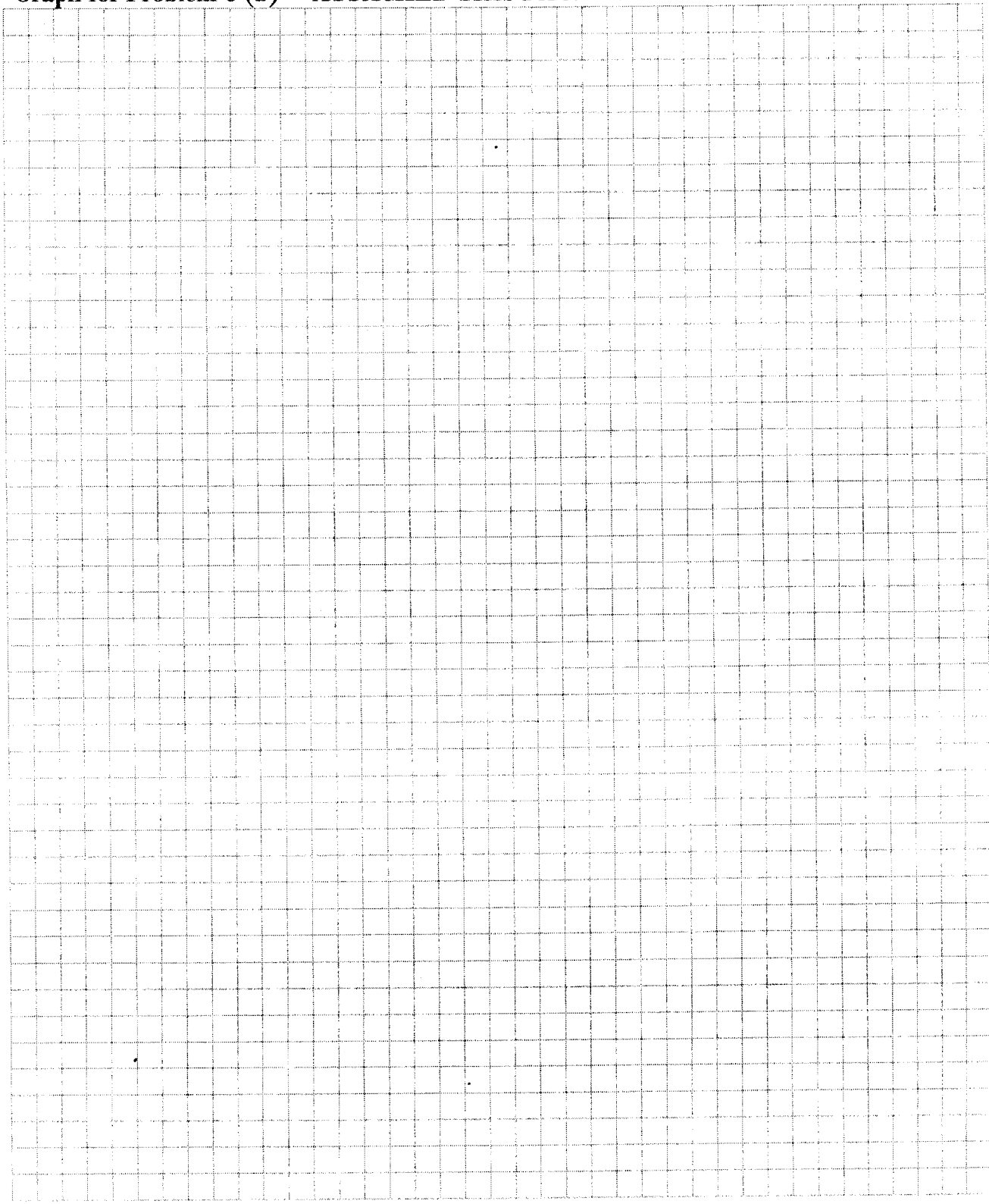


Table for problem 6 (c).
COMPLETE THIS TABLE AND ATTACH THIS PAGE TO YOUR ANSWER BOOKLET
IF YOU HAVE SELECTED QUESTION 6. You may do the calculations at the bottom
of the table.

Time (weeks to recurring of problem) combined samples t_i	Number of times that are less than t_i	Number of times that are greater than t_i	U_i	Garage indicator
5				
6				
11				
13				
14				
18				
20+				
22				
23				
31				
39+				
50				

END OF EXAMINATION

The University of Zambia
Department of Mathematics & Statistics
First Semester Examinations - November 2009
M911 - Mathematical Methods V

Time allowed : Three (3) hrs

Full marks : 100

Instructions: • Attempt **any five (5)** 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.

This paper consists of 3 pages of questions.

1. a) Given the vector

$$\mathbf{V}(x, y) = \frac{-x \mathbf{i} - y \mathbf{j}}{\sqrt{x^2 + y^2}},$$

(i) Graph the vector field defined by \mathbf{V} .

(ii) Find the divergence of \mathbf{V} .

b) Given that $\phi(x, y, z)$ and $\mathbf{A} = A_1 \mathbf{i} + A_2 \mathbf{j} + A_3 \mathbf{k}$, prove that

$$\nabla \times (\phi \mathbf{A}) = (\nabla \phi) \times \mathbf{A} + \phi (\nabla \times \mathbf{A}).$$

c) What is the volume of the largest rectangular box which can be placed inside the ellipsoid

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$$

so that its edges will be parallel to the coordinate axes?

2. a) Let

$$f(x, y) = \begin{cases} (x^3y - xy^3)/(x^2 + y^2) & \text{if } (x, y) \neq (0, 0), \\ 0 & \text{if } (x, y) = (0, 0). \end{cases}$$

(i) ✓ Show that $f_x(0, 0) = f_y(0, 0) = 0$.

(ii) ✓ Hence show that $f_{xy}(0, 0) \neq f_{yx}(0, 0)$.

b)✓ Find the directional derivative of $P(x, y, z) = 4e^{2x-y+z}$ at the point $(1, 1, -1)$ in the direction of the point $(-3, 5, 6)$.

c)✓ Determine whether

$$u = x + y + z$$

$$v = x^2 + y^2 + z^2$$

$$w = xy + yz + zx$$

are functionally dependent, and if so, find the relation between u , v and w .

3. a)✓ Given the transformation $x = 2u + v$, $y = u - 3v$,

(i) sketch the region R' of the uv plane into which the region R of the xy plane bounded by $x = 0$, $x = 1$, $y = 0$, $y = 1$ is mapped under the transformation.

(ii) compute

$$\frac{\partial(x, y)}{\partial(u, v)}.$$

(iii) Hence deduce the area of R' .

b)✓ Determine whether or not the vector field

$$\mathbf{F}(x, y, z) = (y^2 - 2xyz^3)\mathbf{i} + (3 + 2xy - x^2z^3)\mathbf{j} + (6z^3 - 3x^2yz^2)\mathbf{k}$$

is conservative. If it is conservative, find a function f such that $\mathbf{F} = \nabla f$.

4. a) Let $f(x, y) = 8 - 3(x - 2)^2 - 4(y - 1)^2$.

(i) Sketch a few level curves of $f(x, y)$.

(ii) Sketch the surface $z = f(x, y)$.

(iii) Sketch and describe the curve of intersection C of the surface $z = f(x, y)$ with the plane $x = 3$.

b) Given that $u = x^2 - y^2$, $v = 2xy$ and $x = r \cos \theta$, $y = r \sin \theta$, find the Jacobian

$$\frac{\partial(u, v)}{\partial(r, \theta)}.$$

c) Find and classify the stationary points of $f(x, y) = \exp\left(-\frac{1}{3}x^3 + x - y^2\right)$.

5. a) Let $4x^2 + y^2 - 4z^2 - 16x - 6y - 16z + 9 = 0$ be the equation of a surface.

(i) Identify the surface and write down its centre.

(ii) Find the tangent plane to the surface at the point $(3, 1, -2 + \sqrt{2})$.

b) Evaluate the integral

$$\int_1^2 \int_0^{4-x^2} (x+y) dy dx .$$

c) By using the transformation $x+y=u$, $y=uv$, evaluate the integral

$$\int_0^1 \int_0^{1-x} e^{\left(\frac{y}{x+y}\right)} dy dx .$$

6. a) A surface is given by the equation

$$z = \sqrt{x^2 + y^2} + (x^2 + y^2)^{\frac{3}{2}} .$$

(i) Find a vector $\mathbf{V}(x, y, z)$ normal to the surface at any point (x, y, z) of the surface.

(ii) Find the cosine of the angle θ between $\mathbf{V}(x, y, x)$ and the z -axis and determine the limit of $\cos \theta$ as $(x, y, z) \rightarrow (0, 0, 0)$

b) A curve in space is given parametrically by

$$\mathbf{x}(t) = e^t \cos t \mathbf{i} + e^t \sin t \mathbf{j} + e^t \mathbf{k}, \quad 0 \leq t \leq 1 .$$

(i) Find the length of the curve $\mathbf{x}(t)$.

(ii) Find the re-parameterization of the curve by the arc length $S(t)$.

c) Use cylindrical coordinates to evaluate the triple integral

$$\int_{-3}^3 \int_{-\sqrt{3-x^2}}^{\sqrt{3-x^2}} \int_{\sqrt{x^2+y^2}}^3 \sqrt{x^2 + y^2 + z^2} dz dy dx .$$

END!

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2008 ACADEMIC YEAR
SECOND SEMESTER FINAL EXAMINATIONS

M912: Mathematical Methods VI

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS : Attempt any **Five (5)** questions from this paper.
Show all essential working for full credit.

1. (a) Let γ be a curve given parametrically by $\gamma(t) = \mathbf{i} + t\mathbf{j} + e^t\mathbf{k}$, $0 \leq t \leq 4$.
Calculate the line integral $\int_{\gamma} \cos z dx + e^x dy + e^y dz$.
- (b) A surface S is given parametrically by the equation
 $\mathbf{r}(u, v) = u \cos v \mathbf{i} + u \sin v \mathbf{j} + u^2 \mathbf{k}$, $0 \leq u \leq 4$, $0 \leq v \leq 2\pi$
 - (i) Calculate $\frac{\partial \mathbf{r}}{\partial u} \times \frac{\partial \mathbf{r}}{\partial v}$
 - (ii) Given that the area of the surface S is $\frac{\pi(65\sqrt{65} - 1)}{n}$ where n is an integer, find the value of n .
- (c) The cylinder $x^2 + y^2 = 2x$ cuts out a portion of a surface S from the upper part of the cone $x^2 + y^2 = z^2$. Calculate the surface integral
$$\iint_S (x^4 - y^4 + y^2 z^2 - z^2 x^2 + 1) dS.$$
2. (a) Find the potential function $f(x, y, z)$ for the vector field
 $\mathbf{F}(x, y, z) = (2xyz + z^2 - 2y^2 + 1)\mathbf{i} + (x^2 z - 4xy)\mathbf{j} + (x^2 y + 2xz - 2)\mathbf{k}$.
- (b) Let ∂S denote the boundary of the surface S given by
 $z = x^2 + y^2$, $x^2 + y^2 \leq 1$. Use Stoke's theorem to calculate the line
integral $\oint_{\partial S} y^2 dx + x dy + z^2 dz$.
- (c) Use the method of Frobenius to find the roots of the **indicial equation** to the differential equation $4xy'' + 2y' + y = 0$. (Note that you don't need to find the solution of the differential equation).

3. (a) When is a sequence of functions $y_n(x)$, $n = 0, 1, 2, 3, \dots$ said to be orthogonal with respect to the weight function $\phi(x)$ on the interval $[a, b]$?
- (b) Let $C(1, e)$ be the space of continuous functions on the interval $(1, e)$ and let $(f, g) = \int_1^e \log x f(x) g(x) dx$ be an inner product on $C(1, e)$.
- (i) Find $\|f\|$ if $f(x) = \sqrt{x}$.
- (ii) Find a non zero linear polynomial $g(x) = a + bx$ which is orthogonal to the constant function $f(x) = 1$.
- (c) Let $(x, y) = \int_0^1 x(t)y(t)dt$ be an inner product on the space of polynomials.
- (i) Show that the polynomials $x_0(t) = 1$, $x_1(t) = 2t - 1$ and $x_2(t) = 6t^2 - 6t + 1$ are orthogonal.
- (ii) Find an orthonormal set $\{y_0, y_1, y_2\}$ which spans the same subspace as the set $\{x_0, x_1, x_2\}$ in (i).

4. (a) Let a periodic function $f(x)$ be defined in one period by

$$f(x) = \begin{cases} -\frac{\pi}{2}, & -\pi \leq x < 0 \\ \frac{\pi}{2}, & 0 \leq x \leq \pi \end{cases}$$

Find the Fourier series of $f(x)$.

- (b) Find the cosine series of the function $f(x) = x^2$, $-\pi \leq x \leq \pi$. Hence determine the value of the sum $\sum_{n=1}^{\infty} \frac{1}{n^2}$.
- (c) Find the complex form of the Fourier series of the periodic function whose definition in one period is $f(t) = e^{-t}$, $-1 < t < 1$.

5. (a) A fluid flow has flux density vector $\mathbf{F}(x, y, z) = x\mathbf{i} - (2x + y)\mathbf{j} + z\mathbf{k}$. Calculate the mass of fluid flowing through the hemisphere $x^2 + y^2 + z^2 = 1$, $z \geq 0$ in the direction of the unit normal to the surface.

- (b) Let $f(t)$ be a function whose Laplace transform is given by $L[f] = F(s)$. Show that $\frac{d}{ds} F(s) = -L[tf(t)]$.

- (c) Find the function $f(t)$ whose Laplace transform is

$$F(s) = \ln\left(\frac{s^2 - 1}{s^2}\right).$$

6. (a) Consider the functions $f(x) = x^3$ and $g(x) = x^2|x|$ on the interval $[-1, 1]$
- Show that their Wronskian $W(f, g)$ vanishes identically.
 - Show that f and g are not linearly dependent.
- (b) Find the Laplace transform of the functions
- $f(t) = \frac{e^{-3t} \sin 2t}{t}$.
 - $f(t) = e^{-3t} \int_0^t x \sin 2x dx$.
- (c) Use the convolution theorem to find a particular integral of the equation $y'' + 2ay' + a^2 y = f(t)$ where $y'(0) = y(0) = 0$.
7. (a) Show that $y(x) = x^2$ is a solution to the differential equation $x^2 y'' + xy' - 4y = 0$. Find the second solution and hence write the general solution of the equation.
- (b) Find the general solution of the system of equations
- $$\begin{cases} \frac{dx}{dt} = 7x + 6y \\ \frac{dy}{dt} = 2x + 6y \end{cases}$$
- (c) Use power series about the origin to find two solutions to the Hermite's equation $y'' - 2xy' + 2py = 0$ where p is a constant.

End of Exam!



The University of Zambia
School of Natural Sciences
Department of Physics
2009 Academic Year First Semester
Final Examinations
P-191: Introductory Physics - I

All questions carry equal marks. The marks are shown in brackets. Question 1 is compulsory. Attempt four more questions. Clearly indicate on the answer script cover page which questions you have attempted.

Time: Three hours.

Maximum marks = 100.

Do not forget to write your computer number clearly on the answer book as well as on the answer sheet for Question 1. Tie them together!!

=====

Wherever necessary use:

$$g = 9.8\text{m/s}^2$$

$$P_A = 1.01 \times 10^5 \text{ N/m}^2$$

$$1 \text{ cal.} = 4.18 \text{ J}$$

$$\rho_{\text{water}} = 1000\text{kg/m}^3$$

$$1 \text{ hp} = 746\text{W}$$

$$1 \text{ Pascal} = 1 \text{ N/m}^2$$

$$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$$

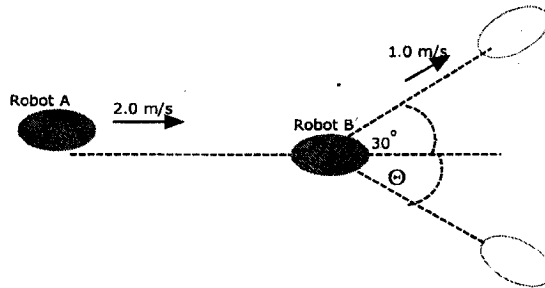
$$1 \text{ metric ton} = 1000 \text{ kg}$$

Question 1: Sample answers: F (a), G (d).... etc. **DO NOT guess** the answer. For each correct answer, **2 marks** are given. For each wrong answer, **0.67** will be deducted. For no answer, zero mark. The minimum total mark for Question 1 is zero. [$10 \times 2 = 20$]

- (A) The rate of change of angular displacement is called:
- a) Angular acceleration
 - b) Angular rotation
 - c) Angular velocity
 - d) Angular displacement
- (B) In any collision between two bodies there need not be conservation of:
- a) Angular momentum
 - b) Kinetic energy
 - c) Total energy
 - d) Linear momentum
- (C) A measure of inertia of a body is termed:
- a) Reaction
 - b) Weight
 - c) Force
 - d) Mass
- (D) The limit of average velocity over a path length that approaches zero but always includes a point P is defined as:
- a) Average speed at P
 - b) Instantaneous acceleration at P
 - c) Instantaneous velocity at P
 - d) Speed P
- (E) A particle of mass m strikes a wall normally (perpendicular to its line of motion) with velocity \mathbf{v} and then its velocity is reversed. The change in momentum is:
- a) mv
 - b) $2mv$
 - c) $-2mv$
 - d) zero
- (F) Work is always done on a body when:
- a) It experiences an increase of energy through a mechanical influence
 - b) A force is exerted on it
 - c) It moves through a certain distance
 - d) It experiences a force while in motion
- (G) Elasticity is the property by virtue of which:
- a) A liquid body occupies minimum surface area
 - b) A body opposes its deformation
 - c) A body is in equilibrium
 - d) A body attracts other bodies

- (H) A force \mathbf{F} acting on a body moving in a circle of radius r is always perpendicular to the instantaneous velocity \mathbf{v} . The work done by the force on the body in one complete revolution is:
- a) Fv
 - b) Fr
 - c) $F \cdot 2\pi r$
 - d) Zero
- (I) A modulus of elasticity is a ratio of:
- a) Force to length
 - b) Stress to strain
 - c) Stress to deformation
 - d) Strain to stress
- (J) An object in equilibrium may not have:
- a) Any acceleration
 - b) Any forces acting on it
 - c) Any torques acting on it
 - d) Any velocity

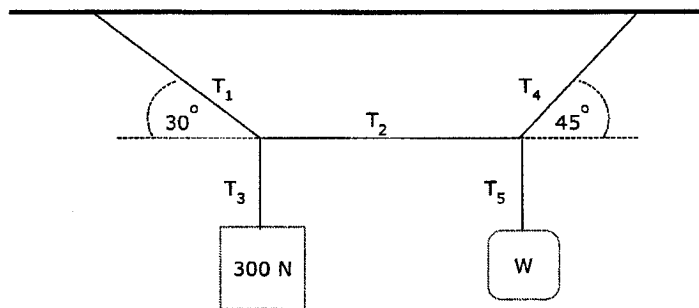
- (b) Two battling robots are sliding on frictionless surface as shown below. Robot A, with mass 20 kg, initially moves at 2.0 m/s parallel to the x -axis. It collides with robot B which has mass 12 kg and initially at rest. After the collision, robot A is moving at 1.0 m/s in the direction that makes an angle of 30° with its initial direction. What is the final velocity of the robot B and direction? [12]



- (c) State the first condition of equilibrium. [1]

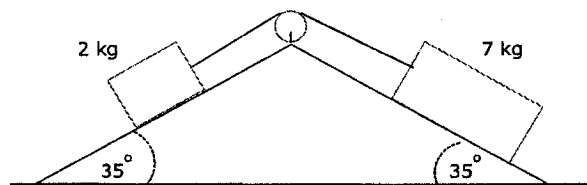
Q.5 (a) What is the essential distinction between 'static' and 'dynamic' equilibrium? [3]

- (b) For the system shown in figure below, find the tensions T_1 , T_2 , T_3 , T_4 and T_5 . Find also the weight W of the hanging mass. [8]



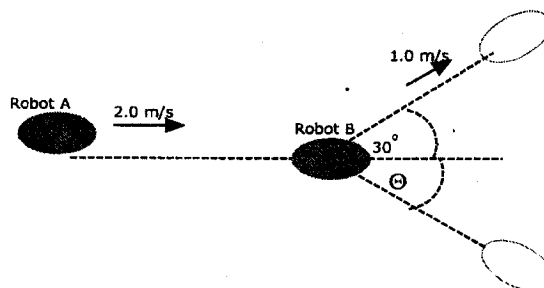
- (c) Two masses 2 kg and 7 kg respectively are connected by an inextensible string which passes over a frictionless pulley and are on inclined frictionless surfaces. Find:

- the acceleration of the blocks, and
- the tension T in the connecting string. [9]



- Q.6 (a)** A block of mass 8.7 kg slides with an initial speed of 1.66 m/s up a ramp inclined at an angle of 27.4° with the horizontal. The coefficient of kinetic friction between the block and the ramp is 0.62. Use energy conservation to find the distance the block slides before coming to rest. [7]

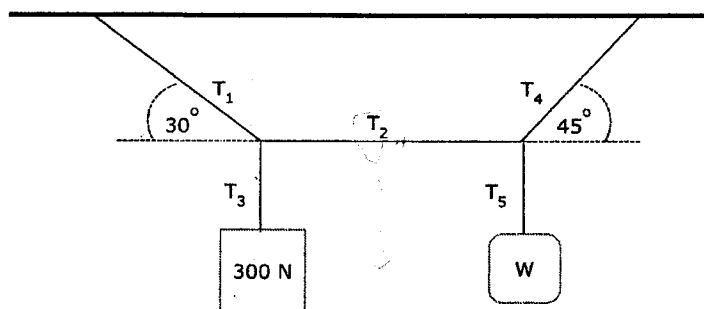
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- (c) State the first condition of equilibrium. [1]

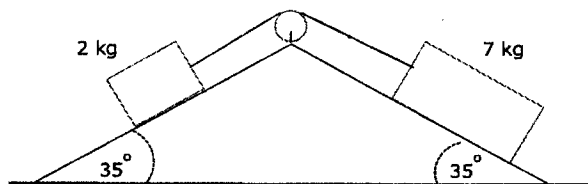
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- (c) Two masses 2 kg and 7 kg respectively are connected by an inextensible string which passes over a frictionless pulley and are on inclined frictionless surfaces. Find:

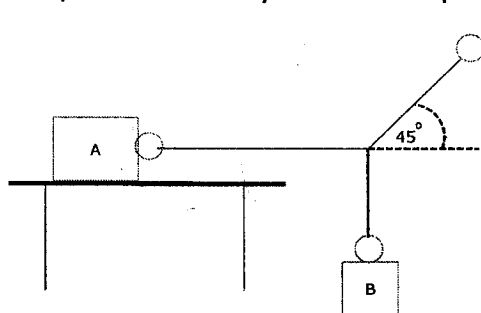
- the acceleration of the blocks, and
- the tension T in the connecting string. [9]



Q.6 (a) A block of mass 8.7 kg slides with an initial speed of 1.66 m/s up a ramp inclined at an angle of 27.4° with the horizontal. The coefficient of kinetic friction between the block and the ramp is 0.62. Use energy conservation to find the distance the block slides before coming to rest. [7]

(b) The blocks shown below are at rest.

- i) Find the frictional force exerted on block *A* given that the mass of block *A* is 8.50 kg, the mass of block *B* is 2.25 kg, and the coefficient of friction between block *A* and the surface on which it rests is 0.320.
- ii) If the mass of block *A* is doubled, does the frictional force exerted on it increase, decrease or stay the same? Explain [10]

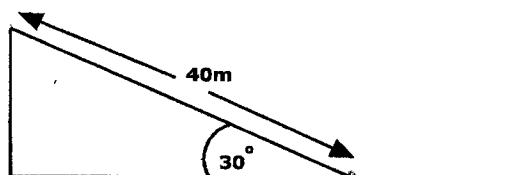


(c) A steel wire 50 cm long and has a diameter of 0.5 mm. Given that Young's modulus of steel is $20 \times 10^{10} \text{ N/m}^2$. What force is required to increase the length of this wire by 1.0 mm? [3]

Q.7 (a) A vector **A** has a magnitude of 30 m at an angle of 225° with respect to the positive *x*-axis. If we add a vector **B**, it is found that the resultant is along the positive *x*-axis and has a magnitude of 13 m, what are the components of vector **B** and its direction? [10]

(b) A skier starts from rest at the top of a slope that makes an angle of 30° with the horizontal and slides 40 m down the slope. At the bottom she continues along the level snow as shown.

- i) If the coefficient of kinetic friction between the skis and the snow is 0.15 and air friction is neglected, what is her speed at the foot of the slope?
- ii) How far away from the foot of the slope does she come to a stop? [9]

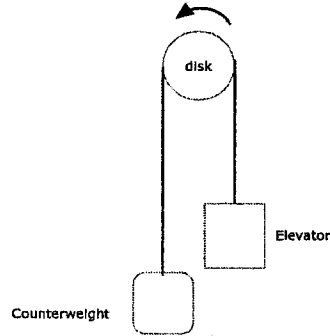


(c) Define lever arm.

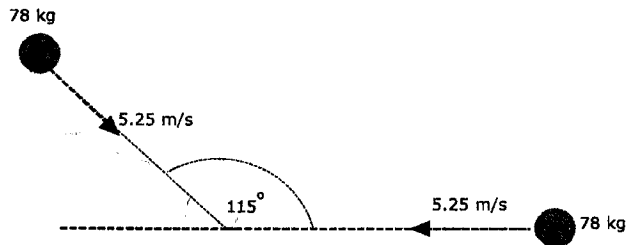
[1]

Q.8 (a) In an old hotel, an old style elevator is connected to a counterweight by a cable that passes over a rotating disk 2.50 m in diameter as shown in the figure below. The elevator is raised or lowered by turning the disk, and the cable does not slip on the rim of the disk as it turns with it.

- At how many rpm must the disk turn to raise the elevator at 25 cm/s?
- To start the elevator moving it must be accelerated at $\frac{1}{8}g$. What must be the angular acceleration of the disk in rad/s^2 ?
- Through what angle (in radians and degrees) has the disk turned when it has raised the elevator 3.25 m between the floors? [10]



- (b) Two 78 kg hockey players skating at 5.25 m/s collide and stick together. If the angle between their initial directions was 115° , what is their speed after the collision? [10]



END OF EXAMINATION

Some equations you may find useful:

$$\begin{aligned}
 v_f &= v_o + at : v_f^2 = v_o^2 + 2ax : x = v_o t + (1/2)at^2 : W = mg : x = v_{avg} t : p = mv \\
 f &= \mu F_N : Ft = m(v_f - v_o) : \text{work} = Fs \cos \theta : \text{kinetic energy} = (1/2)mv^2 : Ft = \Delta p \\
 g, p.\text{energy} &= mgh : v_{avg} = (1/2)(v_o + v_f) : \text{power} = \text{work}/\text{time} : t = 2u \sin \theta / g \\
 \Delta PE + \Delta KE + \Delta TE &= 0 : F = ma : P = Fv : R = (2u^2 \sin \theta \cos \theta) / g : a_r = ar : L = I\omega \\
 v_T &= \omega r : \omega_f = \omega_o + \alpha t : \omega_f^2 = \omega_o^2 + 2\alpha\theta : \theta = \omega_o t + (1/2)\alpha t^2 : p = mv : F_c = mv^2/r \\
 S &= \theta r : \\
 \text{kin. energy}_{\text{total}} &= (1/2)mv^2 + (1/2)I\omega^2 : I = \sum mr^2 : \tau = I\alpha = Fr : B = -\Delta P / (\Delta V/V_o) \\
 \text{kin. energy}_{\text{rot.}} &= (1/2)I\omega^2 : F = (Gm_1 m_2)/r^2 : Y = (F/A)/(\Delta L/L_o) : Q/\Delta t = (kA\Delta T)/\Delta L \\
 W_{\text{app.}} &= mg - B.F. : P = \rho gh : W_{\text{app.}} = W[1 - \rho_n/\rho] : F = -kx : f = 1/\tau : \omega = 2\pi f \\
 I_1\omega_1 &= I_2\omega_2 : \Delta T.E. = f.s : \text{area of a right cylinder} = 2\pi rL : v = \pm \sqrt{(k/m)(x_o^2 - x^2)} \\
 a_{\text{max}} &= kx_o/m : a_c = \omega^2 x_o : P.E. = (1/2)kx^2 : (1/2)kx^2 + (1/2)mv^2 = (1/2)kx_o^2 \\
 a &= -kx/m : \omega = \sqrt{k/m} : v = \sqrt{Y/\rho} : v = \sqrt{T/(m/L)} : 1 \text{ rev} = 360^\circ = 2\pi \text{ rads} \\
 \text{volume of a sphere} &= (4/3)\pi r^3 : \text{area of a sphere} = 4\pi r^2
 \end{aligned}$$



THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
University Examinations
P251-INTRODUCTION TO CLASSICAL
MECHANICS I

Date: November 2009

Duration: Three Hours

Total Marks: 100

Answer any five questions

All working should be shown clearly to earn full credit.

USEFUL DATA

Universal gravitational constant: $G = 6.67 \times 10^{-11} \text{m}^3 \text{kg}^{-1} \text{s}^{-2}$

Radius of the Earth : $R = 6.4 \times 10^6 \text{m}$

Radius of the Sun : $R = 6.955 \times 10^8 \text{m}$

Acceleration due to gravity: $g = 9.8 \text{ms}^{-2}$

Mass of the sun: $M_s = 2.00 \times 10^{30} \text{kg}$

Mass of the earth: $M_E = 5.98 \times 10^{24} \text{kg}$

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots$$

$$\ln(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \dots$$

$$\hat{r} = \hat{i} \cos \theta + \hat{j} \sin \theta$$

$$\hat{\theta} = -\hat{i} \sin \theta + \hat{j} \cos \theta$$

$$\vec{A} \times (\vec{B} \times \vec{C}) = (\vec{A} \cdot \vec{C})\vec{B} - (\vec{A} \cdot \vec{B})\vec{C}$$

1. (a) What is the fundamental difference between the unit vectors \hat{r} and $\hat{\theta}$ and the unit vectors \hat{i} and \hat{j} ? [4 marks]
- (b) Show that the expressions for the velocity and acceleration in two dimensional polar coordinates are
 - i. $\vec{v} = \dot{r}\hat{r} + r\dot{\theta}\hat{\theta}$ and [5 marks]
 - ii. $\vec{a} = (\ddot{r} - r\dot{\theta}^2)\hat{r} + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\hat{\theta}$ [3 marks]
- (c) A particle sliding along a radial groove in a rotating turntable has polar coordinates at time t given by

$$r = ct \quad \theta = \Omega t$$

where c and Ω are positive constants.

- i. Find the velocity and acceleration vectors of the particle at time t and find the speed of the particle at time t . [5 marks]
 - ii. Deduce that, for $t > 0$, the angle between the velocity and acceleration vectors is always acute. [3 marks]
2. (a) Can the center of mass of an object be located at a position at which there is no mass? If so, give examples. [3 marks]
- (b) A particle P of unit mass moves on the positive x -axis under the force field

$$F = \frac{36}{x^3} - \frac{9}{x^2} \quad (x > 0)$$

Initially P is projected from the point $x = 4$ with speed 0.5.

- i. Determine the potential energy [3 marks]
 - ii. Show that there is a single equilibrium position (at what position?) for P and show that it is stable. [5 marks]
 - iii. A particle may oscillate about this equilibrium position. The extreme points on the left and right of this equilibrium position are found by substituting the $v = 0$ in the energy equation. Determine the extreme points of the motion of this particle. [6 marks]
 - iv. Find the period(τ) of oscillations about this equilibrium point. [5 marks]

You may make use of the formula

$$\int_a^b \frac{x dx}{\sqrt{(x-a)(b-x)}} = \frac{\pi(a+b)}{2}, \quad \tau = \sqrt{2m} \int_{x(E)}^{x'(E)} \frac{dx}{\sqrt{E - V(x)}}$$

3. (a) Is it possible to calculate the torque acting on a rigid object without specifying an axis of rotation? Is the torque independent of the location of the axis of rotation Explain?... [5 marks]

- (b) If \vec{r} and $\dot{\vec{r}} = \vec{v}$ are both explicit functions of time, show that

$$\frac{d}{dt}(\vec{r} \times (\vec{v} \times \vec{r})) = r^2 \vec{a} + (\vec{r} \cdot \vec{v}) \vec{v} - (v^2 + \vec{r} \cdot \vec{a}) \vec{r}$$

[8 marks]

- (c) Suppose that a tunnel is drilled through our planet along a diameter. Assume that Earth's mass density is uniform and is given by ρ . Describe the force on a point mass m dropped into the hole as a function of the distance of the mass from the center. [7 marks]

4. (a) i. State Newton's law of universal gravitation. [descriptive and mathematical statements are required]. [2 marks]

- ii. The average distance of the earth from the sun is 1.5×10^{11} m. Show that the centre of mass of the sun and earth lies within the volume of the sun (as measured from the sun). [5 marks]

- (b) A particle P of mass m and a uniform rod of length $2a$ and mass M are placed as shown in Figure 1. Find the gravitational force that the rod exerts on the particle. [12 marks]

5. (a) Consider a system of N particles acted upon by external and internal forces obeying the strong form of Newton's third law.

- i. What is meant by "strong form of Newton's third law". Answer descriptively and mathematically. . . . [3 marks]

- ii. Write down the expression for the total force. [1 mark]

- iii. Show that $\frac{d\vec{P}}{dt} = \vec{F}$ where \vec{P} is the total linear momentum of the system of particles and \vec{F} is the total external force acting on the system [3 marks]

- iv. Show that $\frac{d\vec{L}}{dt} = \vec{\tau}$ where $\vec{L} = \Sigma \vec{L}_i$ is total angular momentum of the particles and $\vec{\tau}$ is the total moment of external forces about the origin. [3 marks]

- (b) Consider a projectile fired at angle θ from the origin.
- Write down the expressions for the horizontal and vertical positions of the projectile as a function of time. [2 marks]
 - Write down the position vector \vec{r} . [1 mark]
 - Show directly that the time rate of change of angular momentum about the origin for this projectile is equal to the moment of force (torque) about the origin. [7 marks]
6. (a) Show that the following forces are conservative and find their corresponding potential energy.
- $F_x = ax^3 + bxy^2 + cz$, $F_y = ay^3 + bx^2y$, $F_z = cx$ [4 marks]
 - $F_x = ax^2$, $F_y = ay^2$, $F_z = az^2$ where a, b and c are constants. [3 marks]
- (b) A spherical marble of radius a in a fluid experiences a drag force given by Stokes' law, $\mathbf{R} = -6\pi\eta a\mathbf{v}$, where η is the fluid viscosity and \mathbf{v} is its velocity. Suppose the marble is placed on the ocean surface and let go,
- Write down Newton's second law for the marble. [3 marks]
 - Derive an expression for the terminal speed of the marble in terms of its density ρ_0 , its radius a , the ocean water density ρ_w , the acceleration due to gravity and the viscosity η . [3 marks]
 - Using Newton's second law, derive the expression for the velocity as a function of time. [Hint: Let $\mathbf{R} = -6\pi\eta a\mathbf{v} = k\mathbf{v}$]. [7 marks]
7. (a) A chain of length L and total mass M is released from rest with its lower end just touching the top of a table, as in Figure 2. Find the force exerted by the table on the chain after the chain has fallen through a distance x , as in Figure b. (Assume each link comes to rest the instant it reaches the table.) [10 marks]
- (b) Even though the total force on a system of particles is zero, the net torque may not be zero. Show that the net torque has the same value in any coordinate system. [Hint: Determine the net torques about two different origins, O and O' .] [10 marks]

P251 -University Examinations-2009

Captions

Figure 1: Question 4b

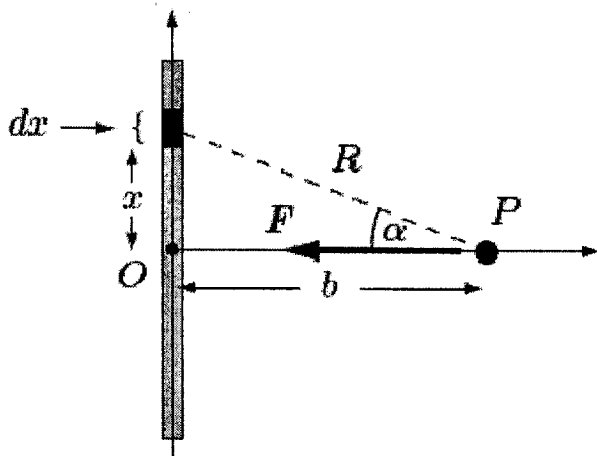
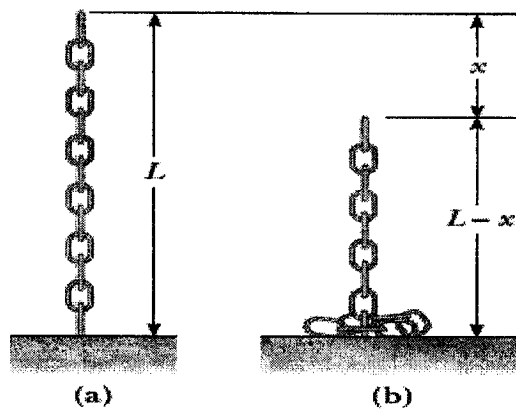


Figure 2: Question 7a



END OF EXAMINATION



The University of Zambia
School of Natural Sciences
Department of Physics
2009 Academic Year First Semester
Final Examinations
P-261: Electricity & Magnetism

Attempt any five questions. All questions carry equal marks. The marks are shown in brackets.

Time: Three hours.

Maximum marks = 100.

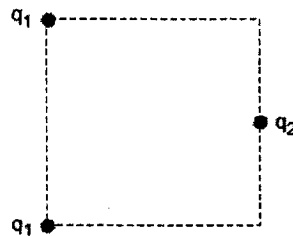
Write clearly your computer number on the answer book.

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Wherever necessary use:

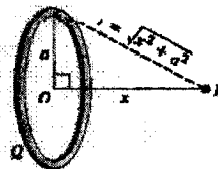
$g = 9.8 \text{ m/s}^2$	$N_{Av.} = 6.02 \times 10^{23} \text{ per mole}$
$e = 1.6 \times 10^{-19} \text{ C}$	$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$
$\mu_0 = 4\pi \times 10^{-7} \text{ Wb/A-m}$	$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N.m}^2$
$m_e = 9.1 \times 10^{-31} \text{ kg}$	$c = 3 \times 10^8 \text{ m/s}$
$B = \mu_0 \frac{i}{2\pi d}, \quad \vec{B} = \mu_0 \frac{i \vec{dl} \sin \theta}{4\pi r^2}$	$k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N.m}^2/\text{C}^2$
$\oint \vec{E} \cdot d\vec{l} = 0, \quad \nabla \cdot \vec{E} = \frac{\rho}{\epsilon_0}, \quad \oint \vec{B} \cdot d\vec{l} = \mu_0 i$	$\vec{F} = \mu_0 \frac{I_1 I_2 l}{2\pi r}, \quad I = I_0(1 - e^{-t/\tau})$
$E_r = -\frac{\partial V}{\partial r}, \quad E_\theta = -\frac{1}{r} \frac{\partial V}{\partial \theta}, \quad E_\phi = \frac{1}{r \sin \theta} \frac{\partial V}{\partial \phi}$	$V = \int \vec{E} \cdot d\vec{r}, \quad \vec{D} = \epsilon \vec{E}$
$\epsilon = \oint \vec{E} \cdot d\vec{l} = -\frac{d\phi}{dt}, \quad i = \frac{V}{R} \left[1 - \exp\left(-\frac{R}{L}t\right) \right]$	$V = L \frac{di}{dt} + ri, \quad R = \rho \frac{L}{A}$
$\oint_{CS} \vec{E} \cdot d\vec{S} = \frac{\int dq}{\epsilon_0}$	$q = q_0 e^{-t/RC}, \quad i = i_0 e^{-tR/L}$

Q1(a) Three charges are arranged on a square as shown; each side has a length a . All three charges are positive. What value of $\frac{q_2}{q_1}$ will produce zero electric field at the centre of the square? [8]



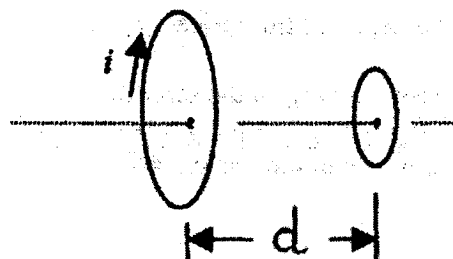
(b) Consider the electric field created by a uniform ring with a uniform charge density of total charge Q and radius a .

- (i) Show that the field at a point P on the ring's axis at a distance x from the plane of the ring is $\frac{1}{4\pi\epsilon_0} \frac{xQ}{(x^2 + a^2)^{3/2}}$. [6]
- (ii) Show that this expression gives $\mathbf{E} = 0$ for $x = 0$ and $\mathbf{E} = \frac{Q}{4\pi\epsilon_0 x^2}$ for x much greater than a . [2]



(c) Two conducting loops face each other a distance d apart. An observer sights along their common axis from left to right. If a clockwise current i is suddenly established in the larger loop:

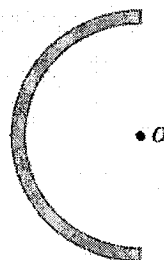
- (i) What is the direction of the induced current in the smaller loop?
- (ii) What is the direction of the force (if any) that acts on the smaller loop? [2+2]



Q2(a) A semi-circular rod is charged uniformly with a total charge of $Q = +7.50 \mu\text{C}$.

Find the electric field intensity at the centre of curvature, and the direction of the field.

[7]



(b) A sphere of radius R carries a charge $+Q$ uniformly distributed in its volume V . If ρ is the volume charge density, find the electric field function

(i) inside the sphere, that is, when $r < R$ and

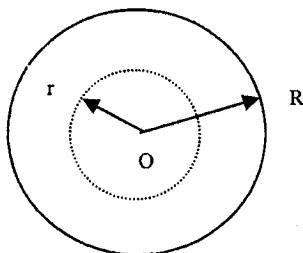
(ii) outside the sphere, that is, when $r > R$.

[Hint: use Gauss's law.]

[6]

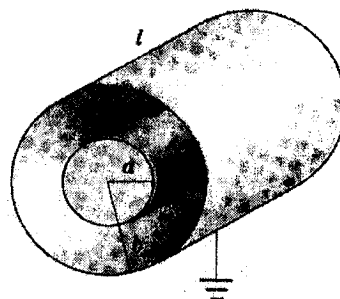
(iii) Find the electric potential at a point $r < R$.

[7]



Q3(a) Find the capacitance of a pair of coaxial metal cylinders of radii a and b and length l as shown.

[6]

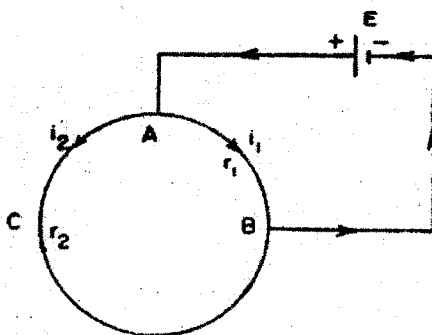


(b) A spherical Gaussian surface surrounds a point charge q . Describe what happens to the total flux through the surface if the

- i. charge is tripled;
- ii. radius of the sphere is doubled;
- iii. surface is changed to a cube, and
- iv. charge is moved to another location inside the surface. [6]

(c) A length of uniform wire of resistance 10Ω is bent into a circle, and two points at a quarter of its circumference apart are connected with a battery of internal resistance 1Ω and e.m.f. 3 volts.

Find the current in different parts of the circuit. [8]

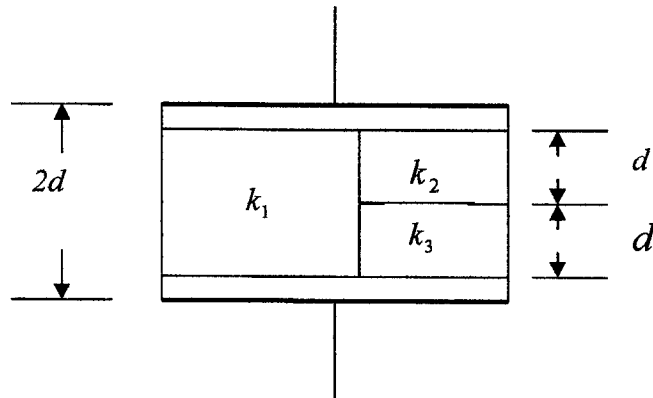


Q4(a) When a dielectric is inserted between the plates of a parallel-plate capacitor, the capacitance is modified. Discuss on molecular level the mechanism responsible for this. [5]

(b) A dielectric slab of thickness $b = 0.50$ cm and dielectric constant $K=7.0$ is placed between the plates of a parallel plate capacitor of area $A = 100$ cm² with plate separation $d = 1.0$ cm. A potential difference $V_0 = 100$ V is applied with no dielectric present. The battery is then removed and a dielectric slab inserted.

- i. Calculate the capacitance C_0 before the slab is inserted.
- ii. Calculate the free charge and the electric field strength in the gap.
- iii. Calculate \mathbf{D} , \mathbf{E} and \mathbf{P} in the dielectric.
- iv. Calculate \mathbf{D} , \mathbf{E} and \mathbf{P} in the air gap. [8]

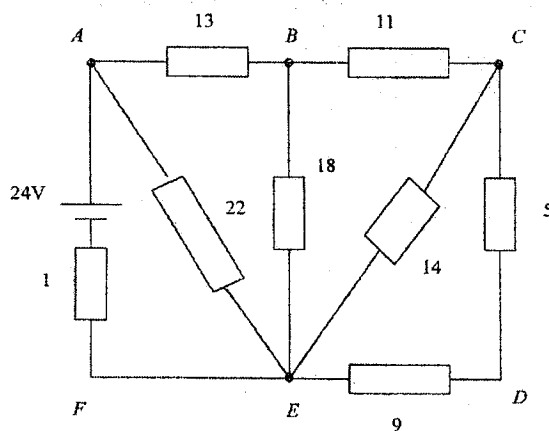
(c) Figure below shows a capacitor assembly filled with materials of dielectric constants k_1, k_2 and k_3 . Calculate the capacitance C of this assembly if A is the area of a plate. [7]



Q5(a) In the circuit given below, all resistances are in ohms.

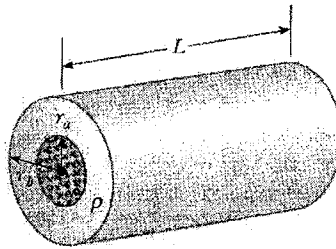
Find: (i) the current flowing in the branch AF , [5]

(ii) the potential difference across the branch CD . [4]



(b) A resistor is constructed by shaping a material of resistivity ρ into a hollow cylinder of length L with inner and outer radii r_a and r_b respectively. When a potential difference is applied between the ends of the cylinder, a current I flows parallel to the axis. See Figure below.

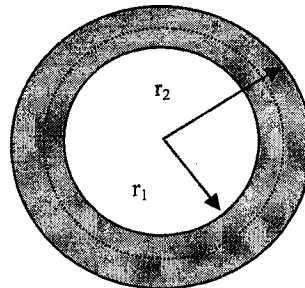
- (i) Find a general expression for the resistance R of this device in terms of R , ρ , r_a and r_b . [3]
- (ii) Show that the material behaves like a solid cylinder of radius r_b when $r_b \gg r_a$. [2]
- (iii) Find a general expression for the resistance of the device in terms of R , ρ , r_a and r_b if a potential difference is applied between the inner and outer surfaces so that the resulting current flows radially outward. [6]



Q6(a) A long straight thick-walled metal tube has inner and outer radii of r_1 and r_2 respectively. A current I flows along it, the current density being the same everywhere within the body of the tube.

Show that the magnetic field inside the body of the tube at a distance r from its axis has the value

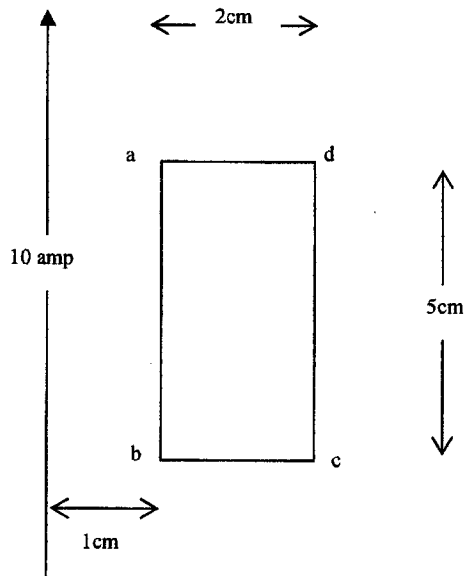
$$B = \frac{\mu_0 I}{2\pi r} \frac{(r^2 - r_1^2)}{(r_2^2 - r_1^2)}. \quad [7]$$



(b) Each of two parallel conducting wires carries a current of 50 A. The force per unit length between the wires is equal to the force of gravitational pull on a wire 1m long. If the mass of 1m of wire is 1g, calculate the distance d between the two parallel wires. [6]

(c) A long wire carries a current of 10 A and a loop carries a current of 5 A around the path $abcd$ clockwise as shown in figure below.

Find the direction and magnitude of the net force on the loop due to the magnetic field of the current in the wire. [7]



Q7(a). Distinguish between *impedance* and *resistance*. [4]

(b) The applied voltage in a circuit is given by $v = v_0 \sin \omega t$. Show that the current i_L passing through a pure inductor L is given by

$$i_L = -\frac{v_0}{\omega L} \cos \omega t .$$

Hence show that the current and the voltage are out of phase by $\frac{\pi}{2}$. [4]

(c) A resistance $R=20\Omega$, an inductance $L=0.2H$, and a capacitance $C=100\mu F$ are connected in series to a 200 V, 50 Hz power supply.

Determine the following:

- (i) Impedance of the circuit
- (ii) Current in the circuit
- (iii) Voltages across R , L , and C . Do they add up to the value of the mains voltage? If not, what must be done to remedy this seeming anomaly?
- (iv) The phase angle between the circuit current and the voltage.

[12]

==End of P-261 2009 Exam==



**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF PHYSICS**

2009 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

P341: ANALOG ELECTRONICS I

TIME: THREE HOURS

MAXIMUM MARKS - 100

**Attempt any four questions.
All questions carry equal marks.
The marks are shown in brackets.**

Q1. (a) Use Thevenin's theorem to find the current through the 5Ω resistor in figure 1. [10]

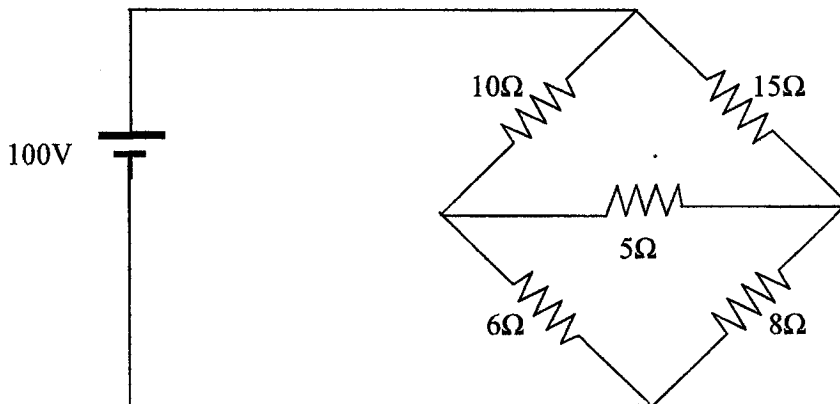


Figure 1

(b) An a.c supply of 230V (rms) is applied to a half wave rectifier circuit through a transformer of turn ratio 10:1. Find the output d.c voltage and the peak inverse voltage. Assume the diode to be real. [5]

(c) Discuss the working of a depletion type MOSFET with suitable figures. [10]

Q2. (a) A series circuit consisting of two pure elements has the following current and voltage.

$$v = 100 \sin (2000t + 50^\circ) \text{ V}$$

$$i = 20 \cos (2000t + 20^\circ) \text{ A}$$

Find the elements in the circuit. [8]

(b) A negative feedback amplifier has the following parameters. $A = 180$, $B = 0.04$, input voltage = 10mV. Compute [6]

- (i) the gain with feedback
- (ii) the output voltage
- (iii) the feedback factor
- (iv) the feedback voltage

(c) Define load regulation. Explain with a figure how a Zener diode maintains constant voltage across the load when the load current changes. [11]

Q3. (a) Derive an expression for the fraction of total power carried by the side bands in amplitude modulation. [15]

(b) In an amplifier, the maximum voltage gain is 2000 and occurs at 2kHz. It falls to 1414 at 10 kHz and 50 Hz. Find [4]

(i) the lower cut off frequency (ii) the upper cut off frequency (iii) the bandwidth

(c) Calculate the current I shown in figure 2 using Millman's theorem. [6]

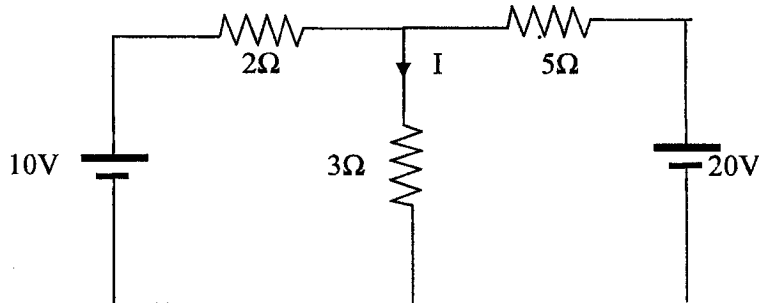


Figure 2

Q4. (a) Determine the maximum power delivered to the load in the circuit shown below. [15]

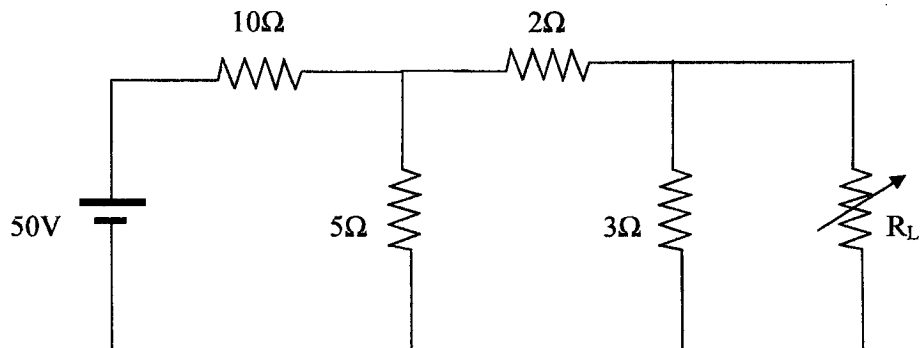


Figure 3

(b) Using appropriate figures discuss the behaviour of a pn junction under forward and reverse biasing. [10]

Q5. (a) For the circuit shown in figure 4, determine the frequency at which the circuit resonates. Also find the voltage across the inductor at resonance and the Q factor of the circuit. [6]

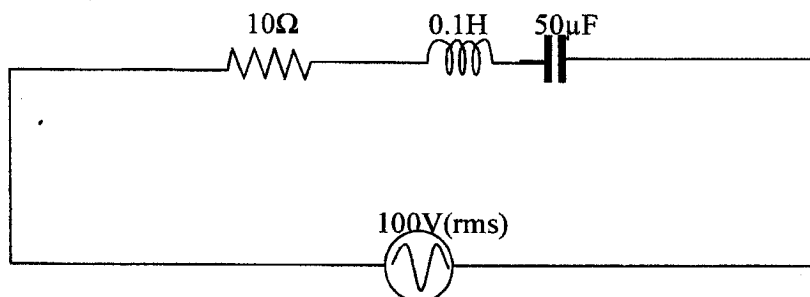


Figure 4

(b) A transistor amplifier is biased with feedback resistor $R_B = 100 \text{ k}\Omega$. If $V_{CC} = 25\text{V}$, $R_C = 1\text{k}\Omega$ and $\beta = 200$, find the values of zero signal I_C and V_{CE} . [8]

(c) Derive an expression for the gain of a negative voltage feedback amplifier. Explain the symbols used. [11]

Q6. (a) Draw the circuit diagram of a transformer coupled transistor amplifier. [7]

(b) The potential divider circuit shown below has the values as follows.

$I_E = 2\text{mA}$, $I_B = 50\mu\text{A}$, $V_{BE} = 0.2\text{V}$, $R_E = 1\text{k}\Omega$, $R_2 = 10\text{k}\Omega$ and $V_{CC} = 10\text{V}$.

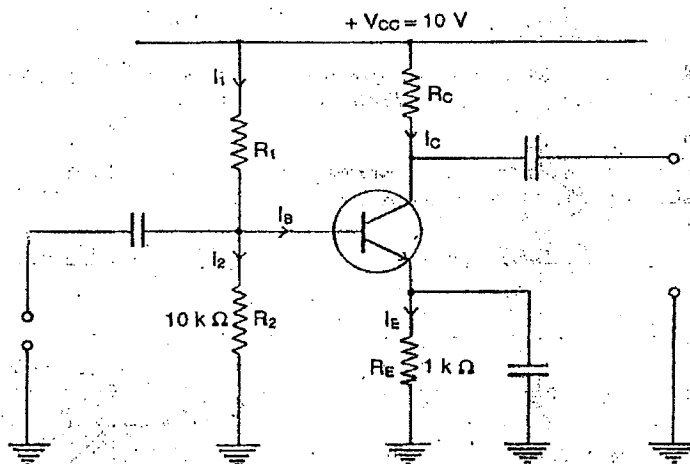


Figure 5

Find the value of R_1 . [6]

(c) Write short notes on [12]

- (i) . Norton's theorem
- (ii) Bandstop filter
- (iii) Ripple factor
- (iv) Operating point

END OF P341 EXAMINATION

UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS
FIRST SEMESTER 2009/2010

P351
INTRODUCTION TO QUANTUM MECHANICS

Time: Three hours

Answer any four questions

All questions carry equal marks

Total marks: 100

1. (a) The kinetic energy operator ~~is operator~~ is defined by

$$\hat{T} = -\frac{\hbar^2}{2m} \frac{d^2}{dx^2}$$

- (i) Show that it is linear. [2marks]
(ii) Show that it is Hermitian. [5marks]
(iii) Explain why it is necessarily Hermitian. [2marks]

Remember that the functions on which it acts vanish at $x = \pm\infty$.

Recall also that for a Hermitian operator:

$$\int \psi^* \hat{A} \phi d\tau = \int (\hat{A} \psi)^* \phi d\tau$$

- (b) (i) Explain the probability interpretation of the wave function and hence justify the procedure of normalisation. [3marks]

- (ii) Derive the time-independent Schroedinger equation from the time-dependent Schroedinger equation. [6marks]

- (c) (i) Define what is meant by orthogonality and degeneracy of eigenfunctions. [2marks]

- (ii) Assuming a non-degenerate spectrum, show that the eigenfunctions corresponding to different eigenvalues of a Hermitian operator are orthogonal. [5marks]

2. (a) A particle of mass m is confined within a box with impenetrable walls of lengths L_x , L_y and L_z such that $0 \leq x \leq L_x$, $0 \leq y \leq L_y$ and $0 \leq z \leq L_z$.

(i) Write down the time-independent Schroedinger equation for the particle. [2marks]

(ii) Show that the time-independent Schroedinger equation for the particle is equivalent to the three equations

$$-\frac{\hbar^2}{2m} \frac{d^2}{dx_i^2} \psi_i(x_i) + V(x_i) \psi_i(x_i) = E_i \psi_i(x_i), \quad x_1 = x, x_2 = y, x_3 = z$$

[4marks]

(iii) Show that the normalised eigenfunctions of the particle are

$$\psi_{n_1 n_2 n_3}(x, y, z) = \frac{2^{3/2}}{\sqrt{L_x L_y L_z}} \sin \frac{n_1 \pi x}{L_x} \sin \frac{n_2 \pi y}{L_y} \sin \frac{n_3 \pi z}{L_z}$$

[12marks]

(iv) Show that the allowed energies are

$$E_{n_1 n_2 n_3} = \frac{\pi^2 \hbar^2}{2m} \left(\frac{n_1^2}{L_x^2} + \frac{n_2^2}{L_y^2} + \frac{n_3^2}{L_z^2} \right)$$

[4marks]

(v) If in fact $L_x = L_y = L$ and $L_z = L/2$, deduce the degeneracies of the two lowest energy levels. [3marks]

3.(a) A particle of mass m is incident from the right on a potential of the form

$$\begin{aligned} V(x) &= 0, \quad x \leq 0 \\ &= V_1, \quad 0 \leq x \leq a \\ &= V_2, \quad x \geq a \end{aligned}$$

The energy of the particle is such that $E > V_2$ and $V_2 > V_1$.

(i) Sketch the potential. [2marks]

(ii) Show that moving leftwards, the wave function in the region $x > a$ is

$$\psi_I = Ae^{-ik_1 x} + Be^{ik_1 x}$$

and identify the terms. Give the expression for k_1 . [7marks]

(iii) Show that the wave function in the region $0 \leq x \leq a$ is

$$\psi_{II} = Ce^{ik_2 x} + De^{-ik_2 x}$$

and identify the terms. Give the expression for k_2 . [5 marks]

(iv) Show that the wave function in the region $x < 0$ is

$$\psi_{III} = Ge^{-ik_3x}$$

and identify the term. Give the expression for k_3 . [3marks]

(v) Obtain expressions for the reflection and transmission coefficients in terms of the constants of integration. [4marks]

(vi) Write down and justify the equations that would be used to determine the constants of integration in terms of one of those constants. [4marks]

Recall that:

$$j = \frac{\hbar}{2mi}(\psi^* \frac{\partial}{\partial x} \psi - \psi \frac{\partial}{\partial x} \psi^*)$$

4. (b) The time-independent Schroedinger equation for the one-dimensional harmonic oscillator

$$-\frac{\hbar^2}{2m} \frac{d^2}{dx^2} \psi(x) + \frac{1}{2} kx^2 \psi(x) = E\psi(x)$$

can be cast in the form

$$\frac{d^2}{dx^2} \psi(\xi) + (\lambda - \xi^2) \psi(\xi) = 0$$

with the aid of the substitutions $\xi = \sqrt{m\omega/\hbar} x$ and $\lambda = 2E/\hbar\omega$. This equation has the solution

$$\psi(\xi) = e^{-\xi^2/2} H(\xi), \quad \text{with} \quad H(\xi) = \sum_{j=0}^{\infty} a_j^j \xi^j.$$

If the coefficients of the powers of ξ satisfy the recursion relation

$$a_{j+2} = \frac{2j+1-\lambda}{(j+2)(j+1)} a_j$$

(i) Explain the boundary conditions that $\psi(\xi)$ must satisfy. [2marks]

(ii) Deduce that the allowed energy values of the harmonic oscillator are given by

$$E_n = (n + \frac{1}{2})\hbar\omega, \quad n = 0, 1, 2, \dots$$

[6marks]

(b) (i) Prove that the wave function of a free particle moving to the right is

$$\Psi(x, t) = Ae^{ikx}e^{-i\omega t}$$

where A is a normalisation constant and

$$k = \sqrt{\frac{2m}{\hbar^2}E}$$

(ii) Why is the energy not quantised?

[6marks]

[2marks]

(c) The normalised wave function of a certain system is

$$\psi(x) = \sum c_n \phi_n(x)$$

where $\phi_n(x)$ are the orthonormal non-degenerate solutions of the time-independent Schroedinger equation of the system.

(i) Obtain the expectation value of the energy of the system. [4marks]

(ii) Use the result above to interpret the expansion coefficients c_n . [2marks]

(iii) Obtain an expression for c_n [3marks]

Q 5. (a)(i) Obtain the components in Cartesian coordinates of the angular momentum operator

$$\hat{\mathbf{L}} = -i\hbar \mathbf{r} \times \nabla$$

[3marks]

(ii) Prove that $[\hat{L}_x, \hat{L}_y] = i\hbar \hat{L}_z$ [6marks]

(iii) Show that $[\hat{L}^2, \hat{L}_z] = 0$. [4marks]

(iv) Explain the significance of the results in parts (i) and (ii). [2marks]

You may need:

$$[AB, C] = A[B, C] + [A, C]B$$

(b) The Hamiltonian of a particle is given by

$$\hat{H} = a\hat{L}^2 - b\hat{L}_z$$

where a and b are constants and \hat{L}^2 and \hat{L}_z are the angular momentum operators.

(i) Write down the time-independent Schroedinger equation for the particle and explain why the eigenfunctions of the particle must be the spherical harmonics $Y_{lm}(\theta, \phi)$. [2marks]

(ii) Obtain the eigenvalues of this particle. [4marks]

(iii) Determine if the eigenvalues are degenerate. [2marks]

(iv) Deduce the ground-state energy of the particle. [2marks]

6. A certain hydrogen atom has the wave function

$$\psi = Bre^{-r/2a_0} \cos \theta$$

where B is a constant and

$$a_0 = \frac{4\pi\epsilon_0\hbar^2}{\mu e^2}$$

is the Bohr radius.

(i) Calculate the normalisation constant B . [6marks]

(ii) Obtain the values of the z component of the angular momentum, the square of the angular momentum and the energy of the system in that order. [17marks]

(iii) Hence specify the quantum numbers of this state. [2marks]

For the hydrogen atom the Hamiltonian is:

$$\hat{H} = -\frac{\hbar^2}{2\mu} \frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial}{\partial r} \right) + \frac{\mathbf{L}^2}{2\mu r^2} - \frac{e^2}{4\pi\epsilon_0 r},$$

The angular momentum operators are:

$$\hat{\mathbf{L}}^2 = -\hbar^2 \left[\frac{1}{\sin \theta} \frac{\partial}{\partial \theta} \left(\sin \theta \frac{\partial}{\partial \theta} \right) + \frac{1}{\sin^2 \theta} \frac{\partial^2}{\partial \phi^2} \right],$$

$$L_z = -i\hbar \frac{\partial}{\partial \phi}$$

Note that:

$$dV = r^2 \sin \theta dr d\theta d\phi$$

and

$$\int_0^\infty x^n e^{-\mu x} dx = n! \mu^{-n-1}$$

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS
FIRST SEMESTER 2009
P361
ELECTROMAGNETIC THEORY

Time: Three Hours

Answer Any Four questions

All Questions Carry Equal marks

Total Marks: 100

Divergence theorem: $\oint_S \mathbf{A} \cdot d\mathbf{a} = \int_V \nabla \cdot \mathbf{A} d\tau$

$$\nabla \times \nabla \times \mathbf{A} = \nabla(\nabla \cdot \mathbf{A}) - \nabla^2 \mathbf{A}$$

$$\nabla' \left(\frac{1}{R} \right) = \frac{\hat{\mathbf{R}}}{R^2}, \quad \nabla \left(\frac{1}{R} \right) = -\frac{\hat{\mathbf{R}}}{R^2}$$

$$\nabla \times (u\mathbf{A}) = (\nabla u) \times \mathbf{A} + u(\nabla \times \mathbf{A})$$

$$\nabla \cdot (u\mathbf{A}) = \mathbf{A} \cdot \nabla u + u \nabla \cdot \mathbf{A}$$

In spherical polar coordinates: $\nabla \cdot \mathbf{A} = \frac{2}{r} A_r + \frac{\partial A_r}{\partial r} + \frac{A_\theta}{r} \cot \theta + \frac{1}{r} \frac{\partial A_\theta}{\partial \theta} + \frac{1}{r^2 \sin^2 \theta} \frac{\partial^2 A_\phi}{\partial \phi^2}$

$$\int \frac{dx}{\sqrt{x^2 + a^2}} = \ln \left| \sqrt{x^2 + a^2} + x \right| + C$$

The Biot-Savart law: $d\mathbf{B} = \frac{\mu_0}{4\pi} \frac{Id\mathbf{l} \times \hat{\mathbf{R}}}{R^2}$

Gauss's law: $\oint_S \mathbf{E} \cdot d\mathbf{a} = \sum Q / \epsilon_0$

For a dipole: $dV = \frac{d\mathbf{p} \cdot \hat{\mathbf{R}}}{4\pi\epsilon_0 R^2}$

Dipole moment of a charge distribution: $\mathbf{p} = \int \mathbf{r} \rho(\mathbf{r}') d\tau'$

Permeability of vacuum: $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$

Permittivity of free space: $\epsilon_0 = 8.854 \times 10^{-12} \text{ F/m}$

Q1. A sphere of radius b has a concentric spherical cavity of radius a inside. The shell between $r = a$ and $r = b$ has a charge Q uniformly distributed over its volume.

(i) Show that the electric field intensity is

$$\mathbf{E} = \begin{cases} 0, & r < a \\ \frac{Q(r^3 - a^3)}{4\pi\epsilon_0 r^2 (b^3 - a^3)} \hat{\mathbf{r}}, & a \leq r \leq b \\ \frac{Q}{4\pi\epsilon_0 r^2} \hat{\mathbf{r}}, & r > b \end{cases}$$

[10marks]

(ii) Show that the absolute potential at a point r from the centre of the sphere is

$$V = \begin{cases} \frac{3Q(b^2 - a^2)}{8\pi\epsilon_0(b^3 - a^3)}, & r < a \\ \frac{Q}{4\pi\epsilon_0 b} - \frac{Q}{4\pi\epsilon_0(b^3 - a^3)} \left[\frac{r^2}{2} - \frac{b^2}{2} + \frac{a^3}{r} - \frac{a^3}{b} \right], & a \leq r \leq b \\ \frac{Q}{4\pi\epsilon_0 r}, & r > b \end{cases}$$

Note that another form for V in the region $a \leq r \leq b$ is

$$V = \frac{Q(r^3 - a^3)}{4\pi\epsilon_0(b^3 - a^3)r} + \frac{3Q(b^2 - r^2)}{8\pi\epsilon_0(b^3 - a^3)}$$

[15marks]

Q2. (a) (i) Describe what is meant by an electric dipole. [2marks]

(ii) Explain the importance of multipoles in electrostatics. [3marks]

(b) (i) Explain what polarization is. [2marks]

(ii) Find the dipole moment of a sphere of radius a which has a charge distribution

$$\rho = \rho_0 r \cos \theta$$

where ρ_0 is a constant. [8marks]

(c) (i) Show that Gauss's law

$$\oint \mathbf{E} \cdot d\mathbf{a} = \sum Q/\epsilon_0$$

leads to Poisson's equation

$$\nabla^2 V = -\rho/\epsilon_0$$

[8marks]

(ii) Use Gauss' law to show why in an electrostatic situation the charge given to a conductor resides entirely on the surfaces and explain why the electric field is perpendicular to the surfaces. [4marks]

Q3. (a) State Ampere's circuital law. [2marks]

(b) (i) Use Ampere's circuital law to find an expression for the magnetic induction \mathbf{B} at a point P inside and outside a cylindrical wire of radius R uniformly carrying a current I . [8marks]

(ii) Show that the expressions for \mathbf{B} inside and outside agree at the surface of the wire. [2marks]

(c) (i) Use the Biot-Savart law

$$\mathbf{B} = \frac{\mu_0}{4\pi} \int \frac{Id\mathbf{l} \times \hat{\mathbf{R}}}{R^2}$$

to show that the vector potential of a magnetic circuit is

$$\mathbf{A} = \frac{\mu_0}{4\pi} \oint \frac{Id\mathbf{l}}{R}$$

[9marks]

(ii) Hence show that the vector potential of a wire of length $2L$ carrying current I is

$$\mathbf{A} = \hat{\mathbf{u}} \frac{\mu_0 I}{4\pi} \ln \left[\frac{\sqrt{L^2 + \rho^2} + L}{\sqrt{L^2 + \rho^2} - L} \right]$$

where $\hat{\mathbf{u}}$ is a unit vector in the direction of the current and ρ is the perpendicular distance from the field point to the midpoint of the wire. [4marks]

Q4. (a) (i) Show that the magnetic induction of a loop of wire of radius a a distance x along its axis is

$$B = \frac{\mu_0}{2\pi} \frac{Ia^2}{(x^2 + a^2)^{3/2}}$$

[7marks]

(ii) Hence obtain the magnetic induction at the centre of the loop on the one hand, and at a long distance from it on the other. [2marks]

(b) (i) Define Faraday's law of electromagnetic induction. [2marks]

(ii) Explain when mutual inductance features in the definition of the induced electromotive force. [3marks]

(c) (i) Using Ampere's circuital law or otherwise, show that the magnetic induction of a solenoid of length L and N turns is

$$B = \mu_0 \frac{N}{L} I$$

[6marks]

(ii) Hence or otherwise, show that the mutual inductance of two long coaxial solenoids of nearly the same radius R , of lengths L_a and L_b ($L_a > L_b$), cross-sectional area A and total number of turns N_a and N_b respectively is

$$M = \frac{\mu_0 N_a N_b A}{L_b}$$

[5marks]

Q5. Show that the total potential energy of a charge distribution $\rho(\mathbf{r})$ is

$$W = \frac{1}{2} \int V(\mathbf{r}) \rho(\mathbf{r}) d\tau$$

[7marks]

(b) Show that a polarized dielectric behaves as if it has volume bound charges and surface bound charges with respective charge densities

$$\sigma_b = \mathbf{P} \cdot \mathbf{n}$$

and

$$\rho_b = -\nabla \cdot \mathbf{P}$$

[10marks]

(c) A sphere has a polarization $\mathbf{P} = kr\hat{\mathbf{r}}$, $\hat{\mathbf{r}}$ being the radial unit vector.

(i) Calculate the volume and surface density of bound charge.

[4marks]

(ii) Calculate the sum of the total surface and volume bound charge and so determine the potential outside the sphere.

[5marks]

Q6. (a) (i) Give a plausible explanation for the appearance of magnetization currents in a substance that is placed in a magnetic field.

[3marks]

(ii) Given that the magnetization current density is given by

$$\mathbf{J}_M = \nabla \times \mathbf{M}$$

show that Ampere's circuital law leads to

$$\nabla \times \mathbf{H} = \mathbf{J}_c$$

[5marks]

(b) Given the original equations of electromagnetism

$$\begin{aligned}\nabla \cdot \mathbf{D} &= \rho_c \\ \nabla \times \mathbf{E} &= -\frac{\partial \mathbf{B}}{\partial t} \\ \nabla \cdot \mathbf{B} &= 0 \\ \nabla \times \mathbf{H} &= \mathbf{J}_c \\ \nabla \cdot \mathbf{J}_c &= -\frac{\partial \rho_c}{\partial t}\end{aligned}$$

justify the modification that Maxwell made to them.

[5marks]

(c) (i) Write down Maxwell's equations in vacuo in terms of the \mathbf{E} and \mathbf{B} vectors.

[2marks]

(ii) Show that in vacuum both the \mathbf{E} and \mathbf{B} vectors satisfy the general wave equation and calculate the velocity of the waves described by these equations.

[10marks]

*****END OF EXAMINATION*****



The University of Zambia

Department of Physics

University Examination-2009

P401

(Computational Physics-II)

Instructions

Max. Marks 100

- Time allowed: Three (3) Hours.
- All questions carry equal marks.
- Marks for each question are shown in the square brackets [].
- Answer
 - i) Question one (1).
 - ii) Any three (3) questions from 2, 3, 4, 5 and 6.

Q.1 A. Identify the errors, if any, in the following program segments:

[10]

- i)

```
char school[16];  
strcpy(school, 'Natural Sciences');
```
- ii)

```
char name[6];  
name='Brooks';
```
- iii)

```
float Temp[56][12];  
int i,j;  
for(i=0;i<12;i++)  
{  
    for(j=0;j<56;j++)  
    {  
        Temp[i][j]=-99.0;  
    }  
}
```
- iv)

```
int i, n=3;  
for(i=0;i<12;i++)  
{  
    switch(i)  
    {  
        case n:  
            printf("n is %d", i);  
    }  
}
```
- v)

```
FILE *fp;  
char title[5]={'P','r','o','f',0};  
fp=fopen("file.dat","w");  
fprintf(fp, "TITLE NAME SURNAME \n");  
close(fp);  
fprintf(fp, "%s", title);
```

B. Explain the difference between;

[10]

- i) The **switch ...case** and the **if ...else if** constructs.
- ii) The **break** and **continue** statements when used in a **while** loop.
- iii) **Interpolation** and fitting the data by the **Least-squares** method.
- iv) The **Discrete Fourier Transform** and the **Fourier Transform**.
- v) The **Fermi-Dirac** and the **Bose-Einstein** distributions.

C. Given a matrix

[5]

$$\begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix}$$

write a set of statements so as to replace all, except diagonal, elements by zeros i.e diagonalize the matrix.

- Q.2** Consider a two dimensional lattice with 200 lattice points along the x -direction and 40 lattice points along the y -direction forming a set of square lattices each of unit length. The total number of lattice points is 200×40 . Assume that all the lattice points of $(x, y = 20)$ and $(x, y = -20)$ for all x have a reflecting property. That is, if a walker reaches $y = 20$ the next step is towards south or if the walker reaches $y = -20$, the next step is towards north. Here assume the Y -direction to be north-south. [25]

Write a program to find the mean displacement of a walker taking 100 steps in 50 trails starting from $x = 0, y = 0$.

Note: Assume that you have a function, `randint(4)`, which generates an integer random number between 1 and 4, inclusive. You are therefore free to choose a number 1-4 to represent a particular direction i.e +Y, -Y, +X and -X.

- Q.3** A. Describe the Monte-Carlo Hit-or-Miss method of calculating a finite integral. [10]
- B. Write a program using the Monte-Carlo Hit-or-Miss method to evaluate the following integral which corresponds to a potential V at any point (x_0, y_0) of a charged thin wire along the X -direction which extends from $x = -a$ to $x = a$. [15]

$$V(x_0, y_0) = \int_{-a}^{+a} \frac{\lambda(x)}{[(x - x_0)^2 + y_0^2]^{\frac{1}{2}}} dx \quad \lambda(x) = \sin(k\pi x)$$

where .

$$a = 0.5mm, \quad k = 0.5mm^{-1}, \quad x_0 = 15mm, \quad y_0 = 10mm$$

Assume that a random number generator, `frandom(min,max)`, that generates real random numbers between `min` and `max` is given.

- Q.4 A. Assume that we have a physical quantity that is a function of time and we measure the time in increments Δt . We then define the **Discrete Fourier Transform** (DFT) as [10]

$$g(n\Delta\omega) = \sum_{m=0}^{N-1} f(m\Delta t) e^{-i2\pi mn/N}$$

where $\Delta\omega = \frac{2\pi}{T}$, T is the period.

Explain

- i) The problem one would encounter if one were to evaluate all the $g(n\Delta\omega)$ using the above formula as N increases.
 - ii) How the Fast Fourier Transform (FFT) algorithm reduces the number of operations required in the above calculation.
- B. Suppose you are given a file, `temperature.dat`, containing monthly temperature data for the period 1920 to 2000 in a single column. Write a program that will read this data, calculate the mean for each month and print the result to an output file `climatology.dat`. The output should be written in two columns, the first column should be headed as `Month` and the second as `Temperature`. The month and its corresponding long-term mean temperature should be printed in their respective columns. [15]

- Q.5 A. Give short answers to the following; [10]

- i) What is the difference between the co-variance and correlation coefficient of two random variables?
- ii) What does a positive co-variance indicate?
- iii) What does a negative co-variance indicate?
- iv) What does a zero co-variance indicate?

- B. The co-variance of two random variables X and Y with sample size N is explicitly defined as [15]

$$\text{Cov}(X, Y) = \sum_{i=1}^N \frac{(x_i - \bar{x})(y_i - \bar{y})}{N - 1}.$$

Write a function subprogram that will calculate the co-variance of any two random variables, X and Y of type float and sample size N . Pass array arguments to the function by reference i.e. $*X$ and $*Y$.

Q.6 The total energy radiated per second R , from a hot object for different temperatures is given in the following table.

[25]

$T(^{\circ}K)$	300.0	350.0	400.0	500.0	550.0
$R(J)$	40.0	430.0	1050.0	3150.0	4750.0

Write a program to:

- i) read the data from the default device and write it to an input file with the name `power.dat`;
- ii) find the Lagrange Polynomial $P(x)$ of degree 4 fitting the data;
- iii) use the polynomial to predict R at the temperatures 450, 530 and 600.

$$P(x) = \sum_{k=0}^n f(x_k) L_{n,k}(x)$$

where

$$L_{n,k}(x) = \prod_{i=0, i \neq k}^n \left(\frac{x - x_i}{x_k - x_i} \right) = \frac{(x - x_0)(x - x_1) \dots (x - x_{k-1})(x - x_{k+1}) \dots (x - x_n)}{(x_k - x_0)(x_k - x_1) \dots (x_k - x_{k-1})(x_k - x_{k+1}) \dots (x_k - x_n)}$$

***** End of Examination *****



The University of Zambia
School of Natural Sciences
Department of Physics
2009 Academic Year First Semester
Final Examinations
P-411: Nuclear Experimental Techniques

Attempt any four questions. All questions carry equal marks. The marks are shown in brackets.

Time: Three hours.

Maximum marks = 100.

Write clearly your computer number on the answer book.

=====

Wherever necessary use:

$g =$	9.8 m/s^2
charge of an electron =	$1.6 \times 10^{-19} \text{ C}$
1 barn =	10^{-24} cm^2
mass of an electron =	$9.1 \times 10^{-31} \text{ kg}$
1 eV =	$1.6 \times 10^{-19} \text{ J}$
1 a.m.u. =	$931.5 \text{ MeV} = 1.66 \times 10^{-27} \text{ kg}$
$N_{Av.} =$	$6.02 \times 10^{23} \text{ per mole}$
1 curie =	$3.7 \times 10^{10} \text{ disintegrations/s}$
Planck's constant $h =$	$6.63 \times 10^{-34} \text{ J.s}$

$$\mu_a = \mu / N = \frac{\mu A}{\rho N_A}$$

Some equations you may find useful:

$$h\nu' = \frac{h\nu}{1 + \frac{h\nu}{m_0 c^2} (1 - \cos \theta)}$$

$$\Omega = \frac{\pi a^2}{d^2}$$

$$N = N_0 e^{-\Sigma_t x} \quad m = \frac{n}{1 + n\tau}$$

$$\mu_m = \frac{\mu}{\rho} = \frac{\sigma N}{\rho} = \frac{N_A \sigma}{\text{atomic mass}}$$

$$n - m = n m \tau$$

$$E_r = \frac{V_0}{r \ln(b/a)}$$

Q1(a) One gram of natural potassium emits 29 beta particles per second due to the decay of ^{40}K (abundance ratio of 0.012 atom percent). Gamma rays are also emitted, and the ratio of gamma:beta = 0.12. The gamma rays follow electron capture in ^{40}K , and one photon is emitted for each orbital electron capture.

What is the half-life of ^{40}K ?

[7]

(b) Neutrons are not charged; how are then they detected? Give some details. Write down three nuclear reactions employed in neutron detection, clearly explaining the meaning of all symbols used.

[10]

(c) Draw a block diagram of the basic components of a scintillation spectrometer. Explain briefly the function of each component.

[8]

Q2(a) The nuclide $^{64}_{29}\text{Cu}$ decays by electron emission, electron capture, and positron emission with relative intensities of 39%, 42%, and 19% respectively. The half-life of $^{64}_{29}\text{Cu}$ is 12.8 hours.

[10]

(i) Write down a nuclear equation for each of the above processes.

(ii) Calculate the partial disintegration constants and $T_{1/2}$ for each mode of decay.

(b) A gold foil 0.02cm thick and 1cm^2 in cross section is irradiated for 1 hour in a nuclear reactor. The thermal neutron flux is $10^{12} \text{ n}/(\text{cm}^2.\text{s})$. ^{197}Au has a density of $19.3 \text{ g}/\text{cm}^3$; its thermal neutron absorption cross section is 98.7 barns. ^{198}Au has a half-life of 2.7 days.

[8]

(i) What is the activity of the foil on being removed from the reactor?

(ii) If the activity of the foil is measured 60 days after the irradiation, with a counter of overall efficiency 1%, what is the counting rate?

(c) Name and explain the three processes which can lead to the emission of visible light in a material following the absorption of energy.

[6]

Which process is used in a scintillator?

[1]

Q3(a) The total absorption coefficient for 5 MeV photons in lead is about $0.04 \text{ cm}^2/\text{g}$.

- (i) If the density of lead is taken as 11.3 g/cm^3 , what is the *half-thickness* of lead for these gamma rays? [5]
- (ii) What thickness of lead would be required to reduce the intensity of such photons to 0.06 of the initial value? [6]

(b) Gamma rays of energy 3.5 MeV are incident on an "intermediate" sized *NaI(Tl)* detector.

(i) Draw the idealized response function; explain its various features. [3]

(ii) Describe how the various regions of the spectrum are related to the three well-known interaction processes of gamma rays with matter. [5]

(iii) For each process, sketch the variation of the interaction cross section with the gamma ray energy E_γ and the atomic number Z of the material. [6]

Q4(a) (i) Describe the principal types of interaction through which swift charged particles such as electrons lose their kinetic energy when they traverse through matter. [4]

(ii) Distinguish between ionizing and radiative processes in the collision of fast electrons with matter. [4]

(iii) Indicate how the importance of each process depends on the electron energy and the Z of the absorber. [8]

(b) A ^{137}Cs source emitting 0.662 MeV rays is placed in front of a 5cm x 5cm *NaI(Tl)* detector. ^{137}Cs emits a 0.662 MeV gamma ray in 92% of its decays. The source-to-detector distance is 25cm. The activity of the source is 1 micro-curie. [9]

- (i) If the number of counts in the *photopeak* for a 2-minute counting period is 13,000, calculate the *intrinsic photopeak efficiency* of the detector.

- (ii) Calculate also the *absolute efficiency* of the detector if the number of counts *outside* the photopeak for the same counting period is 20,000.

Q5(a) Counters *A* and *B* are *non-paralyzable* with dead time of $30\mu\text{s}$ and $100\mu\text{s}$ respectively. At what true count rate will dead time losses in counter *B* be twice as great as those of counter *A*? [8]

(b) (i) Draw the differential pulse-height spectrum and the corresponding *counting curve* for a mixed alpha-beta source of typical energies for a proportional counter; explain these curves. [9]

(ii) Explain and show how these curves would change if instead of a proportional counter a Geiger-Muller counter is used. [2]

(c) Describe the main differences between a *non-paralyzable* and a *paralyzable* counting system. Draw figures if necessary. [6]

Q6(a) Describe and contrast the current and pulse modes of detector operation stating the circumstances when they are used. [7]

(b) An alpha particle of energy 9 MeV loses all its energy in a proportional counter. One electron-ion pair is produced for each 30eV of energy loss. The proportional counter has a multiplication factor $M = 600$, and the total capacitance between the anode and the ground is 35pF. What is the voltage of the output pulse? [6]

(c) Describe a thermoluminescence detector (TLD), and explain how it functions. Contrast this with the functioning of an ordinary inorganic scintillator. [6+2]

Name and explain two desirable properties of TLD materials. [2+2]

==End of P-411 2009 Exam==

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS
FIRST SEMESTER EXAMINATION 2009

P421: SOLID STATE PHYSICS I

TIME: 3 HOURS
INSTRUCTIONS: ANSWER ANY **FOUR** QUESTIONS
TOTAL MARKS 100
ALL QUESTIONS CARRY EQUAL MARKS

Electron charge $e = 1.602 \times 10^{-19}$ coulombs

Electron rest mass $m_e = 9.11 \times 10^{-31}$ kg

Proton rest mass $m_p = 1.67 \times 10^{-27}$ kg

1 atomic mass unit $= 1.6605 \times 10^{-27}$ kg

Planck's constant $h = 6.626 \times 10^{-34}$ Js⁻¹

Boltzmann constant $k_B = 1.38 \times 10^{-23}$ JK⁻¹

Avogadro's number $N = 6.022 \times 10^{23}$ per g mole

Permittivity of free space $\epsilon_0 = 8.854 \times 10^{-12}$ F/m

$$f(\epsilon) = \frac{1}{e^{\frac{\epsilon - \epsilon_F}{k_B T}} + 1} \text{ at low temperatures}$$

$$\int_{-\infty}^{\infty} \frac{x^2 e^x}{(e^x + 1)^2} dx = \frac{\pi^2}{3}$$

- Q.1. (a) What is the minimum condition for diffraction of incident radiation of wave length λ at an angle θ from the (hkl) planes in a crystal? Derive this condition. [6]
- (b) Give a mathematical proof that a five-fold axis of rotational symmetry cannot exist in a crystal lattice. [6]
- (c) Consider an infinite square (2-D) ionic lattice, with each ion having all four nearest neighbours of the opposite sign. Determine the Madelung constant up to the **sixth** nearest neighbour contribution. [7]
- (d) To what plane of the direct cubic lattice is $G_{100} \times G_{111}$ perpendicular? [6]

- Q.2. (a) The cohesive energy of inert gas crystals is frequently approximated by the Lennard-Jones (L-J) potential

$$U = 2N\varepsilon \left(\frac{\sigma}{R} \right)^6 \left\{ \left(\frac{\sigma}{R} \right)^{12} S_{12} - S_6 \right\}$$

where R is the atomic nearest neighbour separation, $S_{12} = 12.13$ and $S_6 = 14.45$ are the structural summation constants while ε and σ are the L-J parameters. Find an expression for the equilibrium value of U . [6]

- (b) Calculate the crystal binding energy per mole of argon for which $\varepsilon = 1.67 \times 10^{-21} \text{ J}$ taking into account a 10% reduction in the energy. [6]
- (c) Consider a line of $2Z$ ions of alternating charge $\pm q$ with a repulsive potential energy λ/R^n between nearest neighbours. The potential energy is

$$U(R) = N \left(\frac{A}{R^n} - \alpha \frac{q^2}{R} \right).$$

Let the crystal be compressed from the equilibrium position so that $R_0 \rightarrow R_0(1 - \delta)$. By expanding $U(R_0 - R_0\delta)$ into a Taylor series with only two terms, show that the change in potential energy will be

$$\Delta U = \frac{1}{2} N(n-1)q^2\alpha\delta^2. \quad [13]$$

Q.3. (a) Assume that the energy of two particles in the field of each other is given by

$$U(r) = -\frac{\alpha}{r} + \frac{\beta}{r^8} \quad \text{where } \alpha, \text{ and } \beta \text{ are constants and } r \text{ is the distance between the centers of the particles. Show that in the stable configuration, the total energy is 8 times lower than the energy of repulsion.} \quad [6]$$

(b) For a monatomic one-dimensional lattice, consider an atom at the equilibrium position na where a is the lattice constant. The displacement from equilibrium is $u(na)$. Without making the assumption that only nearest neighbours interact the potential energy is given by

$$U = \sum_n \sum_{m>0} \frac{1}{2} K_m [u(na) - u([n+m]a)]^2.$$

(i) Show that the dispersion relation must be generalised to

$$\omega = 2 \sqrt{\sum_{m>0} K_m \frac{(\sin^2 \frac{1}{2} mka)}{M}} \quad [11]$$

where M is the mass of the atoms.

(ii) Show that the long wavelength limit of the dispersion relation must be

$$\omega = a \left(\sum_{m>0} m^2 k_m / M \right)^{1/2} |k|,$$

provided that $\sum m^2 K_m$ converges. [8]

Q.4. (a) If ε_F is the Fermi energy, show that:

(i) the number n of free electrons per unit volume is

$$\frac{N}{V} = \left(\frac{1}{3\pi^2} \right) \left(\frac{2m\varepsilon_F}{\hbar^2} \right)^{3/2}; \quad [8]$$

(ii) the energy density U_0 at 0 K is

$$U_0 = \frac{3}{5} n \varepsilon_F; \quad [4]$$

(iii) Derive the relationship

$$p = \frac{2}{3}(U_0/V)$$

connecting the pressure and volume of an electron gas at 0 K. Here U_0 is the total internal energy. [3]

(b) (i) Show that the bulk modulus

$$B = -V \left(\frac{\partial p}{\partial V} \right)$$

of an electron gas at 0 K is

$$B = \frac{5p}{3} = \frac{10U_0}{9V}. \quad [4]$$

(ii) Estimate the value of the electron gas contribution to B for lithium which has an electronic density of $4.7 \times 10^{28} \text{ m}^{-3}$ and a Fermi energy of 4.72 eV. [6]

Q.5. (a) Consider the propagation of longitudinal waves through a linear monatomic lattice. The mass of each atom is m , the equilibrium atomic spacing is a and the stiffness constant with respect to the p^{th} nearest neighbour is C_p . Show that for long wave lengths the equation of motion

$$F_s = \sum_{p>0} C_p [u_{s+p} + u_{s-p} - 2u_s]$$

reduces to the continuum elastic wave equation

$$\frac{\partial^2 u}{\partial t^2} = v^2 \frac{\partial^2 u}{\partial x^2}$$

and find an expression for the speed of sound, v . [8]

(b) From the dispersion relation

$$\omega = \omega_m \left| \sin \frac{1}{2} ka \right|$$

for a monatomic linear lattice of N atoms with nearest neighbour interactions, show that the density of modes is

$$D(\omega) = \frac{2N}{\pi} \frac{1}{(\omega_m^2 - \omega^2)^{1/2}}$$

where ω_m is the maximum frequency.

[8]

(c) Assuming that the thermal energy in some hypothetical crystal is given by

$$U = \frac{1}{2} \hbar \omega \frac{[1 + 3e^{\frac{\hbar \omega}{kT}}]}{[1 + 2e^{\frac{\hbar \omega}{kT}}]},$$

find an expression for the heat capacity at constant volume C_V .

[9]

Q.6. (a) The atom He^3 has spin half and is a fermion. The density of He^3 is 81 kg cm^{-3} near absolute zero and it has a molecular mass of 3. The mass of the atom is 3.017 atomic mass units. Calculate the Fermi energy ε_F and the Fermi temperature T_F .

[8]

(b) The electronic contribution to the heat capacity of metals at low temperatures is experimentally found to be linear in temperature and can be written as

$$C_{el} = \gamma T$$

where the Sommerfeld parameter γ is a constant. Using the free electron model, obtain an expression for γ . The density of states for a free electron gas is given by

$$D(\omega) = \frac{3N}{2\varepsilon}$$

where the symbols have the their usual meaning.

[17]

END OF P421 EXAMINATION

THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF PHYSICS SECOND SEMESTER EXAMINATION 2009

P422: SOLID STATE PHYSICS II

TIME: 3 HOURS

INSTRUCTIONS: ANSWER ANY **FOUR** QUESTIONS

TOTAL MARKS 100

ALL QUESTIONS CARRY EQUAL MARKS

Electron rest mass $m_e = 9.109 \times 10^{-31}$ kg

Proton rest mass $m_p = 1.673 \times 10^{-27}$ kg

Electron charge $e = 1.602 \times 10^{-19}$ C

Planck's constant $h = 6.626 \times 10^{-34}$ Js⁻¹

Boltzmann constant $k_B = 1.381 \times 10^{-23}$ JK⁻¹

Avogadro's number $N_A = 6.022 \times 10^{23}$ per g mole

Permittivity of free space $\epsilon_0 = 8.854 \times 10^{-12}$ F/m

Bohr magneton $\mu_B = 9.274 \times 10^{-24}$ Am²

Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ Hm⁻¹

$$n = 2 \left[\frac{2\pi m_e^* k_B T}{h^2} \right]^{3/2} \exp \left[\frac{E_F - E_C}{k_B T} \right]$$

$$p = 2 \left[\frac{2\pi m_p^* k_B T}{h^2} \right]^{3/2} \exp \left[\frac{E_V - E_F}{k_B T} \right]$$

$$M = Ng\mu_B JB_J(y) \text{ where } y = \left(\frac{g\mu_B JB}{k_B T} \right)$$

$$B_J(y) \approx \frac{y(J+1)}{3J} \text{ for } y \ll 1$$

Q.1. (a) State and prove Bloch's theorem.

[7]

(b) According to the Kronig-Penney model the equation

$$P \frac{\sin \alpha a}{\alpha a} + \cos \alpha a = \cos ka$$

$$\text{where } \alpha^2 = \frac{8\pi^2 m E}{h^2} \text{ and } E = \frac{\alpha^2 h^2}{8\pi^2 m}$$

can be used to explain the appearance of energy bands in solids.

Derive the determinant that simplifies into the above equation from first principles.

[18]

Q.2. (a) The tight-binding wavefunction is

$$\psi_k(\vec{r}) = \sum_{\vec{T}} e^{i\vec{k} \cdot \vec{T}} \phi(\vec{r} - \vec{T})$$

where $\phi(\vec{r} - \vec{T})$ are atomic wave functions and \vec{T} are lattice translation vectors.

Show that the energy bands resulting from these wave functions are given by the expression

$$E(\vec{k}) = E_\phi - \gamma_0 - 2(\gamma_x \cos(k_x a) + \gamma_y \cos(k_y b) + \gamma_z \cos(k_z c))$$

where the symbols have their usual meaning.

[16]

(b) Find the energy band width in terms of the exchange integral, γ , for the following cubic crystal structures using the Tight-Binding approximation:

(i) The simple cubic structure;

[3]

(ii) The body centred cubic structure;

[3]

(iii) The face centred cubic crystal.

[3]

Q.3. (a) Calculate the current produced in a small germanium plate of area 1 cm^2 and of thickness 0.3 mm when a potential difference of 2 volts is applied across the

faces. Given: concentration of free charge carriers in germanium is $2 \times 10^{19} / \text{m}^3$ and the mobility of electrons and holes are $0.36 \text{ m}^2 \text{V}^{-1} \text{s}^{-1}$ and $0.17 \text{ m}^2 \text{V}^{-1} \text{s}^{-1}$ respectively. [6]

(b) In an intrinsic semiconductor the effective mass of the electron is $0.07m_0$ and that of the hole is $0.4m_0$ where m_0 is the rest mass of the electron. Calculate the intrinsic concentration of charge carriers at 300 K. Given: $E_g = 0.7 \text{ eV}$. [7]

(c) For an intrinsic semiconductor with gap width $E_g = 0.7 \text{ eV}$ determine the following:

- (i) the position of the Fermi level with respect to the middle of the band gap, $\frac{E_c + E_v}{2}$, at $T = 300 \text{ K}$ if $m_p^* = 6m_e^*$; [5]
- (ii) the density of holes and electrons at 300 K. [3]
- (iii) How do the quantities in (ii) alter if $E_g = 7 \text{ eV}$ and how would you then classify this material? [4]

Q4. (a) Describe the photon absorption processes in direct and indirect gap semiconductors and explain how the band gap can be determined through these processes. [6]

(b) (i) Show that the Hall coefficient for the two types of carriers is given by

$$R_H = \frac{p\mu_h^2 - n\mu_e^2}{e(p\mu_h + n\mu_e)^2}$$

where p and n are the concentrations of holes and electrons respectively, μ_h and μ_e are the respective mobilities. [10]

(ii) A sample of germanium shows no Hall effect and the mobility of electrons is 2.1 times that of holes. What is the ratio of the number density of conduction electrons to that of holes for germanium? [5]

(iii) What fraction of the current is carried by holes? [4]

Q.5. (a) Derive the Curie law using:

(i) classical mechanics; [7]

(ii) quantum mechanics under weak field conditions. [4]

(b) The atoms of a paramagnetic oxide have a value of the Landé factor $g = 2$ and the total angular momentum quantum number $J = 9/2$. Calculate the ratio of the magnetisation at a temperature of 300 K to the saturated magnetisation at very low temperatures. The Curie temperature is $\theta = 70$ K. [6]

(c) Determine the magnitude of the total angular momentum quantum number J for the following using the Hund rules:

(i) Ce^{3+} with outer shell configuration, $4f^1 5s^2 5p^6$; [4]

(ii) Pr^{3+} with outer shell configuration, $4f^2 5s^2 5p^6$. [4]

Q.6. (a) Explain briefly what you understand the following to be:

(i) Excitons; [2]

(ii) Plasmons; [2]

(iii) Polarons; [2]

(iv) Polaritons. [2]

(b) Derive an expression for the super current density which results from the AC Josephson effect observed in superconductors. Hence find the ratio of the electronic charge and Plank's constant if the measured current oscillates at 725 Mhz when a DC voltage , $V=1.5 \mu\text{V}$ is applied across the junctions. [11]

(c) Find an expression for the relative permittivity of dielectrics in terms of the total and induced charge densities. [6]

END OF P422 EXAMINATION



THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF PHYSICS

2009 ACADEMIC YEAR FIRST SEMESTER
DEFERRED FINAL EXAMINATIONS

P441: ANALOGUE ELECTRONICS II

TIME: THREE HOURS

MAXIMUM MARKS = 100

INSTRUCTIONS:

Answer any four questions

All questions carry equal marks.

The marks are shown in brackets.

1. (a) Explain the terms 'common mode voltage gain' and 'common mod rejection ratio' for operational amplifiers. Explain the significance of relatively large CMRR. [7]
- (b) The 714C is configured as a non-inverting amplifier. The following data are given for the circuit.

$A = 400,000$, $R_1 = 100\Omega$, $R_i = 33M\Omega$, $R_F = 4.7K\Omega$, $R_o = 60\Omega$
 Supply voltages = $\pm 15V$, Maximum output voltage swing = $\pm 13V$, $U_{GB} = 0.6\text{ MHz}$

Compute the following closed loop parameters: [12]

- (i) Gain
 - (ii) Input resistance
 - (iii) Output resistance
 - (iv) Bandwidth
 - (v) Total output offset voltage
 - (vi) Compute the output voltage and sketch it if $V_{in} = 100\text{mV}$ pp sine wave at 1 KHz.
- (c) The 741 operational amplifier is used as a non- inverting amplifier. Determine the maximum Possible output offset voltage due to [6]
- (i) Input offset voltage V_{io}
 - (ii) Input bias current
 - (iii) What value offset minimizing is needed to reduce effect of input bias current I_B ?

Given that $V_{io\text{ max}} = 6\text{mV dc}$, $I_B\text{ max} = 500\text{nA dc}$, $V_s = \pm 15V$, $R_1 = 470\Omega$ and $R_F = 47K\Omega$.

2. (a) Draw the circuit diagram of a peaking amplifier. What determines the peak frequency f_p in amplifier? [6]
- (b) The LM312 operational amplifier is used as an inverting amplifier with the following Specifications:

$$\frac{\Delta V_{io}}{\Delta T} = 30 \mu\text{V}/^\circ\text{C} \quad \frac{\Delta I_{io}}{\Delta T} = 10\text{nA}/^\circ\text{C} \quad V_s = \pm 15V \quad R_1 = 100\Omega$$

$$R_F = 8.2K\Omega \quad R_L = 10 K\Omega$$

Assume that the amplifier is nulled at 25°C . If V_{in} is a 20 mV peak sine wave at 100Hz:

- (i) Calculate the error voltage and the output voltage at 45°C . [4]
 - (ii) Repeat the above problem with the same operational amplifier [3]
- (c) Design an input voltage compensating network for the $\mu A715$ operational amplifier for Which $V_{io} = 5\text{ mV}$ maximum. The operational amplifier uses $13\pm$ supply voltages and is to be

Used as an inverting amplifier. Why is it necessary to use as an external offset voltage-Compensating network with practical operational amplifier circuits? [12]

3. (a) Derive input resistance of a voltage shunt feedback amplifier using appropriate circuit diagrams. [6]
- (b) For an inverting amplifier, suppose that the circuit is nulled when the voltage across the Terminals is $+V_{cc}$ and V_{EE} varies with time from 20V to 28V. Determine
- (i) The total change in the input offset voltage caused by the change in dc supply [4]
- (ii) The total output voltage V_o if $V_{in} = 5\text{mV}$ dc [2]

The operational amplifier is MC1741 with $R_1 = 100\Omega$, $R_F = 4.7\text{K}\Omega$ and $\frac{\Delta V_{io}}{\Delta V} = 15.85 \mu\text{V/V}$

(c) What is Schmitt trigger? Draw the circuit diagram and explain its operation showing the Input and output waveforms. [13]

4. (a) (i) Define an oscillator. What are the two general requirements for oscillation? [4]
- (ii) Design a phase shift oscillator so that the frequency of oscillation is 2KHz. [9]

(b) For the circuit given of figure 1, if $R_1 = R_2 = 1\text{K}\Omega$, $R_F = R_3 = 47\text{K}\Omega$, $V_d = 10\text{mV}$ sine wave at 1KHz and $V_{in} = 2\text{mV}$ at 60Hz, calculate:

- (i) The output voltage at 1KHz [3]
- (ii) The amplitude of the induced 60Hz noise at the output. [3]
- The operational amplifier is a $\mu\text{A}741$ with $\text{CMRR (dB)} = 90\text{dB}$.

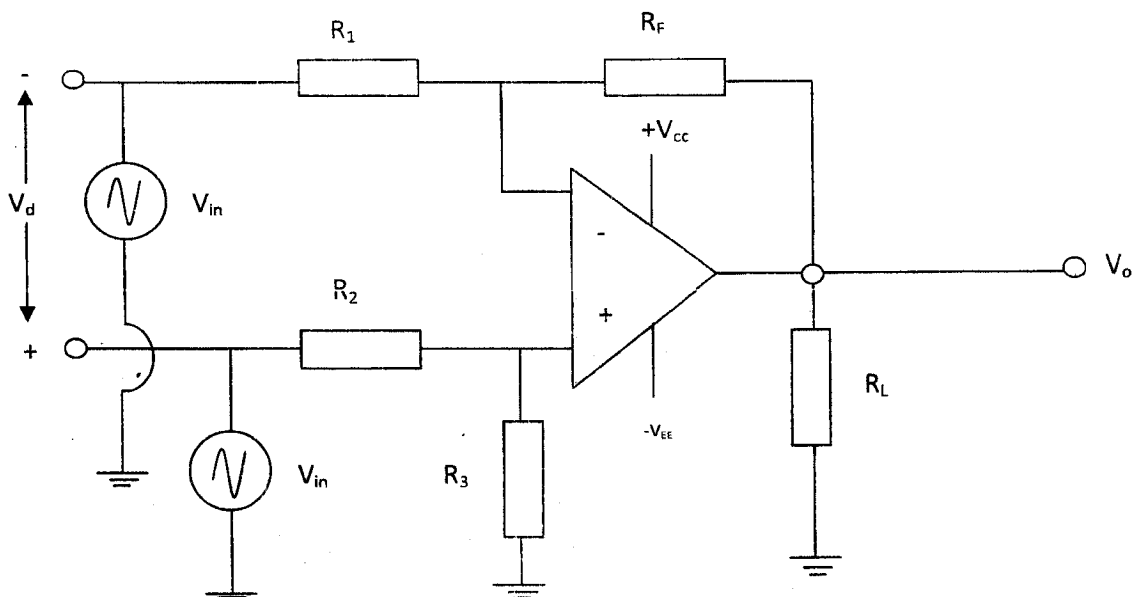


Figure1.

(c) Calculate the following for a first order low pass Butterworth filter:

[6]

- (i) Cut off frequency
- (ii) Pass band of the filter
- (iii) Phase angle at the cut off frequency

Given that $R_1 = 10\text{ K}\Omega$, $R_F = 10\text{ K}\Omega$, $R = 15.9\text{ K}\Omega$, $C = 0.01\mu\text{F}$, $R_L = 10\text{ K}\Omega$

5, (a) Design a wide band pass filter with $f_L = 400\text{ Hz}$, $f_H = 2\text{ KHz}$ and pass band gain = 4

Calculate the Q value of the filter.

[16]

(b) In the figure below,

$V_a = 100\text{ mV}$

$V_b = -200\text{ mV}$

$V_c = 300\text{ mV}$

$R_a = 3\text{ K}\Omega$

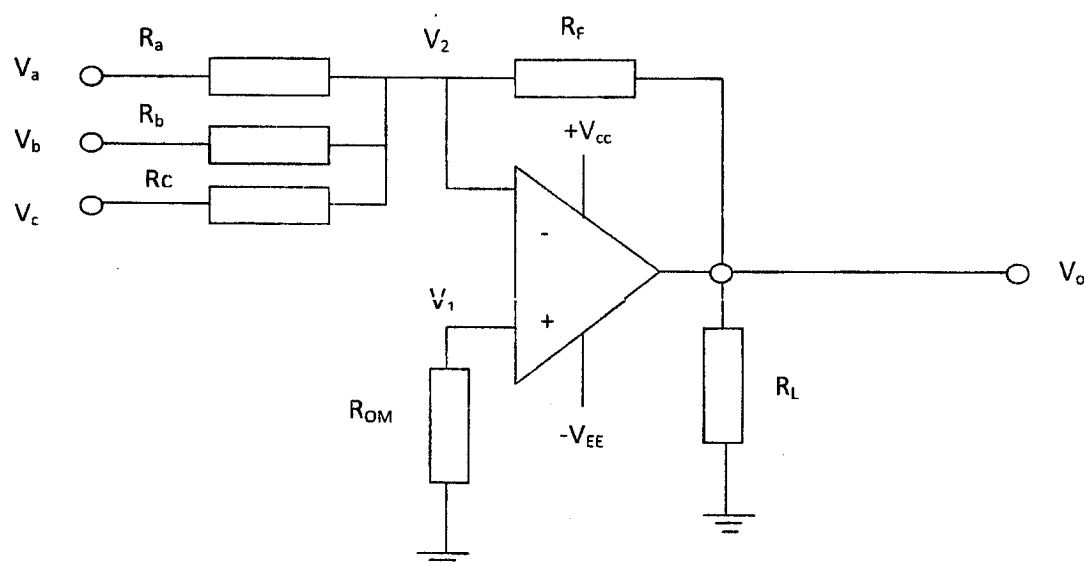
$R_b = 2.2\text{ K}\Omega$,

$R_c = 1\text{ K}\Omega$

$R_F = 4.7\text{ K}\Omega$

$R_{OM} = 470\Omega$

$R_L = 10\text{ K}\Omega$



(i) Determine the output voltage

[3]

(ii) Identify the circuit from its operation

[1]

(c) Convert figure 2 to function as summing amplifier to add three dc input voltages. The output of this circuit must be equal to two times the negative sum of the inputs.

[5]

6. (a) Draw the schematic diagram of a Wien bridge oscillator. A certain Wien bridge oscillator use $R = 4.7\text{ K}\Omega$, $C = 0.01\mu\text{F}$ and $R_F = 2R_1$. What is the frequency of oscillation?

[5]

(b) Determine the magnitude of gain (dB) for the following frequencies for a first order pass band Butterworth filter. Given that the low cut off frequency = 1 KHz , and the pass band gain = 2.

[12]

100Hz 200Hz 400Hz 700Hz 1000Hz 3000Hz

7000Hz 10,000Hz 30,000Hz 100,000Hz

(c) Write short notes on the following

- (i) Thermal voltage drift
- (ii) Differentiator
- (iii) Zero crossing detector
- (iv) Voltage follower