THE UNIVERSITY OF ZAMBIA SCHOOL OF NATURAL SCIENCES

2012 FIRST SEMESTER

1. BIO1011- CELLS AND BIOMOLECULES
2. BIO2041- BASIC PHYSIOLOGY
3. BIO2051- DIVERSITY OF PLANTS
4. BIO2075- ECOSYSTEMS AND BIODIVERSITY
5. BIO3155- ECOLOGICAL MONITORING AND IMPACT ASSESSMENT
6. BIO3161- ETHOLOGY OF BIRDS AND MAMMALS
7. BIO3161- ETHOLOGY OF BIRDS AND MAMMALS
8. BIO3141- ECOLOGICAL METHODS
9. BIO3171- EVOLUTIONARY BIOLOGY
10. BIO3231- MOLECULAR BIOLOGY
11. BIO3261- PLANT AND ANIMAL TAXONOMY
12. BIO3261- PLANT AND ANIMAL TAXONOMY
13. BIO4391- FRESHWATER ECOLOGY
14. BIO4391- FRESHWATER ECOLOGY
15. BIO4415- IMMUNOLOGY
16. BIO4471- PLANT-INSECTRELATIONSHIPS
17. BIO4521- VERTEBRATE BIOLOGY
18. BIO4521-VERTEBRATE BIOLOGY
19. BS3421- MYCOLOGY
20. C101- INTRODUCTION TO CHEMISTRY I
21. C205- ANALYTICAL AND INORGANIC CHEMISTRY
22. C225- ANALYTICAL CHEMISTRY I
23. C341- INORGANIC CHEMISTRY II

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
BIOLOGICAL SCIENCES DEPARTMENT

2012 ACADEMIC YEAR FIRST SEMESTER
EXAMINATIONS

BIO 1011: CELLS AND BIOMOLECULES
THEORY PAPER

TIME: THREE HOURS

Answer all questions

Instructions:
All questions carry equal marks

Use the answer sheet provided to record answers

A correct answer carries +4 marks

A wrong answer carries −1 mark

The option "I do not know" carries 0 mark

Use ink to record the answers on the mark sheet

Cross out a wrong entry and write the correct one by the side

Please handover the question paper to the invigilator at the end of the examination

1. Which of the following organelles is not found in an animal cell?
   1. Plastids
   2. ribosomes
   3. golgi bodies
   4. mitochondria
   5. plasmamembrane.
   6. I do not know

2. Hereditary materials in *Escherichia coli* are located in ...
   1. mitochondria.
   2. plasmids.
   3. the cytoplasm.
   4. the cell wall.
   5. nucleus.
   6. I do not know

3. Which of the following parts of a cell is responsible for protein synthesis?
   1. smooth endoplasmic reticulum
   2. microfilaments
   3. golgi body
   4. microtraberculae
   5. rough endoplasmic reticulum
   6. I do not know

4. Which of the following does not contribute to keeping a polypeptide molecule in its form?
   1. Peptide bond
   2. Van der Waals forces
   3. Sulphydryl bonds
   4. Ionic interactions
   5. Hydrogen bonds
   6. I do not know

5. A lipid that is partly oxidised ...
   1. has a maximum number of peptide bonds.
   2. has fatty acids that bend in places along the molecule.
   3. has a minimum of oxygen atoms.
   4. has a maximum of oxygen atoms.
   5. is more hydrophilic.
   6. I do not know

6. Lipids are ...
   1. polymers.
   2. monomers.
   3. micromolecules.
   4. inorganic molecules.
   5. macromolecules.
   6. I do not know.

7. How are nucleotides added to a growing polymer of ribonucleic acid?
   1. Hydroxyl group of a phosphate group to a hydrogen atom in a nitrogenous base.
   2. Hydroxyl group at carbon one of a ribose sugar to a phosphate group on carbon five.
   3. Hydrogen in a nitrogenous base to a ribose sugar.
   4. hydroxyl group at carbon three of ribose to phosphate group at carbon five of the next ribose
   5. Phosphate group at carbon five of ribose to hydroxyl group at carbon three of the next ribose
   6. I do not know

8. Manufacture of energy in *Escherichia coli* takes place in ...
   1. the plasmamembrane.
   2. mitochondria.
   3. ribosomes..
   4. the cell wall.
   5. The chlorophyll pigments.
   6. I do not know

9. Which of the following statements is **not true**?
   1. Proteins are joined by peptide bonds.
   2. Nucleoside are held together by ester bonds.
   3. Nitrogenous bases have nitrogen in them.
   4. Ribonucleic acid has phosphate groups as part of the molecule.
   5. DNA has nucleotides in them.
   6. I do not know

10. Which of the following levels of protein is responsible for movement of oxygen in the circulatory system of mammals?
    1. primary structure
    2. secondary structure
    3. Quaternary structure
    4. tertiary structure.
    5. beta pleated sheet.
    6. I do not know

11. The molecule made up of glucose and galactose is called ...
    1. sucrose.
    2. amylopectin.
    3. starch
    4. maltose
    5. lactose.
    6. I do not know

12. Collagen is an example of a ... protein
    1. a kind of cell
    2. alpha helical
    3. teriary
    4. secondary
    5. primary
    6. I do not know

13. Which of the following nucleic acids is responsible for reading messages on mRNA.?
    1. Deoxyribonucleic acid.
    2. ribosomes
    3. Transfer ribonucleic acid.
    4. messenger RNA
    5. fatty acids.
    6. I do not know

14. The following sequence of nitrogenous bases is found on mRNA;
    5'AACUUACGGCUGCAG3'. How is this information read?
    1. 5'AAC CUU ACG GCU GCA3'
    2. 5'CUU ACG GCU GCA GAA3'
    3. 5'GAA CUU ACG GCU GCA3'
    4. 5'AAU UAC GGC UGC AGA3'
    5. 5'AAC UUA CGG CUG CAG3'
    6. I do not know

15. The chemical elements in a deoxyribonucleic acid are ...
    1. C, O, S and P
    2. C, N, O and H
    3. N, P, C, H and S
    4. C, H, O and P
    5. C, H, O, N and P
    6. I do not know

16. Lipids are processed by the ... in a eukaryotic cell.
    1. plastids
    2. golgi bodies
    3. rough endoplasmic reticula
    4. nucleolus.
    5. mitochondria
    6. I do not know

17. What type of bond is found in lipids?
    1. glycosidic
    2. ester
    3. phophodiester
    4. peptide
    5. van der waals forces
    6. I do not know.

18. Protein function is determined by ... amino acids in a polypeptide chain and is maintained by
    ...
    1. the type of; its covalent bonds.
    2. the number of; their sequence
    3. the complexity of; hydrogen bonds.
    4. the structure of the side chain of; sulphydryl bonds.
    5. polar side chains of ; hydrophobic bonds.
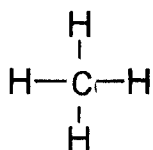   6. I do not know.

19. The shape of a molecule ...
   1. influences its biological function.
   2. is sometimes dependent on its electronegativity.
   3. is dependent in part on the angle of bonds between its atoms.
   4. All 1, 2 and 3 are correct
   5. is dependent on its position in the periodic table.
   6. I do not know.

20. A phospholipid molecule has a 'head' and 'two tails'. The tails are found ...
   1. on the outer part of a membrane.
   2. in the cytoplasm.
   3. spanning the central part of a membrane.
   4. where the environment of a cell is hydrophilic.
   5. where the environment of a cell is hydrophobic.
   6. I do not know.

21. Which of the following covalently bonded molecules are polar?
   (a) COOH   (b) HNO_3,   (c) O_2 (d) CO_2
   1. (a) and (b)
   2. (c)
   3. (c) and (d)
   4. (d)
   5. (a) and (c)
   6. I do not know.

22. Which one of the following **does not** depend on hydrogen bonding ...
   1. cohesiveness of water.
   2. formation of ice.
   3. ascent of water in xylem vessels.
   4. temperature maintenance.
   5. polarity of water.
   6. I do not know

23. Why is $-NH_2$ a polar group?
   1. Because hydrogen is more electronegative than nitrogen.
   2. Because amino group is not a reactive group in organic solvents.
   3. The bonds between nitrogen and hydrogen are ionic bonds.
   4. Nitrogen is more electronegative than hydrogen.
   5. electron sharing between hydrogen and nitrogen is equal.
   6. I do not know.

24. Which one of the following is **not** a characteristic of carbon atom?
   1. It forms four covalent bonds around it.
   2. It is capable of forming bonds with other carbon atoms.
   3. It is sometimes ionic.
   4. It is capable of forming polymers.
   5. It can share two pair of electrons with another atom.
   6. I do not know

5

25. The group –COOH is …
    1. basic
    2. nonpolar
    3. part of nucleotides.
    4. acidic.
    5. a nonfunctional group.
    6. I do not know.

26. Two neighbouring cells are connected by …
    1. stomata
    2. plasmodesmata
    3. plasmids
    4. lenticels
    5. channel proteins
    6. I do not know

27. Determine the most critical characteristic for cell survival.
    1. Cells that are large with a large vacuole.
    2. Cell with a large mitochondrion.
    3. Cells with an average size of one micron.
    4. Large cells with a tiny vacuole.
    5. Cells with a longest perimeter.
    6. I do not know

28. Identify the **false** statement.
    1. Respiration takes place in mitochondria in all cells.
    2. Nucleic acids are found in both prokaryotes and eukaryotes.
    3. Ribosomes perform the same functions in all cells.
    4. A nucleoid is a feature found in prokaryotes only.
    5. Bacterial cell walls are more complex than plant cell walls.
    6. I do not know

29. Which of the following terms is **not correctly** described?
    1. Glycosidic bonds are found in carbohydrates.
    2. Histones are protein molecules for support.
    3. A plant vacuole is for storage of cell waste.
    4. Some animal cells have tiny vacuoles.
    5. Chloroplasts contain chlorophyll.
    6. I do not know.

30. Where in mitochondria are the stalked particles ?
    1. Stroma
    2. Mitochondrial matrix
    3. Inner membrane
    4. In the intracristal space
    5. Granum
    6. I do not know.

31. Identify the statement that is **correct** about chloroplasts.
    1. Chloroplasts are capable of synthesizing their own proteins.
    2. DNA is absent in 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.

32. The genetic code is said to be degenerate because ...
    1. it uses a triplet code of bases.
    2. a triplet code cannot be read by the ribosomes.
    3. uracil can be used as an alternative base to thymine.
    4. some amino acids have more than one codon.
    5. it fails to code for all the 20 amino acids.
    6. I do not know.

33. An examples of a purine is ...
    1. Guanine
    2. Adenine
    3. Thymine
    4. Uracil
    5. 1 and 2 above.
    6. I do not know.

34. The polymers used as sensor receptors on the surface of cell membranes are called ...
    1. lipoproteins.
    2. glycolipids.
    3. proteins.
    4. lipids.
    5. glycoproteins.
    6. I do not know.

35. Which of the following statements explains why water has high surface tension.
    1. water ionizes quite readily.
    2. water resists temperature changes.
    3. water is a polar molecule.
    4. water is an organic molecule.
    5. water expands when it freezes.
    6. I do not know

36. A molecule of glycerol has oxygen, hydrogen and carbon in the following numbers ... respectively.
    1. 3:8:3
    2. 3:3:8
    3. 1:2:2
    4. 4:2:2.
    5. 2:2:4.
    6. I do not know

37. What is the cell theory about?
    1. All cells come from pre-existing cells.
    2. All cells have a plasmamembrane.
    3. All cells are microscopic.
    4. All cells are made of atoms.
    5. All cells have nucleic acids.
    6. I do not know.

38. 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.

39. Which of the following substances would cross the plasmamembrane without resistance?
    (a) Oxygen   (b) Water   (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.

40. 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.

41. Which of the following is not a subunit of a nucleotide?
    1. Phosphate
    2. ribose sugar
    3. purine
    4. pyrimidine
    5. hexose sugar
    6. I do not know.

42. Which of the following pairs of terms is **not** matched?
    1. Nucleus-deoxyribonucleic acid
    2. Ribosome-protein synthesis
    3. Cell wall-cellulose
    4. Chloroplast-chlorophyll
   5. Flagella-chromatin
    6. I do not know

8

43. In the molecule given below ....

$$
\begin{array}{c}
\text{H} \\
| \\
\text{H} - \text{C} - \text{H} \\
| \\
\text{H}
\end{array}
$$

1. all atoms have eight electrons in the outer shell.
2. carbon could accept more hydrogen atoms.
3. carbon atom is more electronegative than hydrogen.
4. carbon atom is not sharing electrons equally.
5. all atoms are sharing electron.
6. I do not know

44. Enzymes in the human body ...
    1. reduces the energy of activation of a chemical reaction.
    2. are modified during chemical reaction.
    3. are completely used up during chemical reaction.
    4. increase the activation energy of a chemical reaction.
    5. increase the speed of proton pumps.
    6. I do not know.

45 Which organelle in a cell is capable of self replication?
    1. Golgi body
    2. Mitochondrion
    3. Endoplasmic reticulum
    4. Lysosome
    5. Ribosome
    6. I do not know

46. In protein, alpha helices and beta pleated structures are associated with the ...
    1. primary structure
    2. tertiary structure
    3. quaternary structure
    5. secondary structure
    6. I do not know

47. All of the following molecules are components of bacterial cell walls except ...
    1. proteins
    2. lipids
    3. cellulose
    4. polysaccharides
    5. disaccharides
    6. I do not know.

9

48. A molecule with a high number of hydrogens in it is said to be ...
    1. oxidised.
    2. reduced.
    3. more condensed.
    4. more dehydrated.
    5. neutralized.
    6. I do not know.

49. Which one of the following combinations is correct?
    1. Glucose + galactose = Maltose.
    2. Glucose + glucose = sucrose
    3. Glucose + fructose = maltose
    4. Fructose + galactose = lactose
    5. Glucose + galactose = lactose
    6. I do not know.

50. Which of the following characteristics does not represent ionic compounds?
    1. They have high melting and boiling points.
    2. They conduct electricity in liquid form.
    3. They are mostly solid substances at room temperature and pressure.
    4. They readily crumble when heated.
    5. They are soluble in water.
    6. I do not know.

Study the set of molecules given below and **answer queations 51, 52 and 53**.
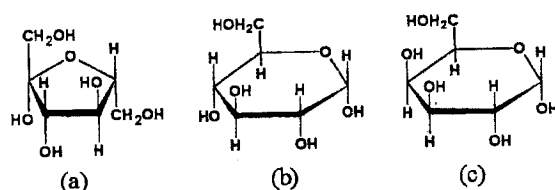
51. Give the name of molecule **(c)** from the set of molecules given above.
    1. Fructose
    2. Lactose.
    3. Galactose.
    4. Glucose.
    5. Ribose.
    6. I do not know.

52. Identify the molecules that would combine to form the compound sucrose from the set of molecules given above.
    1. (b) and (c)
    2. (a) and (c)
    3. (a), (b) and (c)
    4. None of them can combine to form sucrose.
    5. (a) and (b)
    6. I do not know.

10

53. Identify the structural isomer(s) of glucose from the set of molecules given above.
   1. (a) and (b)
    2. (a) and (c)
    3. (b) and (c)
    4. (b)
    5. (c)
    6. I do not know.

54. What are functional groups in molecules?
    1. set of atoms that form bonds with other molecules.
    2. set of atoms that determine chemical characteristics of a molecule.
    3. set of atoms that play a part in the solubility of a molecule.
    4. set of atoms that can sometimes be used to classify molecules.
    5. All the above statements correctly describe a functional group in a molecule.
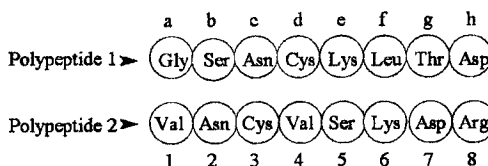   6. I do not know.

55. Identify the carbon atom in the molecule given below that normally goes into a chemical reaction with a neighbouring molecule.

    1. (a)
    2. (b)
    3. (c)
    4. (d)
    5. (e and f)
    6. I do not know
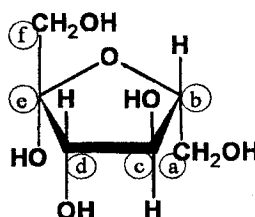
56. Identify the circled amino acids that would form sulphydryl bridge between neighbouring amino acids in the two polypeptide chains.
    1. (h) and (6)
    2. (c) and (2)
    3. (e) and (5)
    4. (d) and (3)
    5. (h) and (7)
    6. I do not know

57. Which of the following nucleotide chains could be part of a molecule of ribonucleic acid?.
    1. AATTUA
    2. GCCTUA
    3. AATAAA
    4. ATGCCA
    5. AUGCCA
    6. I do not know.

58. Which of the following messenger ribonucleic acid codons would stop protein synthesis?
    1. UAG
    2. GGC
    3. UAC
    4. AAG
    5. UCG
    6. I do not know.

59. Which of the following base pairs would not be found in a cell?
    1. Adenine-Thymine
    2. Cytosine-Guanine
    3. Thymine-Uracil
    4. Adenine-Uracil
    5. Uracil-Adenine
    6. I do not know.

60. Two molecules which are reflections of each other with the same number of atoms are called ...
    1. Structural isomoers
    2. Isotopes
    3. Polymers
    4. Stereoisomers
    5. Non aromatic structures
    6. I do not know.

61. The β (1-4) glycosidic bond between two glucose molecules would result in the formation of ...
    1. sucrose
    2. cellulose
    3. maltose
    4. lactose
    5. amylopectin
    6. I do not know.

62. A complete hydrolysis of ribonucleic acid would yield ...
    1. hexose sugars, phosphate groups and nitrogenous bsases.
    2. nucleosides and nunleotides.
    3. nitrogenous bases, nucleosides and phosphate groups.
    4. nucleotides and nitrogenous bases.
    5. pentose sugars, phosphate groups and nitrogenous bases.
    6. I do not know.

63. Which of the following statements is **not correct**?
    1. Fat stores more energy than carbohydrates.
    2. Lipids are macromolecules.
    3. sugars are more oxidized than oils.
    4. Saturated fats have several double bonds in their hydrocarbon cahins.
    5. steroids are an example of lipids.
    6. I do not know.

64. Which one of the following is true about amylopectin?
    1. more 1-6 glycosidic bonds than 1-4 bonds.
    2. Less 1-4 glycosidic bonds than 1-6 bonds.
    3. same number of 1-4 and 1-6 glycosidic bonds.
    4. more 1-4 glycosidic bonds than 1-6 bonds.
    5. amylopectin has only 1-4 glycosidic bond.
    6. I do not know.

65. The activity of an enzyme depends on ... keeping the other factors constant.
    1. substrate concentration
    2. enzyme concentration
    3. suitable pH
    4. optimum temperature
    5. all the factors stated above
    6. I do not know.

66. Keratin is an example of a ...
    1. fibrous protein.
    2. quaternary structure.
    3. tertiary structure.
    4. globular protein
    5. wax
    6. I do not know.

67. When enzymes are subjected to an environment with a pH of twelve, it would ...
    1. function more actively.
    2. deactivated.
    3. accelerate chemical reaction.
    4. more active sites.
    5. recover in a short time.
    6. I do not know.

68. The important parts of a eukaryotic cell are ...
    1. the endoplasmic reticulum, golgi apparatus.
    2. the nucleus, nucleolus and the nuclear envelope.
    3. the cytoplasm, organelles and chromosomes.
    4. the nucleus, cytoplasmic matrix and cell membrane.
    5. cell membrane, cell wall and vacuoles.
    6. I do not know.

69. The plasmamembrane ...
    1. provides selective permeability to charged molecules.
    2. allows passage to charged molecules.
    3. is permeable to ions only.
    4. is impermeable to charged molecules.
    5. is permeable to hydrophobic compounds.
    6. I do not know.

70. All the following molecules could be hydrolysed except ...
    1. deoxyribonucleic acid.
    2. monosaccharides.
    3. Nucleosides.
    4. Nucleotides.
    5. lipids.
    6. I do not know.

71. Lipase ...
    1. is an inorganic catalyst.
    2. can catalyse several chemical reactions.
    3. reduces activation energy during a chemical reaction.
    4. catalyses the synthesis of proteins.
    5. is distributed throughout the cytoplasm.
    6. I do not know.

72. Explain why life forms live normally when a pond freezes.
    1. Because organisms go into dormancy waiting for suitable conditions to return.
    2. Some organisms are able to resist freezing conditions.
    3. Because organisms can slow down their metabolic activities and survive.
    4. Life forms manage to live in solid ice.
    5. Because ice floats leaving the bottom conditions favourable.
    6. I do not know.

73. DNA has a net negative charge, and therefore it is able to ...
    1. attract negatively charged atoms.
    2. bind to histones.
    3. bind to phosphates.
    4. coil into a helix.
    5. repel nucleosomes.
    6. I do not know.

74. How many water molecules are produced during the formation of a nucleotide?
    1. one
    2. two
    3. three
    4. four
    5. five
    6. I do not know.

75. Which of the following statements is false about DNA?
    1. It contains a sugar called ribose.
    2. It is made up of nucleotides.
    3. It contains guanine.
    4. It has ester bonds.
    5. It has a sugar-phosphate backbone.
    6. I do not know.

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76. At which carbon in an aldehyde is the carbonyl group positioned?
    1. One
    2. Two
    3. Three
    4. Four
    5. Five
    6. I do not know.

77. Bacterial cells were raised in a solution with an isotope of nitrogen for several generations. At the end of the experiment the isotope was found in ...
    1. the nuclear envelope.
    2. cell walls.
    3. Deoxyribonucleic acids.
    4. Plasmamembrane.
    5. Fatty acids.
    6. I do not know

78. Amino acids exist as Zwitterion ions at their normal pH. What happens when they are in an alkaline solution?
    1. They continue to exist as Zwitterion ions.
    2. They develop a net charge of zero.
    3. The positive end of the amino acid gets neutralised.
    4. The negatively charged end of amino acid gets neutralised.
    5. Amino acids become positively charged.
    6. I do not know.

79. DNA replication is semiconservative. This means that ...
    1. Half of the daugher DNA have 50% parent DNA strands.
    2. Seventyfive percent of the daughter DNA have 50% parental DNA strands.
    3. All the daughter DNA have parental DNA strands.
    4. All the daughter DNA have new DNA strands.
    5. Fifty percent of daughter DNA molecules both have new DNA strands.
    6. I do not know

80. What process could convert an unsaturated fatty acid into a saturated one?
    1. Hydrolysis.
    2. Reduction.
    3. Oxidation.
    4. Condensation.
    5. Dehydration.
    6. I do not know.

81. What are triglycerides?
    1. Lipids with three glycerol molecules.
    2. Carbohydrates with three carbon atoms.
    3. Molecule that have three glycerol molecules and one fatty acid.
    4. Molecules that contain glycerol and three fatty acids.
    5. Triose carbohydrates.
    6. I do not know.

82. The difference between plant and animal cells can be determined partly by the presence of ...
    1. mitochondria in animal cells.
    2. ribosomes in plant cells.
    3. cell walls in animal cells.
    4. a plasmamembrane in plant cells.
    5. a centriole in animal cells.
    6. I do not know.

83. Which of the following statement(s) is **true**?
    1. Water is a polar substance.
    2. Carbohydrates are a source of energy.
    3. Enzymes are an example of globular proteins.
    4. Plant cell walls are porous.
    5. All the statements above are true.
    6. I do not know.

84. Which of the following statements is **not correct** about water?
    1. Water molecules are cohesive.
    2. Adhesive and cohesive forces of water molecules account for capillary action.
    3. The density of water is greatest at 4°C.
    4. Cohesive forces of water are responsible for wetting surfaces.
    5. Water helps mammals to maintain a stable body temperature.
    6. I do not know.

85. Sugars, starches and cellulose are collectively called...
    1. organic compounds.
    2. carbohydrates.
    3. proteins.
    4. waxes.
    5. lipids.
    6. I do not know.

86. The most abundant sugar in the bodies of humans and other animals is ...
    1. Glycogen.
    2. ribose sugars.
    3. glucose.
    4. fructose.
    5. lactose.
    6. I do not know.

87. The sugar present in milk is called ...
   1. glucose.
   2. maltose.
   3. sucrose.
   4. lactose.
   5. fructose.
   6. I do not know.

88. Which of the following statements is **correct**?
   1. Amino group is a functional group in fatty acids.
   2. A carboxyl group is always present in fatty acid molecules.
   3. Fatty acids do not get completely saturated.
   4. Fatty acids are the main source of energy in mammals.
   5. Waxes are similar in structure to fatty acids.
   6. I do not know.

89. The way in which elements form bonds depends on their ...
   1. ability to form isotopes.
   2. contents of the nucleus.
   3. number and arrangement of electrons in the atoms.
   4. number of protons in the nucleus.
   5. number of neutrons in the nucleus.
   6. I do not know.

90. The process in which a chemical compound loses an electron is called...
   1. reduction.
   2. reduction-oxidation reaction.
   3. molecular stabilisation.
   4. oxidation.
   5. hydrolysis.
   6. I do not know.

91. Plants store glucose for metablism in the form of...
   1. proteins.
   2. trglycerides.
   3. starch.
   4. steroids.
   5. chitin.
   6. I do not know.

92. A structural molecule in plants which is strengthened by hydrogen bonding is called ...
   1. cellulose.
   2. starch.
   3. glycogen.
   4. pectin.
   5. amylopectin.
   6. I do not know.

93. When two amino acids bond ...
    1. water is taken in by the product.
    2. hydrolysis occurs.
    3. a dipeptide is formed.
    4. a monopeptide is formed.
    5. tripeptide is formed.
    6. I do not know.

94. Lipids are distinguished from other organic molecules because they ...
    1. are composed of fatty acid monomers.
    2. dissolve in water completely..
    3. are of one type only.
    4. contain carbon, hydrogen and oxygen in a ratio of 1:2:1 respectively.
    5. are amphipathic.
    6. I do not know.

95. Most enzymes ar ...
    1. glycoproteins.
    2. proteins.
    3. lipoproteins.
    4. phospholipids.
    5. lipids.
    6. I do not know.

96. The major components of cell membranes are ...
    1. lipids.
    2. protins and nucleic acids.
    3. phospholipids and proteins.
    4. cholesterql and proteins.
    5. carbohydrates and lipids.
    6. I do not know.

97. Amino acids are differentiated from each other by ...
    1. the nature of their amino group.
    2. the nature of their carboxylic group.
    3. number of alpha carbons. .
    4. structure of their side chains.
    5. the number of peptide bonds.
    6. I do not know.

98. If the sequence of bases in one strand of DNA is 5'TAGCCT3', then the sequence of bases in the other strand will be ...
    1. 3'TCCGAT5'.
    2. 3'ATCGGA5'.
    3. 3'TAGCCT5'.
    4. 3'AACGGU5'.
    5. 3'AUCGGA5'.
    6. I do not know.

99. Which one of the following fatty acids is saturated?
    1. $C_5H_{10}O_2$
    2. $C_5H_8O_2$
    3. $C_5H_6O_2$
    4. $C_5H_4O_2$
    5. $C_5H_2O_2$
    6. I do not know.

100. Starch is made from ...
    1. β-glucose monomer units.
    2. α-amino acid monomer units.
    3. α-glucose monomer units.
    4. α and β-glucose monomer units.
    5. α-triose monomer units.
    6. I do not know.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2012 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 2041: BASIC PHYSIOLOGY
THEORY PAPER

TIME: THREE HOURS

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

SECTION A: Plant Physiology

1. (a) The data in Table 1 below were obtained in an experiment to study the
interaction between transpiration and xylem pressure in a maize
seedling. The seedling, with its root system immersed in nutrient
solution with osmotic potential of -0.45MPa, was set up in a
transpiration chamber where changes were induced by lowering the
relative humidity of the air until a steady state was reached between
water flow into the plant and water loss by transpiration.

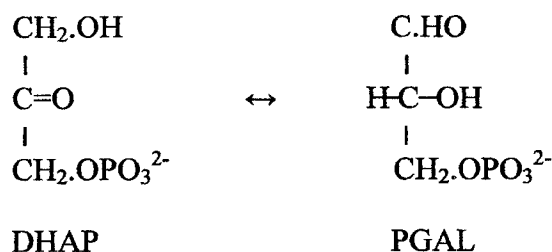Table 1. Hydraulic resistance and xylem water potential in maize roots.

Root surface area (m^2)	Hydraulic root resistance $(MPa\ s\ m^{-3})$	Xylem water potential (MPa)
7.5×10^{-3}	1.3×10^9	-0.55

Calculate:
(i) The hydraulic conductivity of the maize roots.
(ii) The volume flow density of water in the xylem
(b) Discuss water movement from the root hairs, through the stem to the
leaf-air interface in woody plant species.

2. Carbon dioxide fixation in the C_3 (Calvin) cycle proceeds in three phases:
carboxylation, reduction and regeneration. Write the steps of chemical
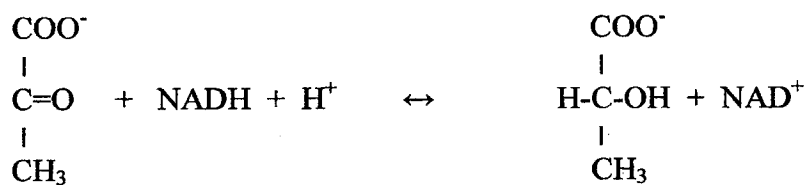reactions involved in carboxylation, reduction, and regeneration phases.

TURN OVER

1

3. (a) Isomerization of Dihydoxyacetone-3-phosphate (DHAP) to Glyceraldehyde-3-phosphate (PGAL) takes place in glycolysis as shown below:

$$
\begin{array}{lcl}
CH_2.OH & & C.HO \\
| & & | \\
C=O & \leftrightarrow & H\text{-}C\text{-}OH \\
| & & | \\
CH_2.OPO_3^{2-} & & CH_2.OPO_3^{2-} \\
\\
DHAP & & PGAL
\end{array}
$$

At equilibrium the ratio of PGAL to DHAP is 0.0475 at 25 ^{0}C and pH 7.

(i) Calculate the standard free energy change for the above reaction in kJ/ mol. (R= 8.315 J/K. mol).

(ii) If the initial concentrations were 2×10^{-4} for DHAP and 3×10^{-6} for PGAL, calculate free energy change (ΔG) at these concentrations.

(b) The formation of lactate from pyruvate in cellular glucose metabolism is a form of fermentation.

$$
\begin{array}{lcl}
COO^- & & COO^- \\
| & & | \\
C=O \quad + NADH + H^+ & \leftrightarrow & H\text{-}C\text{-}OH + NAD^+ \\
| & & | \\
CH_3 & & CH_3
\end{array}
$$

Reduction potentials for the substances involved are:

$NAD^+ : NADH \qquad E'_0 = -0.32$ V

Pyruvate: Lactate $\qquad E'_0 = -0.19$ V

Answer the following:

(i) Write the half (partial) reactions for the reduction of pyruvate to lactate by NADH.

(ii) Calculate $\Delta E'_0$ for the reduction of pyruvate to lactate.

(iii) Calculate standard free energy change for the reduction of pyruvate by NADH (Faraday constant is given as 96485 J/ V. mol.

4. (a) Compare and contrast the physiological effects of Auxin and Gibberellin with respect to stem growth.

(b) State one commercial application of each of the above growth hormones.

SECTION B: Animal Physiology

5. (a) Describe the composition of mammalian blood plasma.
   (b) Explain the roles of the following blood cells in the human body:
      (i) Neutrophils.
      (ii) Monocytes.
      (iii) Lymphocytes.
      (iv) Basophils.
   (c) Describe carbon dioxide transport in mammalian blood.

6. Discuss the roles of the pancreas and small intestine brush-border enzymes in the digestion of proteins and carbohydrates in humans.

7. Describe the major processes and mechanisms that lead to the formation of hypertonic urine in higher vertebrates.

8. Summarise each of the following:
   (a) Synaptic transmission.
   (b) Physiological roles of thyroid and parathyroid glands.
   (c) Roles of brainstem in the control of respiration.
   (d) Respiratory dead space.

END OF EXAMINATION

BIO 2051: DIVERSITY OF PLANTS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS, **TWO** QUESTIONS FROM EACH SECTION AND THE FIFTH QUESTION FROM EITHER SECTION. USE **SEPARATE ANSWER BOOKS** FOR EACH SECTION.

SECTION A: Algae and Bryophytes

1. Describe asexual structures of green algae and explain what could be the main reason behind their structural and behavioural variability.

2. (a) Describe features of *Oedogonium* species that make them an uncommon green alga.
   (b) Briefly describe sexual reproduction in this alga.

3. Describe *Riccia* with particular reference to:
   (a) Thallus structure.
   (b) Reproduction and alternation of generations.

4. Describe the typical structure of a moss and indicate which structures belong to the different generations and their ploidy levels.

SECTION B: Tracheophytes

5. Summarize any **four** of the following:
   (a) Dictyostele
   (b) Diplohaplontic life cycle
   (c) Circinate vernation
   (d) Synergid cells of the Angiosperm female gametophyte.
   (e) Dioecious plant.

6. Give an account of the general vegetative, reproductive and life cycle features characteristic of the Sphenophyta.

7. Describe the characteristic features, distribution and diversity of the Angiosperm family Solanaceae.

8. Describe the angiosperm microgametophytes and megagametophytes and their interaction during angiosperm sexual reproduction.

END OF EXAMINATION

BIO 2075: ECOSYSTEMS AND BIODIVERSITY
THEORY PAPER

TIME: THREE HOURS
INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. ILLUSTRATE YOUR ANSWERS
WHERE NECESSARY

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1. Discuss the effect of light on plants.

2. Summarise the following:
    (a) Food chain.
    (b) A horizon.
    (c) Biogeochemical cycle.
    (d) Realised niche.

3. Discuss how the following properties of water affect the distribution and abundance of aquatic organisms:
    (a) Water depth.
    (b) Salinity.

4. Explain:
    (a) why temperatures above 50°C are termed as lethal for living organisms.
    (b) how endotherms and ectotherms respond to lethal high temperatures.

5. Discuss the different types of herbivory and their effects on plants.

6. Describe the structure of an ecosystem using a named example.

7. Discuss the level(s) at which biodiversity is assessed or studied.

8. Discuss the determinants of fire damage and how plants adapt to the occurrence of fire.

END OF EXAMINATION

BIO 3155: ECOLOGICAL MONITORING AND IMPACT ASSESSMENT
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS, QUESTIONS **ONE** AND **TWO** ARE
COMPULSORY. ANSWER ANY **THREE** OTHER QUESTIONS. USE ILLUSTATIONS
WHERE NECESSARY IN YOUR ANSWERS

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1. Summarise the following as commonly used in conservation biology and ecological
   monitoring:
   (a) Biodiversity.
   (b) Stepping stone corridor.
   (c) Edge effect.
   (d) Meta-population.
   (e) Nested subset model.

2. Describe the processes commonly adopted for the preparation of an Environmental Impact
   Statement highlighting the following:
   (a) Requirements for objectivity.
   (b) Need for transparency.
   (c) Shortcomings of the process.

3. Describe Paine's (1966) predator removal experiments and explain their implications in
   understanding species interactions.

4. Summarise ecological mechanisms that are negatively impacted by increased habitat
   fragmentation.

5. Discuss the competitive advantages that introduced species may have in comparison to
   indigenous ones that lead to their dominance.

TURN OVER

6. Explain why and environmental management authority may require an Environmental Project Brief instead of an Environmental Impact Assessment.

7. Discuss the main elements of an ecological monitoring programme.

8. Describe the views of Gleason (1926) relating to community organization and species distribution.

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2012 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 3161: ETHOLOGY OF BIRDS AND MAMMALS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER QUESTION **ONE** AND **FOUR** OTHERS. ILLUSTRATE YOUR
ANSWERS WHERE NECESSARY.

1. Charles Darwin proposed that evolution by natural selection was the basis for the differences
   in similar organisms. Discuss in detail any **two** of the following:
   (a) The theory of evolution by Natural Selection as presented by Darwin.
   (b) Natural Selection and antibiotic-resistant bacteria.
   (c) Sexual selection in mammals and birds.

2. Summarise the following:
   (a) Ritualization.
   (b) Ivan Pavlov experiment.
   (c) Genetic drift.
   (d) Cooperative foraging.

3. Discuss the following concepts used in studies of ethology:
   (a) Associative learning.
   (b) Kin selection.
   (c) Handicap principle.
   (d) Territory.

4. Describe the main features of chemical communication in animal species, and explain how
   such communication could be an essential mechanism in prey species.

5. Discuss the main areas of controversy of nature and nurture in the development of behaviour
   in species.

6. Discuss how imprinting behavior could be useful in both offspring and parents in precocial
   species such as ducks and geese.

7. Compare and contrast Character Displacement and Habituation in the evolution of social
   species.

TURN OVER

1

8. Discuss the main differences between Lamarckísm and Darwinism as they relate to the evolution of aggressive behaviour in social species.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2012 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 3161: ETHOLOGY OF BIRDS AND MAMMALS
PRACTICAL PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE
NECESSARY.

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1. Suppose in a court case being contested in a Ndola Resident Magistrate Court, the Ndola City
   Council was being sued for having allowed a chemical manufacturing plant to be located
   within a residential area. It is alleged that since the plant started operating, the incidences of
   child violence in schools had increased during the same period, that this behavioral disorder
   was attributed to a gas produced from the chemical plant. In a court order, the following data
   were collected in two schools (near and far from the plant) for a period of five months to be
   used as evidence

   Table 1: The number of cases of violent behaviour in a Ndola community

Location (School)	June	August	October	January	March
		Period and Number of cases of violence			
Near the plant	11	8	24	21	35
Far location	3	12	17	17	29

   (a) From the data given above, discuss whether or not it was justifiable for the community to
   have taken the City Council to court.
   (b) Discuss theories that would explain abnormal behaviour in children and other species of
   animals.

2. A study of aggressive acts per day in two troops of Olive Baboons (*Papio ursinus*) gave the following results as indicated in Table 2 below:

Table 2: Number of aggressive acts in each troop per day

Troop 1	Troop 2
62	44
74	56
30	40
51	35

(a) Determine whether or not the two groups are significantly different.

(b) Discuss theories that would explain the variation in the frequencies of genes of aggressive behaviour in these two local populations.

3. A survey of a breeding population of a bird species in Bangweulu swamp provided the following data on clutch sizes and percent hatching success.

Table 3: Clutch size and breeding success in a selected bird species

Clutch size	Number of Nests with Young	Percent surviving after 3months
3	80	60
7	72	52
10	70	40
13	65	10

Since it is possible for the species to produce clutches up to 13, discuss why not all the females do this, so as to pass on as many genes as possible to the offspring.

4. Figure 1 below shows a territorial distribution of breeding male Uganda Kob (*Adenota kob thomasi* Erxleben 1777) under the lekking system in Uganda Toro Game Reserve. This breeding characteristic is common in genus *Kobus*, and similarly this lekking system has been described in Kafue Lechwe (*Kobus leche kafuensis* Gray 1850) in Kafue Flats and in Puku *(Kobus vardoni* Livingstone) in the Luangwa valley. Territories are circular with black dots as centers. The shaded area is a wetland (swamp) while the unshaded area is an arena. There are two main territorial grounds where territories are concentrated. Using the diagram in Fig1;

(a) Describe the lekking system in this genus, and discuss the significance of this breeding model in the species.

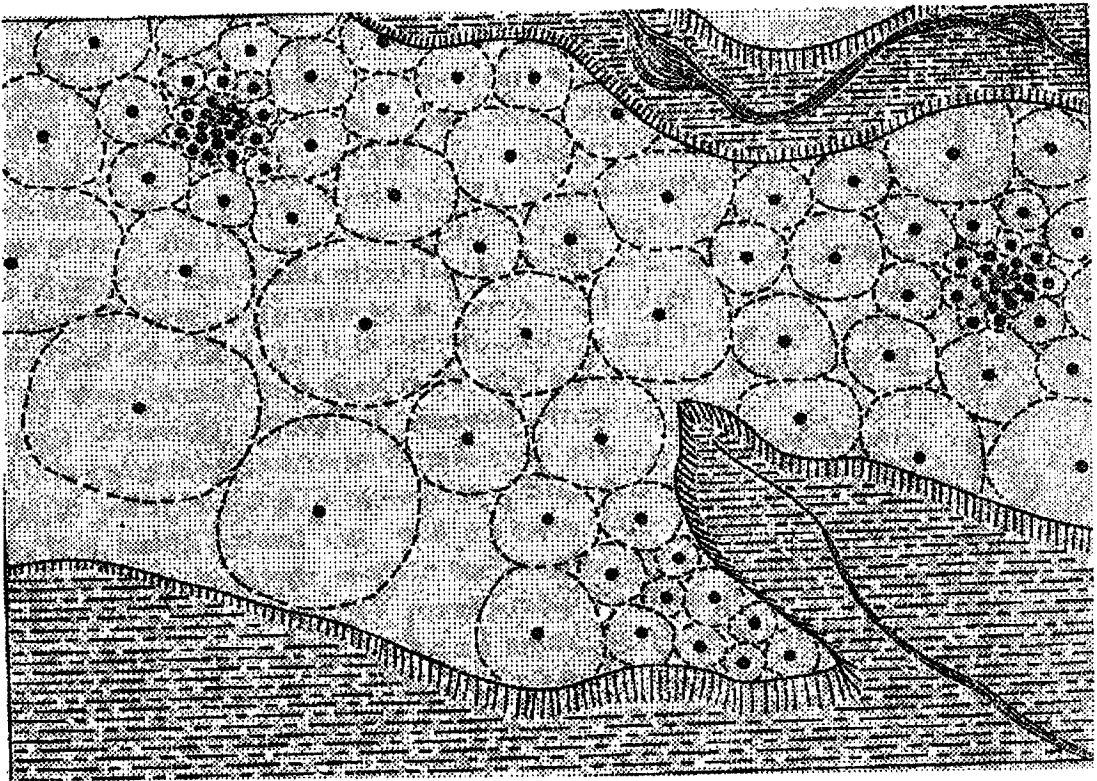(b) Compare this breeding model with that of the monogamous species.

Figure 1: The distribution of Lek territories of Uganda Kob in Toro Game Reserve, Uganda.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2012 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 3141: ECOLOGICAL METHODS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS, TWO QUESTIONS FROM EACH SECTION AND THE FIFTH QUESTION FROM EITHER SECTION. **USE SEPARATE ANSWER BOOKS** FOR EACH SECTION.

SECTION A: Sampling, Experimental Methods and Design

1. Table 1 below provides data of an experiment involving a Completely Randomized Design (CRD). Test the Null Hypothesis (NH) that there are no significant differences among the treatment means.

Table 1. Completely randomized design data.

Replicate	Treatment			
	A	B	C	D
1	2.0	1.7	2.0	2.1
2	2.2	1.9	2.4	2.2
3	1.8	1.5	2.7	2.2
4	2.3		2.5	1.9
5	1.7		2.4	

2. Mean biomass (g) of grassland plants in each of 20 experimental plots is presented in Table 2 below. Half of the experimental plots were burned, while the other half were not.

Table 2. Biomass (g) of grassland plants from burned and unburned experimental plots.

Burned	10.56	11.97	9.01	10.33	9.53	12.10	8.88	8.50	10.20	11.55
Unburned	8.85	8.01	7.13	7.50	9.10	7.87	6.80	9.50	8.88	6.56

Test the Null hypothesis that there is no significant difference in mean biomass from the two types of experimental units.

3. Bill length and bill depth measurements of 13 song sparrows (*Melospiza melodia*), were collected and the data are presented in Table 3. Determine the correlation coefficient of the two dimensions and test its significance.

Table 3. Measurements of bills of song sparrows.

Length (mm)	8.5	8.1	8.8	8.0	8.4	8.5	8.5	9.0	8.2	9.1	8.7	7.7	7.9
Depth (mm)	6.2	6.0	6.2	5.9	5.6	5.7	6.0	6.0	5.6	5.9	5.8	5.4	5.5

4. A survey was conducted in which the percentage cover of a lawn by a common weed was determined both before and after the application of a selective herbicide by means of 400 randomly-distributed point quadrats. Totals of 160 and 120 "hits" (= point quadrats on which the weed was found), respectively, were recorded. These results were analyzed using a 2x2 contingency table presented in Table 4 below. Determine whether the apparent drop in cover percentage is significant.

Table 4. Percentage cover of a lawn by a common weed prior to and after application of a selective herbicide.

	1st Estimate	2nd Estimate	Total
"Hits"	160	120	280
"Misses"	240	280	520
Total	400	400	800

SECTION B: Data Analysis Methods and Research Proposal Writing

5. Four different methods of growing maize were randomly assigned to different plots of land and the yield of maize in kilograms per acre was determined for each plot. A single-factor ANOVA was conducted using MSEXCEL' on the plot data obtained and the results are shown in Table 5.

Table 5. Single - Factor ANOVA output of maize yield grown using four different methods.

SUMMARY				
Groups	*Count*	*Sum*	*Average*	*Variance*
Method 1	9	815	90.555556	13.277778
Method 2	10	864	86.4	14.266667
Method 3	7	670	95.714286	13.238095
Method 4	8	639	79.875	2.9821429

ANOVA					
Source of Variation	*SS*	*df*	*MS*	*F*	*F crit*
Between Groups	1028.6036				2.9222772
Within Groups	334.92579				
Total	1363.5294				

(a) Complete the ANOVA output in Table 5.
(b) Determine whether there are significant differences in maize yield grown using different methods.

6. A bowling club kept the scores of husband and wife teams to determine whether there was a correlation between their performances. The scores of ten teams were subjected to a correlation and regression analysis using MSEXCEL and the output is given in Table 6.

TURN OVER

3

Table 6. Correlation and regression analysis output of scores of husband and wife bowling teams.

Regression Statistics	
Multiple R	0.5496984
R Square	0.3021683
Adjusted R Square	0.2149393
Standard Error	21.970211
Observations	10

ANOVA					
	df	SS	MS	F	F crit
Regression	1		1672.0786		
Residual	8	3861.5214			
Total	9	5533.6			

	Coefficients
Intercept	39.784588
Husband's score	0.6478414

(a) Complete the regression ANOVA table.

(b) Determine whether there is a relationship between the performance of a husband and wife team.

(c) Summarise the relationship in the form of a linear equation.

(d) Determine the score of a woman whose husband scores 111 points.

7. An experiment consisting of sampling the air quality of homes in Lusaka was conducted. Ten homes each from an unplanned settlement and a government housing project were randomly sampled. The objective of the experiment was to compare whether there were differences in the number of bacterial colonies per cubic metre of air. The number of bacterial colonies was estimated from petri dishes and the results are summarised in Table 7.

Table 7. The number of bacterial colonies per cubic metre of air in two human
Settlements.

Unplanned Settlement	Council Housing Project
37	1
2.6	5.3
48.6	3.4
47.8	2.3
99.3	5.1
1.4	38.7
2.3	5
3.1	50.6
3	1.6
0.3	22.7

(a) Determine the following for each sample:
   (i)   SS.
   (ii)   Variance.
   (iii) Standard Deviation.
(b) Determine whether there is a significant difference in the air quality from
    planned and unplanned settlements using the MSEXCEL© output in Table 8.

Table 8. T-Test assuming unequal variance output of the number of bacterial
colonies in two human settlements.

	Unplanned Settlement	Council Housing Project
Mean	24.54	13.57
Observations	10	10
Hypothesized Mean Difference	0	
df	14	
t Stat	0.922812792	
P(T<=t) one-tail	0.185867937	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.371735873	
t Critical two-tail	2.144786681	

TURN OVER

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8. A Two-Factor ANOVA without replication was used to determine whether there were significant differences in the mean yield of three varieties of wheat grown using four different fertilisers. In the analysis, the columns consisted of fertiliser types whereas rows consisted of wheat varieties.

Table 9. Two-Factor ANOVA output of the yield of three wheat varieties grown using four different fertilisers.

SUMMARY	Count	Sum	Average	Variance
Variety 1	4	344.74	86.185	4.6069667
Variety 2	4	332.96	83.24	4.5607333
Variety 3	4	356.25	89.0625	4.316225

Fertiliser 1	3	249.71	83.236667	8.8516333
Fertiliser 2	3	258.6	86.2	8.8209
Fertiliser 3	3	264.6	88.2	8.9109
Fertiliser 4	3	261.04	87.013333	7.3896333

ANOVA					
Source of Variation	SS	df	MS	F	F crit
Rows	67.80605				5.1432528
Columns	40.311692				4.7570627
Error	0.1400833				
Total	108.25783	11			

(a) Complete the ANOVA output in Table 9.
(b) Determine whether there are significant differences in wheat yield grown using different fertilisers and among different wheat varieties.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2012 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 3171: EVOLUTIONARY BIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS, **TWO** QUESTIONS FROM EACH
SECTION AND THE FIFTH QUESTION FROM EITHER SECTION. USE **SEPARATE**
ANSWER BOOKS FOR EACH SECTION.

SECTION A

1. Summarise the following:
   (a) Neutral theory of molecular evolution.
   (b) Microevolution.
   (c) Gene co-option.
   (d) Mutation rates in Humans.

2. (a) Explain why the recurrent laryngeal nerve is considered good piece of evidence for biological evolution.

   (b) Explain why the genetic code is considered an arbitrary "frozen accident" and not to be the most ideal code by evolutionary biologists.

3. (a) State the sources of the four types of mutations that are most significant for evolution and their evolutionary importance.
   (b) Discuss the role of mutations as the ultimate source of variation in populations,

4. (a) Describe the changes in allele frequencies in the life cycle (over one generation) of an imaginary population of mice with a locus having initial gamete allele frequencies of B1 = 0.6, B2 = 0.4, subsequent zygote population size of 100 and phenotype survival rates of 100% for B1B1, 75% for B1B2 and 50% for B2B2. State the working assumptions.

   (b) State the implication of the changes in allele frequencies in (a) on conclusion 1 of the Hardy-Weinberg equilibrium principle.

TURN OVER

5. . Study the skulls 1 - 3 and then answer (a) – (c) .
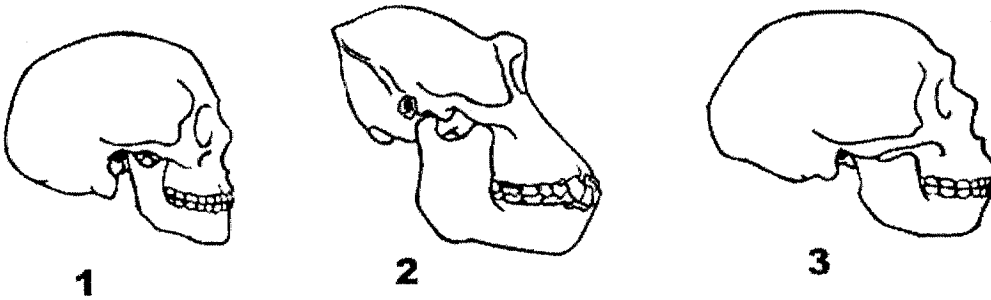

Figure 1: Skulls of different hominoid species.

(a) Identify the skull of *Homo sapiens* and that of *Homo neanderthalensis* and explain the criteria you have used in your identification.

(b) Briefly describe the major adaptations that have taken place since the split between the last common ancestor of humans and the great apes.

(c) Comment on the challenges of encephalisation in modern *Homo sapiens*.

6. (a) Differentiate between material and intangible human culture.
   (b) Briefly describe the various stages of human cultural evolution.
   (c) Differentiate between cultural evolution and evolution through natural selection in humans.

7. (a) Discuss the evolutionary relationships between Homo sapiens, their ancestors and the modern apes.
   (b) Discuss the two models of global human dispersal.

8. (a) Using two named examples of each, differentiate between Batesian mimicry and Mertensian mimicry as two evolutionary survival strategies.

   (b) Summarise two other types of mimicry.
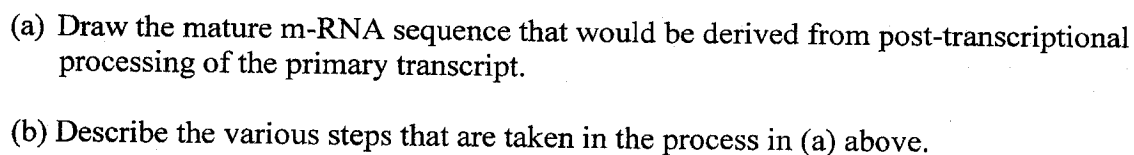   (c) Distinguish between mimicry and camouflage.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2012 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 3231 MOLECULAR BIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS, **TWO** QUESTIONS FROM SECTION A, **TWO** QUESTIONS FROM SECTION B AND A **FIFTH** QUESTION FROM EITHER SECTION. ILLUSTRATE YOUR ANSWERS WHEREVER NECESSARY.

SECTION A

1. Explain the reasons why many geneticists favoured protein over DNA as the genetic material before 1940.

2. Describe Griffith's experiment that contributed to the criteria necessary for identifying hereditary material.

3. Describe the different forms of DNA that have been recognized under different conditions.

4. Below is a sequence of ribonucleotide residues in a primary m-RNA transcript.

I_1 = Intron 1 I_2 = Intron 2

(a) Draw the mature m-RNA sequence that would be derived from post-transcriptional processing of the primary transcript.

(b) Describe the various steps that are taken in the process in (a) above.

TURN OVER

SECTION B

5. Table 1 shows the effects of two mobile genetic elements (Ac/Ds) on the expression of the anthocyanin-coding genes of *Zea mays* plants. All the plants were heterozygous for the anthocyanin-coding genes. Study the table carefully and then answer (a) and (b).

Table 1. Effects of Ac/Ds on the expression of anthocyanin-coding genes in *Zea mays*

Scenario	Genotype	Alleles affected by Ac/Ds	Stage of seed development
1	CC'Bz bz	No allele was affected	Early
2	CC'Bz bz	Only allele C' was affected	Early
3	CC'Bz bz	Alleles Bz and C' were affected	Late
4	CC'Bz bz	Alleles Bz and C' were affected	Early

(a) Explain the functions of alleles C, C', Bz and bz.

(b) Predict the colour of most seeds under each of scenarios (1) – (4) and justify your colour prediction under each scenario.

6. (a) Briefly describe the processes of chain initiation and elongation during translation in prokaryotes.

(b) Explain, using one human example, how protein misfolding leads to disease development.

7. (a) Differentiate between regulation of gene expression in prokaryotic and eukaryotic organisms.

(b) Explain the role of RNA interference in the regulation of eukaryotic gene expression.

8. (a) Explain the regulation of alternative pre-mRNA splicing in eukaryotes

(b) Explain how the expression of the glycoprotein hormone alpha subunit is regulated in mammals.

END OF EXAMINATION

BIO 3261: PLANT AND ANIMAL TAXONOMY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS, TWO QUESTIONS FROM EACH
SECTION AND THE FIFTH QUESTION FROM EITHER SECTION. USE **SEPARATE**
ANSWER BOOKS FOR EACH SECTION

SECTION A: Biological Taxonomy, Nomenclature and Classification

1. In biological nomenclature, a type is defined as an element or specimen on which the
   description associated with the original publication of a name of an organism is based.
   Distinguish the following nomenclatural types:

   (a) Neotype.
   (b) Allotype.
   (c) Syntype.
   (d) Holotype.
   (e) Paralectotype.

2. (a) Discuss the basic tenets of the botanical, zoological and bacteriological codes of
       nomenclature.
   (b) Indicate the major nomenclatural publications that are considered important and
       whose publications dates are taken as the start dates for the codes.

3. Explain the Splitter and Lumper approaches to biological classification and why the two
   schools of thought cannot agree on one approach to the classification of organisms.

4. Explain the significance of biological taxonomy in relation to:

   (a) Other disciplines of biology and sciences.
   (b) Understanding the evolutionary processes.
   (c) Prediction of characteristics of yet-to-be-discovered organismal species.
   (d) Study of effects of anthropogenic factors on biodiversity.

SECTION B: Plant and Animal Nomenclature and Classification

5. Describe the major characteristic features, distribution and diversity of the family
   Aristolochiaceae.

TURN OVER

6. Discuss the International Code of Zoological Nomenclature (ICZN), indicating purpose, types of organisms covered by the code and the significance of it's start date.

7. Discuss the taxonomically important terminology relating to angiosperm floral whorl composition, flower part fusion and ovary position.

8. One Zoologist was heard saying that, "the current consensus is that Chordates are monophyletic, meaning that the phylum Chordata contains all and only the descendents of a single common ancestor which is itself a Chordata". Argue for or against this statement.

END OF EXAMINATION

BIO 3261: PLANT AND ANIMAL TAXONOMY
PRACTICAL PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS, QUESTIONS **ONE** AND **TWO** IN **ONE ANSWER BOOK** AND QUESTION **THREE** IN **A SEPARATE ANSWER BOOK.**

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1. Construct a dichotomous taxonomic key for the identification of animal specimens A – J provided.

2. Examine animal specimens K – P closely and identify six taxonomic features that unify the animal specimens as members of a single named taxon above the rank of species.

3. Using the taxonomic key provided, identify plant specimens Q – U provided, indicating the steps followed in the identification process.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2012 ACADEMIC YEAR: FIRST SEMESTER
FINAL EXAMINATIONS

BIO 4391 FRESHWATER ECOLOGY
PRACTICAL PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS.

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1. Table 1. below shows results of an ecological investigation for a lake where temperature measurements were recorded for one year at different depths. Using the results in Table 1, answer the questions below:

Table 1. Results of temperature in different months and depths of a lake

Month	Values of Temperature (^{o}C) in at different depths																
Jan	0	0	0	0	0	1	2	3	3	3	3	3	3	3	3	3	3
Feb	0	0	0	0	1	2	3	3	3	3	3	3	3	3	3	3	3
Mar	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Apr	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
May	10	8	8	6	5	4.5	4	4	4	4	4	4	4	4	4	4	4
Jun	18	15	10	8	6	5	4	4	4	4	4	4	4	4	4	4	4
Jul	15	15	12	12	10	8	5	4	4	4	4	4	4	4	4	4	4
Aug	12	12	12	10	8	5	5	4	4	4	4	4	4	4	4	4	4
Sep	10	8	8	6	5	4.5	4	4	4	4	4	4	4	4	4	4	4
Oct	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Nov	0	0	0	0	1	2	3	3	3	3	3	3	3	3	3	3	3
Dec	0	0	0	0	0	1	2	3	3	3	3	3	3	3	3	3	3
Depth (m)	0	1	2	5	8	10	15	20	25	30	35	40	45	50	60	70	80 Bottom

(a) Construct an appropriate depth- time diagram that could be used in describing the lake's thermal regime.

(b) Using the diagram constructed in a) above, provide a detailed description of the thermal regime for the lake under investigation.

(c) According to the classification of lakes based on thermal regime name the type of lake that is being investigated.

TURN OVER

2. Figure 1 below is a bathymetric map of lake that is investigated. Given that the total surface of the lake is 1,884 m² and areas corresponding to each depth are provided in Table 2.
   (a) Estimate the total lake volume.
   (b) Construct a an appropriate hyposographic depth-* area curve.
   (c) Construct an appropriate hyposographic volume – depth curve.

Table. 2. Areas of the lake corresponding to each depth.

Depth (m)	5	10	15	20	25	30	34
Area (m²)	1680	1612	1586	1474	1288	892	226
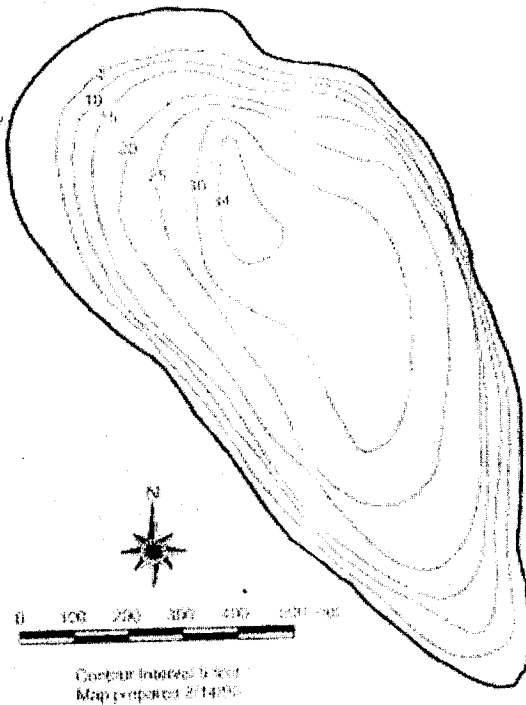
Fig. 1 Bathymetric map of a lake

The volume and shore can be estimated from the formula

$$V = {}^h/_3[A_1 + A_2 (A1 \times A)^{1/2}]$$

PROCEED TO THE NEXT PAGE

2

3. A limnologist is assigned to provide a detailed description of a given lake. He chooses to take the following measurements in summer at different depths: temperature; dissolved oxygen concentrations; and densities of the most abundant phytoplankton species during the early summer phytoplankton bloom. The results obtained are shown in the Table 3 below.

Table 3 Values of temperature (°C), dissolved oxygen and concentrations of Melosira sp (cells per cm³) at different depths.

Depth (m)	0	1	2	5	7	10	12	15	20	25	30	40	50	60	70	80	90
Temp °C	25.5	25	25	25	25	25	25	24	20	16	15.5	15.5	15.5	15.5	15.5	15.5	15.5
O$_2$ mg l^{-1}	4	4.5	5	6	8	8	12	14	8	7	2	1	0	0	0	0	0
Melosira sp	19	25	28	30	50	60	84	98	150	75	30	15	15	15	15	15	15

(a) Construct appropriate diagrams and curves that would be useful in describing the relative productivity of the lake.
(b) Based on curves constructed in (i) above assess the relative productivity of the lake being Described.
(c) Assess the effect of light on the primary productivity.

END OF THE EXAMINATION

3

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2012 ACADEMIC YEAR: FIRST SEMESTER
FINAL EXAMINATIONS

BIO 4391: FRESHWATER ECOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. QUESTIONS **ONE** AND **TWO** ARE
COMPULSORY. AND ANSWER ANY **THREE** OTHER QUESTIONS.
USE ILLUSTRATIONS IN YOUR ANSWERS.

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1. Summarise the following in relation to relative productivity of aquatic ecosystems:
   (a) Shoreline development.
   (b) Secchi disk depth.
   (c) Salinity.

2. (a) Discuss the vertical distribution of oxygen under thermal stratification in a warm
       mesotrophic lake.
   (b) Give reasons for anaerobic hypolimnion in a deep oligotrophic lake.

3. Describe the main sections of aquatic habitats and the type of organisms that are common in
   each section.

4. Discuss the circulation of nitrogen in freshwater ecosystems.

5. Compare and contrast tectonic lakes and those formed by glaciations.

6. Summarise effects of the following on seasonal succession of phytoplankton in a
   warm monomictic lake:
   (a) Winter isothermy.
   (b) Mid summer thermal stratification.

7. (a) Describe a method for determining aquatic primary productivity that uses radioactive
       carbon dioxide.
   (b) Discuss limitations of the method in (a) above for measuring primary productivity.

8. Compare and contrast characteristics of organisms common in lakes and those of river
   ecosystems.

END OF EXAMINATION

2012 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 4415: IMMUNOLOGY
THEORY PAPER

TIME: THREE HOURS

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

1. Compare and contrast the innate and adaptive components of the immune system.

2. Explain the general structure, roles and classes of the Major Histocompatibility Complex (MHC) in the development of cell mediated immune response.

3. Discuss the different pathways of complement activation that occur during microbial infection.

4. Describe the nature, structure, function and classes of antibodies.

5. Describe the major events of an inflammatory response that are initiated by the immune system as a protection against bacterial infection and tissue injury.

6. (a) Discuss the clonal selection and clonal expansion mechanisms when an antigen binds to a B-cell

   (b) Distinguish between a primary and secondary humoral immune response to an antigen.

7. Contrast the properties of professional Antigen Presenting Cells (APCs) that affect their abilities to present antigen to induce T-cell activation.

8. Explain how hematopoiesis gives rise to the various cells that make the immune system function. Give a detailed account of this process.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2012 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BIO 4471: PLANT-INSECT RELATIONSHIPS
THEORY PAPER

TIME: THREE HOURS

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

SECTION A

1. Discuss co-evolution of insects and plants.

2. Discuss with examples patterns of host-plant use by insect herbivores.

3. Summarise the following:
   (a) Secondary plant products.
   (b) Plant defenses against insects.
   (c) Insect galls.
   (d) Figs and fig wasps.

4. Discuss the process of host-plant selection in phytophagous insects.

SECTION B

5. Summarise the following in relation to insect-plant interactions:
   (a) Plant stress hypothesis.
   (b) Effect of late successional plants on insects.
   (c) Host quality.
   (d) Honeydew production.

6. Discuss the effects of insect herbivory on plant performance.

7. Discuss the role of bees and ants in ecosystems in the context of insect- plant
   interactions.

8. Discuss the role of vegetative diversity in the regulation of insect-plant interactions.

END OF EXAMINATION

BIO 4521: VERTEBRATE BIOLOGY
PRACTICAL PAPER

TIME: 1 HOUR 30 MINUTES

INSTRUCTIONS: ANSWER **ALL** QUESTIONS. ILLUSTRATE YOUR ANSWERS
WHERE NECESSARY.

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1. You are provided with vertebrate organs labelled **A1** to **A5** obtained from specimen
   A also provided.
   (a) State the phylum, class, and order to which the specimen belongs.
   (b) Explain how the specimen is best suited to live in its natural habitat.
   (c) State the names of the organs A1 to A5.
   (d) Describe the functions of the organs A1 to A5.

2. Examine carefully figures **B1** to **B4** provided. For each figure:
   (a) State the name of the vertebrate structure represented.
   (b) Identify all the numbered parts.
   (c) State the function(s) of each of the numbered parts.

3. Study figure **C** carefully.
   (a) State the name of figure **C**.
   (b) Identify all the numbered parts.
   (c) State the function(s) of each of the numbered parts.
   (d) Give four examples of vertebrates that possess figure **C**.

END OF EXAMINATION

BIO 4521: VERTEBRATE BIOLOGY
THEORY PAPER

TIME: THREE HOURS

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

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1. Discuss the variations in structure and function of the vertebrate urinary systems.

2. Summarise the following:
    (a) Mammalian dermal composition.
    (b) Buccal pumping.
    (c) Morphogenetic movement patterns involved in gastrulation.
    (d) Coronary circulation.

3. Describe the embryogenetic process of organogenesis in vertebrates.

4. (a) Discuss the evolution of muscles in mammals that are lacking in other
        vertebrates.
    (b) Outline the functions of each of the pairs of cranial nerves in the human body.

5. Compare and contrast the pattern of cleavage in avian and mammalian eggs.

6. Describe the stages and mechanisms involved in the process of endochondrial
    ossification in mammals.

7. Explain how the reptilian integument has adapted to the harsh terrestrial
    environment.

8. Discuss the morphological variation and replacement of teeth in vertebrates.

END OF EXAMINATION

BS 3421: MYCOLOGY
THEORY PAPER

TIME: THREE HOURS

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

1. Describe how the following fungi form their asexual spores.
   (a) *Saprolegnia.*
   (b) *Neurospora crassa.*
   (c) *Aspergillus niger.*

2. Summarise with the aid of an appropriate graph, growth phases that occur in a fungus population maintained in a batch culture.

3. (a) Describe the growth zone structure of a hypha.
   (b) Explain how the apex of a fungal hypha grows by extension.

4. Describe septal structure in the following groups of fungi:
   (a) Zygomycota.
   (b) Ascomycota.
   (c) Mitosporic fungi.
   (d) Basidiomycota.

5. (a) Describe extracellular digestion in filamentous fungi.
   (b) Explain how fungi utilise natural crystalline cellulose as a source of carbon.

6. (a) Describe the structure of a typical hypha.
   (b) Describe the following modifications of hyphae and comment on their role.
      (i) Hyphal traps.
      (ii) Infection structures.

7. Compare and contrast conidiophore morphology in *Aspergillus* and *Penicillium* species.

8. Describe thallus structure and reproductive strategies in *Saprolegnia.*

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2012 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C101: INTRODUCTION TO CHEMISTRY I

TIME: THREE (3) HOURS

INSTRUCTIONS TO THE CANDIDATES

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

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

3.   Section A has ten (10) short answer questions. Questions carry equal marks. (Total marks = **40**).
       ANSWER ALL QUESTIONS IN SECTION A IN THE MAIN ANSWER BOOKLET

4.   Section B has five (5) long answer questions. Questions carry equal marks. (Total marks = **60**).
       ANSWER QUESTION B1 and ANY THREE QUESTIONS, EACH IN A SEPARATE ANSWER BOOKLET.

5.   **ATTEMPT ALL QUESTIONS IN SECTION A; AND B1 AND ANY OTHER THREE QUESTIONS IN SECTION B.**

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

7.   **ENSURE** that you have seven (8) printed pages and Periodic Table.

ADDITIONAL INFORMATION TO THE CANDIDATES:

1.   **Useful data** is printed on **page 8**.
2.   **Periodic table is printed on the last page.**

QUESTION A1

One molecule of an organic compound has molecular mass of 146.16 amu, and has the following data:

	C	H	O
Mole	9.96×10^{-24} mol	16.6×10^{-24} mol	6.64×10^{-24} mol
Ratio of moles			

(a)   Copy and complete the Table above in your answer booklet.
(b)   Write the empirical formula of the compound.
(c)   What is its molecular formula?

(4 marks)

QUESTION A2

Powdered zinc and sulfur react in an extremely rapid, exothermic reaction. Calculate mass of S required to react completely with 6.541 g of Zn according to the reaction below.

$$Zn(s) + S(s) \rightarrow ZnS(s)$$
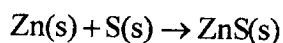
(4 marks)

QUESTION A3

A 0.5813 g of an alkane, C_nH_{2n+2}, gas filled a 0.2500 L flask at a temperature of 297.55 K and a pressure of 742.56 torr. Determine the molar mass of the alkane.

(4 marks)

QUESTION A4

Magnesium was added to hydrochloric acid, and produced 5.25 L of hydrogen gas, at a temperature of 52.0 °C and a pressure of 0.987 atmospere, according to the reaction below. What mass of Mg was used in this single displacement reaction?

$$Mg(s) + 2HCl(aq) \rightarrow MgCl(s) + H_2(g)$$
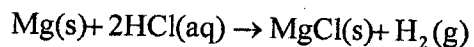
(4 marks)

QUESTION A5

In the Balmer series of the hydrogen atom, the first emission line is observed at a wavelength of 656.3 nm.
(a)   Calculate the value of the Rydberg constant.
(b)   Calculate the energy of one mole of quanta emitted during the transition.

(4 marks)

QUESTION A 6

The following is a schematic diagram for the first five energy levels of the hydrogen atom.

$-E_n$ ↓

```
—————————————————  n = 5
—————————————————  n = 4

—————————————————  n = 3
—————————————————  n = 2

—————————————————  n = 1
```
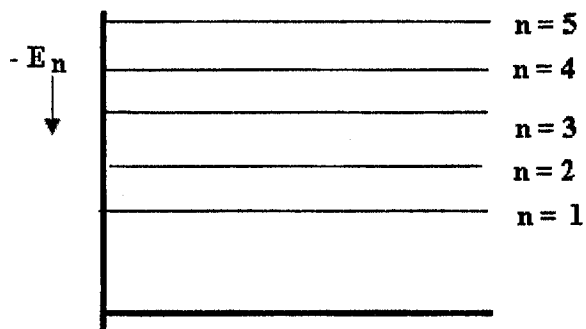
Reproduce the diagram in your answer book. On the diagram draw and label arrows to show:

(a) A transition to the ground state. Label it **A**
(b) The transition which would generate the spectral line of longest wavelength. Label it **B**.
(c) The transition which would generate the spectral line of shortest wavelength. Label it **C**.
(d) The transition for the spectral line of longest wavelength in the Paschen series. Label it **D**.
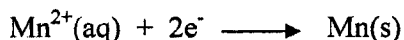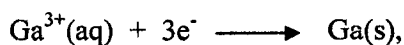
(4 marks)

QUESTION A7

Consider the molecule carbon dioxide.
(a) Write its Lewis diagram.
(b) What is the geometry of the molecule?
(c) What are the magnetic properties of the molecule; that is: is it paramagnetic or diamagnetic? Explain your answer.

(4 marks)

QUESTION A8

A functioning cell is made by coupling the following reactions:

$Ga^{3+}(aq) + 3e^- \longrightarrow Ga(s)$,

$Mn^{2+}(aq) + 2e^- \longrightarrow Mn(s)$

(a) What is the voltage of the cell when it operates under standard conditions?
(b) What is the Gibbs free energy of the cell?

(4 marks)

QUESTION A9

The so called "*noble*" metals like gold are given this fancy name primarily because they do not corrode. Explain why gold does not corrode but iron corrodes when they are exposed to a wet and aerated acidic or basic environment.

(4 marks)

3

QUESTION 10

Write the reactions, if any, that occur when the following substances are mixed. In each case briefly explain your answer.

(a)   iron metal with aqueous zinc(II) ions

(b)   aqueous iron(III) ions with aqueous chromium(II) ions

(4 marks)

SECTION B   ANSWER B1 AND ANY OTHER THREE QUESTIONS

QUESTION B1

(a)   In titrations, what is meant by term primary standard?   **(3 marks)**

(b)   A student standardized potassium permanganate, $KMnO_4$, using a 19.60 g/L
      $FeSO_4(NH_4)SO_4.6H_2O$, (molar mass =392.21 g/mol) standard solution.

      A 20.00 mL of the standard solution, acidified with H_2SO_4 was put in a conical
      flask. A titre volume 15.50 mL of $KMnO_4$ solution was required to reach the end-
      point.

      The titration reaction is

      $$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$$
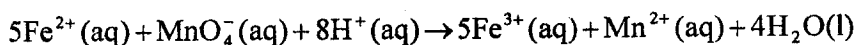
   (i)   Calculate the molarity of the standard solution.   **(3 marks)**
   (ii)   Why was it necessary to acidify the standard solution before titration?
                                                                (3 marks)
   (iii)   Write the mole-mole relationship involving the reactants in the above reaction.
                                                                (2 marks)
   (iv)   Determine molarity of $MnO_4^-(aq)$ in the burette.   **(4 marks)**

QUESTION B2

A 0.263 g sample of impure iron, containing an unreactive impurity, was reacted with an
excess of hydrochloric acid. All of the iron in the sample reacted, evolving hydrogen gas
and forming a solution of iron(II) chloride. The volume of hydrogen evolved was 102 cm^3,
measured at 298 K and 110 kPa.
The percentage, by mass, of iron in the sample can be determined using either the volume of
hydrogen produced or by titrating the solution of iron(II) chloride formed against a standard
solution of potassium dichromate(VI).

(a)   (i)   Write an equation for the reaction between iron and hydrochloric acid.
                                                                (1 mark)
      (ii)   Calculate the number of moles of hydrogen produced in the reaction.
                                                                (3 marks)
      (iii)   Use your answers to parts (a)(i) and (ii) to determine the number of moles of
              iron and the mass of iron in the original sample.
                                                                (2 marks)
      (iv)   Calculate the percentage of iron in the original sample.   **(2 marks)**

(b)   (i)   Write half-equations for the oxidation of Fe^{2+} and for the reduction of
              $Cr_2O_7^{2-}$ in acidic solution, and use these to construct an overall equation for
              the reaction between these two ions.   **(3 marks)**

      (ii)   The number of moles of iron in the sample was determined in part (a)(iii).
              Use this answer to calculate the volume of a 0.0200 $moldm^{-3}$ solution of

5

potassium dichromate(VI) which would react exactly with the solution of iron(II) chloride formed in the reaction. **(1 mark)**

(iii) Use the electrode potential values to explain why an incorrect value for the number of moles of iron(II) chloride formed would have been obtained if the original solution had been titrated with potassium manganate(VII).
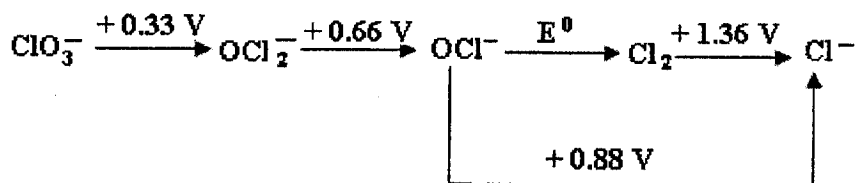
(3 marks)

QUESTION B3

The energy of a hydrogen like atom is given by $E_n = -R_H \frac{Z^2}{n^2}$, where $R_H = -2.18 \times 10^{-18} J$. Consider the Periodic Table Group 1 multi-electron element sodium whose first ionization energy is $8.24 \times 10^{-19} J$. In a multi-electron atom such as sodium, electrons experience what is termed "*the effective nuclear charge*".

(a) What does the letter Z stand for in the formula for the energy of a hydrogen like atom? **(1 mark)**

(b) Briefly explain what is meant by, or define, the term "*the effective nuclear charge*". **(2 marks)**

(c) Write an equation that defines the first ionization energy of the sodium atom. Is the ionization reaction a reduction or an oxidation? Briefly explain your answer. **(2 marks)**

(c) Write the electron configuration of sodium. Which are the valence electrons? **(3 marks)**

(e) Calculate "*the effective nuclear charge*" felt by the valence electrons. **(4 marks)**

(f) Compare "*the effective nuclear charge*" that you calculated in part e) of this question with the expected "*the effective nuclear charge*" as you explained or defined in part b) of this question. Explain your answer. **(3 marks)**

QUESTION B4

Given the following standard reduction potentials for the species that contain chlorine in basic solutions

$$ClO_3^- \xrightarrow{+0.33\ V} OCl_2^- \xrightarrow{+0.66\ V} OCl^- \xrightarrow{E^0} Cl_2 \xrightarrow{+1.36\ V} Cl^-$$

$$OCl^- \xrightarrow{+0.88\ V} Cl^-$$

(a) Calculate the missing electrode potential, E°, in the diagram. **(4 marks)**
(b) Predict whether following reaction is spontaneous.

$$Cl_2 \longrightarrow OCl^- + Cl^-$$

Give the balanced reaction. **(3 marks)**

(c) What is electron affinity? **(2 marks)**

(d) The electron affinities, (EA), of some Period 2 elements are given below

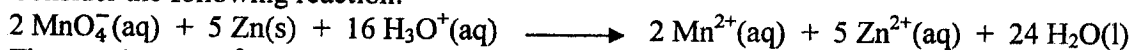| Element	B	C	N	Q	F	Ne
EA (kJ mol^{-1})	+ 27	+ 122	-7	+ 141	+ 328	< 0

(4 marks)

(i) Explain the observed trend in the electron affinities of these elements.
(ii) Explain why the electron affinity of nitrogen differs with the observed trend.

(e) Draw a labeled sketch diagram, on the Cartesian coordinate system, the shape of an orbital with following set of quantum numbers: n = 3, l = 1, m = 0

(2 marks)

QUESTION B5

Consider the following reaction:
$$2\, MnO_4^-(aq) + 5\, Zn(s) + 16\, H_3O^+(aq) \longrightarrow 2\, Mn^{2+}(aq) + 5\, Zn^{2+}(aq) + 24\, H_2O(l)$$
The reaction has E^o_{cell} = + 2.27 V and its equilibrium constant K = 10^{383} at 25° C.

(a) What is the oxidation number for Mn in MnO_4^- ?   **(3 marks)**
(b) How many electrons are transferred in this reaction?   **(3 marks)**
(c) Would you expect a large quantity of MnO_4^- ions at equilibrium at 25° C? Explain your answer.   **(3 marks)**
(d) Calculate the voltage that the cell generates at 35° C when it operates under the following conditions: [MnO_4^-] = 0.50M; [H_3O^+] = 1.00M; [Mn^{2+}] = 0.25M; and [Zn^{2+}] = 0.1M

(6 marks)

END OF EXAM

Avogadro's constant, N_A = 6.022 x10^{23} mol^{-1}
Molar volume of gas at STP = 22.4 dm^3 mol^{-1}
Planck's constant , h = 6.626 x10^{-34} J s
Rydberg constant, R_H = 1.097 x10^7 m^{-1}
Speed of light, c = 3.00 x 10^8 m s^{-1}
Mass of an electron, m_e = 9.11 x10^{-31} kg
1 eV = 1.602 x10^{-19} J
1 Joule = 1 J = 1 kg m^2 s^{-2}

Gas constant R

8.3145 J mol^{-1} K^{-1}
0.083145 L bar mol^{-1} K^{-1}
0.08206 L atm mol^{-1} K^{-1}
62.364 L torr mol^{-1} K^{-1}
62.364 L mmHg mol^{-1} K^{-1}

Pressure

$$1 \text{ atm} = 1.01325 \times 10^5 \text{ Pa}$$
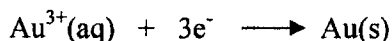$$= 1.01325 \times 10^5 \text{ N m}^{-2}$$
$$= 760 \text{ torr}$$
$$= 760 \text{ mmHg}$$
$$= 1.01325 \text{ bar}$$
$$1 \text{ bar} = 1.00000 \times 10^5 \text{ Pa}$$
$$= 1.00000 \times 10^5 \text{ N m}^{-2}$$
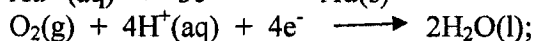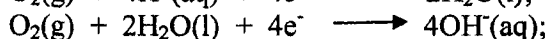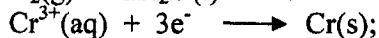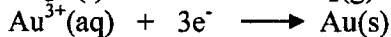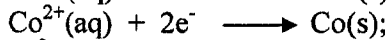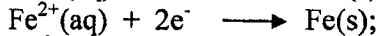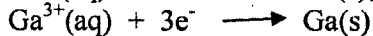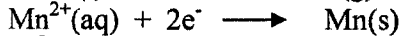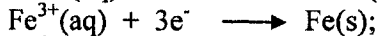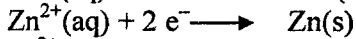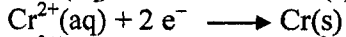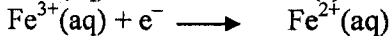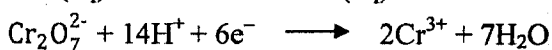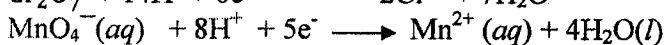
$Au^{3+}(aq) + 3e^- \longrightarrow Au(s)$	E^0 = +1.40 V
$O_2(g) + 4H^+(aq) + 4e^- \longrightarrow 2H_2O(l)$;	E^0 = +1.23 V
$O_2(g) + 2H_2O(l) + 4e^- \longrightarrow 4OH^-(aq)$;	E^0 = +0.40 V
$Cr^{3+}(aq) + 3e^- \longrightarrow Cr(s)$;	E^0 = -0.74 V
$2H_2O(l) + 2e^- \longrightarrow H_2(g) + 4OH^-(aq)$;	E^0 = -0.83 V
$Au^{3+}(aq) + 3e^- \longrightarrow Au(s)$	E^0 = +1.40 V
$Co^{2+}(aq) + 2e^- \longrightarrow Co(s)$;	E^0 = -0.28 V
$Fe^{2+}(aq) + 2e^- \longrightarrow Fe(s)$;	E^0 = -0.44 V
$Ga^{3+}(aq) + 3e^- \longrightarrow Ga(s)$	E^0 = -0.53 V
$2H_2O(l) + 2e^- \longrightarrow H_2(g) + 4OH^-(aq)$;	E^0 = -0.83 V
$Mn^{2+}(aq) + 2e^- \longrightarrow Mn(s)$	E^0 = -1.18 V
$Fe^{3+}(aq) + 3e^- \longrightarrow Fe(s)$;	E^0 = -0.04 V
$Zn^{2+}(aq) + 2e^- \longrightarrow Zn(s)$	E^0 = - 0.76 V
$Cr^{2+}(aq) + 2e^- \longrightarrow Cr(s)$	E^0 = - 0.91 V
$Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)$	E^0 = + 0.77 V
$Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$	E^0 = +1.33
$MnO_4^-(aq) + 8H^+ + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$	E^0 = + 1.52

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2012 SEMESTER I EXAMINATIONS

C 205: ANALYTICAL AND INORGANIC CHEMISTRY
TIME: THREE HOURS.

INSTRUCTIONS:
1. THIS PAPER CONTAINS FIVE QUESTIONS
2. ANSWER ANY FOUR QUESTIONS
3. EACH QUESTION CARRIES 15 MARKS
4. SHOW ALL YOUR WORKING CLEARLY
5. ESSENTIAL DATA TABLES ARE ATTACHED TO THE QUESTION PAPER.

Question 1.

(a). In 1964, a new compound composed of potassium, molybdenum and cyanide, with formula $K_xMo_y(CN)_z$ was reported. Chemical analyses showed the presence of 25.51% K and 31.54% Mo. Determine the empirical formula of the compound.

(b). Ethylene diamminetetraacetic acid (EDTA, H_4Y) has the following dissociation constants $pK_{a1} = 2.008$; $pK_{a2} = 2.683$; $pK_{a3} = 6.098$; and $pK_{a4} = 10.181$.
    (i)   Write down equilibrium constant expressions for the second dissociation of the acid.
    (ii) Calculate the K_a value for the acid.

(c). The use of octane enhancing additives leads to the accumulation of metals such as lead, on the leaves of plant growing by the road-side. The lead content of leaf samples was measured spectrophotometrically by reaction with dithizone. The standard deviation for a triplicate analysis was 2.3ppm. What is the 90% confidence limit?

(d). Deduce the structures of the complexes $[Ni(CO)_4]$ and $[Ni(CN)_4]^{2-}$ using Valence bond theory.

Question 2.

(a). Lead iodate, $Pb(IO_3)_2$, is an example of a sparingly soluble salt with a solubility product of 2.6×10^{-13} in aqueous medium.
    (i)   What is meant by the term 'sparingly soluble'
    (ii) When 35ml of a 0.150 M lead nitrate, $Pb(NO_3)_2$ solution was added to 15ml of a solution of 0.0800 M potassium iodate, KIO_3, a precipitate was formed. What precipitate is it?
    (iii) What is the concentration of Pb^{+2} ions in the equilibrium mixture?

(b). Using M.O diagram indicate paramagnetic nature of B_2 and non existence of He_2.

(c). In the nuclear industry, detailed records are kept of the quality of plutonium received, transported or used. Each shipment of plutonium pellets received is carefully analyzed to check that the purity and hence the total quantity is as the supplier claims. A particular shipment is analyzed with the following results: 99.93, 99.87, 99.91 and 99.86%. The listed purity as received from the supplier is 99.95%. Is the shipment acceptable with 95% confidence?
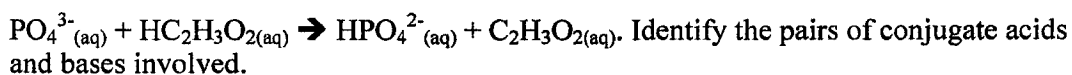
Question 2(Continued).

(d).   (i)   Describe the ingredients you would use to prepare a buffer solution that can be used at values less than pH 7.
       (ii)   Calculate the pH of a buffer solution prepared by adding 10.0 ml of 0.20 M acetic acid to 40.0 ml of 0.50 M sodium acetate.

Question 3.

(a).   What is Inorganic benzene? Comment on its reactivity.

(b).   A batch of cough mixture 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 131.1g.
       (i)   Determine whether the last weight is an outlier datum at 99% confidence level.
       (ii)   Compute the standard deviation of the mean.

(c).   An iron ore is analysed for iron content by dissolving in acid, converting the iron to Fe^{2+}, then titrating with standard potassium dichromate (0.0150 M) solution. If 35.6 mL titrant is required to titrate the iron in 1.85 g of an ore sample, how much iron is in the sample expressed as milligrams of Fe_2O_3 correct to 3 significant figures?

(d).   If 5.82 g of $KHC_2O_4.H_2C_2O_4$ (three ionisable protons) having 10% inert impurities, and 3.02 g of $KHC_8H_4O_4$ (one ionisable proton) are dissolved in water and diluted to 500 cm^3, what is the normality of the solution assuming a complete ionisation.

Question 4.

(a)   When the strong cleaning agent "trisodium phosphate" is mixed with household vinegar, which contains acetic acid, the following equilibrium is established:

$PO_4^{3-}{}_{(aq)} + HC_2H_3O_{2(aq)} \rightarrow HPO_4^{2-}{}_{(aq)} + C_2H_3O_{2(aq)}$. Identify the pairs of conjugate acids and bases involved.

(b)   Classify, with justification, the following reactions as either <u>redox</u> or not <u>redox</u>
       (i) $2Ag + Cl_2 \rightarrow 2AgCl$
       (ii) $2H_2 + O_2 \rightarrow 2H_2O$
       (iii) $Ag^+ + 2NH_3 \rightarrow Ag(NH_3)_2^+$

(c)   Compare the ionization energy of Ca to that of Zn. Explain the difference in terms of balance between shielding with increasing number of d electrons and effect of increasing nuclear charge.

(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.

Question 5.

(a)   Complete and balance the following redox reactions which occur in acid aqueous solution:
       (i) $Cr_2O_7^{2-} + BrO_4^- + H_2O \rightarrow Br_2 + Cr^{+3} + H_2O$ given that E^0 for $Cr_2O_7^{2-}/Cr^{3+}$ =1.33v; and, E^0 for BrO_4^- / Br_2 = 1.52v.

       (ii). $NO_3^- + Cu \rightarrow NO_2 + Cu^{2+} + H_2O$

Question 5 (Continued).

(b). Phthalic acid is a diprotic acid (generally represented as H_2A). The acid constants are given as $K_{a1} = 1.13 \times 10^{-3}$, and $K_{a2} = 3.90 \times 10^{-6}$, determine the following:
   (i) All types of dissociation species present at equilibrium.
   (ii) The equilibrium expression constant for the loss of two protons.
   (iii) The value of pK_a for phthalic acid.

(b) The complex $K_2[Ni(CN)_4]$ has a magnetic moment $\mu_s \approx 0.01$ BM. Using Crystal field theory discuss the shape and bonding of the complex. (Do not use quadratic equations to solve this).

(d). Analytical results are usually expressed as concentration in various units. DDT, a chlorinated insecticide used in the past but banned now from being used in aerial spraying, known to accumulate in the food chain. In Lake Kariba, 0.014ppm DDT has been found in the mud and 5.0ppm DDT in the fish. Express these concentration found in fish, in units of %wt/wt.

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

$v_1 =$ / $v_2 =$	2	3	4	5	6	7	8	9	10	15	20	30
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

The Periodic Table of Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

Example:

1.0
H
hydrogen
1

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

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

*Lanthanide series

140 **Ce** cerium 58	141 **Pr** praseodymium 59	144 **Nd** neodymium 60	[147] **Pm** promethium 61	150 **Sm** samarium 62	152 **Eu** europium 63	157 **Gd** gadolinium 64	159 **Tb** terbium 65	163 **Dy** dysprosium 66	165 **Ho** holmium 67	167 **Er** erbium 68	169 **Tm** thulium 69	173 **Yb** ytterbium 70	175 **Lu** lutetium 71

*Actinide series

232 **Th** thorium 90	[231] **Pa** protactinium 91	238 **U** uranium 92	[237] **Np** neptunium 93	[242] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[245] **Bk** berkelium 97	[251] **Cf** californium 98	[254] **Es** einsteinium 99	[253] **Fm** fermium 100	[256] **Md** mendelevium 101	[254] **No** nobelium 102	[257] **Lr** lawrencium 103

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2012 SEMESTER I EXAMINATIONS

C 225: ANALYTICAL CHEMISTRY I
TIME: 3 HOURS

INSTRUCTIONS:
1. THIS PAPER CONTAINS FIVE (05) QUESTIONS.
2. ANSWER ANY FOUR (04) QUESTIONS.
3. EACH QUESTION CARRIES 20 MARKS.
4. SHOW ALL YOUR WORKING CLEARLY.
5. ESSENTIAL DATA TABLES ARE ATTACHED TO THE QUESTION PAPER.

Question 1.

(a). A wholesaler purchased a truck load of S26 Brand baby milk from the manufacturers. The analysis certificate made out while the truck was being loaded showed 46.70% protein with a standard deviation of 0.07% for five measurements. When the baby milk arrived at the wholesaler's warehouse, it was analyzed with the following results, %protein: 45.58, 45.61, 45.69 and 45.64 should the wholesaler accept the baby milk?

(b). (i). What is a buffer solution? If 0.05 mole of NH_4Cl is added per litre of solution to a 0.01M aqueous ammonia solution, calculate is the concentration of hydronium ion in the resulting solution given that for NH_3, $K_b = 1.8 \times 10^{-5}$.
(ii). A solution contains 75.0 ppm of dissolved $NaNO_3$. Calculate the concentration of nitrate ions in the solution, giving your answer in parts per billion.

(c). (i). By using lead chloride, $PbCl_2$, explain what you understand by the terms solubility and solubility product of a salt.
(ii). Determine whether a precipitate will form if 10 mL of 0. 0.0001 M $AgNO_3$ is added to 90 mL of 0.000045 M NaCl (K_{sp} for AgCl = 1.0×10^{-10}).

Question 2.

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

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

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

Question 2(Continued).

(b). A solution contains 2.50×10^{-4} M copper nitrate, $Cu(NO_3)_2$. Calculate the copper nitrate content of the solution, in ppm; and, the concentration of nitrate ions, giving your answer in units of parts per billion.

(c). The first and second acidity constants of H_2S are 10^{-7} and 10^{-15} respectively. Calculate the equilibrium constant (K_a) for the reaction $H_2S + 2H_2O \rightarrow 2H_3O^+ + S^{2-}$, and the concentration of S^{2-} ions in a 0.1 M H_2S solution at pH 2.0.

Question 3.

(a). (i). What is meant by the term 'tetraprotic acid'? give an example of such acid.
(ii). Citric acid is a triprotic organic acid, $HOC(CH_2COOH)_3$, characterised by the following acid dissociation constants $pK_{a1} = 3.1296$; $pK_{a2} = 4.7570$ and $pK_{a3} = 5.3990$. Determine the equilibrium concentration of the ionic species $HOC(CH_2COOH)^{2-}$ in a 0.500 M solution of the acid.

(b). (i). Given the ingredients ethanoic acid, HOAc; ammonia, NH_3; sodium chloride, NaCl and ammonium chloride, NH_4Cl, how would you prepare a buffer solution of pH above 7.5?
(ii). Calculate the pH of a buffer prepared by adding 85 ml of a 0.20 M acetic acid solution to 115 ml of 0.50 M sodium acetate; given that for acetic acid, the value of K_a = 1.75×10^{-5}.

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

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

Question 4.

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

(b). (i). Define the term 'hydrolysis', and give an example of one compound that hydrolyses.
(ii). What is the degree of hydrolysis and pH of a 0.10 M solution of sodium acetate, NaOAc? For acetic acid, HOAc, $K_a = 1.75 \times 10^{-5}$.

Question 4 (Continued).

(c).   Lead sulphate, $PbSO_4$, is a sparingly soluble salt with a solubility product of is 1.8 x 10^{-8} in aqueous medium.

(i).   Explain the difference between common salt, NaCl, and lead sulphate.

(ii).   Calculate the solubility of lead sulphate in 0.025M $Pb(NO_3)_2$.

Question 5.

(a).   The calcium content of a powdered milk sample was analyzed five times by each of the methods, with similar standard deviations. Are the two mean values significantly different at 95% confidence level?

Method 1	Method 2
0.271	0.0271
0.282	0.0268
0.279	0.0263
0.271	0.0274
0.275	0.0269

(b).   (i).   What is selective precipitation? Give one example of the use of the phenomenon in analytical chemistry.

(ii).   Determine whether a precipitate will form if 0.05 mg $AgNO_3$ is added to 2.0 L of 0.0001 M NaCl (K_{sp} for AgCl = 1.0 x 10^{-10}).

(c).   Arsenic acid, H_3AsO_4, dissociates in water to yield several ionic and molecular species.

(i).   Name any two ionic, and one molecular, dissociation products of the acid.

(ii).   What is the equilibrium concentration of the hydrogen arsenate ion ($H_2AsO_4^-$) at pH 3.0 in a 0.200 M arsenic acid solution given that the dissociation constants for the successive ionisations are given as follows, Ka_1 = 5.65 x 10^{-3}; Ka_2 = 1.75 x 10^{-7} and Ka_3 = 2.54 x 10^{-12}.

END OF EXAMINATION

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

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

Number of Observations	Q_{90}	Confidence Level 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	90%	Confidence Level 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

2012 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C 341: INORGANIC CHEMISTRY II

TIME: THREE HOURS

INSTRUCTIONS: ANSWER ANY TWO QUESTIONS FROM *SECTION A* AND ANY
TWO FROM *SECTON B*
ANSWER EACH QUESTION ON A FRESH PAGE

SECTION A

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(c) Classify the ligands on the basis of charge: CO, CN, NO, NO_2, CNO, ONO, H, NCS, en

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(c) There are 3 unpaired electrons in $[Co(H_2O)_6]^{2+}$ and calculated value of magnetic moment is 3.87 BM which is quite different from experimental value of 4.40 BM. Account for this variation.

QUESTION 3

(a) Explain the following on the basis of CFT.
   (i) Copper sulphate hydrated ($CuSO_4.5H_2O$) is blue in color.
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QUESTION 4

(a) Write down classification of oxides of the group VI: basic, acidic and amphoteric oxides.
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Describe the industrial methods production of following products, indicating reactions, temperatures and pressures of the processes:

(a) Ammonia on a large scale.
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QUESTION 6

(a) Write down main properties, uses, production and reactions with water of fluorine and chlorine.
(b) State properties, uses and production of Noble gases.
(c) Write down reactions production of Xenon compounds: $XeOF_4$, XeO_2F_2 and XeO_3.

END OF EXAMINATIONS

The Periodic Table of Elements

Key

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

Example:

| 1.0 |
| H |
| hydrogen |
| 1 |

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

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* Actinide series

232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2012 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C 341: INORGANIC CHEMISTRY II

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1

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_____
END OF EXAMINATIONS

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Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1.0
H
hydrogen
1

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

232 **Th** thorium 90	[231] **Pa** protactinium 91	238 **U** uranium 92	[237] **Np** neptunium 93	[242] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[245] **Bk** berkelium 97	[251] **Cf** californium 98	[254] **Es** einsteinium 99	[253] **Fm** fermium 100	[256] **Md** mendelevium 101	[254] **No** nobelium 102	[257] **Lr** lawrencium 103

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P 3 8 4 8 2 A 0 2 4 2 4

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2012 ACADEMIC YEAR FIRST SEMESTER

FINAL EXAMINATIONS

C351: ORGANIC CHEMISTRY III

TIME: THREE HOURS

INSTRUCTIONS:

1. Answer **any four** questions
2. Each question carries 30 marks
3. Use a booklet for each question

Question 1

(a) Peak area measurements (integration) are not usually obtained in routine ^{13}C-NMR spectra. Briefly explain. **(2 marks)**

(b) Write the structures of the three isomeric tribromobenzenes ($C_6H_3Br_3$). Against each isomer indicate the number of proton decoupled ^{13}C-NMR peaks. **(8 marks)**

(c) Interpret the attached spectral data for the compound **X** and hence deduce its structure. Assign the ^{1}H-NMR and ^{13}C-NMR peaks to the structure as far as possible.

(20 marks)

Question 2

(a) The isomeric sets of compounds given below may be differentiated using spectroscopy. Elaborate.

(i)

$(H_3C)_2N$ $N(CH_3)_2$ and H_3CHN $N(CH_3)_2$

(6 marks)
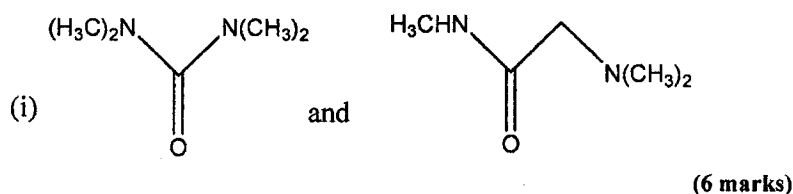
Mass spectroscopy by giving the molecular masses of excited ions, fragmentation patterns and masses of fragments.

(ii)

H_3CO and H_3CO

(6 marks)

UV: by calculation of λ_{max}
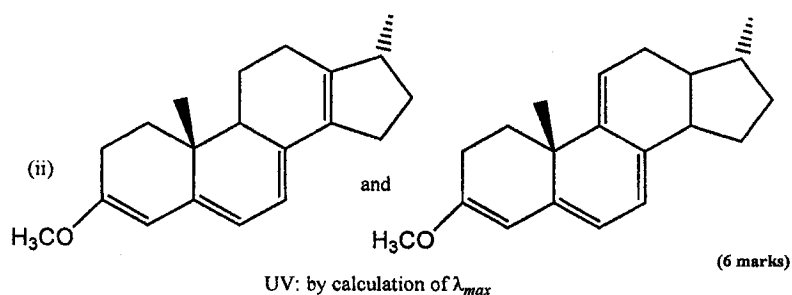
(b) A number of procedures are used to couple benzene rings in a reaction called arylation. Name three such procedures and provide reactants, reagents and products. **(10 marks)**

(c) Formylation of azulene as indicated below takes place at the five-membered ring only. Provide a plausible explanation and write a mechanism for the reaction. **(8 marks)**

$\xrightarrow{\text{CHCl}_3,\ \text{KOH}}$ Product
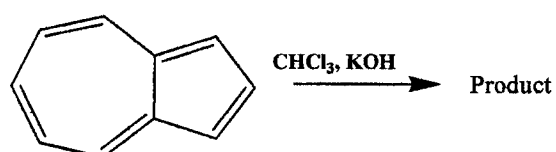
Question 3

(a) A compound **C**, $C_4H_{10}O$, gave ^1HNMR spectrum consisting of two δ values a triplet and quartet with relative area of 3:2. What is its structure and what are the δ-values?

(8 marks)

(b) A compound **D**, C_2H_2BrCl, exhibits two doublets, $J = 16$ Hz, in its ^1H-NMR spectrum. Suggest a stereochemical structure for **D**.

(2 marks)

(c) Interpret the attached spectral data for the compound **Y** and hence deduce its structure. Assign the ^1H-NMR and ^{13}C-NMR peaks to the structure as far as possible.

(20 marks)

Question 4

(a) Explain why the reaction between sodamide and *o*-chlorotoluene gives only two products while that between sodamide and 3-bromotoluene gives three products. Clearly indicate the major product in each case.

(10 marks)

(b) Discuss nitration of 1-nitronaphthalene.

(6 marks)

(c) Both *o*-bromonitrobenzene and 1-bromo-2,4-dinitrobenzene react in a heated solution of sodium hydroxide to give products.

    (i) Write equations for each of these reactions.

(4 marks)

    (ii) Between the two reactions, which one is faster? Explain in detail to support your choice?

(6 marks)

Question 5

(a) Naphthalene and 1-naphthol are commonly prepared from benzene and maleic anhydride as starting materials as indicated in the scheme below. Fill in the reagents and intermediates.   **(10 marks)**
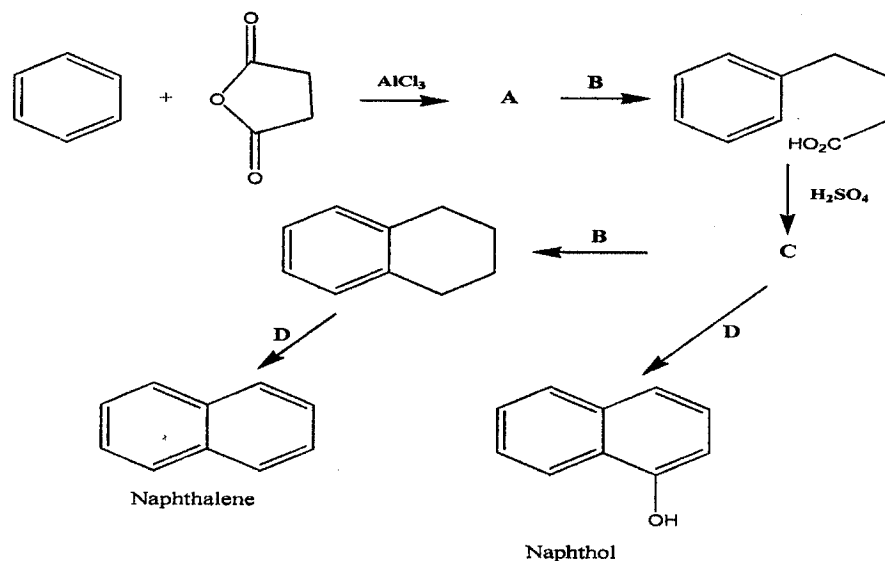
(b) How would you prepare phenathrene using naphthalene?   **(6 marks)**

(c) Provide a procedure for protecting each class of compounds given below. Write equations on how the group is introduced and how the group is removed.

    (i) Primary alcohols.   **(2 marks)**

    (ii) Primary amines.   **(2 marks)**

(d) Identify the compound with molecular formula $C_4H_8O_3$ with ^{1}H-NMR data and IR given in the table below. Briefly interpret the data.

(10 marks)

δ 1.27 (3H) as a triplet	Broad peak spreading from 2500-3100 cm^{-1} and a peak at 1715 cm^{-1}
δ 3.66 (2H) as a quartet	
δ 4.13 (2H) as a singlet	
δ 10.95 (1H) as a singlet	

END OF EXAMINATION

IR Spectrum
(KBr disc)

3284

1658

ν (cm^{-1})

4000   3000   2000   1600   1200   800

Mass Spectrum

100
80
60
40
20

% of base peak

43

108

137

M$^{+\cdot}$
179

$C_{10}H_{13}NO_2$

40   80   120   160   200   240   280

m/e

UV Spectrum

λ_{max} 250 nm (log$_{10}\varepsilon$ 3.1)
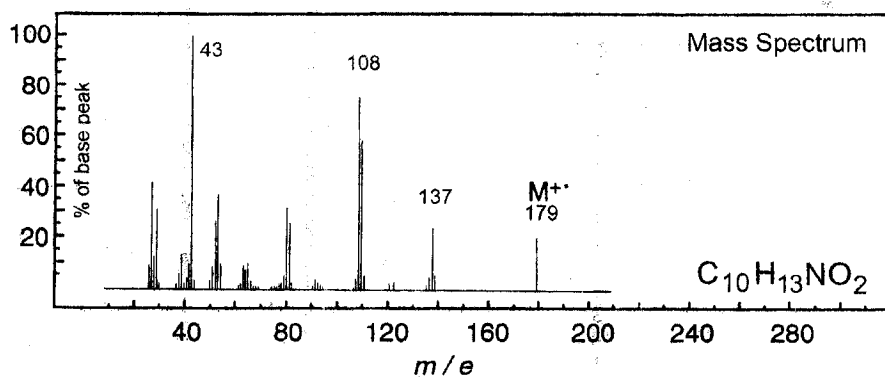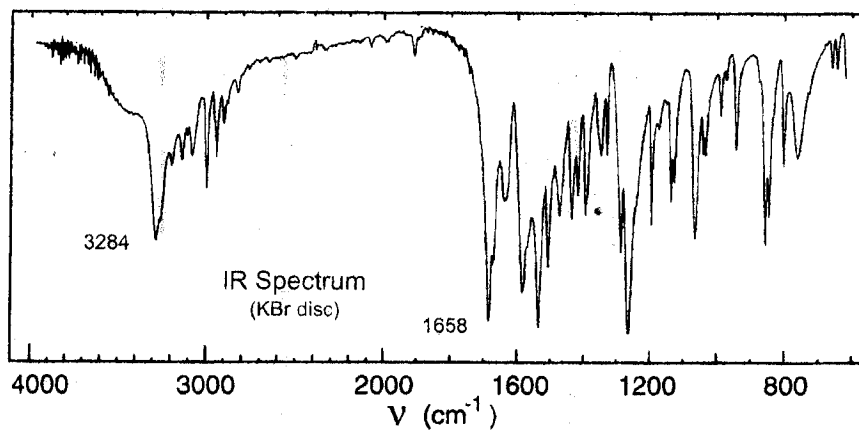
λ_{max} 287 nm (log$_{10}\varepsilon$ 2.2)

solvent : chloroform

^{13}C NMR Spectrum
(50.0 MHz, CDCl$_3$ solution)

DEPT   CH$_2\downarrow$ CH$_3\uparrow$ CH$\uparrow$

solvent

proton decoupled

200   160   120   80   40   0 δ (pp

^{1}H NMR Spectrum
(200 MHz, CDCl$_3$ solution)

expansion

7.6   7.0   ppm

exchanges
with D$_2$O on warming

TM

10   9   8   7   6   5   4   3   2   1   0
δ (pp

5

IR Spectrum
(liquid film)

1747

4000   3000   2000   1600   1200   800

ν (cm^{-1})

Mass Spectrum

100
80
60
40
20

% of base peak

43

59

87

M$^{+\cdot}$
146

$C_6H_{10}O_4$

40   80   120   160   200   240   280

m / e
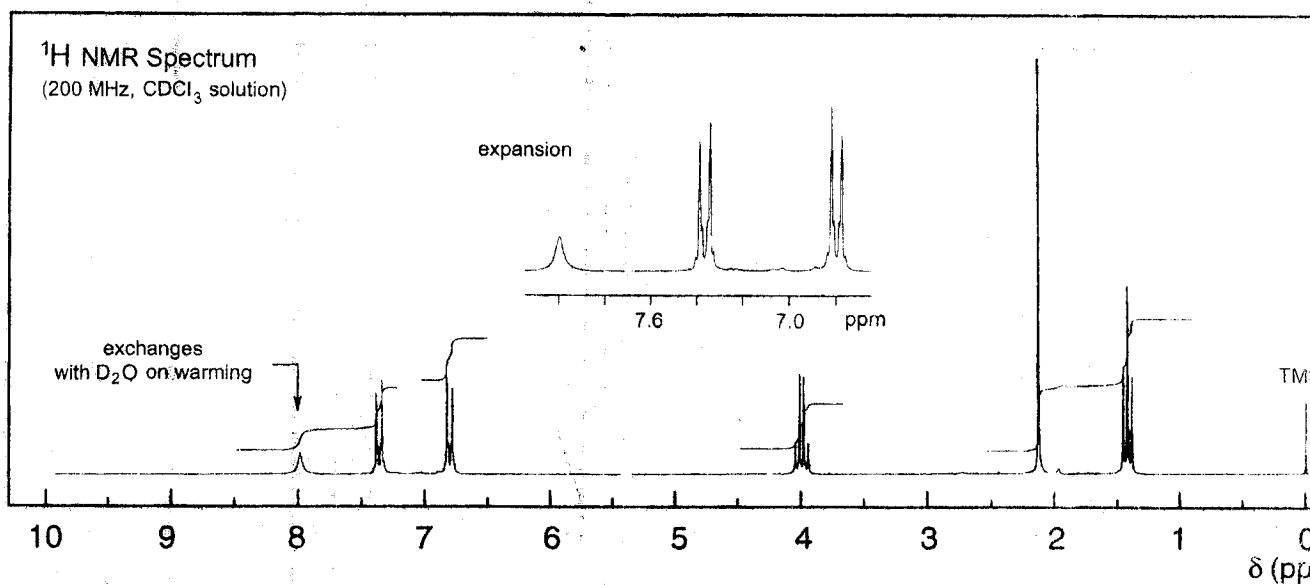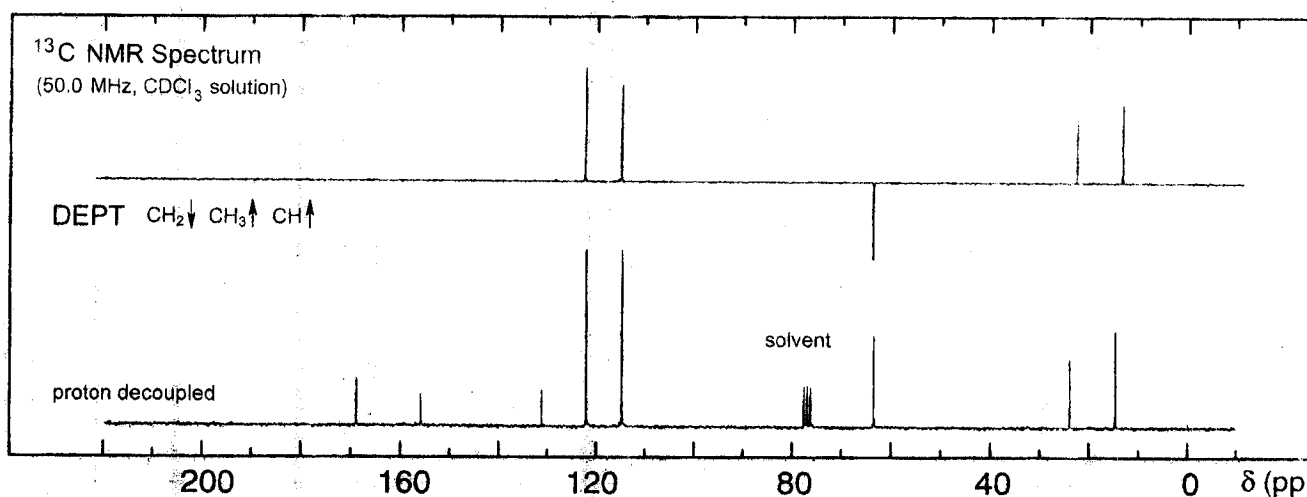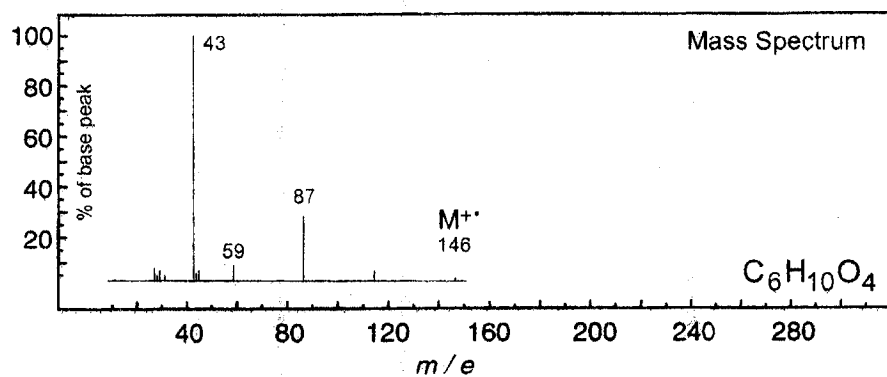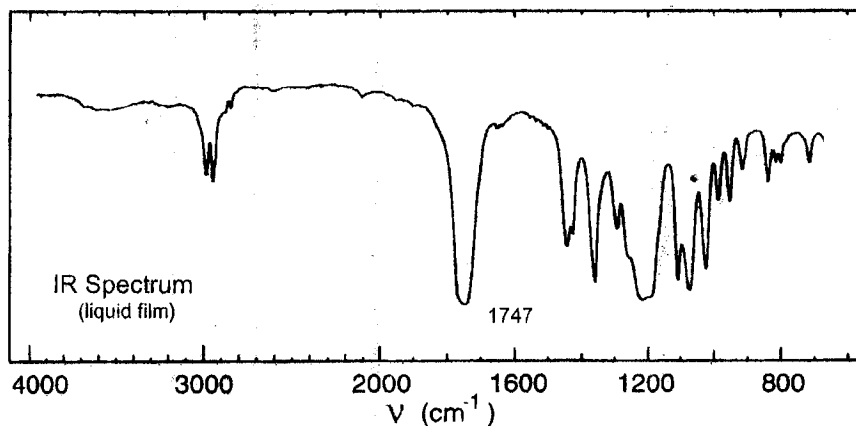
No significant UV
absorption above 220 nm

^{13}C NMR Spectrum
(50.0 MHz, CDCl$_3$ solution)

DEPT   CH$_2\downarrow$ CH$_3\uparrow$ CH$\uparrow$

proton decoupled

solvent

200   160   120   80   40   0 δ (ppm)

^1H NMR Spectrum
(200 MHz, CDCl$_3$ solution)

expansions

2.5   1.5   ppm

5.5   4.5   ppm

10   9   8   7   6   5   4   3   2   1   0

6
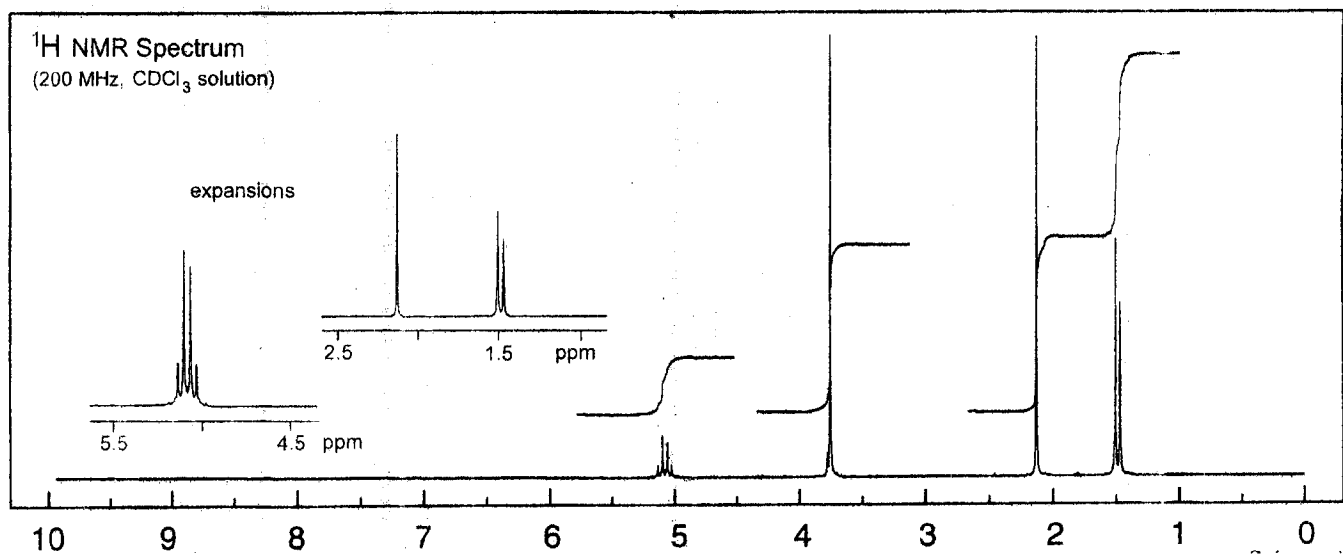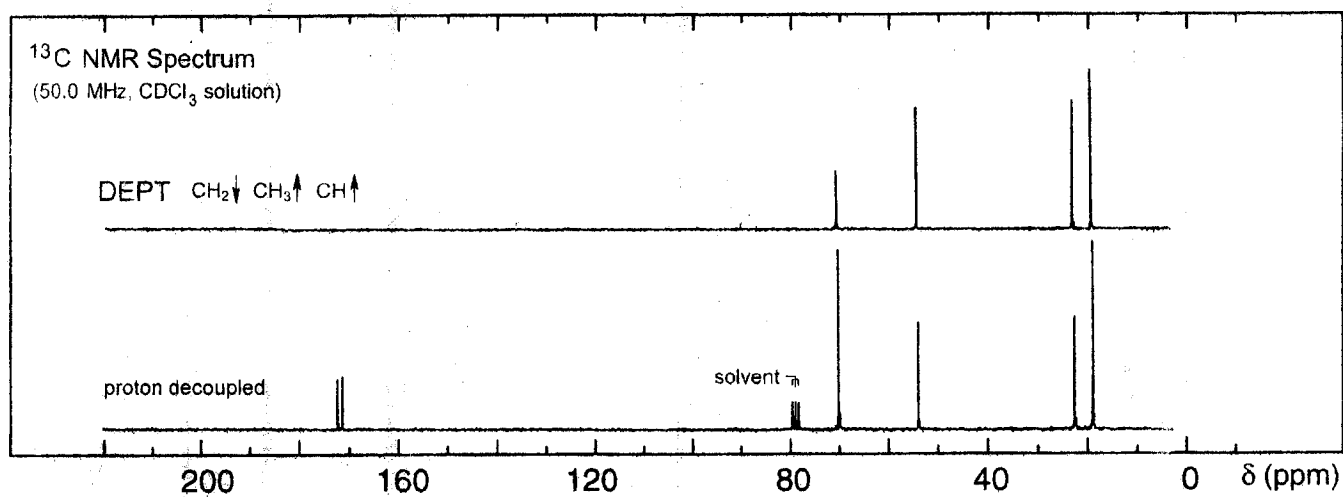
THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF CHEMISTRY

ACADEMIC YEAR 2012 UNIVERSITY SESSIONAL EXAMINATIONS SEMESTER I

25 FEBRUARY 2013

C 361: CHEMICAL KINETICS AND NUCLEAR CHEMISTRY.

TIME: THREE HOURS

INSTRUCTIONS: ANSWER ANY *FIVE* OF THE SIX QUESTIONS.

DATA

$R = 8.314$ J.K^{-1}.mol^{-1}; $h = 6.626 \times 10^{-34}$ J.s; $k_B = 1.38 \times 10^{-23}$ J.K^{-1}; $H = 1.01$; $O = 16.00$
$h = 4.136 \times 10^{-21}$ MeV. s; Mass excess, Δ, in MeV; $^{1}_{0}n = 8.07143$; $^{209}_{83}Bi = -18.268$;
$^{210}_{83}Bi = -14.8015$; $^{210}_{84}Po = -15.9635$; $^{235}_{92}U = 40.9164$; $^{236}_{92}U = 42.4420$

Question 1

(a)   Write expressions for the rate of formation of the products in the following reaction. What are the units of the rate constant?

$$2\,HI(g) + Cl_2(g) \longrightarrow 2\,HCl(g) + I_2(g)$$
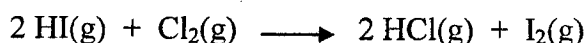
(b)   Consider the decomposition of dinitrogen pentoxide with initial concentration of $2.00M$:

$$2\,N_2O_5(g) \longrightarrow 4NO_2(g) + O_2(g)$$
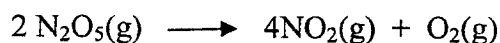
On the same labeled sketch diagram draw graphs to indicate the concentrations of the reactant and products as a function of time.

(c)   The decomposition of ammonia into hydrogen and nitrogen on a quartz surface was studied by C. N. Hinshelwood and R. E. Burk: *J. Chem. Soc.*, **127**; 1105 (1925). The following result was obtained at 1267 K.

P_0	7132.62 Pa	18331.5 Pa
$t_{1/2}$	43 s	44 s

(i)   Write the equation for the decomposition of ammonia on the quartz surface and the rate law.

(ii)   What is the order of the reaction?

(iii)   What is the rate constant of the reaction?

Question 2

Consider the acid hydrolysis of n-valeronitrile to give n-valeric acid:

$$n\text{-}C_4H_9CN + H_2O + H^+ \longrightarrow n\text{-}\overset{\bullet}{C}_4H_9COOH + NH_4^+$$

(a) Write the rate equation in terms of the concentration of the reactant n-valeronitrile.

(b) Write the pseudo-order rate equation if $[H_2O] \gg [n\text{-}C_4H_9CN]$ and if H^+ is regenerated.

(c) Calculate the reaction rate constant k if the pseudo-rate constant $k' = 1.00 \times 10^{-5}$ s^{-1}, $[H^+] = 0.10$ M and the volume of water is 1.00 dm^3. What are the correct units of the rate constant k?

Question 3

Compound A reacts to form the products C, D, and E in the presence of M. This reaction is thought to go according to the following mechanism:

$$A + M \longrightarrow 3B + M \qquad k_1$$
$$3B + M \longrightarrow A + M \qquad k_{-1}$$
$$3B \longrightarrow C \qquad k_2$$
$$3B \longrightarrow D \qquad k_3$$
$$3B \longrightarrow 2E \qquad k_4$$
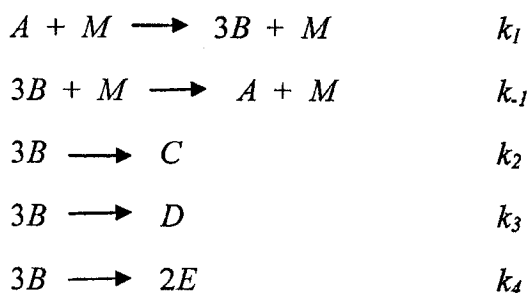
(a) Identify the intermediate(s).

(b) Is there a catalyst entering into this proposed mechanism? Why or why not?

(c) Derive a rate law for the formation of D, assuming that the steady state approximation can be applied to any intermediate(s) in the above mechanism.

(d) Under what conditions would the rate law you obtained in part (c) be second order overall?

(e) Under what conditions would the rate law you obtained in part (c) be first order overall?

(f) What is the rate law for the formation of product E?

Question 4

The following values of V_{max} and K_m have been obtained at various temperatures for the hydrolysis of acetylcholine bromide, catalyzed by acetylcholinesterase.

t °C	V_{max} mol.dm^{-3}.s^{-1}	K_m mol.dm^{-3}
20	1.84 x 10^6	4.03 x 10^{-4}
25	1.93 x 10^6	3.75 x 10^{-4}
30	2.04 x 10^6	3.35 x 10^{-4}
35	2.17 x 10^6	3.05 x 10^{-4}

Assuming the enzyme concentration to be 1.00×10^{-11} M, calculate the energy of activation, the enthalpy of activation, the Gibbs energy of activation and the entropy of activation for the breakdown of the enzyme –substrate complex at 25° C.

Question 5

(a) According to the Nuclear Shell Model,

    (i) Explain why $^{209}_{83}$Bi (100 %) is a magic number nuclide.

    (ii) What is the ground state spin and parity of $^{209}_{83}$Bi ?

(b) (i) Write the radiative capture reaction of $^{209}_{83}$Bi.

    (ii) Calculate the Q-value of the reaction in b(i) above.

(c) $^{210}_{83}$Bi ($t_{1/2}$ = 5.01 d) decays by β^- to $^{210}_{84}$Po according to the reaction:

$$^{210}_{83}\text{Bi} \longrightarrow \ ^{210}_{84}\text{Po} + \ _{-1}^{0}e^- + \bar{\nu} + Q_{\beta^-}$$
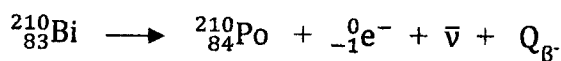
The allowed β^- spectrum is given by the equation

$$N_{P_e}dp_e = \frac{G^2 |M_{if}|^2 F(Z, E_o)\left(E_{\beta^-max} - E_{e^-}\right)^2 p_e^2 dp_e}{2\pi^3 h^7 c^3}$$

    (i) Sketch the shape of β^- decay spectrum.

    (ii) Identify a term in the above equation that makes β^- spectrum approach zero at

E_{β^-max} .

(iii)   Calculate E_{β^-max} of the decay of $^{210}_{83}Bi$ (99+%) to the ground state of $^{210}_{84}Po$.

Question 6

(a)   The isotope of $^{235}_{92}U$ is very important in the Nuclear Power Industry. A specific fission reaction of $^{235}_{92}U$ is

$$^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{236}_{92}U^* \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3({}^{1}_{0}n) + Q_f$$

The critical energy of $^{236}_{92}U$ is 5.3 MeV.

(i)   In the above reaction which isotope of uranium undergoes fission?

(ii)   Calculate the binding energy of the last neutron, E_B, in $^{236}_{92}U$ in the above reaction.

(iii)   Using the information given above, explain in one to two sentences why the above reaction can take place with thermal neutrons of 0.0253 eV.

(b)   An isotope of $^{235}_{92}U$ has a ground state spin and parity, $I^\pi = \frac{7}{2} -$ and the next energy level in this rotational band has an energy of 0.046347 MeV and $I^\pi = \frac{9}{2} -$

(i)   Calculate the energy of the $I^\pi = \frac{11}{2} -$ state.

(ii)   Determine the rotational constant, B, of this band.

NOTE: Data for Question 6 is on the next page.

_____ END OF C 361 EXAMINATION _____

4

State	*l*	Number of nucleon 2j+1	Cumulative nucleons	Magic number
1j_{15/2}	7	16	184	184
3d_{3/2}	2	4	168	
4s_{1/2}	0	2	164	
2g_{7/2}	4	8	162	
1i_{11/2}	6	12	154	
3d_{5/2}	2	6	142	
2g_{9/2}	4	10	136	
1i_{13/2}	6	14	126	126
3p_{1/2}	1	2	112	
3p_{3/2}	1	4	110	
2f_{5/2}	5	6	106	
2f_{7/2}	3	8	100	
1h_{9/2}	5	10	92	
1h_{11/2}	5	12	82	82
3s_{1/2}	0	2	70	
2d_{3/2}	2	4	68	
2d_{5/2}	2	6	64	
1g_{7/2}	4	8	58	
1g_{9/2}	4	10	50	50
2p_{1/2}	1	2	40	
1f_{5/2}	3	6	38	
2p_{3/2}	1	4	32	
1f_{7/2}	3	8	28	28
1d_{3/2}	2	4	20	20
2s_{1/2}	0	2	16	
1d_{5/2}	2	6	14	
1p_{1/2}	1	2	8	8
1p_{3/2}	1	4	6	
1s_{1/2}	0	2	2	2

Energy level of a nucleon using Schrodinger equation with spin-orbit coupling

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2012/2013 ACADEMIC YEAR, FIRST SEMESTER EXAMINATION
MARCH 1, 2013

C491	:	ORGANIC INDUSTRIAL CHEMISTRY I
TIME	:	THREE (3) HOURS
INSTRUCTIONS	:	ANSWER ANY FOUR (4) QUESTIONS

Question1

(a) A pipe is used to carry hard water and accumulates lime over a period of time. Explain how this is likely to affect the flow rate? [4]

(b) Fluids are commonly employed in many heat exchanges to facilitate heat transfer. What type of flow would be preferred in such a system. Explain in brief. [6]

(c) Explain in brief using appropriate diagrams the following:
    (i)   Counter current process in a tubular reactor [4]
    (ii)   Batch process and continuous process [6]

Question 2

(a) Both soaps and detergents contain surface active substances that aid in the cleaning action of a formulation. Show micelle structures that are formed from (i) soap molecules (ii) detergent molecules. [4]

(b) Explain how surface active substances aid cleaning action of detergent formulations. [6]

(c) Explain the concept of water hardness and it affects cleaning in soaps and detergents. [6]

(d) In a detergent formulation, one of the ingredients indicated is EDTA. Explain the function and mechanism of action of this ingredient. [4]

Question 3

(a) What are pesticides? [2]

(b) Classify pesticides according to their mode of action. Give one example for each class identified. [6]

(c) Describe/explain how indiscriminate use of pesticides could affect the environment. [4]

(d) Steam distillation is sometimes used to extract active ingredients from plant materials.
    (i)   Describe the process known as steam distillation. Use suitable diagrams to illustrate your answer. [6]

    (ii) When is it desirable to use steam distillation? [2]

1

Question 4

(a) What is the significance of carrying out distillation under vacuum conditions? [5]

(b) Explain the brief significance of the hydro-cracking process.   [5]

(c) There are several types of gaseous fuels. Write short notes on natural gas. [5]

(d) Use a block diagram to illustrate the processing of producing raw natural gas.
                                                                                   [5]

Question 5

(a) In the Kraft process, wood chips are cooked in a strong alkali solution known as White liquor.

   (i)   What methods are employed to monitor progress in the digester?   [2]
   (ii)   How are the results used to establish the concentration levels of chemicals in the liquor?   [3]
   (iii) Sketch a block diagram of the Kraft process, clearly label all parts. [5]
   (iv)   Write the chemical reactions occur in the Digester.   [5]

(b) With the help of a sketch, describe the paper manufacturing process up the point before the finishing operations.   [5]

- **END OF EXAMINATION** -

2

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS

ADVANCED INORGANIC CHEMISTRY I, 2013

C441

Instructions

- Answer any **four** Questions.   Time: 3 hours
- All questions carry equal marks.
- Start each question on a fresh page of the Answer Booklet.
- Periodic And Character Tables are provided

Question 1

(a)   The infrared spectrum of [ICl$_3$]⁻ has the following peaks:-

Frequency/cm⁻¹	Intensity
1600	v. weak
1485	weak
800	strong
703	weak
690	strong
400	medium
345	weak
300	medium

(i)   Determine the fundamental vibrations in this spectrum.

(ii)   Comment on the likely position of the v_1 in the Raman spectrum of this compound.

(iii) Account for the presence of the remaining peaks.

(b)   By constructing an MO diagram for SiH$_2$, show how the HOMO and LUMO for the molecule. What other spectral information can be adduced from the MO?

Question 2

The secular determinant for the allyl radical, $C_3H_6^{\bullet}$, with frontier orbitals defined as

$\Psi_n = c_1\Phi_1 + c_2\Phi_2 + c_3\Phi_3$, is

$$\begin{vmatrix} \alpha - E & \beta & 0 \\ \beta & \alpha - E & \beta \\ 0 & \beta & \alpha - E \end{vmatrix} = 0$$

(i)   Determine the energies of the molecular orbitals $\Psi_1 \longrightarrow \Psi_3$ and draw these orbitals.

(ii)   A nickel complex is synthesized as $[Ni(C_3H_6)_2]$, discuss the kind of bonding expected to occur between the **'named'** metal orbital(s) and the frontier orbitals Ψ_1 and Ψ_2?

(iii)   Given that $c_1^2 + c_2^2 + c_3^2 = 1$ (normalized), find the value of c_1, c_2 and c_3. Hence state the magnitude of Ψ_3.

Question 3

(a)   The character tables for the 'Cubic Group' chemicals indicate that the Milliken symbols belong to E in point group T, Eg in point group Td, Eg in Oh, etc; correspond to orbitals defined as $2z^2-x^2-y^2$ and x^2-y^2. Describe these orbitals.

(b)   (i)   State the symmetry operations associated with the molecule below:-
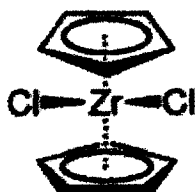
(ii)   Show that these symmetry operations constitute a mathematical group. Show the group properties.

(c)   What are point groups for the complexes below(show your reasoning):-
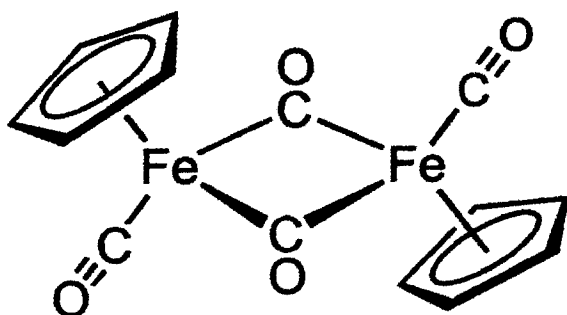
A dimer

(i)
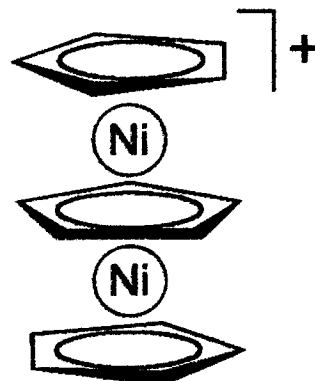
Triple decker nickelocene ion

(ii)

Question 4

(a) A company is contemplating to invest in purchasing either an IR, or a mass spectrophotometer, or both and require your advice on how to make a best investment.
Discuss what advise you would give the company showing facts for your argument.

(b) Sketch the mass spectrum of $GaClBr_3$ (Given that $^{69}Ga = 60\%, ^{71}Ga = 40\%$
$^{35}Cl = 75\%, ^{37}Cl = 25\%,$
$^{79}Br = 50\% \ ^{81}Br = 50\%$)

(c) A Raman spectrum of Fe $(CO)_5$ has peaks at 1885, 2000, 2010, 2040 cm^{-1}.
The IR spectrum of the same complex has 3 peaks. What is the geometrical structure of the complex? Where would you find the IR peaks?

Question 5

(a) In mass spectroscopy of metal complexes, show how the following arise

(i)   OH$^-$ migration
(ii)   Doubly-charged peaks
(iii)   Aryl group migration

(b) An **AB₅** molecule is pyramidal in shape and has reducible representations as **5 1 1 3 1**. Determine the σ-hybridization scheme of this molecule.

(c) The irreducible representations for π-bonding scheme for square planar AB_4 molecule is given as **8 0 0 -4 0 0 0 0 0**.

    (i)   Determine $\Gamma_\pi(\perp)$

    (ii)   Determine $\Gamma_\pi(11)$

    (iii)   Hence show the π-hybridization scheme likely to be displayed by the molecule.

PERIODIC TABLE OF THE ELEMENTS

KEY

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

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.01 Hydrogen																1 H 1.01 Hydrogen	2 He 4.00 Helium
3 Li 6.94 Lithium	4 Be 9.01 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 23.00 Sodium	12 Mg 24.31 magnesium											13 Al 27.99 Aluminium	14 Si 28.09 Silicon	15 P 30.99 Phosphorus	16 S 32.07 Sulphur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.88 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.65 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 71.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc 97.91 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Inidium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 tellurium	53 I 126.90 Iodine	54 Xe 131.29 Xenon
55 Cs 132.91 Caesium	56 Ba 137.33 Barium	57 – 71	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantalum	74 W 183.84 Tungsten	75 Re 186.21 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.97 Gold	80 Hg 200.59 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po 208.98 Polonium	85 At 209.99 Astatine	86 Rn 222.02 Radon
87 Fr (223.02) Francium	88 Ra 226.03 Radium	89 – 103	104 Unq 261.11	105 Unp 262.11	106 unh 263.12	107 uns 262.12	108 Uno 265.00	109 Une 265									

57 La 138.91 Lanthanium	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

Department of Chemistry-UNZA

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2012 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 technological processes for manufacturing soda ash:
- (a) By Leblan method,
- (b) The Ammonia process,
- (c) Outline the advantages and drawbacks associated with the discussed methods.

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 ceramic 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,
- (b) For the measurements of fluids and gas flows – orifices, rotameters and weirs.
- (c) For 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 compounds:

    a) Sodium sulphate, sulphite and thiosulphate,

    b) Sodium nitrite and peroxide,

    c) Sodium and Potassium chlorides obtained from Sylvinite.

Question 6.

    a) How they determine concentrations of H_3PO_4 and H_2SO_4 in the Ortho-phosphoric acid, produced by wet-method? (explained in Problem 18, SECTION A),

    b) Describe monometers used in the measurements flow of fluids: U-type, differential and inclined,

    c) Briefly write down types and compositions of glasses produced in industry.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
Semester II Examination, 2012

CHE5422

Time: 3 Hours   May 2012

Instructions:

Answer any Four (4) Questions.
A Periodic Table is provided.
Character Tables are allowed.

Question 1

(a) Account for the following observations;-

Octahedral Complex	Ion	μ_{eff}^{80K}	μ_{eff}^{300K}
$[Mn(CN)_6]^{4-}$	Mn^{2+}	2.03	2.5
$Cr(SO_4).6H_2O$	Cr^{2+}	4.84	4.82

(b) The ground state term is generally written as $^{2S+1}L_J$, what levels (multiplets J first transition) may arise from the terms

(i) ^1S (ii) ^2P (iii) ^4F

Question 2

(a) What characteristics distinguish these magnetic conditions:- diamagnetism, ferromagnetism, paramagnetism and anti-ferromagnetism.

(b) Distinguish between the Curie law and the Curie-Weiss law.

Question 3

(a) When the multiplet interval $(\mu_o H)$ is several cm^{-1} larger than (kT) show what obtains and how this would reduce to μ_s.

(b) A lot of studies on magnetic moments of Lanthanide ions have been studied. How the observed and the calculated μ_{eff} values for Sm^{3+} compare?

(c) Show how P is isolobal to RSi, where R is an alkyl group, and hence predict the shape of $P_2(SiR)_2$.

Question 4

(a) How would you describe the nature of metal-alkyl bonding in

   (i) CH_3MgI (ii)The Zeise salt   (iii) Ferrocene

(b) Account the nature of bonding in $Al_2(CH_3)_6$ compound.

Question 5

(a) By clearly outlining the relevant conditions, suggest two ways in which a metal-carbonyl complex such as $Cr(CO)_6$ can be synthesized.

(b) ML_5 is C_{4v} molecule isolobal to CR_3. By constructing an MO show the kind interaction to explain the type bonding likely to occur between the two fragment. State what other species are isolobal the ML_5?

End of Examination

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number

X

Atomic mass

Name of the element X

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 **H** 1.01 Hydrogen																1 **H** 1.01 Hydrogen
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
11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium											13 **Al** 26.98 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.65 Copper	30 **Zn** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 71.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 Selenium	35 **Br** 79.90 Bromine
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 Iridium	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 Tellurium	53 **I** 126.90 Iodine
55 **Cs** 132.91 Caesium	56 **Ba** 137.33 Barium	57 – 71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.84 Tungsten	75 **Re** 186.21 Rhenium	76 **Os** 190.23 Osmium	77 **Ir** 192.22 Iridium	78 **Pt** 195.08 Platinum	79 **Au** 196.97 Gold	80 **Hg** 200.59 Mercury	81 **Tl** 204.38 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 208.98 Bismuth	84 **Po** 208.98 Polonium	85 **At** 209.99 Astatine
87 **Fr** (223.02) Francium	88 **Ra** 226.03 Radium	89 – 103	104 **Unq** 261.11	105 **Unp** 262.11	106 **Unh** 263.12	107 **Uns** 262.12	108 **Uno** 265.00	109 **Une** 265								

57 **La** 138.91 Lanthanum	58 **Ce** 140.12 Cerium	59 **Pr** 140.91 Praseodymium	60 **Nd** 144.24 Neodymium	61 **Pm** 144.91 Promethium	62 **Sm** 150.36 Samarium	63 **Eu** 151.97 Europium	64 **Gd** 157.25 Gadolinium	65 **Tb** 158.93 Terbium	66 **Dy** 162.50 Dysprosium	67 **Ho** 164.93 Holmium	68 **Er** 167.26 Erbium	69 **Tm** 168.93 Thulium	70 **Yb** 173.04 Ytterbium	71 **Lu** 174.97 Lutetium
89 **Ac** 227.03 Actinium	90 **Th** 232.04 Thorium	91 **Pa** 231.04 Protactinium	92 **U** 238.03 Uranium	93 **Np** 237.05 Neptunium	94 **Pu** 244.0 Plutonium	95 **Am** 243.06 Americium	96 **Cm** 247.07 Curium	97 **Bk** 247.07 Berkelium	98 **Cf** 251.08 Californium	99 **Es** 252.08 Einsteinium	100 **Fm** 257.10 Fermium	101 **Md** 260 Mendelevium	102 **No** 259.10 Nobelium	103 **Lr** 262.11 Lawrencium

Department of Chemistry-UNZA

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

CS4251: ELECTRONICS FOR COMPUTING III

SEMESTER 1 EXAM

6th MARCH 2013

TIME: THREE HOURS

ANSWER: ANY FIVE (5) QUESTIONS
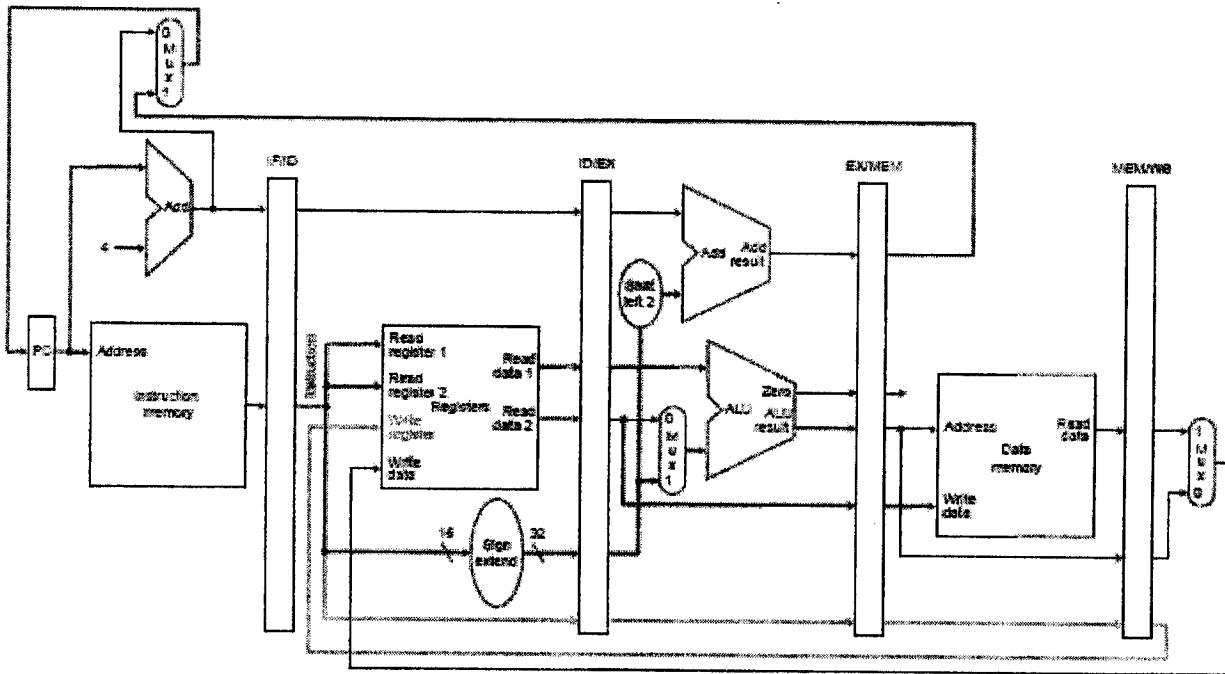
ANSWER ANY FIVE (5) QUESTIONS

QUESTION 1

Using the data path diagrams and by way of shading, describe the stages of pipelining the following instructions.

    (i) sw $30, $20   [5 Marks]

    (ii) add $40, $20   [5 Marks]

QUESTION 2

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 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

(i) Describe the four step protocol of operation when a victim cache is incorporated in a multilevel cache system   [4 Marks]
Define the Inclusion Policy on the following:
(ii) Inclusive multilevel cache,   [3 Marks]
(iii)Exclusive multilevel caches,   [3 Marks]

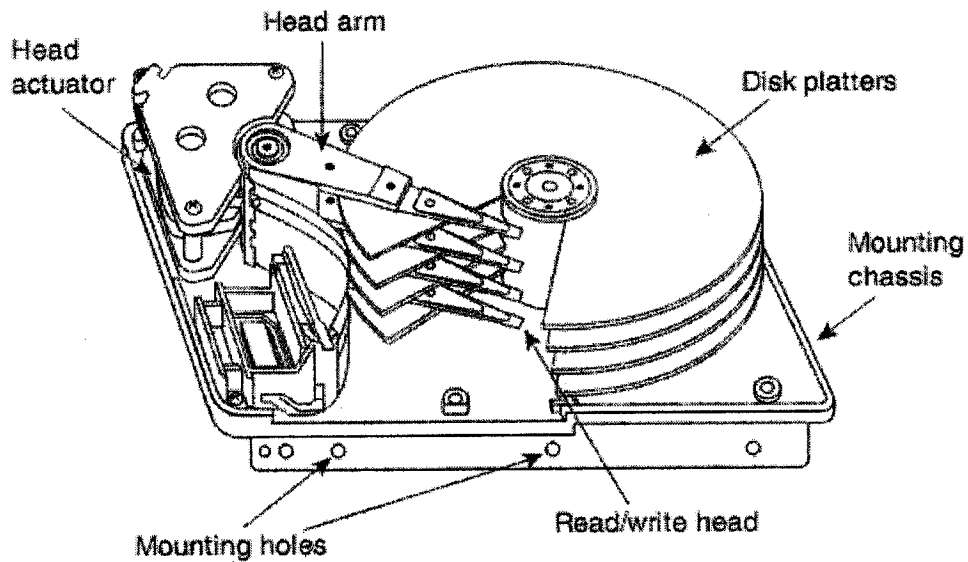## QUESTION 6
Build a 1bit ALU with a zero (0) carryin input   [10 Marks]

QUESTION 7
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.   [5 Marks]
(ii) Describe the reading process.   [5 Marks]

END OF EXAM

CST 2032 Exam
Thursday 7th June 2012
Answer any **five** questions. All questions carry equal marks.
Write clearly and explain steps precisely.
Lecturer: Dr. John Regan

1.
   a) An IEEE floating point number is made up of 3 parts, the sign bit, the significand and the exponent. Explain each of these terms. For a single precision 32 bit value how many bits are assigned to the sign, exp and fractional part.
   b) Given the decimal number 15213.0 write down how the number is stored in a computer as a floating point number on a 32 bit system.
   c) Explain the difference between **normalised** and **denormalised** numbers.
   d) Consider the following 8 bit floating point binary numbers. Compute the floating point additions – round if required. Assume an 8-bit OS with 4 bits for the exponent.
      i. $00100011_2 + 01001101_2$
      ii. $01010101_2 + 01101010_2$

2.
   a) Explain the difference between the **Little Endian** system and the **Big Endian** system. Give an example of a system that uses Little Endian and one that uses Big Endian.
   b) Convert 15123 which is a decimal number to hexamdecimal.
   c) Given the following three unsigned integers compute their product:
      i. 0011
      ii. 1010
      iii. 1100

      In Order to compute the product of the three integers you should convert to decimal to verify your answer.
   d) Given the following signed integer compute its value in decimal
      i. 1100010010010011
      Next compute its value when you right shift it by 2 places (i.e. >> 2).
      Explain how you achieve this and check against the expected decimal value. Explain the discrepancy and describe what needs to be done so that the result correctly rounds towards zero.

3.

a) Explain what a **process** is.

b) **Context switching** can happen for several reasons, give two reasons.

c) Consider the following simple program

```
int main()
{
    int pid = 0;
    pid = fork();
    if(pid == 0)
    {
        printf("My pid is %d\n", pid);
    }

    printf("My pid is %d\n", pid);
}
```

Assume the process identity of the parent is 23 and the process identity of the child is 24. What is the output of the above program? Explain clearly your reasoning.

d) Explain clearly the terms **reaping** and **zombie processes**.

e) Explain how **zombie processes** can be avoided.

4.

a) What is a **signal**?

b) Under what circumstances will the kernel send a signal to a process – name at least two.

c) A process can react in three ways to a signal – what are they?

d) Consider the following C code.

   i. What does the function call `signal(SIGINT, handler);` do? Who calls it the parent or the child?

   ii. What does the `wait(&child_status)` function do? Who calls it the child or the parent?

   iii. Given the pid of child 1 is 1333 and the pid of child 2 is 1334 what is the output of the program below?

```c
#include <stdio.h>
#include <signal.h>
#include <stdlib.h>

#define N 2

void handler(int sig) {
    printf("Process %d received signal %d - exiting\n", getpid(),
sig);
    exit(0);
}

int main() {
    pid_t pid[N];
    int i, child_status;
    signal(SIGINT, handler);

    for (i = 0; i < N; i++)
      {
        if ((pid[i] = fork()) == 0)
          {
                while(1); /* child infinite loop */
          }
      }
    for (i = 0; i < N; i++)
      {
        kill(pid[i], SIGINT);
      }

    for (i = 0; i < N; i++)
      {
        pid_t wpid = wait(&child_status);
        if (WIFEXITED(child_status))
            printf("Child %d terminated with exit status %d\n",
                    wpid, WEXITSTATUS(child_status));
        else
            printf("Child %d terminated abnormally\n", wpid);
      }
}
```

5.

a) Explain what the function of the %esp and %ebp in the Intel IA32 architecture is.

b) Suppose that %edx = 0xF000 and %ecx = 0x0100 fill in the following table:

Expression	Computation	Address
0x8(%edx)		
(%edx, %ecx)		
(%edx, %ecx, 4)		
0x80(, %edx, 2)		

a) Given the following Assembly code:
  1. Copy the assembly code into your answer sheet and comment each line of the assembly explaining clearly what each line does.
  2. Fill in the missing spaces in the given C code which corresponds to the assembly code.

```
pushl   %ebp
movl    %esp,%ebp

movl    12(%ebp),%eax
xorl    8(%ebp),%eax
sarl    $17,%eax
andl    $8185,%eax

popl    %ebp
ret
```

```
int logical(int x, int y)
{
   int t1 = _____;
   int t2 = _____;
   int mask = _____;
   int rval = _____;
   return _____;
}
```

6.
a) Given the following values calculate the capacity of a disk:
  i. 512 bytes/sector
  ii. 300 sectors/track (on average)
  iii. 20,000 tracks/surface
  iv. 2 surfaces/platter
  v. 5 platters/disk

b) Draw a block diagram showing how the I/O bus connects to the I/O bridge, the CPU and to Main Memory. Include any other elements you thing are important in the diagram.

c) Explain each of the following terms:
  i. Seek Time
  ii. Rotational Latency
  iii. Transfer Time

d) The access time for retrieving a piece of data is defined as $T_{access} = T_{seek} + T_{rotational} + T_{transfer}$ given the following information calculate the access time.
  i. Rotational Rate = 7200 RPM
  ii. Average Seek Time = 9 ms
  iii. Average number of sectors per track = 400

7.
a) Explain briefly what the purpose of a cache is.

b) Given the following 16 bit addresses determine the hit ratio for a 2 way cache, assume 16 byte cache lines and a cache capacity of 128 bytes
  i. 0x0000
  ii. 0x0004
  iii. 0x2204
  iv. 0x0002
  v. 0xde0b

c) Explain the difference between a "Write Through" cache and a "Write Back" cache.

d) The Cache is only part of the memory hierarchy, another equally important part if the Translation Lookaside Buffer. Explain it's function with respect to virtual memory management. Include such terms as address translation and locality of reference.

8.
a) Write down and explain the 4 layers of the TCP/IP model giving examples of protocols that operate at each layer. You should give at least two examples of a protocol per layer.

b) Explain clearly the difference between TCP and UDP giving use cases for both protocols.

c) Explain the purpose of the Domain Name System and how it operates.

d) Explain what the purpose of the socket interface is and list 3 well known socket interfaces.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department

Of

Computer Studies

<u>UNIVERSITY EXAMINATION</u>

CST3011 – Data Structures and Algorithms

DATE : MONDAY, 4TH March 2013

VENUE : Sports Hall

TIME : 2 PM

DURATION : 3 HOURS

INSTRUCTIONS

i. THERE ARE SIX (6) QUESTIONS IN THIS EXAMINATION PAPER AND YOU ARE REQUIRED TO ANSWER ONLY FIVE (5) OF THEM IN ANY ORDER.

ii. READ EACH QUESTION CAREFULLY AND ANSWER THE QUESTION AS CLEARLY AS POSSIBLE AND ACCORDING TO THE INSTRUCTIONS GIVEN.

iii. INDICATE THE QUESTIONS YOU ATTEMPT ON THE SPACE PROVIDED. GOOD LUCK!

1.

   a. Prove the following equation, using the principle of Mathematical Induction. *[10 Marks]*

$$\sum_{i=1}^{n} i = \frac{n(n+1)}{2}$$

   b. Hence, or otherwise, evaluate the following summation. *[10 Marks]*

$$\sum_{i=80}^{250} i$$

2.

   a. Define what the statement $f(n) = O(g(n))$ means. *[6 Marks]*

   b. Complete the following Java method that finds the largest element in a list of integers. *[7 Marks]*

```java
public int findMax(int[] intArray){
    int max = intArray[0];
    //fill in
    return max;
}
```

   c. Counting the number of operators and perform a Big-Oh analysis. *[7 Marks]*

3.

   a. Describe the stack data structure stating two of its applications. *[6 Marks]*

   b. Given the following infix expression,

$$56 + 32/4 - 10 * 2$$

     i. convert it to postfix notation with the use of a stack, showing the contents of the stack and output at each stage. *[7 Marks]*

     ii. With the use of a stack illustrate how this postfix expression is evaluated. *[7 Marks]*

4.

   a. Describe what a queue is. *[4 Marks]*

   b. List two uses of a queue. *[4 Marks]*

   c. Implement using a linked structure the queue data structure including the following operations. *[12 Marks]*

     i. isEmpty

     ii. enqueue

     iii. deque

5.

    a. Describe how the following two algorithms for sorting a list of items in ascending order work, giving a Big-Oh analysis the performance of each algorithms.

        i. Bubble sort. *[6 Marks]*

        ii. Merge sort. *[6 Marks]*

    b. Given the following numbers

        8, 33, 16, 1, 43, 12, 55, 58

        i. Perform bubble sort to rearrange them in ascending order showing the state of the list after each iteration. *[8 Marks]*

6.

    a. Describe how the following operations are performed on MinHeaps

        i. Insertion of an element. *[4 Marks]*

        ii. Deletion of the minimum element. *[4 Marks]*

    b. Given the following list of numbers

        8, 33, 16, 1, 43, 12, 55, 58

        i. Insert them into an initially empty MinHeap. *[8 Marks]*

        ii. Delete the minimum element and show the state of the heap thereafter. *[4 Marks]*

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

University of Zambia

School of Natural Science

Department of Computer Studies

CST3142 Software Engineering II

29th May 2012

9.00 Hrs to 12.00 Hrs

Instructions:

1. *This examination has two sections*

2. *Answer any five questions in Section A. Each question carries 5 marks*

3. *Answer any five questions in Section B. Each question carries 15 marks*

4. *Present your answer neat and understandable*

Section – A (5 x 5 = 25 Marks)

Answer any five questions. Each question carries 5 Marks

1. What is a project, and what are its main attributes? How is a project different from what most people do in their day-to-day jobs?

2. What is the role of project manager? What are suggested skills for all project managers and for information technology project manager?

3. Write short notes on weighted scoring model and balanced score card?

4. What is project scope management? What are the processes involved in project scope management?

5. Consider the following table, Network Diagram Data for a Small Project. All duration estimates or estimated times are in days; and the network proceeds from Node 1 to Node 9.

   Table: Network Diagram for a small project

Activity	Initial Node	Final Node	Estimated Duration
A	1	2	2
B	2	3	2
C	2	4	3
D	2	5	4
E	3	6	2
F	4	6	3
G	5	7	6
H	6	8	2
I	6	7	5
J	7	8	1
K	8	9	2

   i. Draw an AOA network diagram representing the project. Put the node in numbers in circles and draw arrows from node to node, labelling each arrow with the activity letter and estimated time.
   ii. Identify all of the paths on the network diagram and note how long they are.
   iii. What is the critical path for this project and how long is it?
   iv. What is the shortest possible time it will take to complete this project

6. Give examples of when you would prepare rough order magnitude, budgetary, and definitive cost estimates for an information technology project.

7. Explain about cost of quality? What are the five major cost categories related to quality?

Section – B (5 x 15 = 75 Marks)

Answer any five questions. Each question carries 15 Marks

1. a. Explain project life cycle and product life cycle? How does a project life cycle differ from product life cycle?

   b. Explain the four frames of organizations. How can they help project managers understand the organizational context for their projects?

2. a. What is project charter? What is the basic information in the project charter?

   b. What is a project management plan? Explain in detail about the common elements of a project management plan?

3. Explain in detail about Work Breakdown Structure (WBS), WBS dictionary and Scope baseline? Describe different ways to develop a WBS? Give some advice for creating a WBS and WBS dictionary.

4. Explain the following schedule development tools and concepts: Gantt Charts, critical path method, PERT, and critical chain scheduling?

5. a. Explain about earned value management and its terms

   b. Given the following information for a one-year project, answer the following questions.

Planned Value (PV)	= $35,000
Earned Value (EV)	= $30,000
Actual Cost (AC)	= $40,000
Budget at completion (BAC)	= $150,000

   i. What is the cost variance, schedule variance, cost performance index (CPI), and schedule performance index (SPI) for the project
   ii. How is the project doing? Is it ahead of schedule or behind of schedule? Is it under budget or over budget?
   iii. Use the CPI to calculate the estimate at completion (EAC) for this project, Is the project performing better or worse than planned?
   iv. Use the SPI to estimate how long it will take to finish this project.
   v. Sketch the earned value chart based for this project.

6. Explain about the quality control and the main categories of outputs for quality control? Explain in detail about the four tools and techniques for quality control?

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF MATHEMATICS AND STATISTICS

SEMESETER II EXAMINATIONS - 2012
DISTANCE EDUCATION
M212 – MATHEMATICAL METHODS IV

INSTRUCTIONS:
1. Answer any **four (4)** questions.
2. All questions carry equal marks.
3. Show all the necessary work to earn full marks.
4. Write down the questions attempted on the front page of the main booklet.
5. Use of calculators is allowed.

TIME ALLOWED: Three (3) hours.

---

1 [a] [i] Given the vectors $a = (a_1, a_2, a_3), b = (b_1, b_2, b_3), c = (c_1, c_2, c_3)$

Show that $a \bullet (b + c) = a \bullet b + a \bullet c$.

[ii] For $a = (1,1,1), b = (2,1,0), c = (0,0,1)$,

Find $a \bullet (b \times c)$. Hence find the volume of the box with a, b and c as adjacent sides.

[b] [i] Find the distance from the point $D(-1, 1, 2)$ to the plane through the points $3x - 2y + 2z = 1$

[ii] Find the curvature for the curve $\bar{r}(t) = \frac{1}{3}t^3 i + \frac{\sqrt{2}}{2} t^2 j + t k$ at $t = 1$

2. [a] Suppose the dimensions (in meters) of a rectangular box change from 9, 6, and 4 to 9.02, 5.97 and 4.01, respectively.

[i] Use differentials to approximate the change in volume.

[ii] Find the exact change in volume.

[b] [i] Let $z = f(u - v, v - u)$, show that $\dfrac{\partial z}{\partial u} + \dfrac{\partial z}{\partial v} = 0$

[ii] If the line l has parametric equations $x = 5 - 3t, y = -2 + t, z = 1 + 9t$,

Find parametric equations for the line through P (5, 4,-3) that is parallel to l.

1

3. [a] Solve the equation:

[i] $\cos x \dfrac{dy}{dx} + y \sin x = \sec^2 x$

[ii] $x \dfrac{dy}{dx} + y = y^2 \ln x$

[b] [i] If $u = \ln \dfrac{x^2 + y^2}{x + y}$, show that $x \dfrac{\partial u}{\partial x} + y \dfrac{\partial u}{\partial y} = 1$

[ii] Verify Euler's theorem for $z = x^n \ln\left(\dfrac{y}{x}\right)$

4 [a] If $f(x, y) = \dfrac{1}{3} x^3 + \dfrac{4}{3} y^3 - x^2 - 3x - 4y - 3$,

find the local extrema and saddle points of f.

[b] Solve the following differentials

[i] $\dfrac{dy}{dx} + \dfrac{3}{x} y = \dfrac{4}{x^2} + 10x$

[ii] $y'' + 10y' + 29y = 0$

5 [a] [i] Find $\dfrac{\partial z}{\partial x}$ and $\dfrac{\partial}{\partial y}\left(\dfrac{\partial z}{\partial x}\right)$ given that $z = e^y \sin xy$

[ii] Let l be the line of intersection of the two planes

$2x - y + 4z - 4 = 0$ and $x + 3y - 2z - 1 = 0$.

Find parametric equations for the line l.

[b] [i] Find the distance between the point $Q\,(1, 5, -4)$ and the plane
given by $3x - y + 2z = 6$.

[ii] Find the limit if it exists:

$$\lim_{(x,y) \to (0,0)} \dfrac{3x^3 - 2x^2 + 3y^2 x - 2y^3}{x^2 + y^2}$$

[iii] Find the second partial derivatives of $f(x, y) = 3xy^2 - 2y + 5x^2 y^2$
and determine the value of $f_{xy}(-1, 2)$.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
Department of Mathematics & Statistics
SECOND SEMESTER FINAL EXAMINATIONS

May, 2012
M412—FUNCTIONS OF A COMPLEX VARIABLE II

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)   State and prove Liouville's theorem.

   (b)   Find the Laurent series expansion of

$$f(z) = \frac{1}{z^2(1-z)}$$

   in the annular domain $1 < |z| < \infty$.

   (c) (i) State the Mean Value theorem.

   (ii) Hence, considering the function $f(z) = \sin z$ on the unit circle, show that

$$\int_0^{2\pi} \cos(\cos\theta)\sinh(\sin\theta)\mathrm{d}\theta = 0.$$

2. (a) State the Minimum Modulus Principle.

(b) Find the minimum value of $|f(z)| = |z^2 + 2|$ over the closed region $|z| \leq 1$.

(c) In each case below write the principal part of the function at its isolated singularity. Then determine if that singularity is a pole, an essential singularity, or a removable singularity.

(i) $f(z) = \frac{1}{z}e^z$.　　(ii) $f(z) = \frac{\cos z}{z}$.

(iii)

$$f(z) = \frac{1}{1 + z + z^2 + z^3 + z^4 + z^5}.$$

3. (a) Without using the Residue theorem, by integrating $f(z) = \frac{ze^{iz}}{z^2 + a^2}$ around a suitable contour, prove that

$$\int_0^\infty \frac{x \sin x}{x^2 + a^2}dx = \frac{\pi}{2e^a}, \quad \text{where} \quad a > 0.$$

(b) Let C denote the circle $|z| = 2$ described in the positive sense. Determine the value of $\Delta_c \arg f(z)$ for the function

$$f(z) = \frac{z - (\frac{1}{2} + \frac{i\sqrt{3}}{2})}{z^3(z - 2\pi)^2}.$$

(c) Find the maximum value of

$$|f(z)| = |z^2 + 3z - 1|$$

on the unit disk $|z| < 1$.

4. (a) State and prove the Cauchy Inequality theorem.

(b) Verify the Cauchy Inequality theorem for the function $f(z) = \frac{1}{2z+1}$ if z lies on the circle $|z - 3| = 2$.

(c) Prove that

$$\int_{-\infty}^\infty \frac{x}{x^3 - 8}dx = \frac{\pi\sqrt{3}}{6}.$$

5. (a) (i) State Rouche's theorem.

(ii) Using Rouche's theorem, show that the roots of the equation

$z^4 + 6z + 1 = 0$ lie within the circle $|z| < 2$ but one root lies inside the circle

$|z| < \frac{3}{2}$.

(b) Evaluate

$$\int_C \frac{f'(z)}{f(z)} dz$$

if C is the circle $|z| = 3\pi$ for

$$f(z) = \frac{\sqrt{2} \sin z - 1}{(z-1)^2(z+5)}.$$

(c) (i) Find the Laurent series expansion of $f(z) = \frac{e^{-z}}{(z-2)^4}$ in the domain

$0 < |z - 2| < R$, for arbitrarily large R.

(ii) Hence find the residue of $f(z)$ at its singularity.

6. (a) State the residue theorem.

(b) Using the residue theorem, evaluate

$$\int_C \frac{1}{z(2z-5)(z-4)} dz,$$

where $C = \{z : |z+2| + |z-2| = 6\}$, positively oriented.

(c) Locate and identify the singularities of:

$$(i) \quad f(z) = \frac{1+z}{\cos z - 2} \qquad (ii) \quad f(z) = \frac{1}{1 - e^{-z}}.$$

END.