

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

2011 ACADEMIC YEAR SECOND SEMESTER  
FINAL EXAMINATIONS

AGC 6452 MOLECULAR GENETICS AND BIOTECHNOLOGY  
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS; QUESTIONS 1 AND 2 ARE  
COMPULSORY

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1. The elucidation of the biology of bacteriophage lambda and M13 has spawned a number of vector types to study plant genomes and gene expression.
  - (a) Analyze the biology of bacteriophage lambda and explain why this bacteriophage has given us various types of gene cloning vectors.
  - (b) Describe four different types of gene cloning vectors that have been developed as a result of our understanding of the biology of bacteriophage lambda.
  - (c) Explain how bacteriophage lambda based vectors differ from yeast artificial chromosomes.
2. In the following nucleic acid sequence the numbers refer to positions. Study the sequence and answer the questions that follow.
  1. aauguaggu ggcuaacua cuggaaaagu ccgugagcuu acaauugcgg aucgagguua  
ccuaaggugc
  - 71 ggccuuagug aaccauugcc ccguuaaaag gaaaaccacc gccaaauugc cgaacuuagg  
ccgagcuuac
  - 141 agacuuaggc ccccguaaga ggaguuuagc ccuuuuuagg ccuauggggcacacaggcau  
gcacauggac
  - 211 ccaggagccu ccuaggauua ggugauagcc gguaccagac ggaccagguu  
agccauuagg
  - 271 aaaaaaaaaa aaaaaaaaaa
  - (a) Imagine that the sequence was for a plant gene, expressed in leaf tissue, describe the technique you would use to amplify the gene sequence.
  - (b) Write the sequences of **three** different primers which you would need to amplify a 230 bp cDNA fragment excluding the first 50 nucleotides.

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- (c) Imagine also that you were required to clone the gene into the *Afl*III (C↓TTAAG) and *Hind*II (A↓AGCTT) sites of the multiple cloning site of a vector, write down the nucleotide sequences of two primers you would use to amplify the fragment in (b) above and explain what you would do to drive the over-expression of the gene, assuming that the two restriction enzymes are not found in the given gene sequence.
- (d) Explain how you would apply Taqman chemistry to analyze the expression of the gene in real time PCR.
3. Summarize each of the following:
- Embryo rescue and its possible uses in plant biotechnology.
  - Protoplast production and applications in plant biotechnology.
  - Anther culture and applications in plant biotechnology.
4. *Agrobacterium tumefaciens* is a pathogen that engineers plants for its own selfish ends. However, various strains of the pathogen have also been re-engineered by humans for their own use, in turn revolutionizing agricultural practices in some countries. Discuss the biology and applications of *A. tumefaciens* for RNA interference crops.
5. The potential application of molecular markers and marker-assisted selection in plant breeding programs has raised a lot of hope for researchers and farmers in Africa. Some however, have argued that direct benefits from marker-assisted breeding have remained hard to come by. Discuss the principles of ISSR and AFLP markers how you would apply AFLPs to a plant breeding program.
6. Public discussion of the research on, use and importation of genetically modified organisms (GMOs) and products containing transgenes in Zambia has been bogged down by varying opinions and emotions some of which tend to be highly charged. Critically analyze the issues surrounding gene modification discussions in Zambia using six points against and five points for gene modification in the country.
7. Discuss how genetic engineering has been used to make herbicide resistant and insect tolerant crops giving a specific example of each case together with technical challenges encountered and how these were solved.

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END OF EXAMINATION

**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. tertiary
  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'AACUACGGCUGCAG3'. 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. phosphodiester
  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; sulphhydryl bonds.
  5. polar side chains of ; hydrophobic bonds.
  6. I do not know.

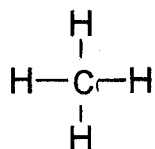
19. The shape of a molecule ...
1. influences its biological function.
  2. is sometimes dependent on its electronegativity.
  3. is dependent in part on the angle of bonds between its atoms.
  4. All 1, 2 and 3 are correct
  5. is dependent on its position in the periodic table.
  6. I do not know.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

25. The group  $\text{-COOH}$  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

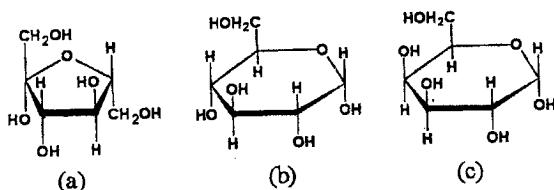
43. In the molecule given below ....



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.

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 questions 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.

53. Identify the structural isomer(s) of glucose from the set of molecules given above.

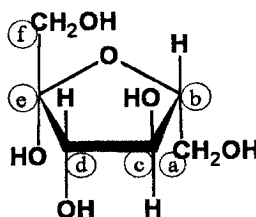
1. (a) and (b)
2. (a) and (c)
3. (b) and (c)
4. (b)
5. (c)
6. I do not know.

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.

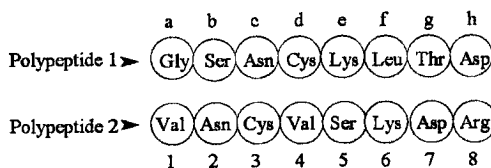
55. Identify the carbon atom in the molecule given below that normally goes into a chemical reaction with a neighbouring molecule.

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 sulphhydryl 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 isomers
  2. Isotopes
  3. Polymers
  4. Stereoisomers
  5. Non aromatic structures
  6. I do not know.
61. The  $\beta$  (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 bases.
  2. nucleosides and nucleotides.
  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 chains.
  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.

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 daughter 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 metabolism in the form of...
1. proteins.
  2. triglycerides.
  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 mono peptide 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 are ...
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. proteins and nucleic acids.
  3. phospholipids and proteins.
  4. cholesterol 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.  $\beta$ -glucose monomer units.
2.  $\alpha$ -amino acid monomer units.
3.  $\alpha$ -glucose monomer units.
4.  $\alpha$  and  $\beta$ -glucose monomer units.
5.  $\alpha$ -triose monomer units.
6. I do not know.

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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.**

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**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  $-0.45\text{MPa}$ , 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.

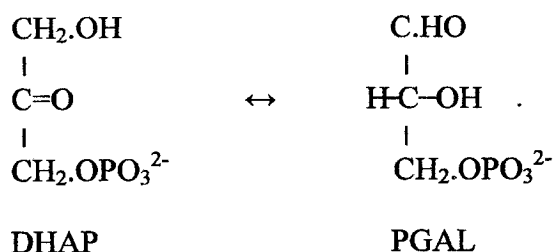
Root surface area ( $\text{m}^2$ )	Hydraulic root resistance ( $\text{MPa s m}^{-3}$ )	Xylem water potential ( $\text{MPa}$ )
$7.5 \times 10^{-3}$	$1.3 \times 10^9$	$-0.55$

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  $\text{C}_3$  (Calvin) cycle proceeds in three phases: carboxylation, reduction and regeneration. Write the steps of chemical reactions involved in carboxylation, reduction, and regeneration phases.

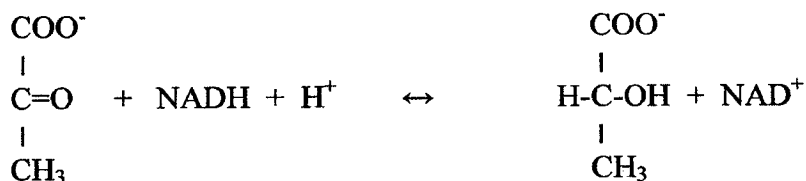
**TURN OVER**

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

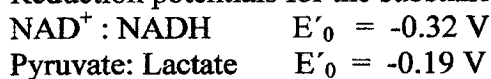


At equilibrium the ratio of PGAL to DHAP is 0.0475 at 25 °C and pH 7.

- (i) Calculate the standard free energy change for the above reaction in kJ/ mol. ( $R = 8.315 \text{ J/K} \cdot \text{mol}$ ).
  - (ii) If the initial concentrations were  $2 \times 10^{-4}$  for DHAP and  $3 \times 10^{-6}$  for PGAL, calculate free energy change ( $\Delta G$ ) at these concentrations.
- (b) The formation of lactate from pyruvate in cellular glucose metabolism is a form of fermentation.



Reduction potentials for the substances involved are:



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.

CONTINUE TO THE NEXT PAGE

## 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.

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END OF EXAMINATION

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

2012 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS

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.

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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.
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END OF EXAMINATION

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

2012 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS

BIO 2075: ECOSYSTEMS AND BIODIVERSITY  
THEORY PAPER

TIME: THREE HOURS

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

- 
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.

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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.

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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.

<b>Burned</b>	10.56	11.97	9.01	10.33	9.53	12.10	8.88	8.50	10.20	11.55
<b>Unburned</b>	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.

TURN OVER

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.

<b>Length (mm)</b>	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
<b>Depth (mm)</b>	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.

	1 <sup>st</sup> Estimate	2 <sup>nd</sup> 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<sup>®</sup> on the plot data obtained and the results are shown in Table 5.

CONTINUE TO THE NEXT PAGE

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

SUMMARY				
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
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					
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>F crit</i>
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<sup>®</sup> and the output is given in Table 6.

TURN OVER

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					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>F crit</i>
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.

CONTINUE TO THE NEXT PAGE

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:
- SS.
  - Variance.
  - Standard Deviation.
- (b) Determine whether there is a significant difference in the air quality from planned and unplanned settlements using the MSEXCEL<sup>®</sup> 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

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.

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END OF EXAMINATION

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

**2012 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS**

**BIO 3301: VIROLOGY  
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.**

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**SECTION A: Plant Viruses**

1. Discuss structural the characteristics and significance of mycoviruses.
2. Describe plant viruses with reference to particle shape, size and genome variability.
3. Describe insect transmission of plant viruses.
4. Describe virus distribution in plants following infection.

**SECTION B: Animal Viruses**

5. With reference to the biology of Polyomaviruses:
  - (a) Draw a labeled diagram of the generic genome of Polyomavirus.
  - (b) Describe four special features of the Polyomavirus genome structure and its replication.
6. Explain the principles of the enzyme-linked immunosorbent assay (ELISA) and Western blotting as applied to virus detection.
7. With the aid of clearly-labeled diagrams, explain the replication of the Human Immunodeficiency Virus (HIV). Your diagram and explanation should include details of special nucleic acid sequences in the HIV genome and, viral and host cell components that play a role in HIV replication.

**TURN OVER**

8. Describe twelve major gene components and proteins that control the transition between the lysogenic and lytic life cycle of bacteriophage lambda as well as the expression of the immediate early and delayed early genes in this transition.
- 

END OF EXAMINATION

**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

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

2012 ACADEMIC YEAR SECOND SEMESTER  
FINAL EXAMINATIONS

BIO 4431: INSECT ECOLOGY  
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.

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SECTION A

1. Discuss with examples, the ecological implications of 'smallness' in insect body size.
2. Compare and contrast individual and population attributes in insects.
3. Summarise the following:
  - (a) Dispersion.
  - (b) Sampling techniques.
  - (c) Relative estimates.
  - (d) Sample size.
4. Discuss with examples the significance of insect surveys and monitoring in insect pest management.

SECTION B

5. Summarise the following:
  - (a) Intraspecific competition.
  - (b) Community.
  - (c) Ecosystem.
  - (d) Natality.
6. Compare and contrast  $r$ - and  $K$ -strategies in insects.
7. Explain how density-dependent and density-independent factors affect population growth.
8. (a) Discuss with examples interspecific competition.  
(b) Discuss under which conditions competing species can coexist.

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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.

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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

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

2011 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS

BIO 5011: RESEARCH STATISTICAL METHODS  
THEORY PAPER II

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY. YOU ARE ALLOWED TO USE PROVIDED COMPUTERS OR AUTHORISED LAPTOPS.

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Data in the table 1 below consists of vegetation structure, bird abundance and bird species richness of a wet miombo woodland in Central Zambia. The data were obtained from twenty plots of equal area. Use SPSSWin<sup>®</sup>, STATISTIX<sup>®</sup>, and MSEXCEL<sup>®</sup> to answer the questions that follow.

1. Use the Ward's method of hierarchical clustering to group the plots based on their similarity in vegetation structure. Use the 80% similarity index to determine the number of clusters and summarise the results in the form of a dendrogram.
2. Determine whether there are significant differences in the basal area cover and mean tree height among the clusters identified in question 1 above.
3. Derive the best subset regression models for determining bird density and bird species richness from vegetation structure data and summarise the regression in the form of a straight line.

CONTINUED ON THE NEXT PAGE

Table 1 Vegetation structure, bird abundance and bird species richness of a wet miombo woodland in Zambia.

	Basal area cover (dm <sup>2</sup> )	Canopy cover (%)	Tree density (#/plot)	Mean tree height (m)	Bird density (#/plot)	Bird species richness
<b>PLOT 1</b>	141.8	55	14	14.1	4	4
<b>PLOT 2</b>	271.6	45	12	18.6	8	4
<b>PLOT 3</b>	109.4	60	18	11.8	15	7
<b>PLOT 4</b>	158.5	40	31	11.9	8	5
<b>PLOT 5</b>	54.23	25	12	9.6	7	2
<b>PLOT 6</b>	305.7	60	19	16.6	0	0
<b>PLOT 7</b>	84.66	45	13	13.3	7	4
<b>PLOT 8</b>	11.27	55	13	11.8	8	4
<b>PLOT 9</b>	103.5	30	10	10.8	6	3
<b>PLOT 10</b>	68.93	5	30	7.5	5	5
<b>PLOT 11</b>	116	40	5	16.6	10	3
<b>PLOT 12</b>	45.07	30	7	12.1	25	7
<b>PLOT 13</b>	204	70	19	15.3	3	3
<b>PLOT 14</b>	90.08	45	16	11.6	4	4
<b>PLOT 15</b>	177.9	60	21	13.9	4	4
<b>PLOT 16</b>	123.3	5	11	13.8	4	4
<b>PLOT 17</b>	120.6	5	56	8.7	16	6
<b>PLOT 18</b>	2.756	10	3	6.4	5	4
<b>PLOT 19</b>	68.08	30	16	8.4	9	6
<b>PLOT 20</b>	100.7	45	28	9.2	5	4

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END OF EXAMINATION

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

2011 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS

BIO 5011: RESEARCH STATISTICAL METHODS  
THEORY PAPER II

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY. YOU ARE ALLOWED TO USE PROVIDED COMPUTERS OR AUTHORISED LAPTOPS.

---

Data in the table 1 below consists of vegetation structure, bird abundance and bird species richness of a wet miombo woodland in Central Zambia. The data were obtained from twenty plots of equal area. Use SPSSWin<sup>®</sup>, STATISTIX<sup>®</sup>, and MSEXCEL<sup>®</sup> to answer the questions that follow.

1. Use the Ward's method of hierarchical clustering to group the plots based on their similarity in vegetation structure. Use the 80% similarity index to determine the number of clusters and summarise the results in the form of a dendrogram.
2. Determine whether there are significant differences in the basal area cover and mean tree height among the clusters identified in question 1 above.
3. Derive the best subset regression models for determining bird density and bird species richness from vegetation structure data and summarise the regression in the form of a straight line.

CONTINUED ON THE NEXT PAGE

Table 1 Vegetation structure, bird abundance and bird species richness of a wet miombo woodland in Zambia.

	Basal area cover (dm <sup>2</sup> )	Canopy cover (%)	Tree density (#/plot)	Mean tree height (m)	Bird density (#/plot)	Bird species richness
<b>PLOT 1</b>	141.8	55	14	14.1	4	4
<b>PLOT 2</b>	271.6	45	12	18.6	8	4
<b>PLOT 3</b>	109.4	60	18	11.8	15	7
<b>PLOT 4</b>	158.5	40	31	11.9	8	5
<b>PLOT 5</b>	54.23	25	12	9.6	7	2
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<b>PLOT 16</b>	123.3	5	11	13.8	4	4
<b>PLOT 17</b>	120.6	5	56	8.7	16	6
<b>PLOT 18</b>	2.756	10	3	6.4	5	4
<b>PLOT 19</b>	68.08	30	16	8.4	9	6
<b>PLOT 20</b>	100.7	45	28	9.2	5	4

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END OF EXAMINATION

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

**2011 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS**

**BIO 5011: RESEARCH STATISTICAL METHODS  
THEORY PAPER II**

**TIME: THREE HOURS**

**INSTRUCTIONS: ANSWER ALL QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY. YOU ARE ALLOWED TO USE PROVIDED COMPUTERS OR AUTHORISED LAPTOPS.**

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Data in the table 1 below consists of vegetation structure, bird abundance and bird species richness of a wet miombo woodland in Central Zambia. The data were obtained from twenty plots of equal area. Use SPSSWin<sup>®</sup>, STATISTIX<sup>®</sup>, and MSEXCEL<sup>®</sup> to answer the questions that follow.

1. Use the Ward's method of hierarchical clustering to group the plots based on their similarity in vegetation structure. Use the 80% similarity index to determine the number of clusters and summarise the results in the form of a dendrogram.
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Table 1 Vegetation structure, bird abundance and bird species richness of a wet miombo woodland in Zambia.

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END OF EXAMINATION

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

**2011 ACADEMIC YEAR FIRST SEMESTER**  
**FINAL EXAMINATIONS**

**BIO 5101: BIOSYSTEMATICS OF TROPICAL PLANT TAXA**  
**THEORY PAPER**

**TIME: THREE HOURS**

**INSTRUCTIONS: ANSWER FIVE QUESTIONS.**

---

1. Summarise the following:
    - (a) Lectotype.
    - (b) Polynomial system of nomenclature.
    - (c) Principle of priority in Botanical nomenclature.
    - (d) Vicariance.
  2. Describe the general purpose and special purpose classification systems giving examples where necessary.
  3. Discuss the phenetic and the biological species concepts and outline the ways in which gene flow is affected during various modes of speciation.
  4. Discuss the concept of taxonomic characters in plant systematics.
  5. Describe the various floristic regions of Africa indicating the provincial composition for each of them.
  6. Describe the distribution, characteristic features and economic importance of the family Solanaceae.
  7. Discuss typification and explain the significance of this process to plant systematics.
  8. (a) Describe the History of the International Code of Nomenclature for Algae, Fungi and Plants (ICN).  
(b) Briefly state the principles of the ICN.
- 

**END OF EXAMINATION**

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

2011 ACADEMIC YEAR SECOND SEMESTER  
FINAL EXAMINATIONS

BIO 5102: BIOSYSTEMATICS OF TROPICAL ANIMAL TAXA  
PRACTICAL PAPER

TIME: THREE HOURS

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

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1. Study the specimens labeled **A** to **D** provided and for each specimen:
    - (a) Classify the specimen to the species level.
    - (b) Describe the breeding habits.
    - (c) Describe the feeding habits.
    - (d) Describe taxonomic characteristics used in identifying the species.
  2. Ten specimens labeled **E1** to **E10** are provided. For each specimen answer the following questions:
    - (a) Suggest preferred habitats of the species.
    - (b) Indicate possible economic uses of species.
    - (c) Assign the specimen to its Class, Order and Family.
  3. You are provided with specimens **F-Q**. For each specimen:
    - (a) Name the invertebrate order to which it belongs.
    - (b) Indicate the habitat in which it is found.
    - (c) Explain the taxonomic relationship to other invertebrates.
- 

END OF EXAMINATION

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

**2011 ACADEMIC YEAR SECOND SEMESTER  
FINAL EXAMINATIONS**

**BIO 5122: BIODIVERSITY ASSESSMENT AND MANAGEMENT  
PRACTICAL PAPER**

**TIME: THREE HOURS**

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

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1. Describe:
  - (a) The different types of quadrats used in the assessment of biodiversity.
  - (b) The type of data that can be recorded from the quadrats in (1a) above.
  - (c) The type of analysis and results that can be obtained from the data in (1b) above.
2. Using PC-ORD<sup>®</sup> software, determine the dominance of woody species at the Great East Road Campus using data in the file ***UNZA TREE DATA.xls*** provided.
3. Using the data in the file ***BIRD DATA.xls*** provided, determine whether the conservation status of an area has an impact on:
  - (a) Species richness.
  - (b) Species diversity.
  - (c) Bird abundance.

---

**END OF EXAMINATION**

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

**2011 ACADEMIC YEAR SECOND SEMESTER  
FINAL EXAMINATIONS**

**BIO 5122: BIODIVERSITY ASSESSMENT AND MANAGEMENT  
PRACTICAL PAPER**

**TIME: THREE HOURS**

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

---

1. Describe:
  - (a) The different types of quadrats used in the assessment of biodiversity.
  - (b) The type of data that can be recorded from the quadrats in (1a) above.
  - (c) The type of analysis and results that can be obtained from the data in (1b) above.
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  - (a) Species richness.
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  - (c) Bird abundance.

---

**END OF EXAMINATION**

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

2011 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS

**BIO 5135: ECOLOGY AND MANAGEMENT OF TROPICAL DRY FORESTS**  
**PRACTICAL PAPER**

**TIME: THREE HOURS**

**INSTRUCTIONS: ANSWER ALL QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY. COMPUTERS WILL BE PROVIDED OR AUTHORISED LAPTOPS**

---

Table 1 has data on vegetation structure and composition collected from 0.1 ha plots established in wet and dry miombo woodland in Zambia. Use the following statistical software, PC-ORD<sup>®</sup>, STATISTIX<sup>®</sup> and SPSSWin<sup>®</sup> to answer questions that follow.

1.
  - (a) Determine the basal area cover of wet and dry miombo.
  - (b) Determine the above ground wood biomass in the two miombo subtypes using the equation  $y = 0.702x - 281.484$  where  $y$  is the above ground wood biomass (kg) and  $x$  is the basal area (cm<sup>2</sup>) at 1.3 metres above ground.
  - (c) Determine whether the above ground wood biomass in the two miombo subtypes is different.
2. Derive the linear equations for determining tree height (m) in wet and dry miombo from DBH (cm) data.
3. Using the vegetation structure data, summarise the relationship between miombo tree species in the form of a dendrogram.

CONTINUED ON THE NEXT PAGE

Table 1. Vegetation structure and composition data of wet and dry miombo woodland.

Miombo type	Species	GBH (cm)	DBH (cm)	Height (m)
Dry	<i>Ochna pulchra</i>	27	8.5943669	3.5
Dry	<i>Monotes africana</i>	25	7.9577472	2.6
Dry	<i>Ochna pulchra</i>	17	5.4112681	3.2
Dry	<i>Julbernardia globiflora</i>	74	23.554932	31.2
Dry	<i>Julbernardia globiflora</i>	69	21.963382	10.9
Dry	<i>Julbernardia globiflora</i>	71	22.600002	13.5
Dry	<i>Ochna pulchra</i>	12	3.8197186	2.6
Dry	<i>Swartzia madagascariensis</i>	6	1.9098593	2.2
Dry	<i>Ochna pulchra</i>	27	8.5943669	3.1
Dry	<i>Julbernardia globiflora</i>	85	27.05634	10.8
Dry	<i>Pericopsis angolensis</i>	7	2.2281692	2.1
Dry	<i>Pericopsis angolensis</i>	8	2.5464791	2.4
Dry	<i>Pericopsis angolensis</i>	8	2.5464791	2.6
Dry	<i>Pericopsis angolensis</i>	6	1.9098593	1.9
Dry	<i>Pericopsis angolensis</i>	5	1.5915494	2
Dry	<i>Pterocarpus angolensis</i>	9	2.864789	2.7
Dry	<i>Pterocarpus angolensis</i>	9	2.864789	2.3
Dry	<i>Pterocarpus angolensis</i>	5	1.5915494	2.2
Dry	<i>Pterocarpus angolensis</i>	6	1.9098593	2
Wet	<i>Albizia versicolor</i>	19.7	6.2707048	5
Wet	<i>Albizia versicolor</i>	15	4.7746483	4.5
Wet	<i>Pseudolachnostylis maupruefolia</i>	5	1.5915494	2.5
Wet	<i>Pseudolachnostylis maupruefolia</i>	7	2.2281692	3
Wet	<i>Pseudolachnostylis maupruefolia</i>	15	4.7746483	3.5
Wet	<i>Annona senegalensis</i>	13	4.1380285	4
Wet	<i>Annona senegalensis</i>	12	3.8197186	3.5
Wet	<i>Annona senegalensis</i>	12	3.8197186	4
Wet	<i>Albizia versicolor</i>	22	7.0028175	6
Wet	<i>Erythrina abyssinica</i>	26.4	8.403381	4.5
Wet	<i>Albizia versicolor</i>	5.3	1.6870424	4
Wet	<i>Lannea discolor</i>	11	3.5014087	2.5
Wet	<i>Brachystegia boehmii</i>	10	3.1830989	3.5
Wet	<i>Brachystegia boehmii</i>	12	3.8197186	4
Wet	<i>Brachystegia boehmii</i>	11.6	3.6923947	3
Wet	<i>Brachystegia boehmii</i>	17	5.4112681	3
Wet	<i>Baphia brachemosa</i>	8.5	2.705634	2
Wet	<i>Swartzia madagascariensis</i>	14.7	4.6791553	2
Wet	<i>Strychnos pugens</i>	5.5	1.7507044	3
Wet	<i>Pseudolachnostylis maupruefolia</i>	11	3.5014087	3
Wet	<i>Pseudolachnostylis maupruefolia</i>	10.5	3.3422538	3
Wet	<i>Albizia adianthifolia</i>	55.2	17.570706	8.5
Wet	<i>Albizia adianthifolia</i>	62.3	19.830706	4.5
Wet	<i>Albizia adianthifolia</i>	34.7	11.045353	8
Wet	<i>Albizia adianthifolia</i>	15	4.7746483	2.5
Wet	<i>Vitex doniana</i>	8.5	2.705634	3
Wet	<i>Albizia adianthifolia</i>	35	11.140846	3.5
Wet	<i>Julbernardia paniculata</i>	22.5	7.1619724	7.5

END OF EXAMINATION

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

2011 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS

**BIO 5135: ECOLOGY AND MANAGEMENT OF TROPICAL DRY FORESTS**  
**PRACTICAL PAPER**

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY. COMPUTERS WILL BE PROVIDED OR AUTHORISED LAPTOPS

---

Table 1 has data on vegetation structure and composition collected from 0.1 ha plots established in wet and dry miombo woodland in Zambia. Use the following statistical software, PC-ORD<sup>®</sup>, STATISTIX<sup>®</sup> and SPSSWin<sup>®</sup> to answer questions that follow.

1.
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  - (c) Determine whether the above ground wood biomass in the two miombo subtypes is different.
2. Derive the linear equations for determining tree height (m) in wet and dry miombo from DBH (cm) data.
3. Using the vegetation structure data, summarise the relationship between miombo tree species in the form of a dendrogram.

CONTINUED ON THE NEXT PAGE

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

2011 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS

BIO 5135: ECOLOGY AND MANAGEMENT OF TROPICAL DRY FORESTS  
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Wet	<i>Lannea discolor</i>	11	3.5014087	2.5
Wet	<i>Brachystegia boehmii</i>	10	3.1830989	3.5
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Wet	<i>Brachystegia boehmii</i>	11.6	3.6923947	3
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Wet	<i>Swartzia madagascariensis</i>	14.7	4.6791553	2
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Wet	<i>Albizia adianthifolia</i>	15	4.7746483	2.5
Wet	<i>Vitex doniana</i>	8.5	2.705634	3
Wet	<i>Albizia adianthifolia</i>	35	11.140846	3.5
Wet	<i>Julbernardia paniculata</i>	22.5	7.1619724	7.5

END OF EXAMINATION

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

2011 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS

BIO 5145: ECOLOGY AND MANAGEMENT OF WILDLIFE POPULATIONS  
PRACTICAL PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY

---

1. Study the specimens provided and answer the questions:

**Specimen A:**

Describe the habitat in which this plant is co-dominant

**Specimen B:**

Describe the habitat of this species

**Specimen C:**

Briefly discuss the conservation status of this species.

**Specimen D:**

Describe the most suitable census method of this species

**Specimen E:**

Describe food habits of this specimen

2. Biologists monitoring populations of Impala (*Aepyceros melampus* Lichtenstein 1812) on Chete Island in Lake Kariba, Sinazongwe between 1968 and 1985 gave figures as given in the Table 1 below. The island is approximately 5km<sup>2</sup> and is generally covered by a thicket of *Combretum* sp. Mean annual rainfall is 900mm. The island is a protected area and is regularly patrolled by Game Scouts. However, artisanal fishermen in the lake are allowed to land fish in certain parts of the island. For nearly 12 years the island was exposed to liberation war between 1968 and 1980, and part of the island was defoliated with herbicides.

CONTINUED ON THE NEXT PAGE

Impalas are polygamous and only one male breeds with a herd of females. Non breeding males form a bachelor herd.

Table 1: Impala population at Chete Island, Lake Kariba, based on transect ground counts.

Year of census	Total population	Juveniles	Males	Females
1968	136	6	54	76
1972	150	10	40	100
1975	308	40	58	210
1980	263	65	60	138
1985	235	75	65	95

- (a) Discuss the population trends of this species on the island
- (b) Describe possible factors limiting distribution and population growth of the species \_\_
3. You are required to use the information provided to answer this question. It is assumed that you have just completed an ecological study of the area, and on the basis of the results of your study,
- (a) Prepare a brief conservation management plan for the area
- (b) Describe one most important habitat for each of the following species:
- (i) Hartebeest (*Alcelaphus buselaphus* Pallas, 1766).
- (ii) Kudu ( *Tragelaphus strepsiceros* Pallas, 1766).

### INFORMATION FOR QUESTION THREE

#### Vegetation types:

- A: Termitaria grassland.
- B: Munga – Combretum woodland.
- C: Chipya woodland.
- D: Miombo woodland.
- E: Hyparrhenia grassland.
- F: Wetland (swamp)

CONTINUED ON THE NEXT PAGE

**Description of the area**

The area is located in the western part of Mpika District in Chief Chiundaponde, Northern Province of Zambia, and it is about 10km<sup>2</sup>. Average annual rainfall is approximately 1300 mm. Lake Bakabaka is a fresh water lake, and has several species of fish. The river is perennial with riparian vegetation mainly *Diospyros sp* and *Syzygium sp*. The Hot spring which is located in south of area is salty. There is only one village of about seven households (or about 40 inhabitants). Its main activities include fishing, hunting and subsistence farming. Farming is done in vegetation types A, B and E. The area is being considered for protection because of its importance to biodiversity.

---

END OF EXAMINATION

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

**2011 ACADEMIC YEAR SECOND SEMESTER  
FINAL EXAMINATIONS**

**BIO 5165: ECOLOGY AND MANAGEMENT OF TROPICAL WETLANDS  
PRACTICAL PAPER**

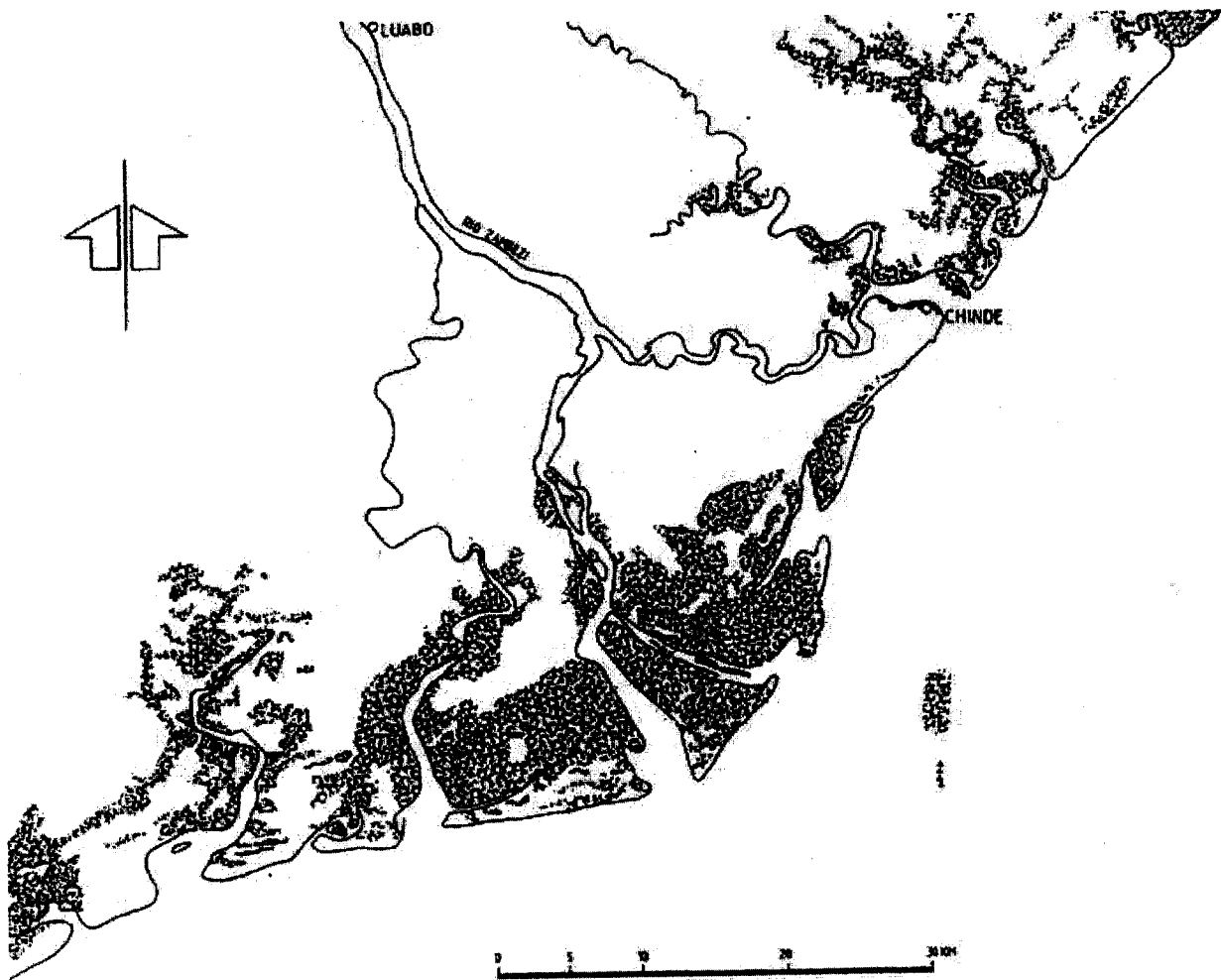
**TIME: THREE HOURS**

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

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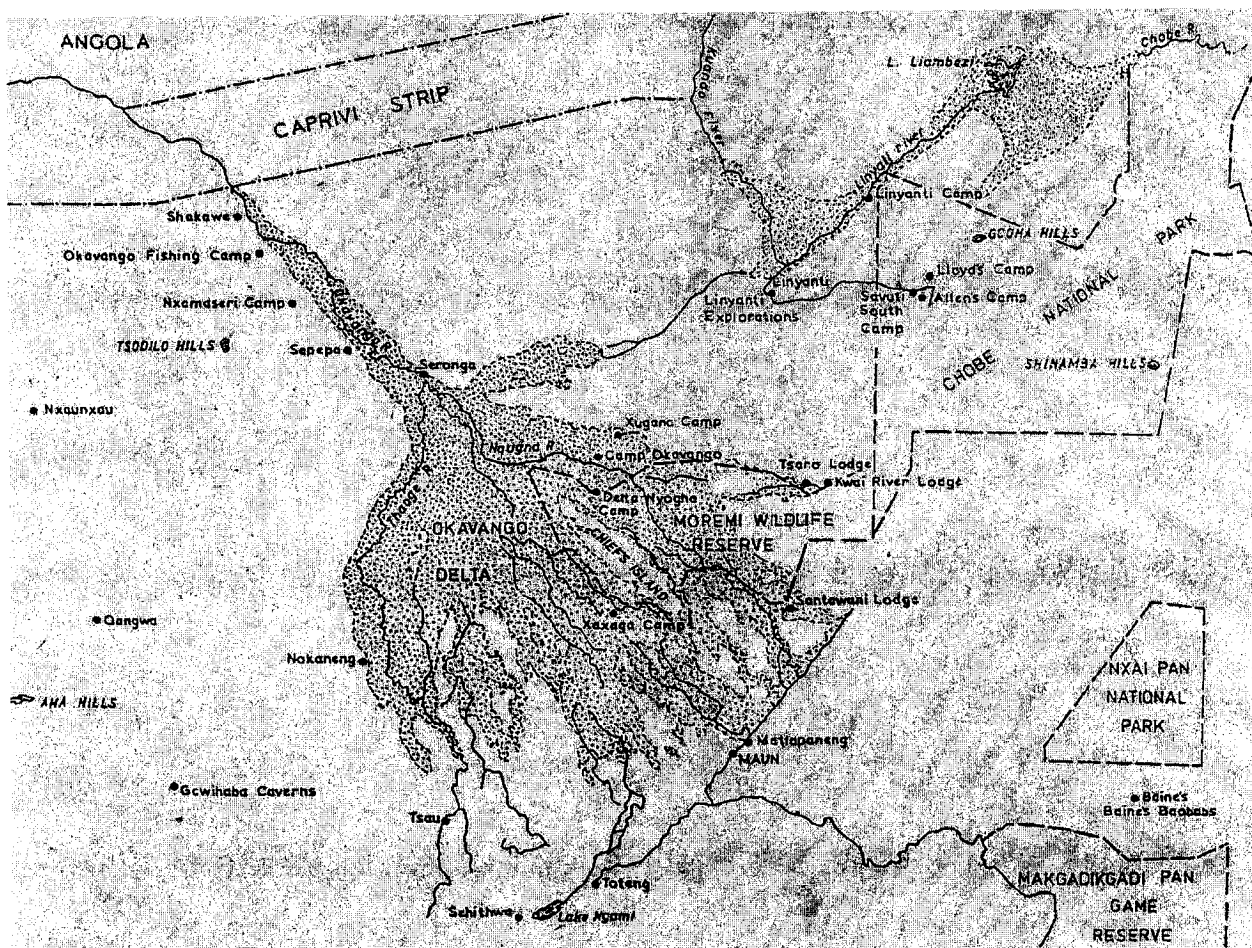
1. Study the maps provided in **Figures 1a and 1b**. Using the wetland ecological character as defined by the Ramsar Convention, compare and contrast the Zambezi delta (Fig. 1 a) along the Indian Ocean and the Okavango internal delta (Fig. 1b) in the arid region of Southern Africa.
  
2. Construct the general map of the wetlands of Zambia and discuss the emerging threats of each of the following wetlands:
  - (a) Mweru -wa- Ntipa marsh
  - (b) Zambezi Flood Plain
  - (c) Lukanga Swamp
  - (d) Kafue Flats
  - (e) Luangwa Flood Plain

**TURN OVER**



**FIGURE 1a: Zambezi Delta**

GO TO NEXT PAGE



**FIGURE 1b: Okavango Delta**

END OF EXAMINATION

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

2011 ACADEMIC YEAR SECOND SEMESTER  
FINAL EXAMINATIONS

BIO 5165: ECOLOGY AND MANAGEMENT OF TROPICAL WETLANDS  
PRACTICAL PAPER

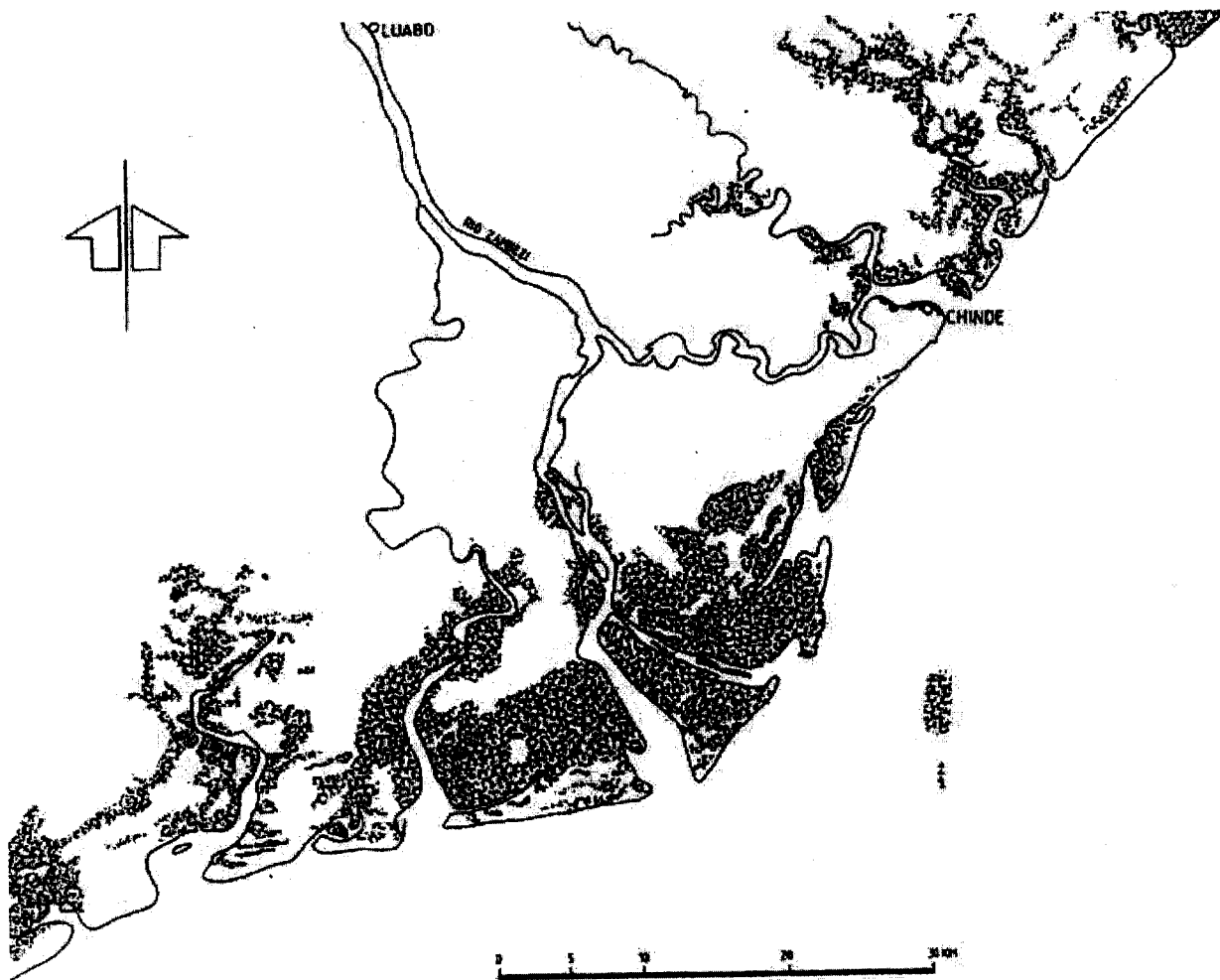
TIME: THREE HOURS

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

---

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TURN OVER



**FIGURE 1a: Zambezi Delta**

GO TO NEXT PAGE



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

2011 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS

BIO 5401: INSECT EVOLUTION AND SYSTEMATICS  
THEORY PAPER II

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS; TWO QUESTIONS FROM EACH  
SECTION AND THE FIFTH QUESTION FROM EITHER SECTION

---

SECTION A: Insect Classification

1. Discuss taxonomic features that separate and are useful in classifying apterygote and pterygote insects.
2. Compare and contrast insect groups classified as orthopteroid and hemipteroid orders with reference to the following:
  - (a) Wing development.
  - (b) Metamorphosis.
  - (c) Flexon.
  - (d) Mouthparts.
3. Give the start date of the International Code of Zoological Nomenclature (ICZN) and explain its significance to insect classification.
4. Describe the distinguishing features of insects classified as the Endopterygota and explain the significance of the pupal stage in their life cycles.

SECTION B: Modern Techniques in Insect Systematics

5. Describe the simple Transparent Specimen Grid and show how it can be constructed and used under a binocular microscope to produce accurate drawings of insect structure.
6. Distinguish between dendrogram/phenogram and cladogram techniques of constructing insect family trees and show which of the two gives natural groupings of insects and why.
7. Discuss different types of taxonomic keys available that are used to identify insect taxa and explain the requirements for their construction.
8. Explain how you would calibrate a dissecting and compound light microscope in order to determine the scale of specimens you are observing.

---

END OF EXAMINATION

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

2011 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS

BIO 5421: INTEGRATED PEST AND VECTOR MANAGEMENT  
THEORY PAPER 1

TIME: THREE HOURS

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

---

SECTION A: Arthropod Pest and Vector Biology

1. The Acarina constitute a major constraint to livestock and crop production. Discuss this statement and propose an integrated vector management programme for cattle and tick-borne diseases in Zambia.
2. Discuss the importance of pesticide selectivity and pesticide bioassay in integrated Pest management (IPM). Give an outline of how this information could be used to manage pesticide resistance in arthropods.
3. Discuss the biology and ecology of the Siphonaptera (fleas) in Zambia.
4. Summarise each of the following:
  - (a) Epidemiology of vector-borne diseases,
  - (b) Surveillance of arthropod diseases,
  - (c) Major Cotton pests.

SECTION B: Integrated Pest and Vector Management

5. Discuss the importance of the book, the *Silent Spring* (Carlson, 1962) and its impact on the development of Integrated Pest Management (IPM).
6. Discuss the view that "Integrated Pest and Vector Management (IPVM) is more of a concept than a reality".
7. Discuss the scientific basis for the introduction of genetically modified organisms (GMOs) and the controversy surrounding it with respect to IPVM.
8. Explain the steps you would take to control the Mediterranean fruit fly (*Ceratitidis capitata*) in Zambia.

---

END OF EXAMINATION

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

2011 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS

BIO 5421: INTEGRATED PEST AND VECTOR MANAGEMENT  
THEORY PAPER 1

TIME: THREE HOURS

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

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END OF EXAMINATION

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

2011 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS

BIO 5421: INTEGRATED PEST AND VECTOR MANAGEMENT  
THEORY PAPER 1

TIME: THREE HOURS

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

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END OF EXAMINATION

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

**2011 ACADEMIC YEAR FIRST SEMESTER**  
**FINAL EXAMINATIONS**

**BIO 5431: IMMATURE INSECTS**  
**THEORY PAPER II**

**TIME: THREE HOURS**

**INSTRUCTIONS: ANSWER FIVE QUESTIONS; TWO QUESTIONS FROM  
EACH SECTION AND THE FIFTH QUESTION FROM EITHER  
SECTION**

---

**SECTION A: The Apterygota, Palaeoptera and Neoptera - Exopterygota**

1. Describe all structures and habits of the immature forms of named Phthiraptera species and explain their economic importance.
2. Discuss the type of metamorphosis and nutrition exhibited by the immature Orthoptera, including their economic importance.
3. Compare and contrast naiads of the Odonata, Ephemeroptera and Plecoptera in terms of the following:
  - (a) Habitat
  - (b) Form and structure
  - (c) Nutrition.
4. Describe aquatic immature Hemiptera in terms of structure, ecology and food habits.

**SECTION B: The Neoptera - Exopterygota**

5. Discuss the larva and pupa types found in the Coleoptera and name two taxa in the Order having immatures that are hypermetamorphic.
6. Describe the feeding habits and economic importance of the immature forms of two named Nematocera.
7. Discuss metamorphosis in the immature stages of the Hymenoptera and name two taxa in the Order with immatures exhibiting Holopneustic and Hemipneustic types of respiratory systems, respectively.

**CONTINUES ON THE NEXT PAGE**

8. Compare and contrast larvae of Lepidoptera with those of the Hymenoptera in terms of structure and nutrition.

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END OF EXAMINATION

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

**2011 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS**

**BIO 5431: IMMATURE INSECTS  
THEORY PAPER II**

**TIME: THREE HOURS**

**INSTRUCTIONS: ANSWER FIVE QUESTIONS; TWO QUESTIONS FROM  
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END OF EXAMINATION

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

**2011 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS**

**BIO 5431: IMMATURE INSECTS  
THEORY PAPER II**

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END OF EXAMINATION

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

2011 ACADEMIC YEAR SECOND SEMESTER  
FINAL EXAMINATIONS

BIO 5452: INSECT-PLANT HOST AND INSECT-ANIMAL HOST RELATIONSHIP  
THEORY PAPER I

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS; **TWO** QUESTIONS FROM EACH SECTION AND THE **FIFTH** QUESTION FROM EITHER SECTION. USE ILLUSTRATIONS WHERE NECESSARY.

---

SECTION A: INSECT-HOST PLANT RELATIONSHIPS

1. Discuss the current understanding of the theory of mutualism.
2. Summarise each of the following:
  - (a) Plant phenology.
  - (b) Pollination.
  - (c) Herbivory.
  - (d) Ecological niche.
3. Giving examples, discuss what is meant by the 'arms race' between plants and insect herbivores.
4. Discuss the mechanisms involved in host-plant finding by insects.

SECTION B: PLANT RESISTANCE IN PEST MANAGEMENT

5. Plant resistance used as a single-pest management factor has achieved outstanding results in pest management. Giving examples, substantiate this statement.
6. Discuss the possible utilization of insect semiochemicals in a pest management programme.
7. Summarise each of the following:
  - (a) Allomones.
  - (b) Biotypes.
  - (c) Kairomones.
  - (d) Klinotaxis.
8. Discuss the advantages and disadvantages of using transgenic plants in pest management programmes.

---

END OF EXAMINATION

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

**2012 ACADEMIC YEAR SECOND SEMESTER  
FINAL EXAMINATIONS**

**BIO 5492: FOREST/WOODLAND PEST MANAGEMENT  
THEORY PAPER I**

**TIME: THREE HOURS**

**INSTRUCTIONS: ANSWER FIVE QUESTIONS; TWO QUESTIONS FROM EACH  
SECTION AND THE FIFTH QUESTION FROM EITHER SECTION. USE  
ILLUSTRATIONS WHERE NECESSARY.**

---

**SECTION A: FOREST PEST POPULATION DYNAMICS**

1. "Pine bark beetles, *Dendroctonus ponderosae* L. can only attack weakened pines when their populations are sparse, but large populations can overwhelm the resistance of relatively vigorous trees", discuss the validity of this statement.
2. Summarise **two** of the following:
  - (a) Classification of forest insect pest outbreaks.
  - (b) Major plantation tree insect pests found in Zambia.
  - (c) Foliage feeding insects.
3. Illustrate with examples, which tree parts act as sources of food for named phytophagous insects in a Miombo woodland.
4. Discuss three important authoritative theories that seek to explain forest insect outbreaks.

**SECTION B: FOREST INSECT PEST NATURAL ENEMIES, MONITORING AND  
FORECASTING PEST-OUTBREAKS**

5. Discuss the conditions under which prey populations are more likely to be regulated by predators in a forestry ecosystem.
6. Citing examples, discuss the means by which forest trees defend themselves against insect attacks.

**TURN OVER**

THE UNIVERSITY OF ZAMBIA  
SCHOOL OF NATURAL SCIENCES

2012 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS

BS 3421: MYCOLOGY  
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS. ILLUSTRATE YOUR ANSWERS  
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.**
-

**SECTION A****ANSWER ALL QUESTIONS****QUESTION A1**

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

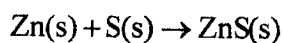
	<b>C</b>	<b>H</b>	<b>O</b>
Mole	$9.96 \times 10^{-24}$ mol	$16.6 \times 10^{-24}$ mol	$6.64 \times 10^{-24}$ mol
Ratio of moles			

- (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.



(4 marks)

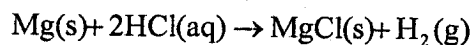
**QUESTION A3**

A 0.5813 g of an alkane,  $\text{C}_n\text{H}_{2n+2}$ , 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 atmosphere, according to the reaction below. What mass of Mg was used in this single displacement reaction?



(4 marks)

**QUESTION A5**

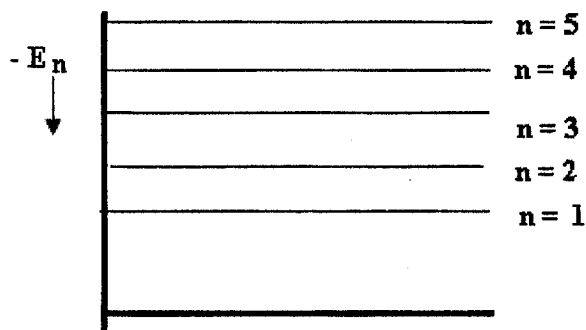
In the Balmer series of the hydrogen atom, the first emission line is observed at a wavelength of 656.3 nm.

- (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.



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

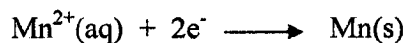
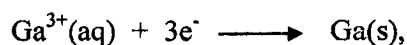
Consider the molecule carbon dioxide.

- (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:



- (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)

### 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)

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)

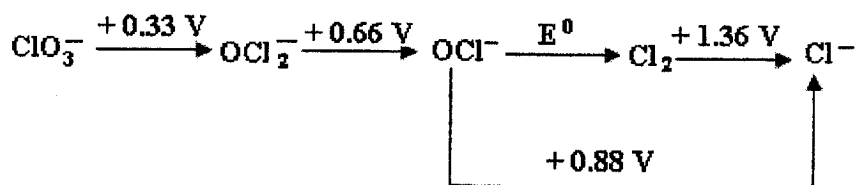
### QUESTION B3

The energy of a hydrogen like atom is given by  $E_n = -R_H \frac{Z^2}{n^2}$ , where  $R_H = -2.18 \times 10^{-18} \text{ J}$ . Consider the Periodic Table Group 1 multi-electron element sodium whose first ionization energy is  $8.24 \times 10^{-19} \text{ J}$ . 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



- (a) Calculate the missing electrode potential,  $E^0$ , in the diagram. (4 marks)
- (b) Predict whether following reaction is spontaneous. (3 marks)
- $$\text{Cl}_2 \longrightarrow \text{OCl}^- + \text{Cl}^-$$
- 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	O	F	Ne
EA (kJ mol <sup>-1</sup> )	+ 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.

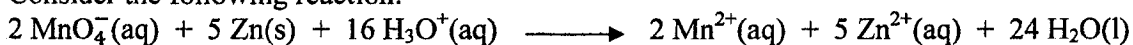
(e) Draw a labeled sketch diagram, on the Cartesian coordinate system, the shape of an orbital with following set of quantum numbers:  $n = 3, l = 1, m = 0$

(2 marks)

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### QUESTION B5

Consider the following reaction:



The reaction has  $E_{\text{cell}}^{\circ} = + 2.27 \text{ V}$  and its equilibrium constant  $K = 10^{383}$  at  $25^{\circ} \text{C}$ .

- (a) What is the oxidation number for Mn in  $\text{MnO}_4^-$ ? (3 marks)
- (b) How many electrons are transferred in this reaction? (3 marks)
- (c) Would you expect a large quantity of  $\text{MnO}_4^-$  ions at equilibrium at  $25^{\circ} \text{C}$ ? Explain your answer. (3 marks)
- (d) Calculate the voltage that the cell generates at  $35^{\circ} \text{C}$  when it operates under the following conditions:  $[\text{MnO}_4^-] = 0.50 \text{ M}$ ;  $[\text{H}_3\text{O}^+] = 1.00 \text{ M}$ ;  $[\text{Mn}^{2+}] = 0.25 \text{ M}$ ; and  $[\text{Zn}^{2+}] = 0.1 \text{ M}$  (6 marks)

(6 marks)

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END OF EXAM

### USEFUL DATA

Avogadro's constant,  $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

Molar volume of gas at STP =  $22.4 \text{ dm}^3 \text{ mol}^{-1}$

Planck's constant,  $h = 6.626 \times 10^{-34} \text{ J s}$

Rydberg constant,  $R_H = 1.097 \times 10^7 \text{ m}^{-1}$

Speed of light,  $c = 3.00 \times 10^8 \text{ m s}^{-1}$

Mass of an electron,  $m_e = 9.11 \times 10^{-31} \text{ kg}$

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

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

### Gas constant R

$8.3145 \text{ J mol}^{-1} \text{ K}^{-1}$

$0.083145 \text{ L bar mol}^{-1} \text{ K}^{-1}$

$0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$

$62.364 \text{ L torr mol}^{-1} \text{ K}^{-1}$

$62.364 \text{ L mmHg mol}^{-1} \text{ K}^{-1}$

### Pressure

1 atm =  $1.01325 \times 10^5 \text{ Pa}$

=  $1.01325 \times 10^5 \text{ N m}^{-2}$

= 760 torr

= 760 mmHg

= 1.01325 bar

1 bar =  $1.00000 \times 10^5 \text{ Pa}$

=  $1.00000 \times 10^5 \text{ N m}^{-2}$

$\text{Au}^{3+}(\text{aq}) + 3\text{e}^- \longrightarrow \text{Au}(\text{s})$	$E^\circ = +1.40 \text{ V}$
$\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \longrightarrow 2\text{H}_2\text{O}(\text{l});$	$E^\circ = +1.23 \text{ V}$
$\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^- \longrightarrow 4\text{OH}^-(\text{aq});$	$E^\circ = +0.40 \text{ V}$
$\text{Cr}^{3+}(\text{aq}) + 3\text{e}^- \longrightarrow \text{Cr}(\text{s});$	$E^\circ = -0.74 \text{ V}$
$2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \longrightarrow \text{H}_2(\text{g}) + 4\text{OH}^-(\text{aq});$	$E^\circ = -0.83 \text{ V}$
$\text{Au}^{3+}(\text{aq}) + 3\text{e}^- \longrightarrow \text{Au}(\text{s})$	$E^\circ = +1.40 \text{ V}$
$\text{Co}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Co}(\text{s});$	$E^\circ = -0.28 \text{ V}$
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Fe}(\text{s});$	$E^\circ = -0.44 \text{ V}$
$\text{Ga}^{3+}(\text{aq}) + 3\text{e}^- \longrightarrow \text{Ga}(\text{s})$	$E^\circ = -0.53 \text{ V}$
$2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \longrightarrow \text{H}_2(\text{g}) + 4\text{OH}^-(\text{aq});$	$E^\circ = -0.83 \text{ V}$
$\text{Mn}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Mn}(\text{s})$	$E^\circ = -1.18 \text{ V}$
$\text{Fe}^{3+}(\text{aq}) + 3\text{e}^- \longrightarrow \text{Fe}(\text{s});$	$E^\circ = -0.04 \text{ V}$
$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Zn}(\text{s})$	$E^\circ = -0.76 \text{ V}$
$\text{Cr}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Cr}(\text{s})$	$E^\circ = -0.91 \text{ V}$
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \longrightarrow \text{Fe}^{2+}(\text{aq})$	$E^\circ = +0.77 \text{ V}$
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \longrightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	$E^\circ = +1.33$
$\text{MnO}_4^-(\text{aq}) + 8\text{H}^+ + 5\text{e}^- \longrightarrow \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\text{l})$	$E^\circ = +1.52$

# PERIODIC TABLE OF THE ELEMENTS

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

1 H 1.01 Hydrogen	4 Be 9.01 Beryllium
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3 Li 6.94 Lithium	12 Mg 24.31 magnesium
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11 Na 23.00 Sodium	20 Ca 40.08 Calcium
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19 K 39.10 Potassium	21 Sc 44.96 Scandium
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37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium
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55 Cs 132.91 Cesium	56 Ba 137.33 Barium
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87 Fr (223.02) Francium	88 Ra 226.03 Radium
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Atomic number <b>X</b> Atomic mass Name of the element X
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22 Ti 47.88 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 71.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc 97.91 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 Tellurium	53 I 126.90 Iodine	54 Xe 131.29 Xenon
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
104 Uuq 261.11	105 Uup 262.11	106 Uuh 263.12	107 Uus 262.12	108 Uuo 265.00	109 Uue 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

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**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  $2.6 \times 10^{-13}$  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).

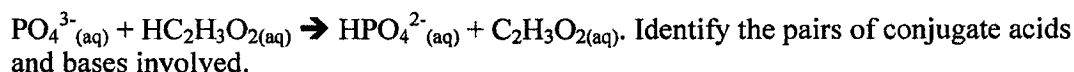
- (d). (i) Describe the ingredients you would use to prepare a buffer solution that can be used at values less than pH 7.  
(ii) Calculate the pH of a buffer solution prepared by adding 10.0 ml of 0.20 M acetic acid to 40.0 ml of 0.50 M sodium acetate.

### 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  $\text{Fe}^{2+}$ , 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  $\text{Fe}_2\text{O}_3$  correct to 3 significant figures?
- (d). If 5.82 g of  $\text{KHC}_2\text{O}_4 \cdot \text{H}_2\text{C}_2\text{O}_4$  (three ionisable protons) having 10% inert impurities, and 3.02 g of  $\text{KHC}_8\text{H}_4\text{O}_4$  (one ionisable proton) are dissolved in water and diluted to 500  $\text{cm}^3$ , 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:



- (b) Classify, with justification, the following reactions as either redox or not redox  
(i)  $2\text{Ag} + \text{Cl}_2 \rightarrow 2\text{AgCl}$   
(ii)  $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$   
(iii)  $\text{Ag}^+ + 2\text{NH}_3 \rightarrow \text{Ag}(\text{NH}_3)_2^+$
- (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)  $\text{Cr}_2\text{O}_7^{2-} + \text{BrO}_4^- + \text{H}_2\text{O} \rightarrow \text{Br}_2 + \text{Cr}^{3+} + \text{H}_2\text{O}$  given that  $E^0$  for  $\text{Cr}_2\text{O}_7^{2-}/\text{Cr}^{3+} = 1.33\text{V}$ ; and,  $E^0$  for  $\text{BrO}_4^-/\text{Br}_2 = 1.52\text{V}$ .  
(ii).  $\text{NO}_3^- + \text{Cu} \rightarrow \text{NO}_2 + \text{Cu}^{2+} + \text{H}_2\text{O}$

**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.

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**END OF EXAMINATION**

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## Universal Statistical Tables:

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

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

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

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

### 3. Values of F at the 95% Confidence Level

$v_1 =$	2	3	4	5	6	7	8	9	10	15	20	30
$v_2 =$	2	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.42	19.4	19.4	19.5
	3	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.70	8.62
	4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.86	5.75
	5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.62	4.50
	6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	3.94	3.81
	7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.51	3.38
	8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.22	3.08
	9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.01	2.86
	10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.85	2.70
	15	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.40	2.25
	20	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.20	2.04
	30	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.01	1.84

# The Periodic Table of Elements

1	2	3	4	5	6	7	0 (8)
<div>1.0 H hydrogen 1</div>							
<div>Key</div> <div>relative atomic mass atomic symbol name atomic (proton) number</div>							
(1)	(2)						
6.9 Li lithium 3	9.0 Be beryllium 4						
23.0 Na sodium 11	24.3 Mg magnesium 12						
39.1 K potassium 19	40.1 Ca calcium 20						
85.5 Rb rubidium 37	87.6 Sr strontium 38						
132.9 Cs caesium 55	137.3 Ba barium 56						
[223] Fr francium 87	[226] Ra radium 88						
		(3)	(4)	(5)	(6)	(7)	(8)
		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
		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
		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
		173.0 Lu lutetium 71	174.9 Yb ytterbium 70	175.0 Tm thulium 69	176.9 Er erbium 68	177.0 Ho holmium 67	178.4 Dy dysprosium 66
		178.4 Lu lutetium 71	179.0 Yb ytterbium 70	180.9 Tm thulium 69	181.9 Er erbium 68	183.8 Ho holmium 67	186.2 Dy dysprosium 66
		188.9 Lu lutetium 71	189.0 Yb ytterbium 70	190.9 Tm thulium 69	191.9 Er erbium 68	193.8 Ho holmium 67	196.9 Dy dysprosium 66
		197.0 Lu lutetium 71	197.1 Yb ytterbium 70	198.1 Tm thulium 69	199.1 Er erbium 68	200.9 Ho holmium 67	203.7 Dy dysprosium 66
		207.2 Lu lutetium 71	207.2 Yb ytterbium 70	208.9 Tm thulium 69	209.0 Er erbium 68	210.9 Ho holmium 67	214.9 Dy dysprosium 66
		223.0 Lu lutetium 71	223.0 Yb ytterbium 70	225.0 Tm thulium 69	227.0 Er erbium 68	229.0 Ho holmium 67	232.0 Dy dysprosium 66
		232.0 Lu lutetium 71	232.0 Yb ytterbium 70	233.0 Tm thulium 69	235.0 Er erbium 68	238.0 Ho holmium 67	244.0 Dy dysprosium 66
		238.0 Lu lutetium 71	238.0 Yb ytterbium 70	239.0 Tm thulium 69	241.0 Er erbium 68	244.0 Ho holmium 67	250.0 Dy dysprosium 66
		250.0 Lu lutetium 71	250.0 Yb ytterbium 70	252.0 Tm thulium 69	254.0 Er erbium 68	257.0 Ho holmium 67	262.0 Dy dysprosium 66
		262.0 Lu lutetium 71	262.0 Yb ytterbium 70	264.0 Tm thulium 69	266.0 Er erbium 68	269.0 Ho holmium 67	272.0 Dy dysprosium 66
		272.0 Lu lutetium 71	272.0 Yb ytterbium 70	274.0 Tm thulium 69	276.0 Er erbium 68	279.0 Ho holmium 67	284.0 Dy dysprosium 66
		287.0 Lu lutetium 71	287.0 Yb ytterbium 70	288.0 Tm thulium 69	290.0 Er erbium 68	293.0 Ho holmium 67	298.0 Dy dysprosium 66
		301.0 Lu lutetium 71	301.0 Yb ytterbium 70	303.0 Tm thulium 69	305.0 Er erbium 68	308.0 Ho holmium 67	312.0 Dy dysprosium 66
		312.0 Lu lutetium 71	312.0 Yb ytterbium 70	314.0 Tm thulium 69	316.0 Er erbium 68	319.0 Ho holmium 67	324.0 Dy dysprosium 66
		324.0 Lu lutetium 71	324.0 Yb ytterbium 70	326.0 Tm thulium 69	328.0 Er erbium 68	331.0 Ho holmium 67	336.0 Dy dysprosium 66
		336.0 Lu lutetium 71	336.0 Yb ytterbium 70	338.0 Tm thulium 69	340.0 Er erbium 68	343.0 Ho holmium 67	348.0 Dy dysprosium 66
		348.0 Lu lutetium 71	348.0 Yb ytterbium 70	350.0 Tm thulium 69	352.0 Er erbium 68	355.0 Ho holmium 67	360.0 Dy dysprosium 66
		360.0 Lu lutetium 71	360.0 Yb ytterbium 70	362.0 Tm thulium 69	364.0 Er erbium 68	367.0 Ho holmium 67	372.0 Dy dysprosium 66
		372.0 Lu lutetium 71	372.0 Yb ytterbium 70	374.0 Tm thulium 69	376.0 Er erbium 68	379.0 Ho holmium 67	384.0 Dy dysprosium 66
		384.0 Lu lutetium 71	384.0 Yb ytterbium 70	386.0 Tm thulium 69	388.0 Er erbium 68	391.0 Ho holmium 67	396.0 Dy dysprosium 66
		396.0 Lu lutetium 71	396.0 Yb ytterbium 70	398.0 Tm thulium 69	400.0 Er erbium 68	403.0 Ho holmium 67	408.0 Dy dysprosium 66
		408.0 Lu lutetium 71	408.0 Yb ytterbium 70	410.0 Tm thulium 69	412.0 Er erbium 68	415.0 Ho holmium 67	420.0 Dy dysprosium 66
		420.0 Lu lutetium 71	420.0 Yb ytterbium 70	422.0 Tm thulium 69	424.0 Er erbium 68	427.0 Ho holmium 67	432.0 Dy dysprosium 66
		432.0 Lu lutetium 71	432.0 Yb ytterbium 70	434.0 Tm thulium 69	436.0 Er erbium 68	439.0 Ho holmium 67	444.0 Dy dysprosium 66
		444.0 Lu lutetium 71	444.0 Yb ytterbium 70	446.0 Tm thulium 69	448.0 Er erbium 68	451.0 Ho holmium 67	456.0 Dy dysprosium 66
		456.0 Lu lutetium 71	456.0 Yb ytterbium 70	458.0 Tm thulium 69	460.0 Er erbium 68	463.0 Ho holmium 67	468.0 Dy dysprosium 66
		468.0 Lu lutetium 71	468.0 Yb ytterbium 70	470.0 Tm thulium 69	472.0 Er erbium 68	475.0 Ho holmium 67	480.0 Dy dysprosium 66
		480.0 Lu lutetium 71	480.0 Yb ytterbium 70	482.0 Tm thulium 69	484.0 Er erbium 68	487.0 Ho holmium 67	492.0 Dy dysprosium 66
		492.0 Lu lutetium 71	492.0 Yb ytterbium 70	494.0 Tm thulium 69	496.0 Er erbium 68	499.0 Ho holmium 67	504.0 Dy dysprosium 66
		504.0 Lu lutetium 71	504.0 Yb ytterbium 70	506.0 Tm thulium 69	508.0 Er erbium 68	511.0 Ho holmium 67	516.0 Dy dysprosium 66
		516.0 Lu lutetium 71	516.0 Yb ytterbium 70	518.0 Tm thulium 69	520.0 Er erbium 68	523.0 Ho holmium 67	528.0 Dy dysprosium 66
		528.0 Lu lutetium 71	528.0 Yb ytterbium 70	530.0 Tm thulium 69	532.0 Er erbium 68	535.0 Ho holmium 67	540.0 Dy dysprosium 66
		540.0 Lu lutetium 71	540.0 Yb ytterbium 70	542.0 Tm thulium 69	544.0 Er erbium 68	547.0 Ho holmium 67	552.0 Dy dysprosium 66
		552.0 Lu lutetium 71	552.0 Yb ytterbium 70	554.0 Tm thulium 69	556.0 Er erbium 68	559.0 Ho holmium 67	564.0 Dy dysprosium 66
		564.0 Lu lutetium 71	564.0 Yb ytterbium 70	566.0 Tm thulium 69	568.0 Er erbium 68	571.0 Ho holmium 67	576.0 Dy dysprosium 66
		576.0 Lu lutetium 71	576.0 Yb ytterbium 70	578.0 Tm thulium 69	580.0 Er erbium 68	583.0 Ho holmium 67	588.0 Dy dysprosium 66
		588.0 Lu lutetium 71	588.0 Yb ytterbium 70	590.0 Tm thulium 69	592.0 Er erbium 68	595.0 Ho holmium 67	600.0 Dy dysprosium 66
		600.0 Lu lutetium 71	600.0 Yb ytterbium 70	602.0 Tm thulium 69	604.0 Er erbium 68	607.0 Ho holmium 67	612.0 Dy dysprosium 66
		612.0 Lu lutetium 71	612.0 Yb ytterbium 70	614.0 Tm thulium 69	616.0 Er erbium 68	619.0 Ho holmium 67	624.0 Dy dysprosium 66
		624.0 Lu lutetium 71	624.0 Yb ytterbium 70	626.0 Tm thulium 69	628.0 Er erbium 68	631.0 Ho holmium 67	636.0 Dy dysprosium 66
		636.0 Lu lutetium 71	636.0 Yb ytterbium 70	638.0 Tm thulium 69	640.0 Er erbium 68	643.0 Ho holmium 67	648.0 Dy dysprosium 66
		648.0 Lu lutetium 71	648.0 Yb ytterbium 70	650.0 Tm thulium 69	652.0 Er erbium 68	655.0 Ho holmium 67	660.0 Dy dysprosium 66
		660.0 Lu lutetium 71	660.0 Yb ytterbium 70	662.0 Tm thulium 69	664.0 Er erbium 68	667.0 Ho holmium 67	672.0 Dy dysprosium 66
		672.0 Lu lutetium 71	672.0 Yb ytterbium 70	674.0 Tm thulium 69	676.0 Er erbium 68	679.0 Ho holmium 67	684.0 Dy dysprosium 66
		684.0 Lu lutetium 71	684.0 Yb ytterbium 70	686.0 Tm thulium 69	688.0 Er erbium 68	691.0 Ho holmium 67	696.0 Dy dysprosium 66
		696.0 Lu lutetium 71	696.0 Yb ytterbium 70	698.0 Tm thulium 69	700.0 Er erbium 68	703.0 Ho holmium 67	708.0 Dy dysprosium 66
		708.0 Lu lutetium 71	708.0 Yb ytterbium 70	710.0 Tm thulium 69	712.0 Er erbium 68	715.0 Ho holmium 67	720.0 Dy dysprosium 66
		720.0 Lu lutetium 71	720.0 Yb ytterbium 70	722.0 Tm thulium 69	724.0 Er erbium 68	727.0 Ho holmium 67	732.0 Dy dysprosium 66
		732.0 Lu lutetium 71	732.0 Yb ytterbium 70	734.0 Tm thulium 69	736.0 Er erbium 68	739.0 Ho holmium 67	744.0 Dy dysprosium 66
		744.0 Lu lutetium 71	744.0 Yb ytterbium 70	746.0 Tm thulium 69	748.0 Er erbium 68	751.0 Ho holmium 67	756.0 Dy dysprosium 66
		756.0 Lu lutetium 71	756.0 Yb ytterbium 70	758.0 Tm thulium 69	760.0 Er erbium 68	763.0 Ho holmium 67	768.0 Dy dysprosium 66
		768.0 Lu lutetium 71	768.0 Yb ytterbium 70	770.0 Tm thulium 69	772.0 Er erbium 68	775.0 Ho holmium 67	780.0 Dy dysprosium 66
		780.0 Lu lutetium 71	780.0 Yb ytterbium 70	782.0 Tm thulium 69	784.0 Er erbium 68	787.0 Ho holmium 67	792.0 Dy dysprosium 66
		792.0 Lu lutetium 71	792.0 Yb ytterbium 70	794.0 Tm thulium 69	796.0 Er erbium 68	799.0 Ho holmium 67	804.0 Dy dysprosium 66
		804.0 Lu lutetium 71	804.0 Yb ytterbium 70	806.0 Tm thulium 69	808.0 Er erbium 68	811.0 Ho holmium 67	816.0 Dy dysprosium 66
		816.0 Lu lutetium 71	816.0 Yb ytterbium 70	818.0 Tm thulium 69	820.0 Er erbium 68	823.0 Ho holmium 67	828.0 Dy dysprosium 66
		828.0 Lu lutetium 71	828.0 Yb ytterbium 70	830.0 Tm thulium 69	832.0 Er erbium 68	835.0 Ho holmium 67	840.0 Dy dysprosium 66
		840.0 Lu lutetium 71	840.0 Yb ytterbium 70	842.0 Tm thulium 69	844.0 Er erbium 68	847.0 Ho holmium 67	852.0 Dy dysprosium 66
		852.0 Lu lutetium 71	852.0 Yb ytterbium 70	854.0 Tm thulium 69	856.0 Er erbium 68	859.0 Ho holmium 67	864.0 Dy dysprosium 66
		864.0 Lu lutetium 71	864.0 Yb ytterbium 70	866.0 Tm thulium 69	868.0 Er erbium 68	871.0 Ho holmium 67	876.0 Dy dysprosium 66
		876.0 Lu lutetium 71	876.0 Yb ytterbium 70	878.0 Tm thulium 69	880.0 Er erbium 68	883.0 Ho holmium 67	888.0 Dy dysprosium 66
		888.0 Lu lutetium 71	888.0 Yb ytterbium 70	890.0 Tm thulium 69	892.0 Er erbium 68	895.0 Ho holmium 67	900.0 Dy dysprosium 66
		900.0 Lu lutetium 71	900.0 Yb ytterbium 70	902.0 Tm thulium 69	904.0 Er erbium 68	907.0 Ho holmium 67	912.0 Dy dysprosium 66
		912.0 Lu lutetium 71	912.0 Yb ytterbium 70	914.0 Tm thulium 69	916.0 Er erbium 68	919.0 Ho holmium 67	924.0 Dy dysprosium 66
		924.0 Lu lutetium 71	924.0 Yb ytterbium 70	926.0 Tm thulium 69	928.0 Er erbium 68	931.0 Ho holmium 67	936.0 Dy dysprosium 66
		936.0 Lu lutetium 71	936.0 Yb ytterbium 70	938.0 Tm thulium 69	940.0 Er erbium 68	943.0 Ho holmium 67	948.0 Dy dysprosium 66
		948.0 Lu lutetium 71	948.0 Yb ytterbium 70	950.0 Tm thulium 69	952.0 Er erbium 68	955.0 Ho holmium 67	960.0 Dy dysprosium 66
		960.0 Lu lutetium 71	960.0 Yb ytterbium 70	962.0 Tm thulium 69	964.0 Er erbium 68	967.0 Ho holmium 67	972.0 Dy dysprosium 66
		972.0 Lu lutetium 71	972.0 Yb ytterbium 70	974.0 Tm thulium 69	976.0 Er erbium 68	979.0 Ho holmium 67	984.0 Dy dysprosium 66
		984.0 Lu lutetium 71	984.0 Yb ytterbium 70	986.0 Tm thulium 69	988.0 Er erbium 68	991.0 Ho holmium 67	996.0 Dy dysprosium 66
		996.0 Lu lutetium 71	996.0 Yb ytterbium 70	998.0 Tm thulium 69	1000.0 Er erbium 68	1003.0 Ho holmium 67	1008.0 Dy dysprosium 66
		1008.0 Lu lutetium 71	1008.0 Yb ytterbium 70	1010.0 Tm thulium 69	1012.0 Er erbium 68	1015.0 Ho holmium 67	1020.0 Dy dysprosium 66
		1020.0 Lu lutetium 71	1020.0 Yb ytterbium 70	1022.0 Tm thulium 69	1024.0 Er erbium 68	1027.0 Ho holmium 67	1032.0 Dy dysprosium 66
		1032.0 Lu lutetium 71	1032.0 Yb ytterbium 70	1034.0 Tm thulium 69	1036.0 Er erbium 68	1039.0 Ho holmium 67	1044.0 Dy dysprosium 66
		1044.0 Lu lutetium 71	1044.0 Yb ytterbium 70	1046.0 Tm thulium 69	1048.0 Er erbium 68	1051.0 Ho holmium 67	1056.0 Dy dysprosium 66
		1056.0 Lu lutetium 71	1056.0 Yb ytterbium 70	1058.0 Tm thulium 69	1060.0 Er erbium 68	1063.0 Ho holmium 67	1068.0 Dy dysprosium 66
		1068.0 Lu lutetium 71	1068.0 Yb ytterbium 70	1070.0 Tm thulium 69	1072.0 Er erbium 68	1075.0 Ho holmium 67	1080.0 Dy dysprosium 66
		1080.0 Lu lutetium 71	1080.0 Yb ytterbium 70	1082.0 Tm thulium 69	1084.0 Er erbium 68	1087.0 Ho holmium 67	1092.0 Dy dysprosium 66
		1092.0 Lu lutetium 71	1092.0 Yb ytterbium 70	1094.0 Tm thulium 69	1096.0 Er erbium 68		

1.0  
H  
hydrogen  
1

Key

relative atomic mass  
atomic symbol  
name  
atomic (proton) number

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

\* Lanthanide series

\* Actinide series



**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  $\text{NH}_4\text{Cl}$  is added per litre of solution to a 0.01M aqueous ammonia solution, calculate the concentration of hydronium ion in the resulting solution given that for  $\text{NH}_3$ ,  $K_b = 1.8 \times 10^{-5}$ .  
(ii). A solution contains 75.0 ppm of dissolved  $\text{NaNO}_3$ . Calculate the concentration of nitrate ions in the solution, giving your answer in parts per billion.
- (c). (i). By using lead chloride,  $\text{PbCl}_2$ , 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 0.0001 M  $\text{AgNO}_3$  is added to 90 mL of 0.000045 M  $\text{NaCl}$  ( $K_{sp}$  for  $\text{AgCl} = 1.0 \times 10^{-10}$ ).

**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  $2.50 \times 10^{-4}$  M copper nitrate,  $\text{Cu}(\text{NO}_3)_2$ . 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  $\text{H}_2\text{S}$  are  $10^{-7}$  and  $10^{-15}$  respectively. Calculate the equilibrium constant ( $K_a$ ) for the reaction  $\text{H}_2\text{S} + 2\text{H}_2\text{O} \rightarrow 2\text{H}_3\text{O}^+ + \text{S}^{2-}$ , and the concentration of  $\text{S}^{2-}$  ions in a 0.1 M  $\text{H}_2\text{S}$  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,  $\text{HOC}(\text{CH}_2\text{COOH})_3$ , characterised by the following acid dissociation constants  $\text{pK}_{a1} = 3.1296$ ;  $\text{pK}_{a2} = 4.7570$  and  $\text{pK}_{a3} = 5.3990$ . Determine the equilibrium concentration of the ionic species  $\text{HOC}(\text{CH}_2\text{COOH})^{2-}$  in a 0.500 M solution of the acid.
- (b). (i). Given the ingredients ethanoic acid,  $\text{HOAc}$ ; ammonia,  $\text{NH}_3$ ; sodium chloride,  $\text{NaCl}$  and ammonium chloride,  $\text{NH}_4\text{Cl}$ , 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  $K_a = 1.75 \times 10^{-5}$ .
- (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,  $\text{NaOAc}$ ? For acetic acid,  $\text{HOAc}$ ,  $K_a = 1.75 \times 10^{-5}$ .

**Question 4 (Continued).**

- (c). Lead sulphate,  $\text{PbSO}_4$ , is a sparingly soluble salt with a solubility product of  $1.8 \times 10^{-8}$  in aqueous medium.
- Explain the difference between common salt,  $\text{NaCl}$ , and lead sulphate.
  - Calculate the solubility of lead sulphate in  $0.025\text{M Pb}(\text{NO}_3)_2$ .

**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**

0.271  
0.282  
0.279  
0.271  
0.275

**Method 2**

0.0271  
0.0268  
0.0263  
0.0274  
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  $0.05 \text{ mg AgNO}_3$  is added to  $2.0 \text{ L}$  of  $0.0001 \text{ M NaCl}$  ( $K_{\text{sp}}$  for  $\text{AgCl} = 1.0 \times 10^{-10}$ ).
- (c). Arsenic acid,  $\text{H}_3\text{AsO}_4$ , dissociates in water to yield several ionic and molecular species.
- Name any two ionic, and one molecular, dissociation products of the acid.
  - What is the equilibrium concentration of the hydrogen arsenate ion ( $\text{H}_2\text{AsO}_4^-$ ) at  $\text{pH } 3.0$  in a  $0.200 \text{ M}$  arsenic acid solution given that the dissociation constants for the successive ionisations are given as follows,  $K_{\text{a}1} = 5.65 \times 10^{-3}$ ;  $K_{\text{a}2} = 1.75 \times 10^{-7}$  and  $K_{\text{a}3} = 2.54 \times 10^{-12}$ .

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**END OF EXAMINATION**

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

**2012 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS**

**C245: INORGANIC CHEMISTRY 1**

**TIME: THREE HOURS**

**INSTRUCTIONS:**

**ALL QUESTIONS CARRY EQUAL MARKS**

**ANSWER ANY FOUR QUESTIONS**

**ANSWER EACH QUESTION ON A FRESH PAGE**

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**Some Universal Constants**

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Quantity	Symbol	Value and Units
Avogadro's number	$N_A, L$	$6.022 \times 10^{23} \text{ mol}^{-1}$
Electron mass	$m_e$	$9.109 \times 10^{-31} \text{ kg}$
Electron charge	$-e$	$1.602 \times 10^{-19} \text{ C}$
Bohr radius	$a_0$	$5.292 \times 10^{-11} \text{ m}$
Planck's constant	$h$	$6.626 \times 10^{-34} \text{ Js}$
Permittivity of free space	$\epsilon_0$	$8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$
Speed of light	$c$	$2.998 \times 10^8 \text{ ms}^{-1}$

### QUESTION 1

- (a) Which one of each of the following pairs of isostructural compounds is likely to undergo thermal decomposition at lower temperature? Give your reasoning.
- $\text{MgCO}_3$  and  $\text{CaCO}_3$
  - $\text{CsI}_3$  and  $\text{N}(\text{CH}_3)_4\text{I}_3$
- (b) Calculate the value of Madelung constant  $A$  for  $\text{MgO}$ , given  $r_0 = 2.10 \text{ \AA}$ ,  $n = 7$ ,  $N = 6.023 \times 10^{23}$ ,  $U_0 = -3940 \text{ KJ/mol}$ ,  $e = 4.8 \times 10^{-10} \text{ e.s.u}$
- (c) Borazine  $\xrightarrow{3\text{HCl}}$  ?  $\xrightarrow{-3\text{H}_2}$  ?
- $\downarrow$  electric discharge  
 ?

### QUESTION 2

- (a) Discuss the stability of  $\text{In}^+$  and  $\text{Tl}^+$  ions.
- (b) The triiodide ion  $\text{I}_3^-$  in which the Iodine atoms are arranged in a straight line is stable, but the corresponding  $\text{F}_3^-$  ion does not exist. Explain using its nature of bonding.
- (c) In certain polar solvents  $\text{PCl}_5$  undergoes an autoionisation reaction in which  $\text{Cl}^-$  ion leaves one  $\text{PCl}_5$  molecule and attaches itself to another.
- $$2\text{PCl}_5 \rightleftharpoons \text{PCl}_4^+ + \text{PCl}_6^-$$
- What are the changes in geometrical shapes and hybridisation that occur in its ionization.

### QUESTION 3

- (a) The 2nd ionization of carbon and 1<sup>st</sup> ionization of boron both fit the reaction  $1s^2 2s^2 2p^1 = 1s^2 2s^2 + 1e^-$ . Compare the two ionization energies (24.383 eV and 8.289 eV respectively) and the effective nuclear charges,  $Z_{\text{eff}}$ . Is this an adequate explanation of the difference in ionization energy? If not suggest other factors.
- (b) Covalent radius of Fluorine is  $0.72 \text{ \AA}$ . Calculate its Allred-Rochow's electronegativity.
- (c) Show that the spin only magnetic moment for a  $d^6$  ion is normally 4.90 or 0.0 B.M in an octahedral field but 4.90 or 2.83 B.M in tetrahedral field.

#### QUESTION 4

- (a) The aqueous ions  $\text{Zn}^{2+}$  and  $\text{Ag}^+$  form complexes with  $\text{NH}_3$  that have similar stabilities, yet zinc and silver are in different columns (groups) in the periodic table. Suggest a reason for this similar Chemistry.
- (b) The dipole moment of methylsilane,  $\text{CH}_3\text{SiH}_3$  is  $2.4 \times 10^{-30}$  C.m. The bond moments are H-C 0.4 D, Si-H 1D, Si-C 1.2 D. Which end of the molecule will show the negative end of dipole.
- (c) Explain why the substantial decrease in first ionization energy observed between Na and K, and Mg and Ca, not observed between Al and Ga.

#### QUESTION 5

- (a) Compute the de Broglie wavelength of the wave associated with an electron that has been accelerated through a potential difference of 60 volts.
- (b) The equation of the Photoelectric Effect (PE) can be written as:

$$eV_s = h\nu - \Phi$$

- (i) Define and explain the terms:  $V_s$ ,  $\nu$  and  $\Phi$
- (ii) If  $V_s$  is 50 volts, what is the maximum kinetic energy of the system?
- (iii) Determine the upper limit to the velocity of the electrons emitted.
- (c) Indicate the nature and characteristic of the constructive bonding between:
- (i) a p orbital and a  $d_{xy}$  orbital.
- (ii) an s orbital and a  $p_z$  orbital.

#### QUESTION 6

- (a) A wave function of  $2p_y$  orbital is:

$$\Psi = \frac{1}{4\sqrt{2\pi}} \left( \frac{Z}{a_0} \right)^{\frac{3}{2}} \left( \frac{Zr}{a_0} \right) \exp\left( -\frac{Zr}{2a_0} \right) \sin\theta \sin\phi$$

- (i) Predict the shape of the electron density charge cloud for this orbital
- (ii) Show the shape of the Radial distribution Function (RDF) for this orbital and state where the electron will mostly be found.
- (iii) How will your answer in (ii) compare with the RDF for a 3d orbital

- (b) Stating your assumptions, show how Neils Bohr was able to arrive at the expression for  $a_0$ . Compute its value.
- (C) Using a stationary orbiting electron, derive an expression for the Bohr angular momentum condition.

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**END OF EXAMINATION**

## The Periodic Table of Elements

1 2

3

4

5

6

7

0 (8)

(1) (2)

Key

1.0  
H  
hydrogen  
1relative atomic mass  
atomic symbol  
name  
atomic (proton) number

(13)

(14)

(15)

(16)

(17)

(18)

Key		relative atomic mass atomic symbol name atomic (proton) number		H hydrogen 1													
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
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						

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

\* Lanthanide series

\* Actinide series

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

**C442 .**  
**Advanced Inorganic Chemistry II**

Time: 3 Hours

May 2012

**Instructions:**

Answer **Question 1** and any other three(3) Questions.  
A Periodic Table is provided.

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**Question 1**

- (a) The spectrum of the  $\text{CoCl}_4^{2-}$  ion in aqueous solution shows UV/Vis bands at  $6\,100\text{ cm}^{-1}$  and  $17\,000\text{ cm}^{-1}$  with absorption coefficients of 100 and 820 respectively. Assign these bands to appropriate spin-allowed transitions. Where these all the bands expected? Explain your arguments.
- (b) When do doubly charged ion peaks arise? What the characteristics of such peaks in mass spectroscopy?

**Question 2**

- (a) Poly-pyrole is an organic polymer material which can be doped to give an extrinsic semi-conductor. What materials should the use to yield (i) *n*-type and (ii) *p*-type semi-conductor. Show and account for the variation of conductivity with temperature for the doped semi-conductors.
- (b) Comment on the magnitude of the Band gap (eV) in the following:-

Si(grey), VO(black) and MgO(white),

Hence, or otherwise, discuss the electro-conductivity of these species.

### Question 3

- (a) Give the guidelines for d-band formation essential for transition metal compound to show conductivity.
- (b) Compare on the nature of conductivity expected in the transition metal oxides: -
  - (i) TiO and CuO
  - (ii)  $\text{CrO}_3$  and  $\text{WO}_3$
  - (iii) Insertion compound  $\text{Li}_{0.3}\text{WO}_3$

### Question 4

- (a) At room temperature ZnO is white while when heated it turns yellow. Discuss the nature of conductivity observed in ZnO at room temperature and when it is heat to temperatures above 500°C. State the challenges arising from the material obtained upon heating.
- (b) Explain, and show a graphical variation, of the effect of increasing temperature on the resistivity for
- (i) a metal conductor
  - (ii) graphite
  - (iii)  $\text{YBa}_2\text{Cu}_2\text{O}_7$

### Question 5

- (a) Predict the mass spectrum of the following compounds
- (i)  $\text{BCl}_2\text{Br}$                       (ii)  $\text{CH}_2\text{Br}_2$

Given the following data:  $^{10}\text{B} = 20\%$ ,  $^{11}\text{B} = 80\%$ ,  $^{79}\text{B} = 50\%$ ,  
 $^{81}\text{B} = 50\%$ ,  $^{35}\text{Cl} = 75\%$ ,  $^{37}\text{Cl} = 25\%$

- (b) The mass spectrum of  $\text{EuL}_3$ , where  $\text{L} = \text{PhCOCHCOCF}_3^-$  anion, has the following peaks and percent abundances:

m/e	798	583	387	368	256.9	232.3	191	94.3
R.A(%)	100	60	60	75	0.4	0.3	42	0.5

Account and verify the existence of the peak at 387. ( $^{151}\text{Eu} = 48\%$ ,  $^{153}\text{Eu} = 52\%$ ).

**END OF EXAMINATION**

# PERIODIC TABLE OF THE ELEMENTS

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
<div>KEY</div> <div>Atomic number <b>X</b> Atomic mass Name of the element X</div>																	
1 <b>H</b> Hydrogen 1.01	4 <b>Be</b> Beryllium 9.01																
3 <b>Li</b> Lithium 6.94																	
11 <b>Na</b> Sodium 23.00	12 <b>Mg</b> magnesium 24.31																
19 <b>K</b> Potassium 39.10	20 <b>Ca</b> Calcium 40.08	21 <b>Sc</b> Scandium 44.96	22 <b>Ti</b> Titanium 47.88	23 <b>V</b> Vanadium 50.94	24 <b>Cr</b> Chromium 52.00	25 <b>Mn</b> Manganese 54.94	26 <b>Fe</b> Iron 55.85	27 <b>Co</b> Cobalt 58.93	28 <b>Ni</b> Nickel 58.69	29 <b>Cu</b> Copper 63.65	30 <b>Zn</b> Zinc 65.39	31 <b>Ga</b> Gallium 69.72	32 <b>Ge</b> Germanium 71.61	33 <b>As</b> Arsenic 74.92	34 <b>Se</b> Selenium 78.96	35 <b>Br</b> Bromine 79.90	36 <b>Kr</b> Krypton 83.80
37 <b>Rb</b> Rubidium 85.47	38 <b>Sr</b> Strontium 87.62	39 <b>Y</b> Yttrium 88.91	40 <b>Zr</b> Zirconium 91.22	41 <b>Nb</b> Niobium 92.91	42 <b>Mo</b> Molybdenum 95.94	43 <b>Tc</b> Technetium 97.91	44 <b>Ru</b> Ruthenium 101.07	45 <b>Rh</b> Rhodium 102.91	46 <b>Pd</b> Palladium 106.42	47 <b>Ag</b> Silver 107.87	48 <b>Cd</b> Cadmium 112.41	49 <b>In</b> Indium 114.82	50 <b>Sn</b> Tin 118.71	51 <b>Sb</b> Antimony 121.76	52 <b>Te</b> Tellurium 127.60	53 <b>I</b> Iodine 126.90	54 <b>Xe</b> Xenon 131.29
55 <b>Cs</b> Caesium 132.91	56 <b>Ba</b> Barium 137.33	57 - 71 Lanthanum 138.91	72 <b>Hf</b> Hafnium 178.49	73 <b>Ta</b> Tantalum 180.95	74 <b>W</b> Tungsten 183.84	75 <b>Re</b> Rhenium 186.21	76 <b>Os</b> Osmium 190.23	77 <b>Ir</b> Iridium 192.22	78 <b>Pt</b> Platinum 195.08	79 <b>Au</b> Gold 196.97	80 <b>Hg</b> Mercury 200.59	81 <b>Tl</b> Thallium 204.38	82 <b>Pb</b> Lead 207.2	83 <b>Bi</b> Bismuth 208.98	84 <b>Po</b> Polonium 209	85 <b>At</b> Astatine 209	86 <b>Rn</b> Radon 222.02
87 <b>Fr</b> Francium (223.02)	88 <b>Ra</b> Radium 226.03	89 - 103	104 <b>Unq</b> Ununquadium 261.11	105 <b>Unp</b> Unpentium 262.11	106 <b>Unh</b> Unhexium 263.12	107 <b>Uns</b> Unseptium 262.12	108 <b>Uno</b> Unoctium 265.00	109 <b>Une</b> Unenneium 265									
57 <b>La</b> Lanthanum 138.91	58 <b>Ce</b> Cerium 140.12	59 <b>Pr</b> Praseodymium 140.91	60 <b>Nd</b> Neodymium 144.24	61 <b>Pm</b> Promethium 144.91	62 <b>Sm</b> Samarium 150.36	63 <b>Eu</b> Europium 151.97	64 <b>Gd</b> Gadolinium 157.25	65 <b>Tb</b> Terbium 158.93	66 <b>Dy</b> Dysprosium 162.50	67 <b>Ho</b> Holmium 164.93	68 <b>Er</b> Erbium 167.26	69 <b>Tm</b> Thulium 168.93	70 <b>Yb</b> Ytterbium 173.04	71 <b>Lu</b> Lutetium 174.97			
89 <b>Ac</b> Actinium 227.03	90 <b>Th</b> Thorium 232.04	91 <b>Pa</b> Protactinium 231.04	92 <b>U</b> Uranium 238.03	93 <b>Np</b> Neptunium 237.05	94 <b>Pu</b> Plutonium 244.0	95 <b>Am</b> Americium 243.06	96 <b>Cm</b> Curium 247.07	97 <b>Bk</b> Berkelium 247.07	98 <b>Cf</b> Californium 251.08	99 <b>Es</b> Einsteinium 252.08	100 <b>Fm</b> Fermium 257.10	101 <b>Md</b> Mendelevium 260	102 <b>No</b> Nobelium 259.10	103 <b>Lr</b> Lawrencium 262.11			

Atomic number	X
Atomic mass	
Name of the element X	

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

**C442 .**  
**Advanced Inorganic Chemistry II**

Time: 3 Hours

May 2012

**Instructions:**

Answer **Question 1** and any other three(3) Questions.  
A Periodic Table is provided.

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**Question 1**

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- (b) When do doubly charged ion peaks arise? What the characteristics of such peaks in mass spectroscopy?

**Question 2**

- (a) Poly-pyrole is an organic polymer material which can be doped to give an extrinsic semi-conductor. What materials should the use to yield (i) *n*-type and (ii) *p*-type semi-conductor. Show and account for the variation of conductivity with temperature for the doped semi-conductors.
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  - (ii) CrO<sub>3</sub> and WO<sub>3</sub>
  - (iii) Insertion compound Li<sub>0.3</sub>WO<sub>3</sub>

### Question 4

- (a) At room temperature ZnO is white while when heated it turns yellow. Discuss the nature of conductivity observed in ZnO at room temperature and when it is heat to temperatures above 500°C. State the challenges arising from the material obtained upon heating.
- (b) Explain, and show a graphical variation, of the effect of increasing temperature on the resistivity for
- (i) a metal conductor
  - (ii) graphite
  - (iii) YBa<sub>2</sub>Cu<sub>2</sub>O<sub>7</sub>

### Question 5

- (a) Predict the mass spectrum of the following compounds



Given the following data: <sup>10</sup>B = 20%, <sup>11</sup>B = 80%, <sup>79</sup>B = 50%,  
<sup>81</sup>B = 50%, <sup>35</sup>Cl = 75%, <sup>37</sup>Cl = 25%

- (b) The mass spectrum of EuL<sub>3</sub>, where L = PhCOCHCOCF<sub>3</sub><sup>-</sup> anion, has the following peaks and percent abundances:

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(<sup>151</sup>Eu = 48%, <sup>153</sup>Eu = 52%).

END OF EXAMINATION

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

**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 SECTION B  
ANSWER EACH QUESTION ON A FRESH PAGE**

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**SECTION A**

**QUESTION 1**

- (a) The complex  $\text{Co}(\text{NH}_3)_2(\text{H}_2\text{O})_2\text{Cl}_2\text{Br}_2$  exists in two forms. One form yields two moles of AgBr when treated with  $\text{AgNO}_3$ , the other yields one mole of AgBr. Write the structures for these compounds.
- (b) Pick the complex with highest molar conductivity: (i)  $[\text{Cr}(\text{NH}_3)_6]\text{Cl}_3$  (ii)  $[\text{CrCl}(\text{NH}_3)_5]\text{Cl}_2$  (iii)  $[\text{CrCl}_3(\text{NH}_3)_3]$
- (c) Classify the ligands on the basis of charge: CO, CN, NO,  $\text{NO}_2$ , CNO, ONO, H, NCS, en

**QUESTION 2**

- (a) Explain the effect of (i) conjugation of chromophores (ii) auxochrome substituents in absorption maximum of a compound.
- (b) For  $\text{CS}_2$  all vibrations that are Raman active are infrared inactive and vice versa, whereas for nitrous oxide,  $\text{N}_2\text{O}$  the vibrations are simultaneously Raman active and IR active. What can one conclude about the structures of  $\text{N}_2\text{O}$  and  $\text{CS}_2$ .
- (c) There are 3 unpaired electrons in  $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$  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 ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ) is blue in color.
  - (ii) Cuprous compounds ( $\text{Cu}^+$ ) are colorless.
  - (iii) Anhydrous copper sulphate is white.
- (b) Why is crystal field theory not suitable for explaining bonding in  $[\text{Ni}(\text{CO})_4]$  complex?
- (c) A transition metal complex believed to have less than half filled d-orbital and has a high spin ground state ligand term of  $^5\text{E}_g$ . What is the ground state term for the free ion?

## **SECTION B**

### **QUESTION 4**

- (a) Write down classification of oxides of the group VI: basic, acidic and amphoteric oxides.
- (b) State the reactions between acidic oxides and alkalis and acidic oxides and water.
- (c) Write down reactions production of hydrogen from coal and natural gases.

### **QUESTION 5**

Describe the industrial methods production of following products, indicating reactions, temperatures and pressures of the processes:

- (a) Ammonia on a large scale.
- (b) Sulphuric acid from sulphur by contact process.
- (c) Dilute Nitric acid.

### **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:  $\text{XeOF}_4$ ,  $\text{XeO}_2\text{F}_2$  and  $\text{XeO}_3$ .

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END OF EXAMINATIONS

## 24

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

Actinide series

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

**2012 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS**

**C351: ORGANIC CHEMISTRY III**

**TIME: THREE HOURS**

**INSTRUCTIONS:**

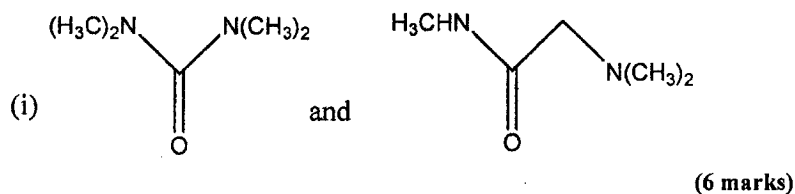
1. Answer any four questions
2. Each question carries 30 marks
3. Use a booklet for each question

### Question 1

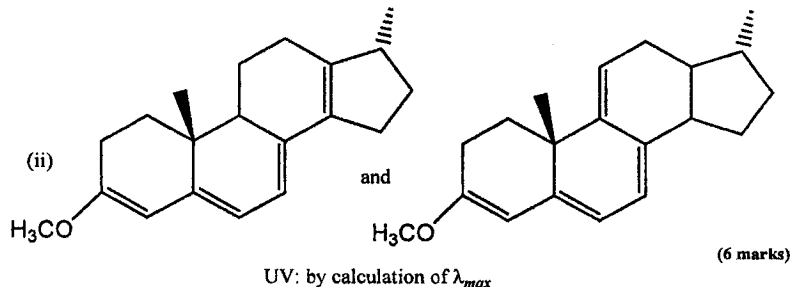
- (a) Peak area measurements (integration) are not usually obtained in routine  $^{13}\text{C}$ -NMR spectra. Briefly explain. (2 marks)
- (b) Write the structures of the three isomeric tribromobenzenes ( $\text{C}_6\text{H}_3\text{Br}_3$ ). Against each isomer indicate the number of proton decoupled  $^{13}\text{C}$ -NMR peaks. (8 marks)
- (c) Interpret the attached spectral data for the compound **X** and hence deduce its structure. Assign the  $^1\text{H}$ -NMR and  $^{13}\text{C}$ -NMR peaks to the structure as far as possible. (20 marks)

### Question 2

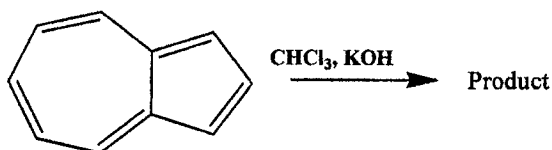
- (a) The isomeric sets of compounds given below may be differentiated using spectroscopy. Elaborate.



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



- (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)



**Question 3**

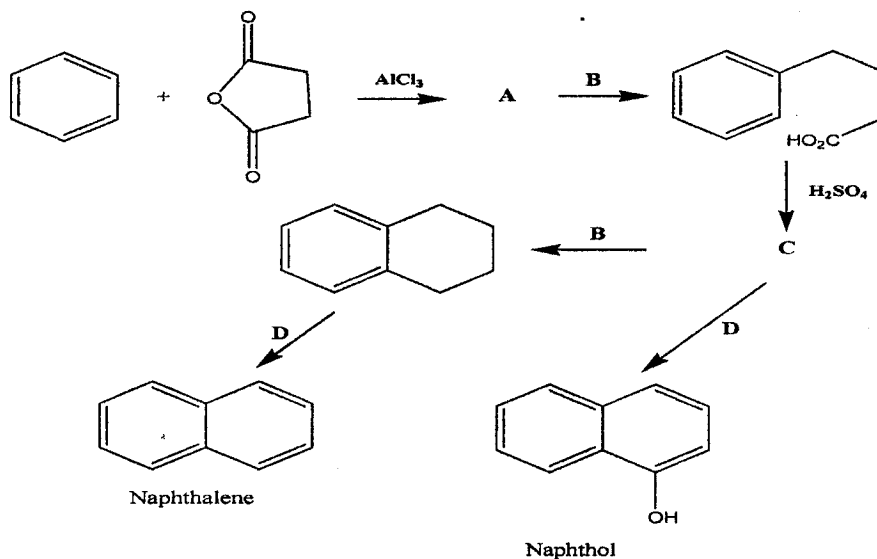
- (a) A compound **C**,  $C_4H_{10}O$ , gave  $^1H$ NMR spectrum consisting of two  $\delta$  values a triplet and quartet with relative area of 3:2. What is its structure and what are the  $\delta$ -values?  
(8 marks)
- (b) A compound **D**,  $C_2H_2BrCl$ , exhibits two doublets,  $J = 16$  Hz, in 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)

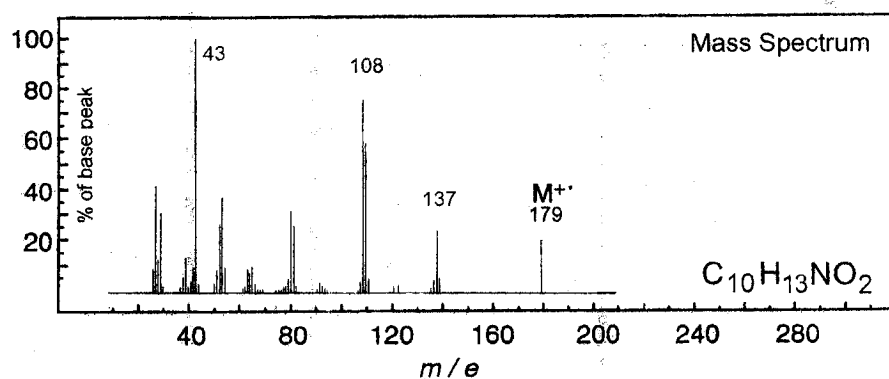
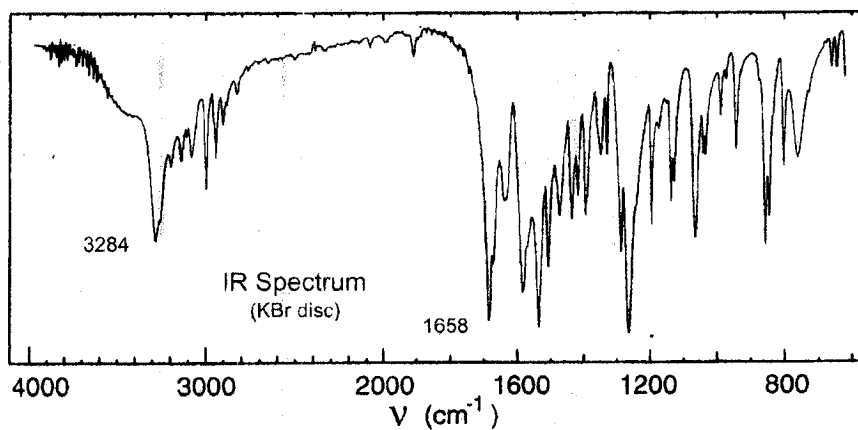


- (b) How would you prepare phenanthrene using naphthalene? (6 marks)
- (c) Provide a procedure for protecting each class of compounds given below. Write equations on how the group is introduced and how the group is removed.
- Primary alcohols. (2 marks)
  - Primary amines. (2 marks)
- (d) Identify the compound with molecular formula  $\text{C}_4\text{H}_8\text{O}_3$  with  $^1\text{H}$ -NMR data and IR given in the table below. Briefly interpret the data. (10 marks)

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

**END OF EXAMINATION**

# Problem x

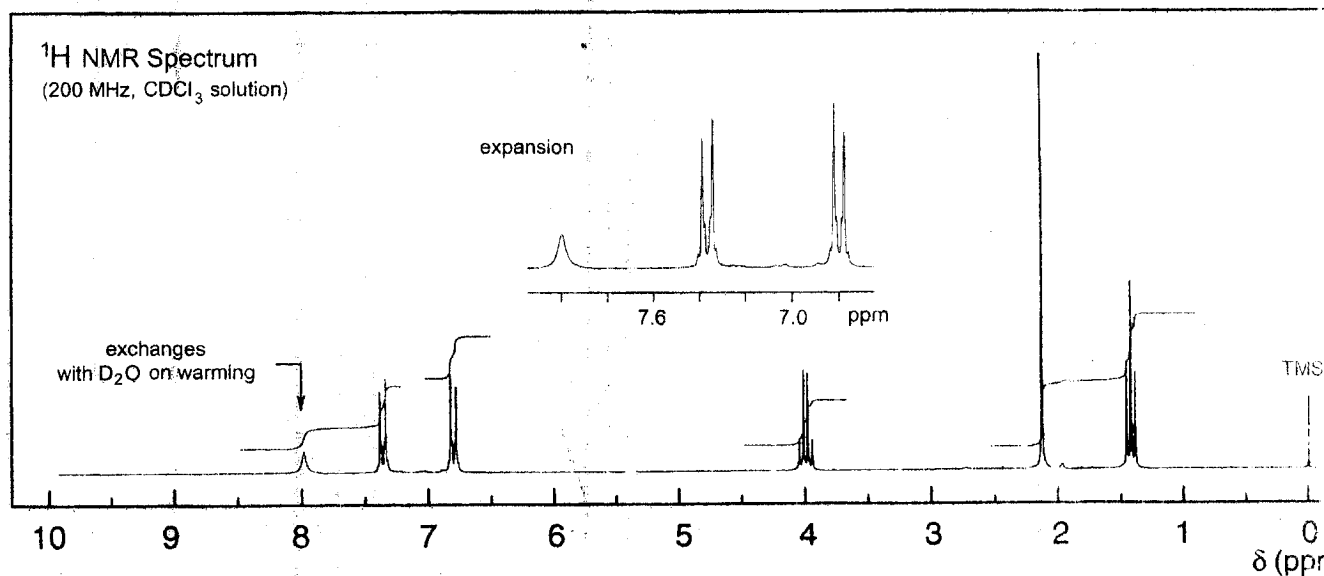
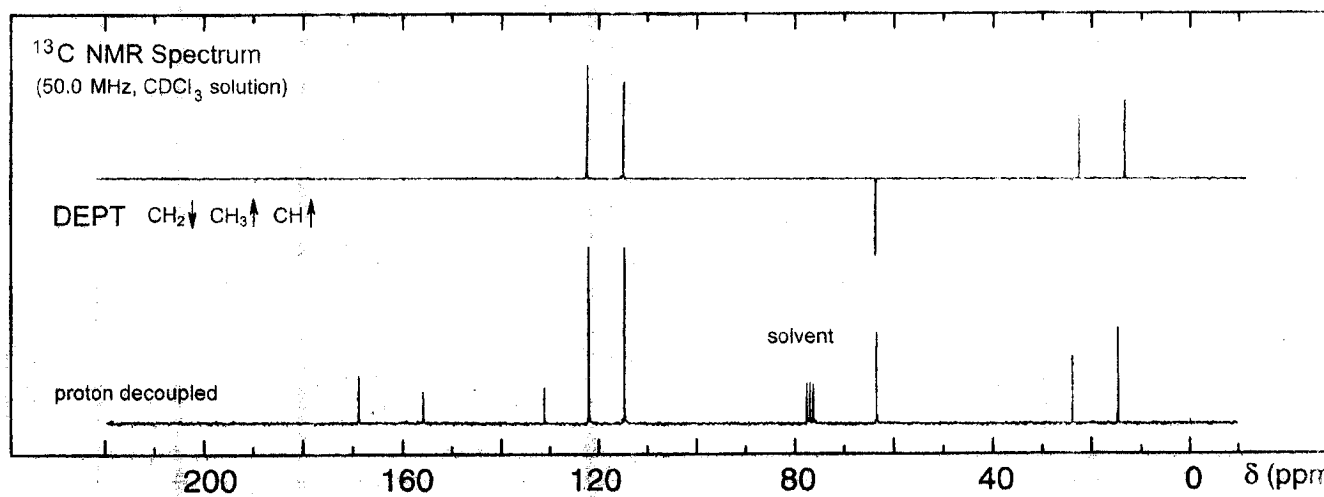


UV Spectrum

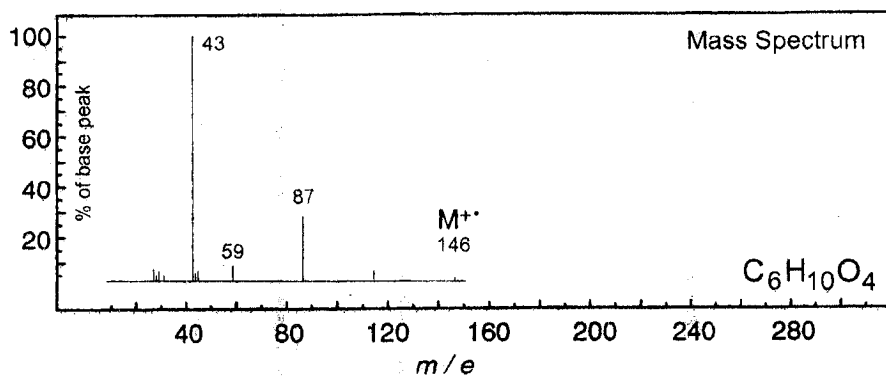
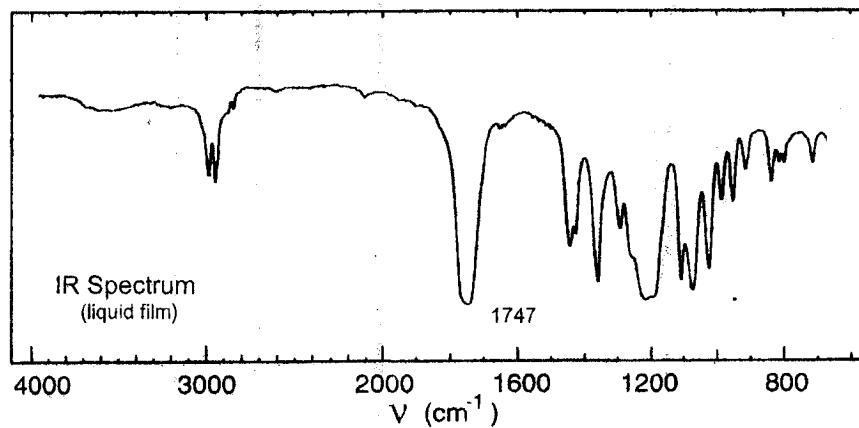
$\lambda_{\text{max}}$  250 nm ( $\log_{10} \epsilon$  3.1)

$\lambda_{\text{max}}$  287 nm ( $\log_{10} \epsilon$  2.2)

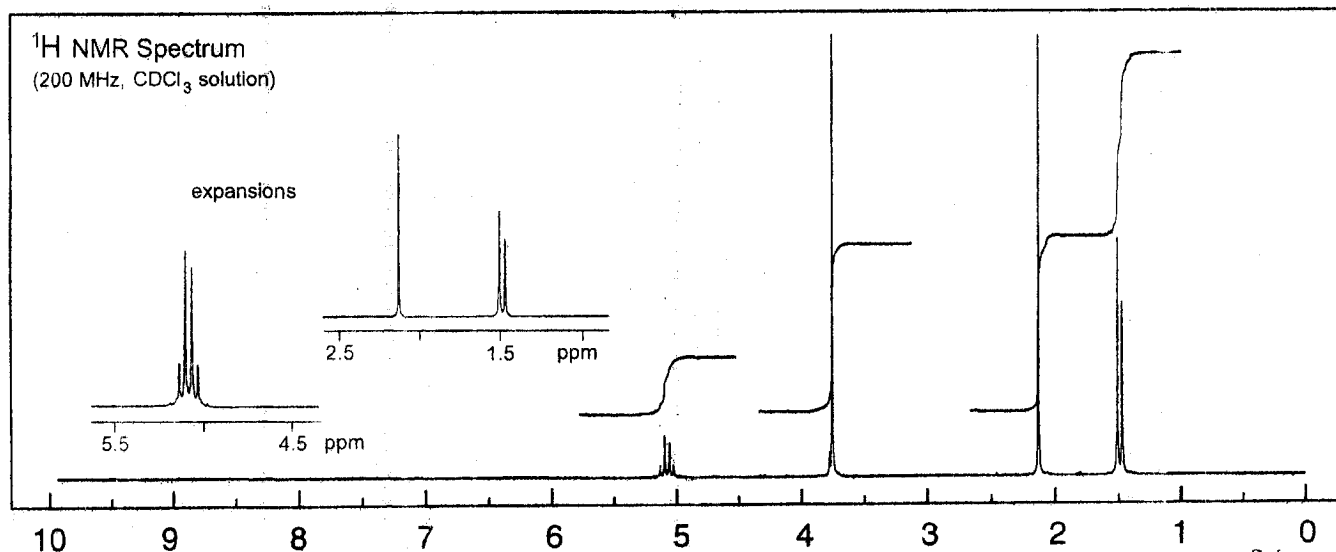
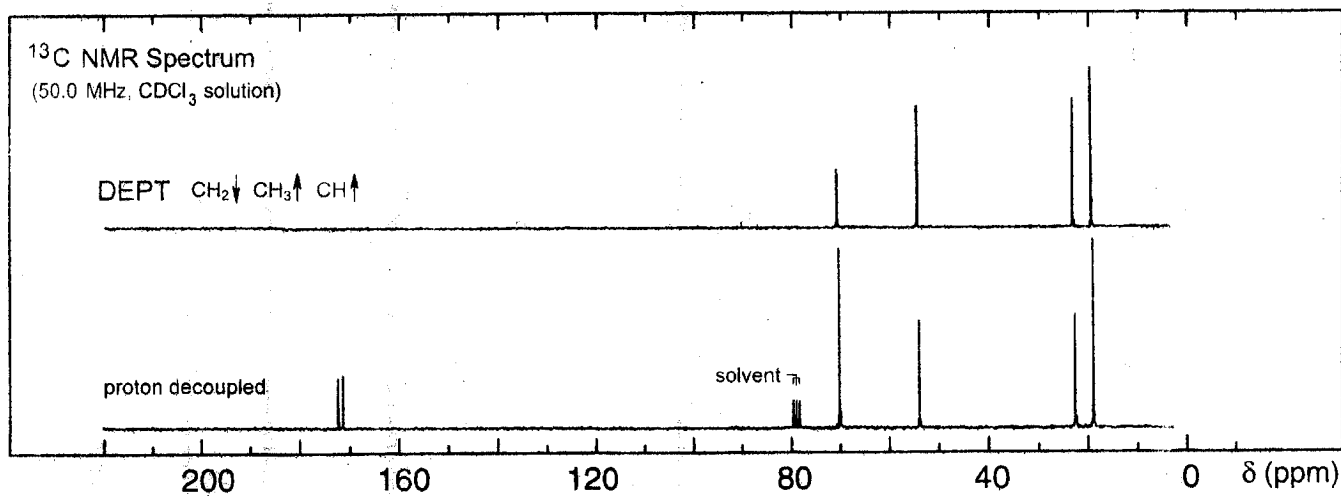
solvent: chloroform



# Problem 7



No significant UV  
absorption above 220 nm



**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.**

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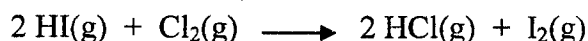
**DATA**

$R = 8.314 \text{ J.K}^{-1}.\text{mol}^{-1}$ ;  $h = 6.626 \times 10^{-34} \text{ J.s}$ ;  $k_B = 1.38 \times 10^{-23} \text{ J.K}^{-1}$ ;  $H = 1.01$ ;  $O = 16.00$   
 $h = 4.136 \times 10^{-21} \text{ MeV. s}$ ; Mass excess,  $\Delta$ , in MeV;  ${}^1_0n = 8.07143$ ;  ${}^{209}_{83}\text{Bi} = -18.268$ ;  
 ${}^{210}_{83}\text{Bi} = -14.8015$ ;  ${}^{210}_{84}\text{Po} = -15.9635$ ;  ${}^{235}_{92}\text{U} = 40.9164$ ;  ${}^{236}_{92}\text{U} = 42.4420$

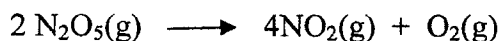
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Question 1

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



- (b) Consider the decomposition of dinitrogen pentoxide with initial concentration of 2.00M:



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

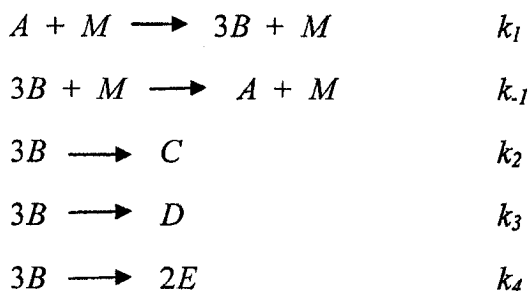
Consider the acid hydrolysis of n-valeronitrile to give n-valeric acid:



- (a) Write the rate equation in terms of the concentration of the reactant n-valeronitrile.
- (b) Write the pseudo-order rate equation if  $[\text{H}_2\text{O}] \gg [\text{n-C}_4\text{H}_9\text{CN}]$  and if  $\text{H}^+$  is regenerated.
- (c) Calculate the reaction rate constant  $k$  if the pseudo-rate constant  $k' = 1.00 \times 10^{-5} \text{ s}^{-1}$ ,  $[\text{H}^+] = 0.10 \text{ M}$  and the volume of water is  $1.00 \text{ dm}^3$ . 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) 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

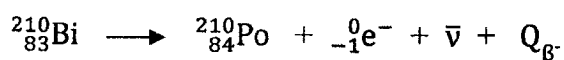
The following values of  $V_{\max}$  and  $K_m$  have been obtained at various temperatures for the hydrolysis of acetylcholine bromide, catalyzed by acetylcholinesterase.

t °C	$V_{\max}$ mol.dm <sup>-3</sup> .s <sup>-1</sup>	$K_m$ mol.dm <sup>-3</sup>
20	$1.84 \times 10^6$	$4.03 \times 10^{-4}$
25	$1.93 \times 10^6$	$3.75 \times 10^{-4}$
30	$2.04 \times 10^6$	$3.35 \times 10^{-4}$
35	$2.17 \times 10^6$	$3.05 \times 10^{-4}$

Assuming the enzyme concentration to be  $1.00 \times 10^{-11}$  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,
- Explain why  $^{209}_{83}\text{Bi}$  (100 %) is a magic number nuclide.
  - What is the ground state spin and parity of  $^{209}_{83}\text{Bi}$  ?
- (b) (i) Write the radiative capture reaction of  $^{209}_{83}\text{Bi}$ .
- (ii) Calculate the Q-value of the reaction in b(i) above.
- (c)  $^{210}_{83}\text{Bi}$  ( $t_{1/2} = 5.01\text{d}$ ) decays by  $\beta^-$  to  $^{210}_{84}\text{Po}$  according to the reaction:



The allowed  $\beta^-$  spectrum is given by the equation

$$N_{p_e} dp_e = \frac{G^2 |M_{if}|^2 F(Z, E_0) (E_{\beta^- \max} - E_{e^-})^2 p_e^2 dp_e}{2\pi^3 \hbar^7 c^3}$$

- Sketch the shape of  $\beta^-$  decay spectrum.
- Identify a term in the above equation that makes  $\beta^-$  spectrum approach zero at

$E_{\beta^- \max}$  .

*Question 5(c) (iii) is on the next page*

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

Question 6

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



The critical energy of  $^{236}_{92}\text{U}$  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  $^{236}_{92}\text{U}$  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  $^{235}_{92}\text{U}$  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.

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END OF C 361 EXAMINATION

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State	$l$	Number of nucleon $2j+1$	Cumulative nucleons	Magic number
<b>1j<sub>15/2</sub></b>	7	<b>16</b>	184	184
<b>3d<sub>3/2</sub></b>	2	<b>4</b>	168	
<b>4s<sub>1/2</sub></b>	0	<b>2</b>	164	
<b>2g<sub>7/2</sub></b>	4	<b>8</b>	162	
<b>1i<sub>11/2</sub></b>	6	<b>12</b>	154	
<b>3d<sub>5/2</sub></b>	2	<b>6</b>	142	
<b>2g<sub>9/2</sub></b>	4	<b>10</b>	136	
<b>1i<sub>13/2</sub></b>	6	<b>14</b>	126	126
<b>3p<sub>1/2</sub></b>	1	<b>2</b>	112	
<b>3p<sub>3/2</sub></b>	1	<b>4</b>	110	
<b>2f<sub>5/2</sub></b>	5	<b>6</b>	106	
<b>2f<sub>7/2</sub></b>	3	<b>8</b>	100	
<b>1h<sub>9/2</sub></b>	5	<b>10</b>	92	
<b>1h<sub>11/2</sub></b>	5	<b>12</b>	82	82
<b>3s<sub>1/2</sub></b>	0	<b>2</b>	70	
<b>2d<sub>3/2</sub></b>	2	<b>4</b>	68	
<b>2d<sub>5/2</sub></b>	2	<b>6</b>	64	
<b>1g<sub>7/2</sub></b>	4	<b>8</b>	58	
<b>1g<sub>9/2</sub></b>	4	<b>10</b>	50	50
<b>2p<sub>1/2</sub></b>	1	<b>2</b>	40	
<b>1f<sub>5/2</sub></b>	3	<b>6</b>	38	
<b>2p<sub>3/2</sub></b>	1	<b>4</b>	32	
<b>1f<sub>7/2</sub></b>	3	<b>8</b>	28	28
<b>1d<sub>3/2</sub></b>	2	<b>4</b>	20	20
<b>2s<sub>1/2</sub></b>	0	<b>2</b>	16	
<b>1d<sub>5/2</sub></b>	2	<b>6</b>	14	
<b>1p<sub>1/2</sub></b>	1	<b>2</b>	8	8
<b>1p<sub>3/2</sub></b>	1	<b>4</b>	6	
<b>1s<sub>1/2</sub></b>	0	<b>2</b>	2	2

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



**THE UNIVERSITY OF ZAMBIA**  
**UNIVERSITY EXAMINATIONS**  
**ADVANCED INORGANIC CHEMISTRY I, 2013**

**C441**

**Instructions**

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

Time: 3 hours

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**Question 1**

- (a) The infrared spectrum of  $[\text{ICl}_3]^-$  has the following peaks:-

<i>Frequency/cm<sup>-1</sup></i>	<i>Intensity</i>
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  $\nu_1$  in the Raman spectrum of this compound.
  - (iii) Account for the presence of the remaining peaks.
- (b) By constructing an MO diagram for  $\text{SiH}_2$ , 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

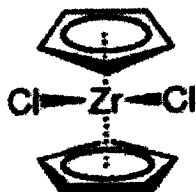
$\Psi_n = c_1\Phi_1 + c_2\Phi_2 + c_3\Phi_3$ , is

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

- (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  $\Psi_1$  and  $\Psi_2$ ?
- (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  $\Psi_3$ .

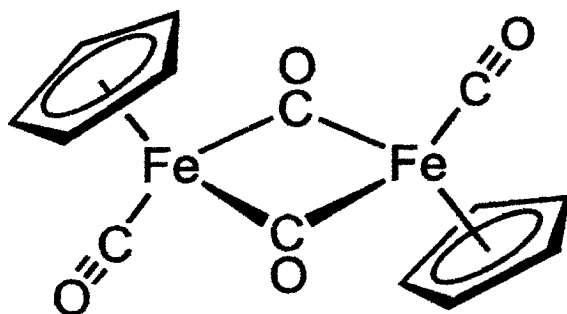
## Question 3

- (a) The character tables for the 'Cubic Group' chemicals indicate that the Milliken symbols belong to E in point group T,  $E_g$  in point group Td,  $E_g$  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:-



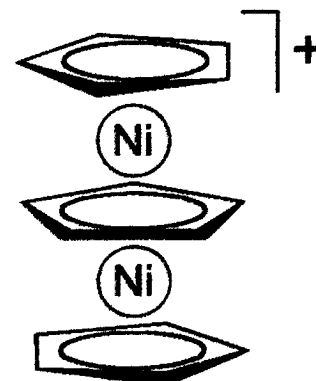
- (ii) Show that these symmetry operations constitute a mathematical group. Show the group properties.

(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  $\text{GaClBr}_3$  ( Given that

$^{69}\text{Ga} = 60\%$ ,  $^{71}\text{Ga} = 40\%$   
 $^{35}\text{Cl} = 75\%$ ,  $^{37}\text{Cl} = 25\%$ ,  
 $^{79}\text{Br} = 50\%$   $^{81}\text{Br} = 50\%$ )

- (c) A Raman spectrum of  $\text{Fe}(\text{CO})_5$  has peaks at 1885, 2000, 2010, 2040  $\text{cm}^{-1}$ .

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)  $\text{OH}^-$  migration
- (ii) Doubly-charged peaks
- (iii) Aryl group migration

(b) An  $AB_5$  molecule is pyramidal in shape and has reducible representations as **5 1 1 3 1**. Determine the  $\sigma$ -hybridization scheme of this molecule.

(c) The irreducible representations for  $\pi$ -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  $\pi$ -hybridization scheme likely to be displayed by the molecule.

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# PERIODIC TABLE OF THE ELEMENTS

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**THE UNIVERSITY OF ZAMBIA**  
**SCHOOL OF NATURAL SCIENCES**  
**2011 ACADEMIC YEAR FIRST SEMESTER**  
**UNIVERSITY SESSIONAL FINAL EXAMINATIONS**

**8 DECEMBER 2011**

**C 461; QUANTUM CHEMISTRY AND MOLECULAR SPECTROSCOPY**

**TIME: THREE HOURS**

**INSTRUCTIONS: ANSWER QUESTION 1 WHICH CARRIES 40 MARKS.**  
**ANSWER ANY FOUR OTHER QUESTIONS**

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**DATA**

$$\begin{aligned} h &= 6.63 \times 10^{-34} \text{ J s}; c = 3.00 \times 10^8 \text{ m s}^{-1}; {}^{14}\text{N} = 14.01 \text{ amu}; {}^1\text{H} = 1.01 \text{ amu}; \\ {}^2\text{H}(\text{deuterium}) &= 2.01; {}^{12}\text{C} = 12.01 \text{ amu}; {}^{16}\text{O} = 16.00 \text{ amu}; 1 \text{ amu} = 1.661 \times 10^{-27} \text{ kg}; \\ N_A &= 6.02 \times 10^{23} \text{ mol}^{-1}; 1 \text{ J} = 1 \text{ kg m}^2 \text{ s}^{-2} \end{aligned}$$

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**QUESTION 1**

- (a) Calculate the number of degrees of freedom,  $F$ , for the following molecules
- (i)  $\text{CO}_2$
  - (ii)  $\text{SO}_2$
- (b) Give the lowest energy for (i) a particle in a one dimensional box; and (ii) a linear harmonic oscillator in one dimension.
- (c) The operator for the kinetic energy of rotation in a plane of a diatomic molecule about the  $z$ -axis is given by

$$L_z^2 = -\frac{h^2}{8\pi^2 I} \frac{d^2}{d\phi^2}$$

- (i) Show that  $\Phi(\phi) = \cos\phi$  is an eigenfunction of the operator  $L_z^2$ .
  - (ii) What is the eigenvalue?
- (d) The frequency of the N—H stretching vibration in the infrared spectra of primary amines occurs at  $3400 \text{ cm}^{-1}$ . Calculate the frequency of the stretching vibration of the N—D bond in deuterated primary amines. Assume that the bond force constant is the same.

## QUESTION 2

The classical Hamiltonian for a linear harmonic oscillator in one dimension is given by:

$$H = \frac{1}{2m} p^2 + \frac{1}{2} k x^2$$

where  $p$  and  $k$  are the linear momentum and force constant respectively.

- (a) Write the quantum mechanical operator for the linear harmonic oscillator.
- (b) Write, but do not solve, the time independent Schrodinger equation for the linear harmonic oscillator.
- (c) Write an equation for the energy of the linear harmonic oscillator.
- (d) The ground state wavefunction of a linear harmonic oscillator is

$$\psi_0(x) = \left[ \frac{\alpha}{\pi} \right]^{1/4} e^{-\alpha x^2 / 2}$$

Calculate the average value of the linear momentum,  $p$ , of the harmonic oscillator.

The following integrals may be useful:

$$\int e^{-ax^2} dx = \left[ \frac{\pi}{a} \right]^{1/2}; \quad \int_0^\infty x e^{-ax^2/2} dx = \frac{1}{2a}; \quad \int_0^\infty x^2 e^{-ax^2/2} dx = \frac{1}{4} \left[ \frac{\pi}{a^3} \right]^{1/2}$$

## QUESTION 3

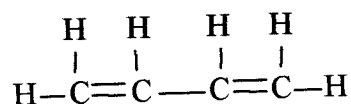
Carbon monoxide  $^{12}\text{C}^{16}\text{O}$  has been studied extensively as a rigid rotator.

- (a) Write the rotational energy of the CO molecule.
- (b) Derive an expression for the frequency when carbon monoxide undergoes a rotational transition from  $J = 0 \rightarrow J = 1$ .
- (c) In the microwave spectrum of CO, the  $J = 0 \rightarrow J = 1$  rotational transition occurs at a frequency of 115,271.204 MHz. Calculate
  - (i) The value of the moment of inertia of carbon monoxide; and
  - (ii) the internuclear separation,  $r_e$ , (the bond distance) in the CO molecule.

#### QUESTION 4

A useful first approximation to the optical properties of polyenes (linear conjugated molecules) is the free electron molecular orbital model. In this model  $\pi$  electrons are considered as electrons in a one dimensional box with infinitely high walls.

Consider 1,3-butadiene:



with four  $\pi$  electrons that will fill the  $n = 1$  and  $n = 2$  energy levels of the “box” in accordance with the Pauli principle. Each double bond is 0.134 nm long while the single bond is 0.148 nm long. The first transition from  $n = 1 \rightarrow n = 2$  is observed at a wavelength,  $\lambda = 210$  nm.

- Write the allowed energy of the system.
- Derive an expression for the wavelength of the transition that gives rise to the observed wavelength.
- What is the length of the box that corresponds to this wavelength?
- How does this compare to the actual length of 1,3-butadiene?

#### QUESTION 5

- In the Rutherford model of the atom, the energy of the electron in an atom was calculated to be

$$E = -\frac{1}{2} \frac{ze^2}{4\pi\epsilon_0 r}$$

Give a brief explanation why this result is inconsistent with theories of classical electrodynamics.

- The principal result of the Bohr theory of the hydrogen atom is that the energy of the electron in the atom is

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

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

- In spite of its success, the Bohr theory of the hydrogen atom had its failures or shortcomings. What were the major failures of the theory?

### QUESTION 6

Consider a particle in a one dimensional box of length  $a$ . Suppose that the wavefunction for the particle is

$$\Phi(x) = N \sin^2\left(\frac{\pi}{a}\right)x$$

- (a). Calculate  $N$ .
- (b) In accordance with Postulate IV of quantum mechanics, the average or expectation value of the energy of this system is given by

$$\langle E \rangle = \frac{\int \Phi H \Phi dx}{\int \Phi \Phi dx} = \frac{h^2}{12ma^2}$$

Without doing the actual integration, is the answer correct? Indicate or show your reasoning.

*The following integrals may be useful in your reasoning:*

$$\int_0^a \sin^2\left(\frac{\pi}{a}\right)x dx = \frac{a}{2}; \quad \int_0^a \sin^4\left(\frac{\pi}{a}\right)x dx = \frac{3a}{8}$$

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**END OF C 461 EXAMINATION**

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**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**

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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  $\text{H}_3\text{PO}_4$  and  $\text{H}_2\text{SO}_4$  in the Orthophosphoric 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.

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END OF EXAMINATION

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**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

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**Question 1**

- (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]

**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 -

**THE UNIVERSITY OF ZAMBIA**  
**SCHOOL OF NATURAL SCIENCES**  
**2011 UNIVERSITY SESSIONAL EXAMINATIONS SEMESTER II**  
**C 462: STATISTICAL MECHANICS AND THERMODYNAMICS**

**JUNE 2012**

**ANSWER ANY FIVE OF SIX QUESTIONS**

**TIME: THREE HOURS**

**DATA: DATA YOU MAY WISH TO USE IS ON THE ATTACHED SHEET**

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**QUESTION 1**

- a). The entropy of deuterated methane,  $\text{CH}_3\text{D}$  was experimentally determined at 100 K and 1 bar by calorimetric methods to be,  $S_{\text{cal}}^\circ = S(T=100 \text{ K}) - S(T=0 \text{ K}) = 153.553 \text{ J K}^{-1} \text{ mol}^{-1}$ . The entropy was also determined statistically at the same temperature and pressure by spectroscopic methods and calculated to be,  $S_{\text{spect}}^\circ = 165.268 \text{ J K}^{-1} \text{ mol}^{-1}$ . Explain the apparent discrepancy between the two values.
- b). Calculate the entropy of mixing,  $\Delta S_{\text{mix}}$  when 0.8 moles of nitrogen is mixed with 0.2 moles of oxygen at 25° C under conditions where no chemical reaction occurs.
- c). The standard enthalpy of formation of carbon dioxide is expressed as a function of temperature as follows:

$$(\Delta H_f^\circ)_T = -391,120.32 - 2.523T - 2.824 \times 10^{-4}T^2 - \frac{4.188 \times 10^5}{T} \text{ J mol}^{-1}$$

Calculate the heat capacity of carbon dioxide at 300 K.

- d). Consider the following statement: “*In the reversible adiabatic expansion of a real gas, the enthalpy always decreases*”. Is this statement **True** or **False**? Give an explanation for your answer.

## QUESTION 2

Measurements of the Joule coefficient,  $\eta_J$  and the Joule-Thomson coefficient,  $\eta_{JT}$  in the Joule and the Joule-Thomson free expansion gas experiments respectively, led to the conclusion that for an ideal gas, both the internal energy,  $E$  and the enthalpy,  $H$  depend on the temperature only.

- Derive general equations for  $(\partial E/\partial V)_T$  and  $(\partial H/\partial P)_T$ . Apply the derived equations to the equation of state for one mole of an ideal gas and confirm that the above conclusion is rigorously true by showing that  $(\partial E/\partial V)_T = 0$  and  $(\partial H/\partial P)_T = 0$ .
- Apply the equation derived in part a) above to show that for one mole of a gas obeying van der Waal's equation of state, the internal energy,  $E$  depends on both temperature and volume; that is  $(\partial E/\partial V)_T \neq 0$ .

## QUESTION 3

One mole of water vapour is compressed reversibly to liquid water at the boiling point, 373 K and pressure of 1 bar. The enthalpy of vaporization of water at 373 K and 1 bar is 2258.10 J g<sup>-1</sup>. Assume that water vapour is an ideal gas at 1 bar.

- Write the change of state of water.
- Calculate  $w$ ,  $q$ , and each of the thermodynamic quantities:  $\Delta H$ ,  $\Delta E$ ,  $\Delta G$ , and  $\Delta S$ .

## QUESTION 4

A general expression for an enthalpy of reaction as a function of temperature and pressure is:

$$\Delta H_{\text{reaction}} = \Delta H_{\text{reaction}}(T_1, P_1) + \sum n_i \left\{ \int_{T_1, P_1}^{T_2, P_2} C_{P,i} dT + \int_{T_2, P_1}^{T_2, P_2} \left[ V_i - T \left( \frac{\partial V_i}{\partial T} \right)_P \right] dP \right\}$$

Consider the reaction:  $\text{SO}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightleftharpoons \text{SO}_3(\text{g})$ .

The reaction occurs at a pressure,  $P = 1$  bar and both reactants and products are assumed to obey the ideal gas law. Calculate the heat of reaction at 873 K, given the following information:

$$\Delta H(291 \text{ K}, 1 \text{ bar}) = -5351 \text{ J mol}^{-1}$$

$$C_P(\text{SO}_2) = 2.72 + 4.10 \times 10^{-4} T - \frac{4.89 \times 10^4}{T^2}$$

$$C_P(\text{O}_2) = 1.80 + 1.93 \times 10^{-4} T - \frac{2.1 \times 10^4}{T^2}$$

$$C_P(\text{SO}_3) = 3.02 + 1.53 \times 10^{-3} T$$

### QUESTION 5

39.95 g of argon whose heat capacity at constant volume,  $C_v = \frac{3}{2}R$  are subjected to the following sequence of steps:

- The gas is heated reversibly at a constant pressure of 1 bar from 25° to 100° C.
- Next, the gas is expanded reversibly and isothermally to double its volume.
- Finally the gas is cooled reversibly and adiabatically to 35° C.

Calculate  $\Delta E$ ,  $\Delta H$ ,  $q$ , and  $w$  for the overall process [(a) + (b) + (c)].

### QUESTION 6

The van der Waals equation of a gas can be expanded in the form

$$\frac{PV}{RT} = 1 + \left(b - \frac{a}{RT}\right) \frac{1}{V} + \frac{b^2}{V^2} + \dots$$

At low pressures the equation of state for the gas can be accurately approximated by the virial equation

$$PV = RT + BP$$

- Explain the constants  $a$  and  $b$  in the van der Waals equation.
- Express the virial coefficient  $B$  in terms of the van der Waals constants  $a$  and  $b$ .
- Sketch a graph of  $B$  as a function of temperature  $T$  for the gas. On your sketch clearly indicate:
  - the Boyle temperature  $T_B$ ;
  - the region of the graph in which the ideal gas equation is valid;
  - the regions of the graph that are associated with the van der Waals constants  $a$  and  $b$ .
- Calculate the Boyle temperature of ammonia gas whose constants are  $a = 4.25 \text{ bar L}^2 \text{ mol}^{-2}$  and  $b = 0.0374 \text{ L mol}^{-1}$ .

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**END OF C 462 EXAMINATION**

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UNIVERSITY OF ZAMBIA

2011 UNIVERSITY SESSIONAL EXAMINATIONS SEMESTER II

C 462 STATISTICAL MECHANICS AND THERMODYNAMICS

DATA SHEET

$$R = 8.315 \text{ J K}^{-1} \text{ mol}^{-1} = 8.315 \times 10^{-2} \text{ L bar K}^{-1} \text{ mol}^{-1} = 8.206 \times 10^{-2} \text{ L atm K}^{-1} \text{ mol}^{-1};$$
$$k_B = 1.38 \times 10^{-23} \text{ J K}^{-1}; N_A = 6.02 \times 10^{23} \text{ mol}^{-1}.$$

$$S = k_B \ln \Omega$$

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT;$$

$$dE = TdS - PdV;$$

$$dH = TdS + VdP$$

$$H = 1.01; O = 16.00; Ar = 39.95$$

$$dA = -SdT - PdV$$

$$dG = -SdT + VdP$$

**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**

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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  $\text{H}_3\text{PO}_4$  and  $\text{H}_2\text{SO}_4$  in the Orthophosphoric 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.

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END OF EXAMINATION

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

**2011 ACADEMIC YEAR FIRST SEMESTER  
FINAL EXAMINATIONS**

**C5551: PHYSICAL ORGANIC CHEMISTRY**

**TIME: THREE HOURS**

**INSTRUCTIONS:**

1. Answer any three questions.
2. Each question carries 40 marks

## QUESTION ONE

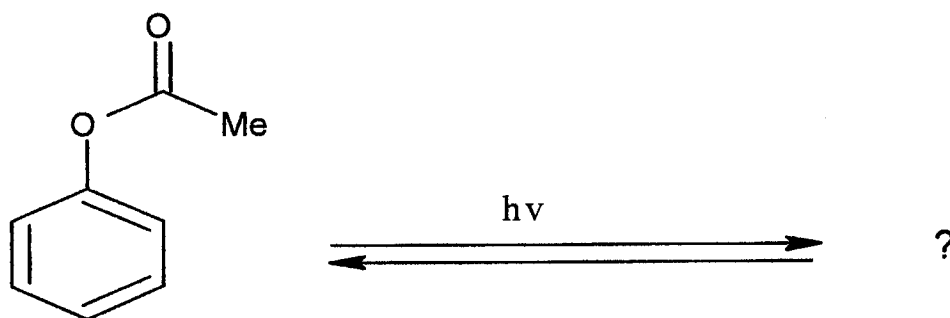
(a) Provide the definitions for the following terms in photochemistry:

- (i) Photosensitisation
- (ii) A quantum of radiation
- (iii) Frank-Condon electronic transition (Principle)
- (iv) Photolysis

(8 marks)

(b) Draw the Jablonski diagram and clearly show schematically the options available for a molecule to move from the ground state to excited states and upon relaxation move back to ground state. (16 marks)

(c) Upon absorption of a quantum of light phenolic esters undergo photolytic rearrangement. Using this information write all the steps and show the intermediate products of the reaction shown below and give the final major organic product of this reaction. (8 marks)



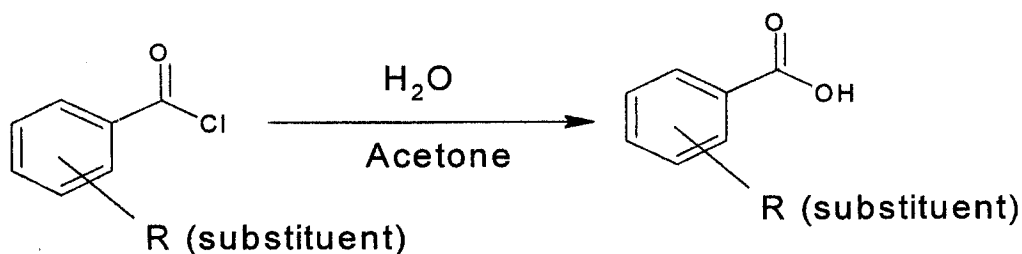
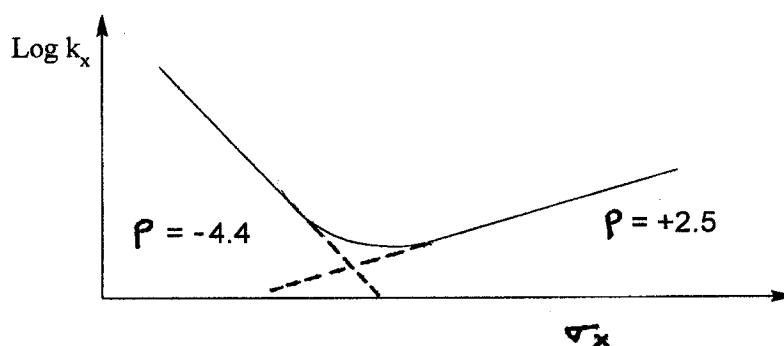
(d) Write a short note on only one of the following:

- (i) DEPT Spectra
- (ii) H-H COSY Spectra

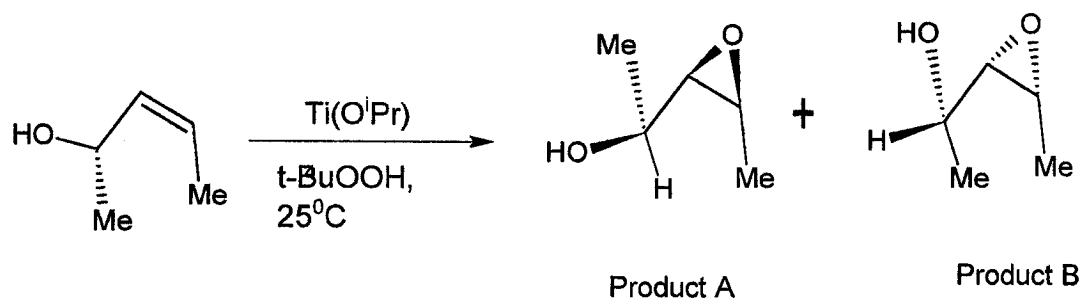
(8 marks)

## QUESTION TWO

- (a) (i) Write the Hammett equation and briefly explain the significance of the terms in this equation. (5 marks)
- (ii) Hammett  $\sigma_m$  and  $\sigma_p$  constants fail to correlate certain reaction series. Explain why. (4 marks)
- (ii) Write the Yukawa-Tsuno and Swain-Lupton equations. Briefly discuss the approaches that are involved in these equations. (8 marks)
- (b) (i) Base catalysed hydrolysis of ethyl m-nitrobenzoate is 63.5 times faster than the unsubstituted ester under identical conditions. What comparative rate of hydrolysis would you expect for ethyl p-methoxybenzoate under the same conditions? (6 marks)
- (iii) The Hammett plot for hydrolysis of aromatic acyl chlorides is shown below. What conclusions can you draw about this reaction? (5 marks)

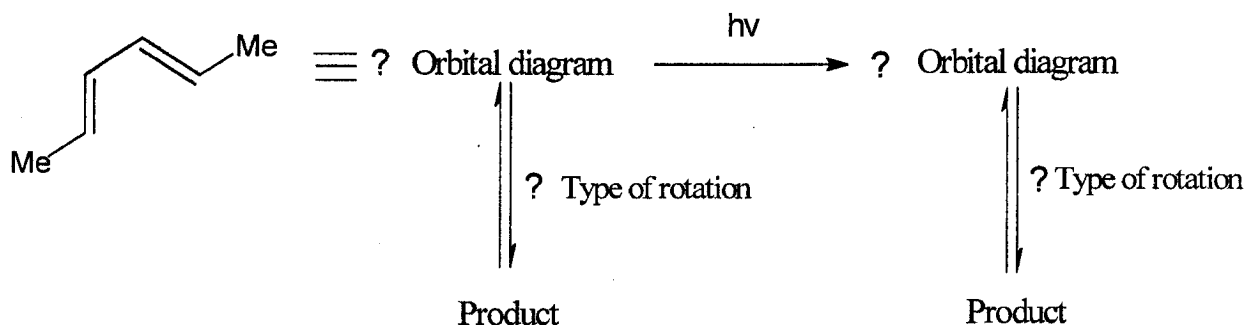


- (c) (i) State the Curtin –Hammett principle. Using this information derive the Curtin –Hammett equation for the reaction whose rate of interconversion of enantiomeric reactants is faster than the rate of the reaction. **(8 marks)**
- (ii) Epoxydation reaction shown below yields two enantiomeric products, A (major) and B (minor), in an enantiomeric excess of 84%. Calculate the difference in free energies of activation. **(4 marks)**

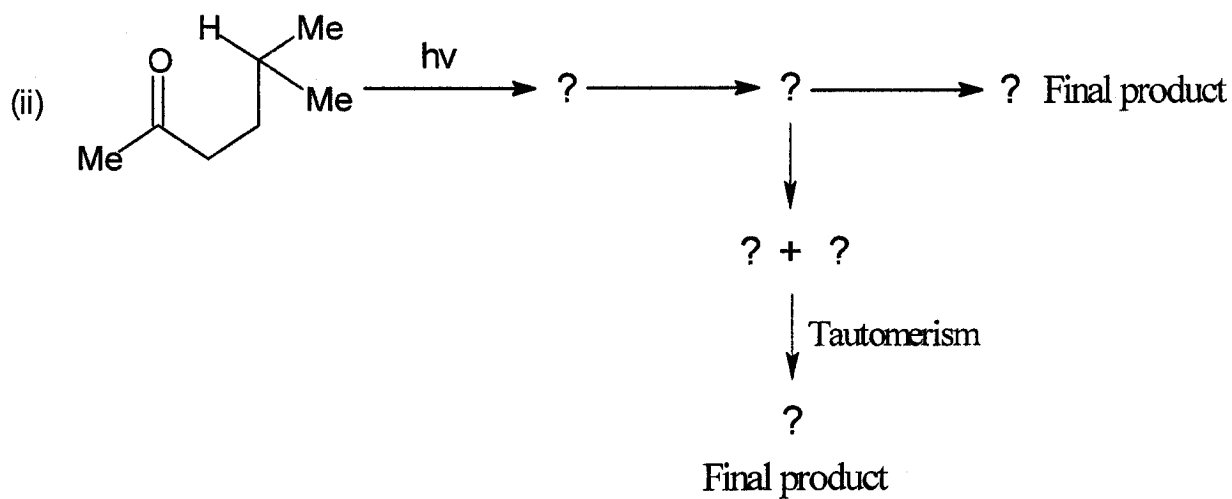
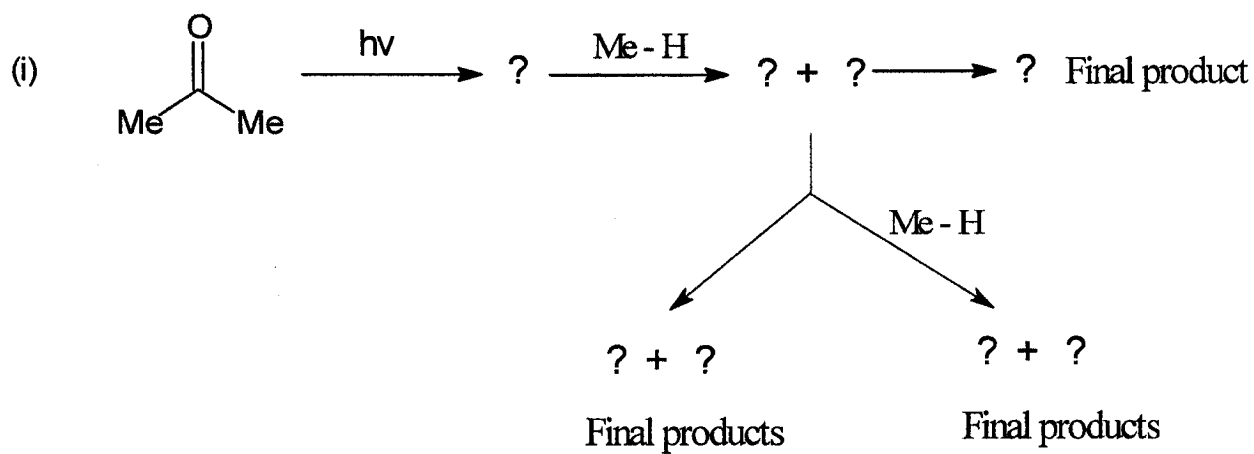


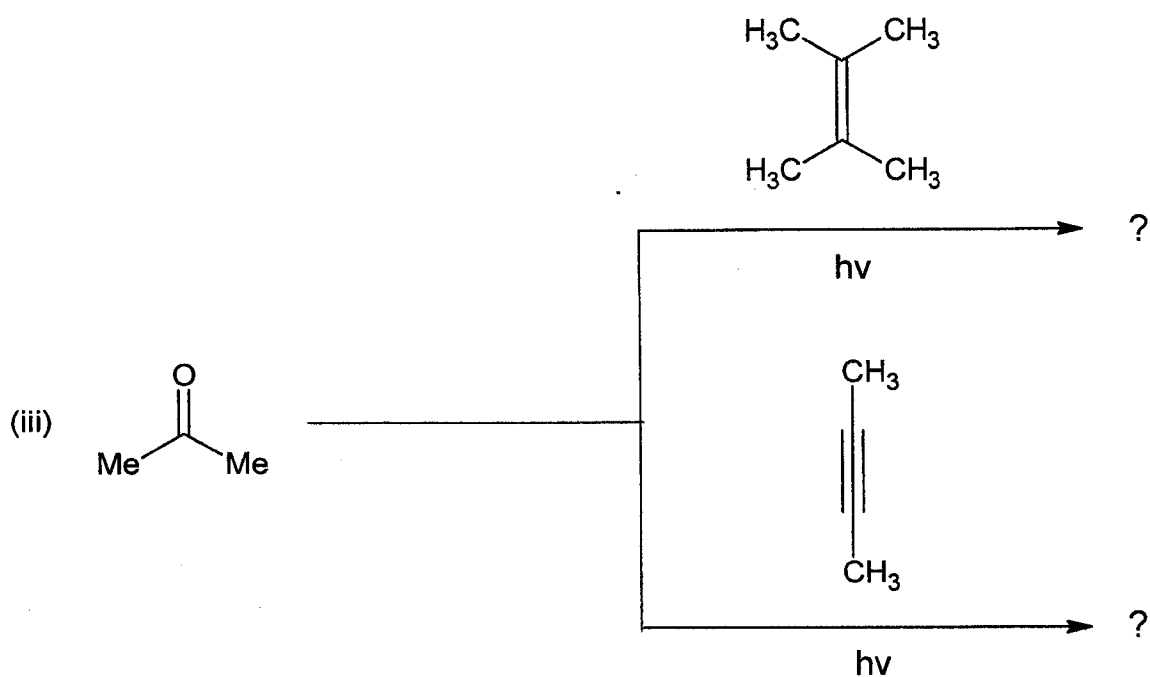
### QUESTION THREE

- (a) Basing on the molecular orbital symmetry theory (the principle of conservation of orbital symmetry), provide the missing information and write the products for the following reactions. **(10 marks)**



- (b) Provide the missing intermediate products and final products for the following reactions. (30 marks)

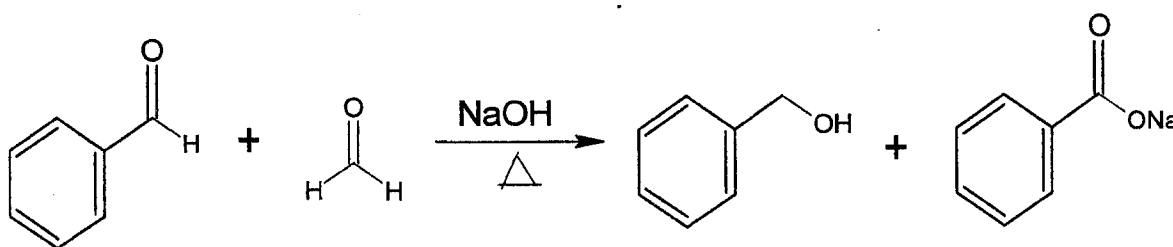




#### QUESTION FOUR

- (a) Determine the position of the nitro group in the nitrated benzodiazepinone derivative from the NOE difference spectra given on page 8. Briefly explain your answer. **(6 marks)**
- (b) Deduce the structure of a compound X,  $C_7H_7NO_3$ , from the spectra given as problem 29 on pages 9 and 10. Show your reasoning. The interpretation and assignment of the data carries most marks. **(20 marks)**

- (c) The Cannizzaro reaction is a disproportionation which takes place in strongly basic solutions and converts the carbonyl compounds with no  $\alpha$ -hydrogens to an alcohol and a salt of a carboxylic acid. For example:



Several mechanisms have been postulated, all of which propose a hydride ion transfer as the key step. The results of kinetic, isotopic labelling and other experiments are given below:

- The reaction rate is given by the expression:  

$$\text{Rate} = k_{\text{obs}} [\text{PhCH=O}]^2 [\text{OH}^-]$$
- When the reaction is carried out in  $\text{D}_2\text{O}$ , the benzyl alcohol contains no deuterium in the methylene group.
- When the reaction is carried out in  $\text{H}_2^{18}\text{O}$ , both the benzyl alcohol and sodium benzoate contain  $^{18}\text{O}$ .
- The rates of substituted benzaldehydes are correlated by Hammett equation with  $\rho = +3.76$
- The solvent isotope effect  $k_{\text{D}_2\text{O}}/k_{\text{H}_2\text{O}}$  is 1.90

- (i) On the basis of the above results, postulate one or more mechanisms which are consistent with all the data provided.

(4 marks)

- (ii) Indicate the significance of each observation with respect to the mechanism you have postulated.

(10 marks)

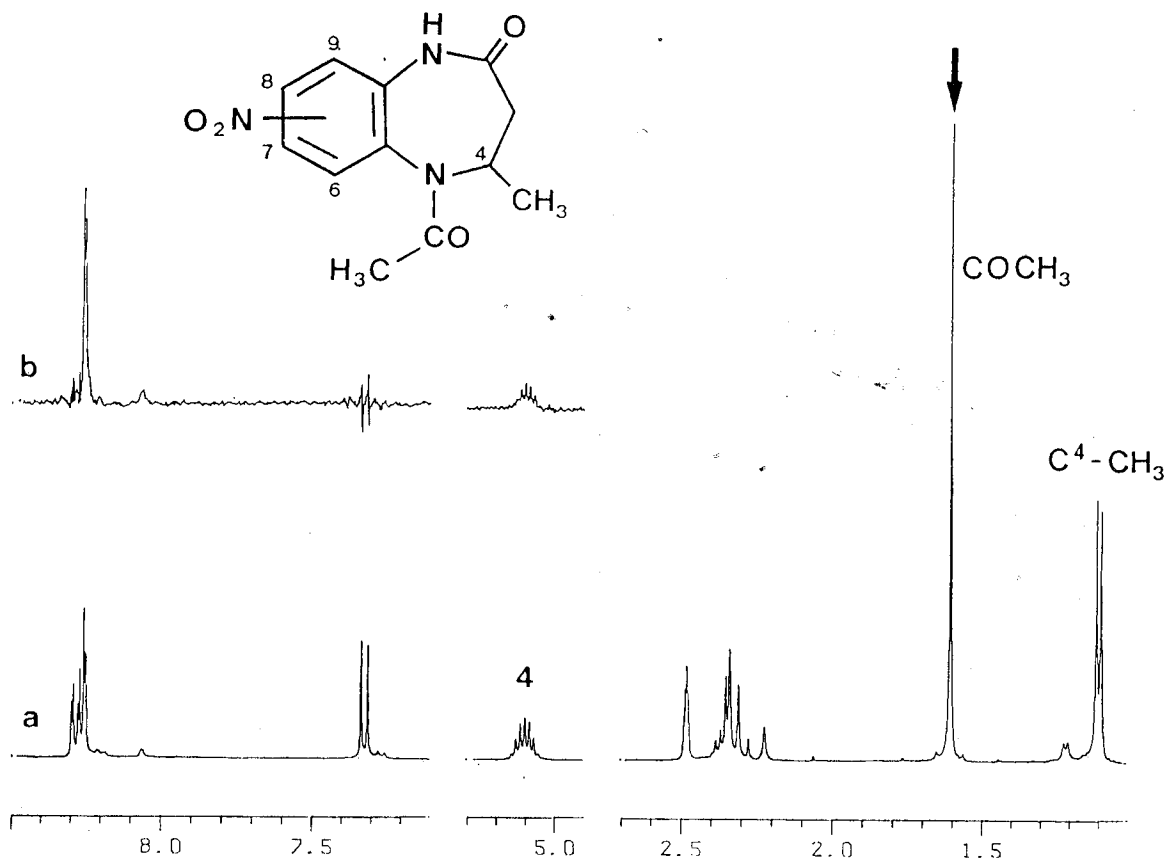
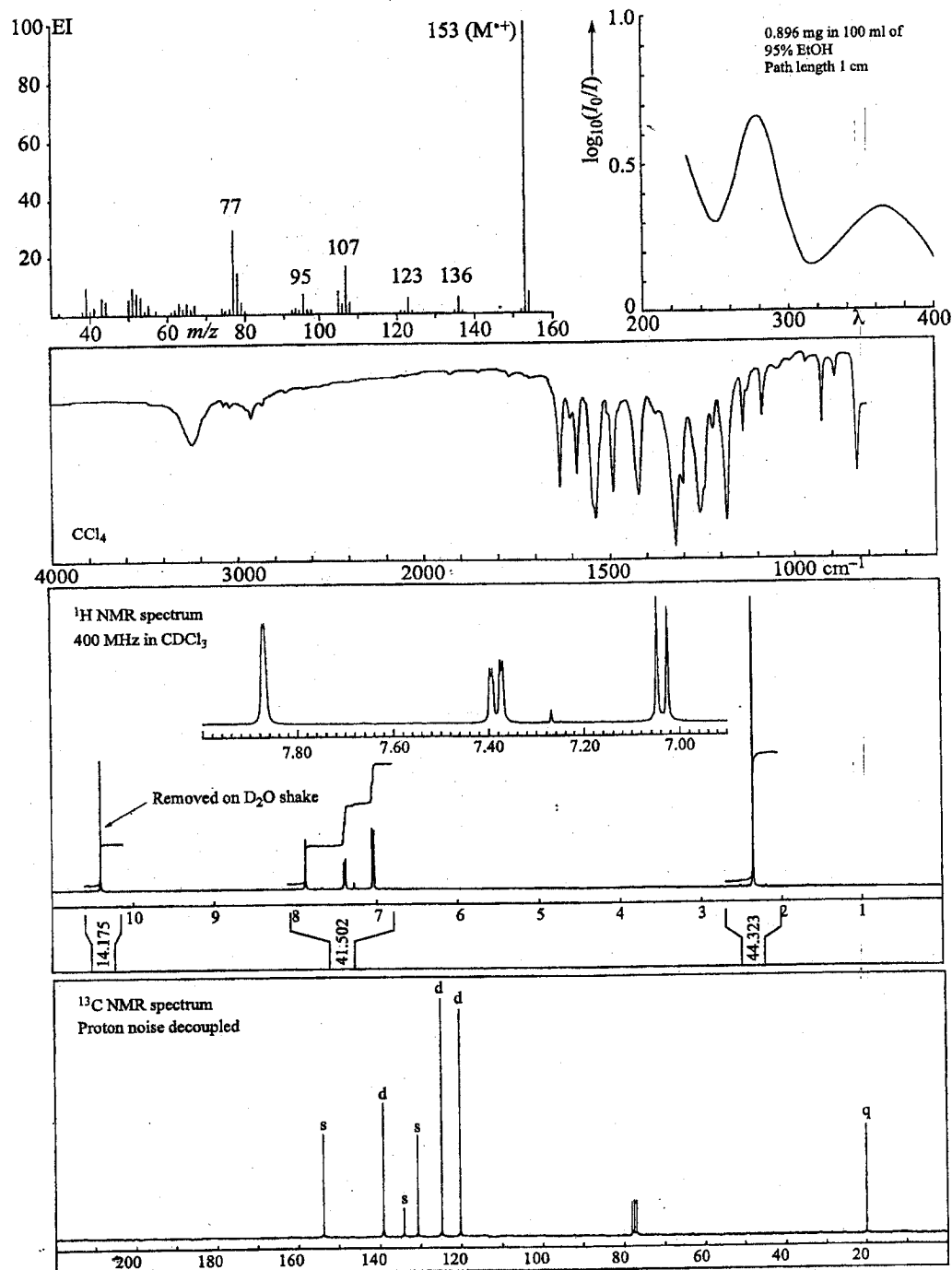


Fig. 2.3.1a and b. NOE difference experiment with a nitrated benzodiazepinone derivative, in  $\text{DMSO-d}_6$ . a  $^1\text{H}$  NMR spectrum; b NOE difference spectrum with irradiation at the position of the acetoxy methyl signal (marked by the arrow).

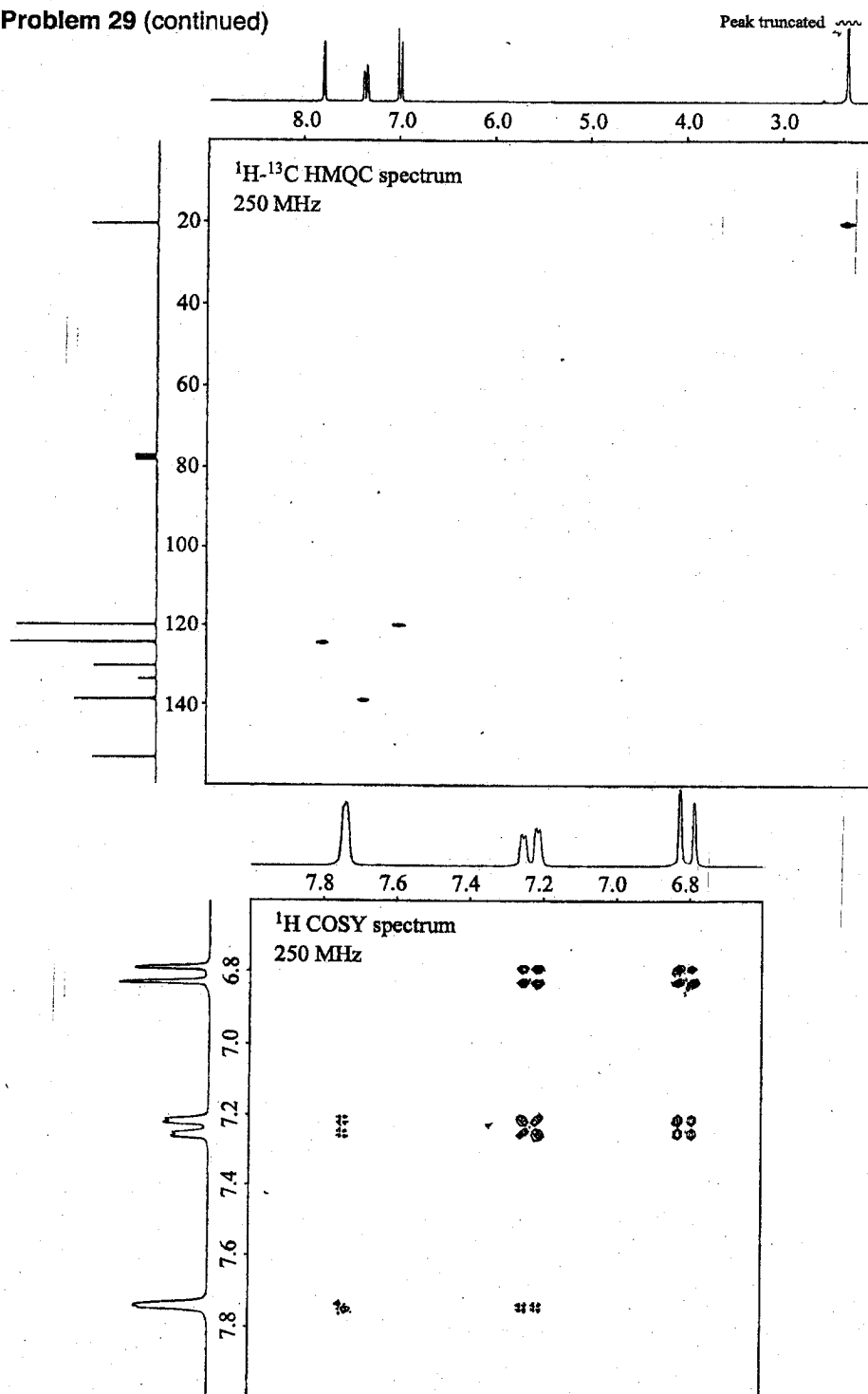
# Problem 29

C, 54.8%; H, 4.8; N, 9.3%



Problem 29 continues on the next page with HMQC and COSY spectra

Problem 29 (continued)



**THE UNIVERSITY OF ZAMBIA**

**SCHOOL OF NATURAL SCIENCES**

**2011 ACADEMIC YEAR FIRST SEMESTER**

**FINAL EXAMINATIONS**

**CHE 5011: GENERAL CHEMICAL TECHNIQUES**

**TIME: THREE HOURS**

**INSTRUCTIONS:**

- 1. Answer question one and only two other questions.**
- 2. Each question carries 40 marks**

### QUESTION ONE

- (a) (i) Explain the term photo-excitation as it relates to photochemical processes
- (ii) Show diagrammatically the relative energy levels and the electronic states of all the singlet and triplet states
- (b) Explain what is meant by radiative and non-radiative processes. Give one example of each.
- (c) Briefly explain the following terms:
- (i) Fermi resonance
- (ii) Chemical Shift
- (d) Provide an explanation to account for the following observations:
- (i) Peak area measurements are not obtained in routine  $^{13}\text{C}$ -NMR.
- (ii) Propene and propyne show carbon-carbon multiple bond stretching band in the IR region but ethene and ethyne don't.
- (e) Aliphatic aldehydes containing unconjugated double bonds exhibit  $\text{C}=\text{O}$  and  $\text{C}=\text{C}$  stretching at  $1720 - 1740\text{ cm}^{-1}$  and near  $1650\text{ cm}^{-1}$  respectively. However, crotonaldehyde,  $\text{CH}_3\text{CH}=\text{CHCHO}$ , shows corresponding absorptions at  $1640\text{ cm}^{-1}$  and  $1715\text{ cm}^{-1}$ . Explain.

### QUESTION TWO

- (a) The energy gap between the triplet ground state and the excited singlet state for molecular oxygen is  $90\text{ kJ mol}^{-1}$ . Calculate the wavelength of photons given off if an excited state singlet relaxes to the ground state with the emission of light.
- (b) (i) Why is the phosphorescence spectrum significantly red shifted compared to the fluorescence spectrum?
- (ii) Draw a Jablonski diagram to illustrate excitation and absorption processes leading to phosphorescence and fluorescence.
- (c) The equation below shows the rate of transitions between the ground state and excited states. Define all the parameters in the equation.

$$\frac{N_h}{N_g} = \frac{B_{gh}\rho(\nu_{gh})}{B_{gh}\rho(\nu_{gh}) + A_{gh}}$$

### QUESTION THREE

- (a) The capillary viscometers are widely used for determination of viscosity and molecular mass of polymers.
- (i) Describe and write the formulas for determination of absolute, kinematic, relative and specific viscosities and fluidity.
  - (ii) How will you determine the relative viscosity using Ostwald's viscometer? Give the equation for calculation.
  - (iii) What are the disadvantages of the capillary viscometers used for the relative viscosity measurements?
- (b) Describe the following:
- (i) Speed of light in vacuum and air.
  - (ii) Difference between natural and artificial light.
  - (iii) Spectrum of the light and mixing coloured light. How are colours seen?
  - (iv) Light reflection, refraction, absorption and dispersion.

### QUESTION FOUR

- (a)
- (i) How will you distinguish between inter- and intra- molecular hydrogen bonding by infra-red spectroscopy?
  - (ii) How will you verify that a particular nmr signal arises from the proton on a hetero atom, such as -OH or -NH or -SH group, in a molecule? Briefly explain your answer.
- (b)
- (i) Explain what is meant by the nuclear Overhauser effect.
  - (ii) With the aid of an example illustrate how you would use NOE to determine stereochemical relationships in molecules.
  - (iii) Quaternary carbons show small NOE enhancements. Explain why.
- (c)
- (i) What is involved in the APT and DEPT techniques?
  - (ii) Briefly describe how the methyl, methylene, methyne and quaternary carbons in a molecule can be unambiguously assigned by the DEPT technique.

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.

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**Question 1**

(a) Account for the following observations:-

Octahedral Complex	Ion	$\mu_{eff}^{80K}$	$\mu_{eff}^{300K}$
$[\text{Mn}(\text{CN})_6]^{4-}$	$\text{Mn}^{2+}$	2.03	2.5
$\text{Cr}(\text{SO}_4) \cdot 6\text{H}_2\text{O}$	$\text{Cr}^{2+}$	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  $\text{cm}^{-1}$  larger than ( $kT$ ) show what obtains and how this would reduce to  $\mu_s$ .

- (b) A lot of studies on magnetic moments of Lanthanide ions have been studied. How the observed and the calculated  $\mu_{\text{eff}}$  values for  $\text{Sm}^{3+}$  compare?
- (c) Show how P is isolobal to RSi, where R is an alkyl group, and hence predict the shape of  $\text{P}_2(\text{SiR})_2$ .

#### Question 4

- (a) How would you describe the nature of metal-alkyl bonding in
- (i)  $\text{CH}_3\text{MgI}$       (ii) The Zeise salt      (iii) Ferrocene
- (b) Account the nature of bonding in  $\text{Al}_2(\text{CH}_3)_6$  compound.

#### Question 5

- (a) By clearly outlining the relevant conditions, suggest two ways in which a metal-carbonyl complex such as  $\text{Cr}(\text{CO})_6$  can be synthesized.
- (b)  $\text{ML}_5$  is  $\text{C}_{4v}$  molecule isolobal to  $\cdot\text{CR}_3$ . 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  $\text{ML}_5$ ?

**End of Examination**

# PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number <b>X</b>
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	4 Be 9.01 Beryllium															1 H 1.01 Hydrogen
3 Li 6.94 Lithium												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 Aluminum	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 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 71.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc 97.91 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 Tellurium	53 I 126.90 Iodine
55 Cs 132.91 Caesium	56 Ba 137.33 Barium	57-71 89-103	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		104 Uuq 261.11	105 Uup 262.11	106 Uuh 263.12	107 Uus 262.12	108 Uuo 265.00	109 Uue 265								

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

THE UNIVERSITY OF ZAMBIA  
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2011 UNIVERSITY SESSIONAL EXAMINATIONS SEMESTER II

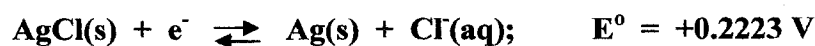
CHE 5612: THERMO-ELECTRODYNAMICS OF SOLUTION

TIME: THREE HOURS

ANSWER ANY FIVE OF THE SIX QUESTIONS

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DATA



For solvent water at 298.15 K, the Debye-Hückle constant  $A = 0.509$ .

---

QUESTION 1

- Calculate the ionic strength and activity coefficient of a 0.002 *m* aqueous solution of Ba(NO<sub>3</sub>)<sub>2</sub> at 25°C.
- The activity coefficient in a 0.100 *m* aqueous solution of MnCl<sub>2</sub> is 0.47 at 25°C. What is the percentage error in the value predicted by the Debye-Hückel limiting law?
- The activity coefficient of LiBr in a dilute aqueous solution at 25°C is 0.907 in a 0.01 *m* solution. Estimate the value of the constant *B* in the extended Debye-Hückle law.

QUESTION 2

- Identify the following equation and the symbols in it:

$$\ln \gamma_i = - \frac{q^2 z_i^2 \kappa}{8\pi\epsilon_0 D k_B T}$$

State one condition under which this equation is valid.

- Electromotive measurements for KCl at 298 K in the solvent methanol gave the following results for the values of the activity coefficient:

<i>m</i>	0.002	0.005	0.008
$\gamma_{\pm}$	0.81	0.72	0.66

- Show that the Debye-Hückle limiting law is valid in methanol at the given molalities.
- What is the value of the constant *A* for the solvent methanol?

### QUESTION 3

When 1 mol of  $\text{H}_2\text{SO}_4$  is mixed with  $n$  moles of water at  $25^\circ\text{C}$ ,

$$\Delta H = \frac{-75.6n}{n+1.80}$$

The units of  $\Delta H$  are kilojoules and  $n < 20$ . Calculate the differential heat of solution of water,

$$\Delta H_w = \left(\frac{\partial \Delta H}{\partial n_w}\right)_{n_s} \text{ and that of sulfuric acid, } \Delta H_s = \left(\frac{\partial \Delta H}{\partial n_s}\right)_{n_w} \text{ when } n = 1 \text{ and when } n = 10$$

### QUESTION 4

The integral heat of solution of  $m$  moles of  $\text{NaCl}$  in 1000 g  $\text{H}_2\text{O}$  at 298 K is given as

$$\Delta H \text{ (kJ)} = 3.861m + 1.992m^{3/2} - 3.038m^2 + 1.019m^{5/2}.$$

Calculate: a)  $\Delta H$  per mole of  $\text{NaCl}$  to form 1 molal solution, b)  $\Delta H$  per mole of  $\text{NaCl}$  to infinite dilution, c) the  $\Delta H$  of dilution per mole of  $\text{NaCl}$  from 1.0 to 0.1  $m$ ; and d) the differential  $\Delta H$  per mole at 1.0  $m$   $\text{NaCl}$ .

### QUESTION 5

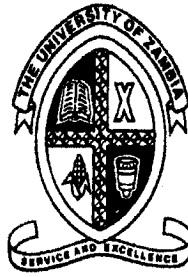
Consider dissociation of a weak acid  $\text{HA}$  in an aqueous solution.

- Derive in logarithmic form an equation for the thermodynamic equilibrium constant,  $K_T$  in terms of the acid dissociation constant  $K_A$  and the Debye-Hückle limiting law.
- Calculate the thermodynamic equilibrium constant,  $K_T$  of acetic acid,  $\text{CH}_3\text{COOH}$  in an aqueous solution of ionic strength 0.250. The dissociation constant,  $K_A$  of acetic acid in water is  $1.75 \times 10^{-5}$ .

### QUESTION 6

- The partial molar volumes of acetone and chloroform in a mixture in which the mole fraction of  $\text{CHCl}_3$  is 0.4693 are  $74.166 \text{ cm}^3 \text{ mol}^{-1}$  and  $80.235 \text{ cm}^3 \text{ mol}^{-1}$  respectively. What is the volume of a solution of mass 1.000 kg?
- The emf of the cell  $\text{Pt(s)}|\text{H}_2(\text{g}, p = 1 \text{ bar})|\text{HCl(aq.)}|\text{AgCl(s)}|\text{Ag(s)}$  is 0.322 V at  $25^\circ\text{C}$ . What is the pH of the electrolyte solution?

**END OF CHE 5612 EXAMINATION**



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

**CS4251: ELECTRONICS FOR COMPUTING III**

**SEMESTER 1 EXAM**

**6<sup>th</sup> MARCH 2013**

**TIME: THREE HOURS**

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

## ANSWER ANY FIVE (5) QUESTIONS

### QUESTION 1

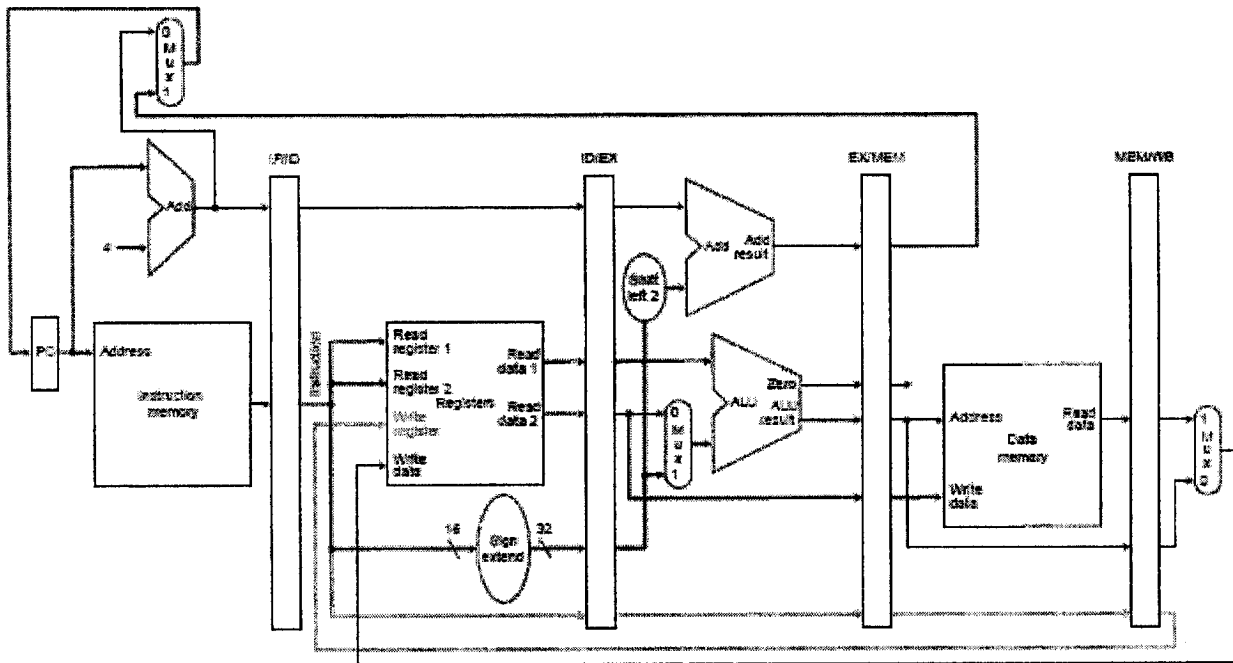
Using the data path diagrams and by way of shading, describe the stages of pipelining the following instructions.

(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]

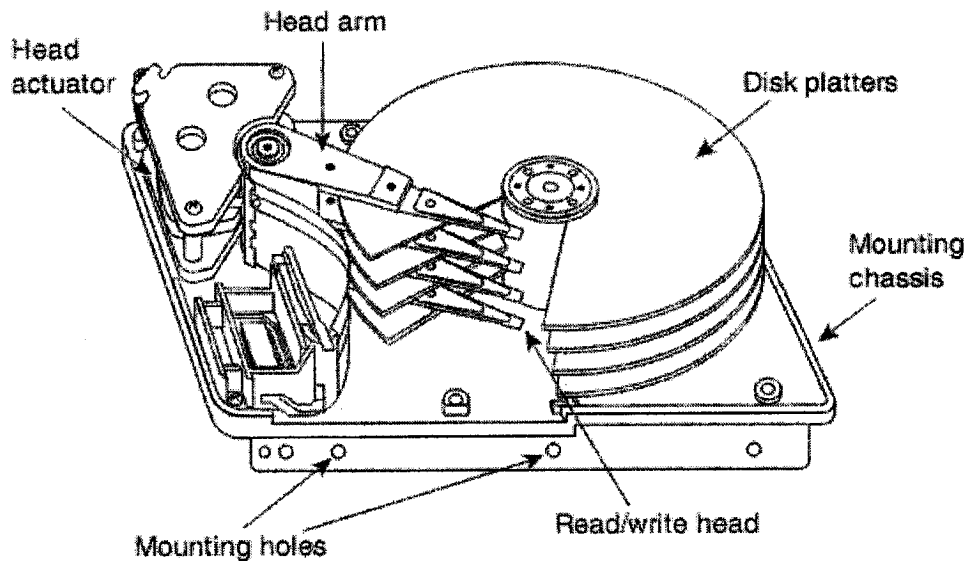
### QUESTION 6

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.  
 (ii) Describe the reading process.

[5 Marks]

[5 Marks]

END OF EXAM

**THE UNIVERSITY OF ZAMBIA**  
**SCHOOL OF NATURAL SCIENCES**  
**Department**  
**Of**  
**Computer Studies**

**UNIVERSITY EXAMINATION**

**CST3011 – Data Structures and Algorithms**

**DATE** : MONDAY, 4<sup>TH</sup> 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]**

```
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**  
**CST3031 SOFTWARE ENGINEERING**

**UNIVERSITY EXAMINATIONS**  
**DURATION – 3 HOURS**

*Instructions*

- 1. Answer any five(5) questions in section A*
- 2. Answer any four(4) questions in section B*

## **Section – A**

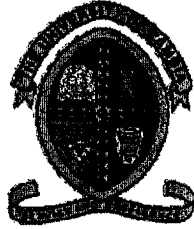
Answer any five questions, each carries 8 marks

1. A. Explain the different types of applications in software engineering?  
B. Briefly explain the principles in code of ethics?
2. Explain about the software prototyping and the types of prototyping?
3. A. What are the principles in agile methods?  
B. Write down the benefits in SCRUM?
4. Explain about the structure of requirement documents?
5. Develop a sequence diagram showing the interactions involved when a student registers for a course in a university. Courses may have limited enrollment, so the registration process must include checks that places are available. Assume that the student accesses an electronic course catalog to find out about available courses.
6. Explain the process activities and the benefits in Test Driven Development (TDD) ?

## **Section – B**

Answer any four questions, each carries 15 marks

1. Explain in detail about the software process model?
2. A. Extreme programming expresses user requirements as stories, with each story written on a card. Discuss the advantages and disadvantages of this approach to requirements description?  
  
B. Explain the pair programming and its advantages?
3. A. Using the technique suggested here, where natural languages is presented in a standard way, write plausible user requirements for the following functions:
  - The cash dispensing function in a bank ATM
  - The spelling check and correcting function in a word processor
  - An unattended petrol (gas) pump system that includes a credit card reader. The customer swipes the card through the reader and then specifies the amount of fuel required. The fuel is delivered and the customer's account debited.  
B. Explain in detail about the functional and non-functional requirements?
4. Explain in detail about any four architectural patterns?
5. Using the UML graphical notation for object classes, design the following object classes, identifying attributes and operations. Use your own experience to decide on the attributes and operations that should be associated with these objects.
  - A telephone
  - A printer for a personal computer
  - A personal stereo system
  - A bank account
  - A library catalogue
6. Explain in detail about the Development testing?



**THE UNIVERSITY OF ZAMBIA**  
**School of Natural Sciences**  
Department of Computer Studies

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**FIRST SEMESTER - FINAL EXAMINATION**

**COMPUTER NETWORKS AND DATA  
COMMUNICATIONS - CST 3061**

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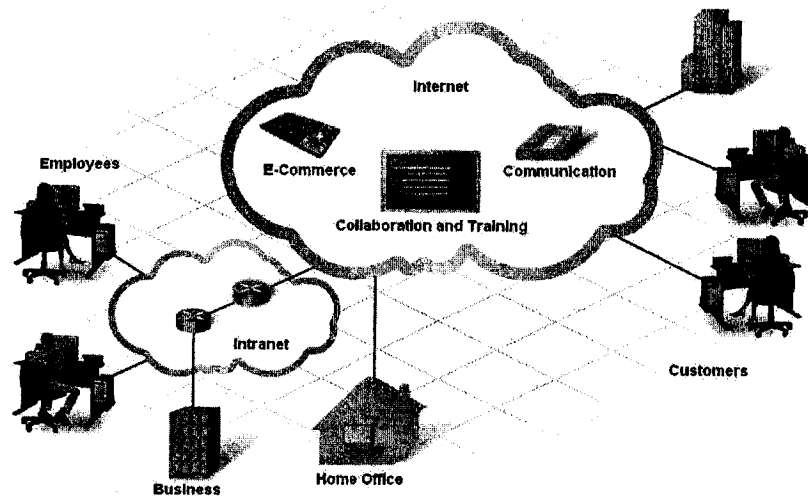
Date: 7<sup>th</sup> March 2013  
Time: 09:00hrs – 12:00hrs  
Duration: 3Hours  
Venue: GLT

**Instructions**

- 1) There are six (6) questions in this paper.
- 2) Each question carries **20 marks**
- 3) *Chose ANY Five (5) Questions*

## Question I

- a) Define each of the following terms [2]
- Computer Network
  - Networking Devices
- b) The diagram below shows the basic structure of the Internet, its use and users.

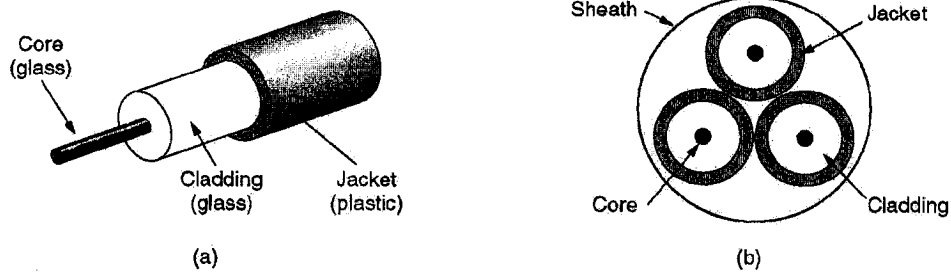


Give at least two examples of the application of computers networks in each of the following categories [4]

- Business
  - Homes
  - Industry
  - Education
- c) What is the difference between **Broadcast Links** and **Point-to-Point Links** transmission technologies [4]
- d) Draw a diagram for the OSI reference model [10].
- Give the function for each layer.
  - Give an example of at least two examples of the protocols at each layers
  - Give an example of the device operating at each layer

## Question II

- a) List any four guided media that can be used to transmit data from one terminal to another [2]
- b) The diagram below shows the components of the fiber optic cable. Give the function of each of the fiber optic components shown in the diagram[4]



- c) The table below shows the transmission bands for the communication satellites. Draw and the complete the missing data in the table below [4]

No.	Band	Downlink	Uplink	Bandwidth	Problems
1	L			15 MHz	Low Bandwidth; Crowded
2	S			70 MHz	
3	C	4.0 GHz	6.0GHz	500 MHz	Terrestrial Interference
4	Ku			500 MHz	Rain
5	Ka	20GHz	30GHz	3500 MHz	

- d) Draw a well labeled diagram showing the **Structure of the Telephone System** [4]
- e) Give a brief description for of the following [6]
- Frequency Division Multiplexing
  - Wavelength Division Multiplexing
  - Time Division Multiplexing

### **Question III**

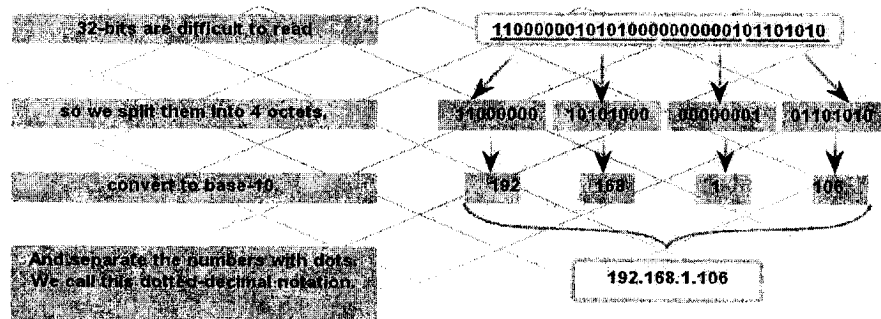
- a. List any three Functions of the Data Link Layer [3]
- b. Draw and complete the table below by filling in the blanks [4]

No.	Band	Cable	Maximum Segment
1	10Base5	Coaxial	
2	10Base2		
3	10Base-T	UTP	100 m
4	100Base-TX		
5	1000Base-SX		
6	1000Base-T		100 m

- c. Give a brief description for each of the following in relation to 802.11 Distribution Services [3]
- Association
  - Distribution
  - Integration
- d. Draw a well labelled diagram for an Ethernet Frame [4]
- e. Give a brief description for each of the following [6]
- Circuit switching
  - Message switching
  - Packet switching

## Question IV

- a. Define the following terms [2]
  - i. NAT
  - ii. VPN
- b. The main function of the network layer is routing packets from the source node to the destination node. Give a brief description of each of the following routing algorithms [6]
  - i. Distance Vector Routing
  - ii. Link State Routing
  - iii. Shortest Path Routing
- c. The diagram below shows a basic illustration of the IP version 4 addressing. [12]



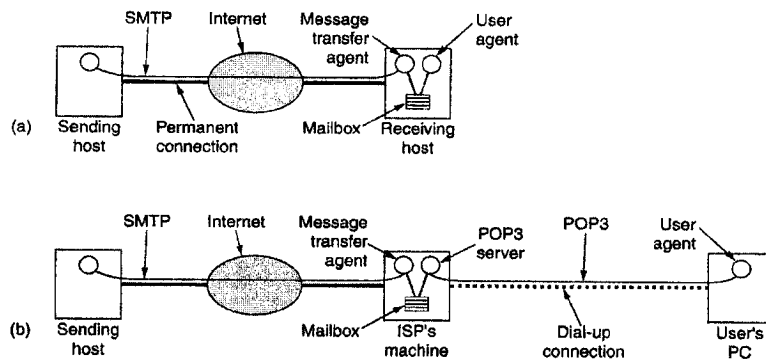
Given a network IP address as **197.129.39.0**.

- i. Convert this dotted decimal IP address into the binary form
- ii. If you have 6 departments and would like them to be in different broadcast domain (subnets) each with 13 computers;
  1. Explain how you can divide this network address into the required subnets for your six (6) departments (subnets).
  2. How many bits should be borrowed from the network
  3. Draw and complete the table below showing the IP Addresses for each of the subnets created, the usable IP addresses range in that subnet and the broadcast IP address.

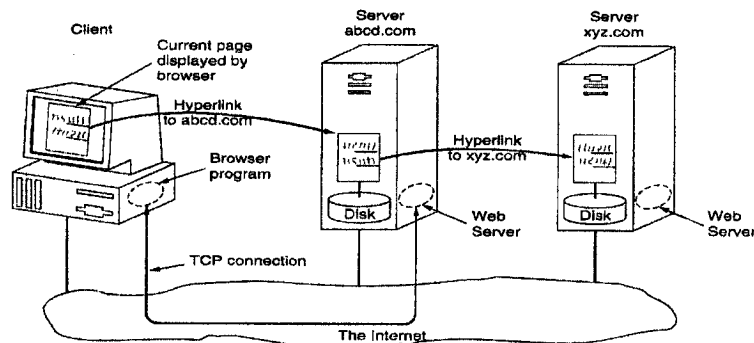
Subnet	Network Address	Usable IP Address Range	Broadcast IP Address
0			
1			
⋮	⋮	⋮	⋮
n			

## Question V

- a. The session, presentation, and application layers of the OSI model are bundled into the application layer of the TCP/IP model. Below is a list of seven TCP/IP application layer protocols. Give a brief description for each one of them and where it is used [6]
- i. DNS
  - ii. FTP
  - iii. HTTP
  - iv. SMTP
  - v. SNMP
  - vi. Telnet
- a. The diagram below shows an illustration of the email system. Briefly explain how the email system works using POP3, SMTP, MIME, IMAP and any other protocols [4]



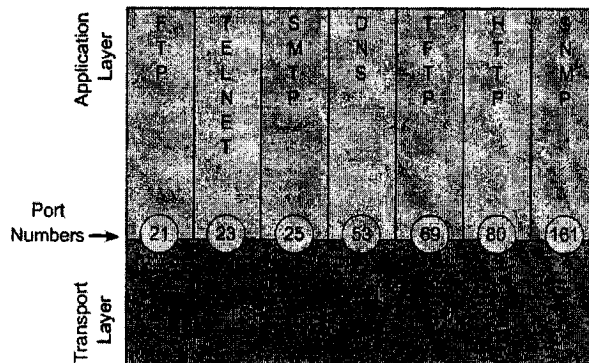
- b. The diagram below show the web model. Give a brief explanation how the World Wide Web (WWW) Works with reference to the diagram below containing the hyperlinks [4]



- c. **Draw** a diagram showing the basic structure of [6]
- i. The Wireless Application Protocol (WAP) architecture
  - ii. Internet Radio

## Question VI

- a. The two primary duties of the transport layer are to provide flow control and reliability. Give any four basic transport layer services [2]
- b. The transport layer is basic made up of *two protocols* called **UDP** and **TCP**. *For each protocol Give;*
- A brief description [2]
  - Two application layer protocols that use this protocol [2]
  - Draw a segments with well labelled fields [6]
- c. Port numbers are an important addressing scheme used between the transport and the application layers as shown in the diagram below. Explain how the transport layer uses the port numbers to communicate with the application layer [4].



- d. With the aid of a diagram, explain how a *three way hand shake* works [4]

**The End**

**THE UNIVERSITY OF ZAMBIA**  
**SCHOOL OF NATURAL SCIENCES**  
**DEPARTMENT OF COMPUTER STUDIES**  
**COURSE NAME: OBJECT ORIENTED ANALYSIS AND DESIGN**  
**COURSE CODE: CST 3141**  
**UNIVERSITY EXAMINATIONS**

**Time: 3 (Three) Hours**

**You MUST answer ALL questions from Section A which are worth 40 marks**

**AND THREE questions from section B which are worth 60 marks .**

**If you answer more than three questions from section B, marks will ONLY be awarded for your three best answers.**

**CALCULATORS AND ELECTRONIC DEVICES ARE NOT PERMITTED**

### **Section A (Compulsory)**

1. What is the difference between real objects and virtual objects? Give an example for each.  
[6 marks]
2. Explain the four phases of the Rapid Application Development (RAD) methodology. How do they differ from the “traditional” SDLC approach?  
[8 marks]
3. How sequence diagram differs from use-case modeling?  
[4 marks]
4. What are the building blocks of a collaboration diagram?  
[3 marks]
5. Explain the three types of visibility for package elements: public, private and protected.?   
[6 marks]
6. Why do we need different levels of testing? Can’t we just test the finished software? [5 marks]
7. What is the difference between an essential and real use case?  
[4 marks]
8. What is a lifeline?  
[5 marks]
9. List four criteria for good analysis  
[4 marks]

**Total marks 40**

**Section B (Answer any THREE questions)**

**Q.1**

- A. Arrange the following into a hierarchy that depends on their relative generation or specialization: person ,thing ,green, shape,primary school teacher .cub,polar bear,square ,law ,child ,colour ,animal . Add more clasifications as necessary so that it is clear what is generalized or specialized at each level.

**[14marks]**

- B. What is the UML notation for each of the following : package , subsystem and model?

**[06 marks]**

**Q.2**

- A. Categorize the following relationship into generalization, aggregation, composition and association.

**[10 marks]**

1. Files contain records.
2. A drawing object is text, a geometrical object or group.
3. Modems and keyboards are input/output devices.
4. Object classes may have several attributes.
5. Car has accelerator, break and wheels as parts.
6. Windows is composed of lot of frames.
7. An account is either type savings or type current.

- B. How do asynchronous messages differ from synchronous messages (i) in their behavaviour and (ii) in their notation ?

**[10marks]**

### **Q.3**

- A.** Read the following description of a requirement for foodCo , and decide which parts of it are functional requirements and which are non-functional requirements.

The allocation of staff to production lines should be mostly automated. A process will be run once a week to carry out the allocation based on skills and experience of operatives. Details of holidays and sick leave will also be taken into account. A first draft allocation list will be printed off by 12.00 noon on Friday for the following week. Only staff in Production planning will be able to amend the automatic allocation to fine-tune the list. Once the amendments have been made, the final allocation List must be printed out by 5.00 pm. The system must be able to handle allocation of 100 operatives at present, and should be capable of expansion to handle double that number.

**[10 marks]**

- B.** Name the five main fact-finding techniques and list one advantage and one disadvantage of each.

**[10 marks]**

### **Q.4**

- A.** What are the main differences between sequence diagrams and communication diagrams?

**[04 marks]**

- B.** What are the advantages of an iterative lifecycle?

**[06 marks]**

- C.** How does the object-oriented concept of message passing help to encapsulate the implementation of an object, including its data?

**[05 marks]**

- D.** What does object 'state' mean?

**[05 marks]**

**Total marks 60**

**End of Paper**

**THE UNIVERSITY OF ZAMBIA**  
**SCHOOL OF NATURAL SCIENCES**  
**Department**  
**Of**  
**Computer Studies**

**UNIVERSITY EXAMINATION**

**CST4021 – NUMERICAL ANALYSIS I**

**DATE** : MONDAY, 25<sup>TH</sup> FEBRUARY 2013

**VENUE** : GLT

**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. State the following
  - i. The limit  $L$  of a function  $f$  at a point  $x = x_0$  [3 Marks]
  - ii. Continuity of a function  $f$  at a point  $x = x_0$  [3 Marks]
- b. Show that if  $f$  and  $g$  are continuous at  $x = x_0$ , then  $f + g$  is continuous at  $x = x_0$  [8 Marks]
- c. Find the largest interval in which  $p^*$  must lie to approximate  $\sqrt{2}$  with relative error at most  $10^{-4}$  [6 Marks]

2.

- a. State, without proof, the Mean Value Theorem. [5 Marks]
- b. Using the Mean Value theorem show that if  $f \in C[a, b]$  and there exists a number  $K$  such that  $|f'(x)| \leq K, \forall x \in (a, b)$ , then  $|f(a) - f(b)| \leq K|a - b|$ . [10 Marks]
- c. Hence, show that  $|\sin(a) - \sin(b)| \leq |a - b|$ . [5 Marks]

3.

- a. State, without proof, the Intermediate Value Theorem. [4 Marks]
- b. Hence show that the  $\sqrt[3]{25}$  lies between 2.0 and 3.0. [4 Marks]
- c. Using the Newton's method, approximate this value to  $10^{-4}$  accuracy. [12 Marks]

4.

- a. Suppose  $x_j = j$ , for  $j = 0, 1, 2, 3$  and it is known that  $P_{0,1}(x) = 2x + 1$ ,  $P_{0,2}(x) = x + 1$ , and  $P_{1,2,3}(2.5) = 3$ .

Find  $P_{0,1,2,3}(2.5)$ . [10 Marks]

- b. Approximate  $f(0.3)$  using the following data and the Newton forward divided-difference formula: [10 Marks]

$x$	0.0	0.2	0.4	0.6	0.8
$f(x)$	1.00000	1.22140	1.49182	1.82212	2.22554

5.

- a. Given  $f(x) = \sin(x)$ , use the appropriate three-point formula for the points  $x_0 = 0.2$ ,  $x_1 = 0.4$ ,  $x_2 = 0.6$ , to approximate  $f'(0.6)$ . [8 Marks]
- b. Given that  $f(x) = \cos(x)$  approximate  $f''(0.7)$ , using
  - i.  $h = 0.1$ . [6 Marks]
  - ii.  $h = 0.01$ . [6 Marks]

6.

- a. Derive the trapezoidal rule for approximating. [Hint: use the first Lagrange polynomial at  $x = x_0$ ,  $x = x_1$  and use  $h = x_1 - x_0$ .] **[8 Marks]**

$$\int_{x_0}^{x_1} f(x) dx$$

- b. Use it to approximate the following using  $h = 0.1$ . **[8 Marks]**

$$\int_{0.0}^{0.4} \sin(x) dx$$

- c. Evaluate the relative error for this approximation. **[4 Marks]**

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

**THE UNIVERSITY OF ZAMBIA**  
**SCHOOL OF NATURAL SCIENCES**  
**DEPARTMENT OF COMPUTER STUDIES**  
**COURSE NAME: MULTIMEDIA AND HUMAN COMPUTER**  
**INTERACTION**

**COURSE CODE: CST 4141**

**UNIVERSITY EXAMINATIONS**

**Time : 3 hours**

**You MUST answer ALL questions from Section A AND choose EITHER  
PART1 OR PART2 from Section B.**

**CALCULATORS AND ELECTRONIC DEVICES ARE NOT PERMITTED**

## Section A

1. A fundamental feature of multimedia is interactivity. What is interactivity? (3 marks)
2. What are the three reasons for the growth of multimedia from a marketing standpoint? (3 marks)
3. Fonts help focus attention on certain text on the screen, enhance readability, set a tone and project an image. List the types of fonts. (3 marks)
4. Name the three most common sample rates used to digitize sound. (3 marks)
5. List two significant considerations that must be taking when developing multimedia applications for the Web. (2 marks)
6. Define Rendering. (1mark)
7. List the elements of multimedia. (5 marks)
8. To ensure that text is displayed in the desired way, what does the web page designer uses? (2 marks)
9. Why is it that Bitmap graphics are often used with photographic images? (2 marks)
10. How do we obtain the best results when developing multimedia? (3 marks)

**TOTAL MARKS 27**

## Section B

### PART 1

10. Explain the different types of keyboards. (6 marks)
11. List and explain the tips that one should follow when using sound on the web. (12 marks)
12. What input and output devices would you use for the following systems? For each, compare and contrast alternatives, and if appropriate indicate why the conventional keyboard, mouse and CRT screen may be less suitable. (10)
  - a. Portable word processor
  - b. Tourist information systems
  - c. worldwide personal communications system

13. Explain briefly about software for working with graphics. (10 marks)
14. Illustrate digitizing an analog video signal. (6 marks)
15. List and explain the two types of video compression. (6 marks)
16. Explain briefly on the following elements of multimedia text, graphics and animation. (16 marks)
17. Multimedia is applied in so many areas in life. Explain briefly in areas where multimedia is applied. (7 marks)

TOTAL MARKS 73

## PART 2

10. Explain about the short term memory and long term memory in human? (8 marks)
11. There are essentially two types of video transfer through the Internet. Discuss the two types of video transfer through the Internet. (8 marks)
12. Explain about the designing experience? Differentiate virtual crackers and real crackers? (10 marks)
13. Explain briefly about multimedia authoring tools. (10 marks)
14. Explain in detail about Musical Instrument Digital Interface (MIDI). (5 marks)
15. Explain in detail about the elements in WIMP interface. (10 marks)
16. Explain briefly about multimedia on the web and the growth of multimedia. (9 marks)
17. Explain briefly about Multimedia computer playback systems. (12 marks)

TOTAL MARKS 73

**THE UNIVERSITY OF ZAMBIA  
SCHOOL OF NATURAL SCIENCES  
2012 ACADEMIC YEAR  
FIRST SEMESTER FINAL EXAMINATIONS  
EM411: ENGINEERING MATHEMATICS V**

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**INSTRUCTIONS :** There are six questions in this examination paper. Answer any five questions. Show all intermediate work.

**MAXIMUM TIME ALLOWED:** Three (3) hours.

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- Q1    a.    (i)    Expand  $\ln(1+x)$  as a Taylor polynomial of order four about  $x_0 = 1$
- (ii)    Obtain a bound on the error when approximating  $\ln(1.2)$  using the polynomial of part (i).
- b.    (i)    Show graphically that the equation  $e^{-x} = 3 \ln x$  has only one root and that root is larger than one.
- (ii)    Use Newton Raphson method and initial approximation  $p_0 = 1.1$  to estimate the true root  $p$  of equation described in part (i) to a precision of  $10^{-3}$ .
- c.    Suppose the Bisection method is to be applied to the equation of part (b) with initial interval  $[1, 2]$  to approximate the solution to an accuracy of  $10^{-3}$ , find the minimum number of iterations needed if a bound on the true error in the usual sense is  $(b_n - a_n)/2^n$ .
- Q2    a.    The system of equations
- $\ln(x^2 + y) - 1 + y = 0, \quad \sqrt{x} + xy = 0$
- has an approximate solution  $(x_0, y_0) = (2.4, -0.6)$ . Carry out one iteration of Newton Raphson method to improve this approximation.
- b.    Solve the following system of equations by Gauss Elimination method
- $4u - v = 1, \quad -u + 4v - w = 0, \quad -v + 4w - z = 0, \quad -w + 4z = 0$
- c.    Apply Gauss Seidal method to approximate the solution of the following system of equations, within a precision of  $10^{-2}$  starting with initial approximation  $X_0 = (0, 0, 0)$
- $x_1 + 4x_2 + x_3 = 2, \quad 4x_1 + x_2 = 1, \quad x_2 + 4x_3 = 3$

- Q3 a. (i) Find the Newton forward difference polynomial fitted to the following data

x	0.1	0.2	0.3	0.4	0.5
f(x)	1.4	1.56	1.76	2.0	2.28

- (ii) Interpolate f(x) at x= 0.25  
 (iii) Use the polynomial derived in a(i) to find approximate values of  $f'(0.1)$  and  $f''(0.1)$ .

- b. In the following table,  $\Theta$  is the observed temperature in degrees centigrade of cooling water in a vessel, t is the time in minutes from the beginning of observation

t	1	3	7
$\Theta$	85.3	74.5	60.5

Find the approximate rate of cooling at t=5 using the three point formula

$$f'(x_0) = \frac{f(x_0+h) - f(x_0-h)}{2h}$$

- c. Using  $\sin(0.1) = 0.09983$  and  $\sin(0.2) = 0.19867$ , find an approximate value of  $\sin(0.15)$  by Lagrange interpolation and obtain a bound on the truncation error.

- Q4 a. Find an approximate value of the integral  $\int_0^\pi e^{\cos x} dx$  by partitioning the interval  $[0, \pi]$  into eight subintervals of equal width and applying the composite Trapezoidal rule.  
 b. Determine the number of equal width subintervals required to partition the interval  $[0, \pi]$  to approximate the integral  $\int_0^\pi \sin^2 x dx$  within six correct decimal places by Simpson's rule.

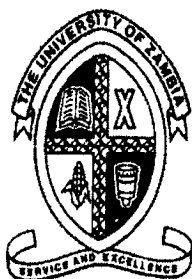
You are given that the error associated with Simpson's rule is

$$-\frac{(b-a)h^4}{180} f^{iv}(c), a \leq c \leq b, \text{ where all terms follow usual meaning.}$$

- c. Using the following formulae for Runge Kutta method of order 4, find  $y(0.7)$  correct to four decimal places if  $y' = y - x^2$ ,  $y(0.6) = 1.7379$ ,  $h = 0.1$   
 $k_1 = hf(t_i, w_i)$ ,  $k_2 = hf\left(t_i + \frac{h}{2}, w_i + \frac{k_1}{2}\right)$ ,  $k_3 = hf\left(t_i + \frac{h}{2}, w_i + \frac{k_2}{2}\right)$   
 $k_4 = hf(t_{i+1}, w_i + k_3)$ ,  $w_{i+1} = w_i + \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)$

- Q5 a. Given  $f(z) = |z|^2$ ,
- Express  $f(z)$  in the form  $u(x,y) + iv(x,y)$
  - Discuss that  $f(z)$  is continuous everywhere
  - Show that  $f(z)$  is nowhere analytic
- b. Compute  $\oint_C \frac{dz}{z}$  where C denotes
- the square described in the positive sense, having its centre at the origin, and each side is parallel to the coordinate axes and has length  $2a$
  - the circle  $|z| = 100$  traversed anti clock wise
- c. Evaluate  $\int_C R(z)dz$  where C denotes
- straight line joining 0 to  $1+i$
  - straight lines from 0 to  $i$  and from  $i$  to  $1+i$
  - straight lines from 0 to 1 and from 1 to  $1+i$
- Q6 a. (i) Show that the function  $f(z) = e^z$  is analytic everywhere
- find  $\frac{d}{dz}(e^z)$
  - find all roots of the equation  $e^z = -i$
  - evaluate  $\int_{1-i}^{1+i} e^z dz$
  - evaluate  $\oint_C e^z dz$ , where C is a triangle oriented in the positive sense and having vertices at 0,  $1+i$  and  $2-i$
- b. (i) show that  $\sin^2 z + \cos^2 z = 1$
- find zeros of the function  $f(z) = \cos z$
  - evaluate  $\oint_C \frac{\sin z}{z - \frac{\pi}{2}} dz$ , where C is a unit circle centered at  $c_0 = \frac{\pi}{2}$  and oriented anti clock wise
- c. (i) find the values of  $z$  for which  $\text{Ln}(z + 1) = \pi i$
- find the principal value of  $2^{2i}$

----- End of Examination -----



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

**ELECTRONICS FOR COMPUTING 1**

**END OF SEMESTER EXAMINATION**

**Time Allowed: 3 Hours**

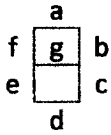











**Date of Examination: 13<sup>th</sup>, March 2013.**

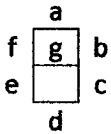





**INSTRUCTIONS**

1. This paper contains two sections namely **Section A** and **B**.
2. Section A contains **two** questions which are **Compulsory**.
3. Section B contains **THREE** questions of which you are expected to answer **any two** questions of your choice.
4. Please write as clearly as possible as illegible handwriting cannot be marked.
5. Number the answers to the questions clearly before answering

## SECTION A [30 Marks]

### Truth Table

#	Code Input to Decoder (4 Bits)				Display Number	Output of the Seven Segment Display Decoder (7 Bits)						
No.	D	C	B	A		a	b	c	d	e	f	g
0	0	0	0	0		1	1	1	1	1	1	0
1	0	0	0	1		0	0	0	0	1	1	0
2	0	0	1	0		1	1	0	1	1	0	1
3	0	0	1	1		1	1	1	1	0	0	1
4	0	1	0	0		0	1	1	0	0	1	1
5	0	1	0	1		1	0	1	1	0	1	1
6	0	1	1	0		1	0	1	1	1	1	1
7	0	1	1	1		1	1	1	0	0	0	0
8	1	0	0	0		1	1	1	1	1	1	1
9	1	0	0	1		1	1	1	1	0	1	1
10	1	0	1	0		1	1	1	0	1	1	1

#	Code Input to Decoder (4 Bits)				Display Number	Output of the Seven Segment Display Decoder (7 Bits)						
No.	D	C	B	A		a	b	c	d	e	f	g
11	1	0	1	1		1	1	1	1	1	1	1
12	1	1	0	0		1	0	0	1	1	1	0
13	1	1	0	1		1	1	1	1	1	1	0
14	1	1	1	0		1	0	0	1	1	1	1
15	1	1	1	1		1	0	0	0	1	1	1

### Question 1:

Using Karnaugh Maps, write the equations for each output (a,b,c,d,e,f,g), that were used to draw the electronic circuit shown below. [28 Marks]

BA \ DC	00	01	11	10
00				
01				
11				
10				

a =

BA \ DC	00	01	11	10
00				
01				
11				
10				

b =

BA \ DC	00	01	11	10
00				
01				
11				
10				

c =

BA \ DC	00	01	11	10
00				
01				
11				
10				

d =

BA \ DC	00	01	11	10
00				
01				
11				
10				

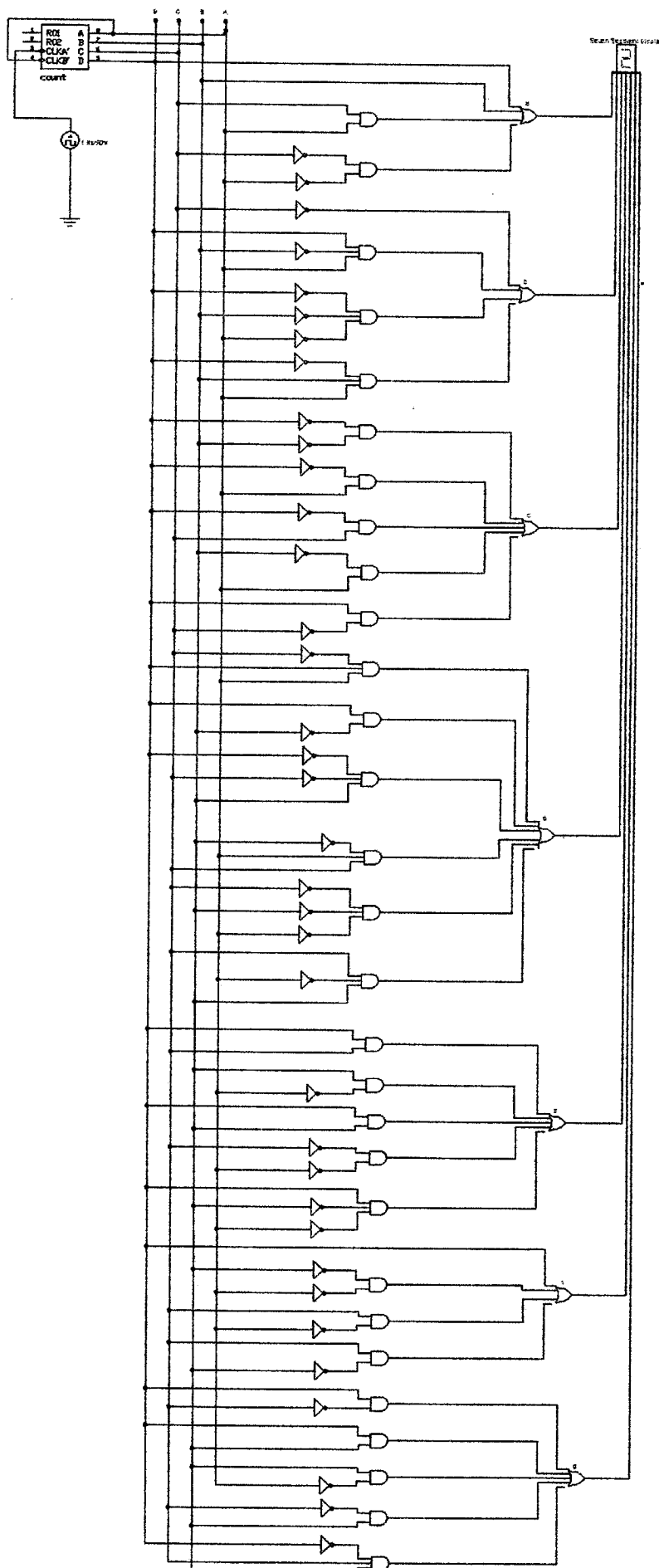
e =

BA \ DC	00	01	11	10
00				
01				
11				
10				

f =

BA \ DC	00	01	11	10
00				
01				
11				
10				

g =



**Question 2:**  
Identify and Label all the  
Outputs in circuit. [2 Marks]

## SECTION A [70 Marks]

### QUESTION 1

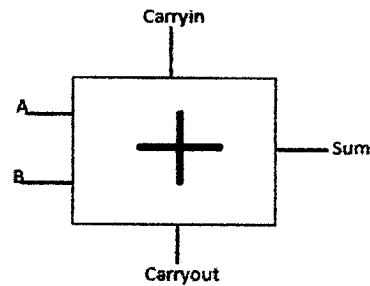
Design a digital circuit that will produce programmed output signals to enable the lift(elevator) mounted in a 15 floored building to stop automatically on all even-numbered floors (0,2,4,6,8,10,12,14)

- ✓ Truth table [10 Marks]
- ✓ Karnaugh maps [15 Marks]
- ✓ Digital circuit [10 Marks]

### QUESTION 2

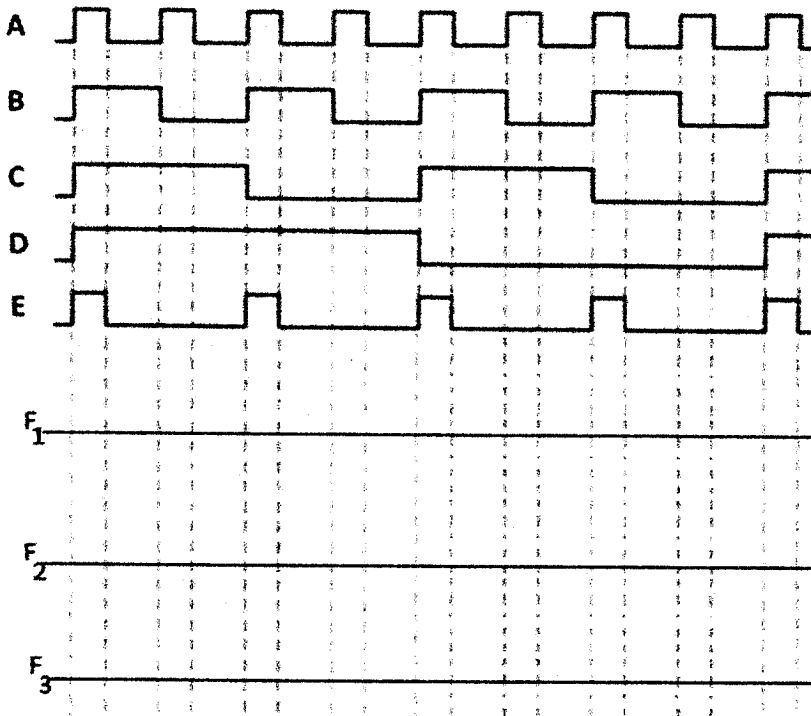
Design a digital circuit of a 1-bit adder that will have 3 inputs (A,B,Carryin) and two outputs (Sum,Carryout). This will be able to add any 2 bits and taking into consideration that the Carryin input can either be a 1 or 0.

- ✓ Truth table [20 Marks]
- ✓ Karnaugh maps [10 Marks]
- ✓ Digital circuit [5 Marks]

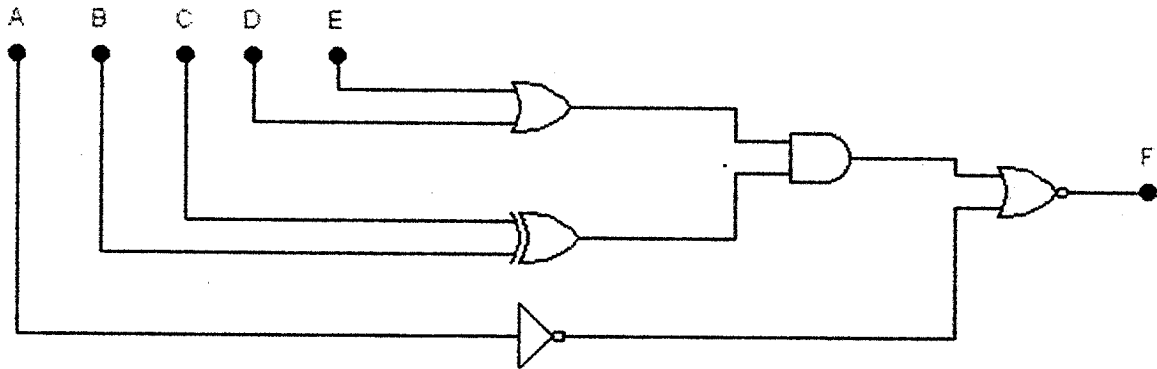


### QUESTION 3

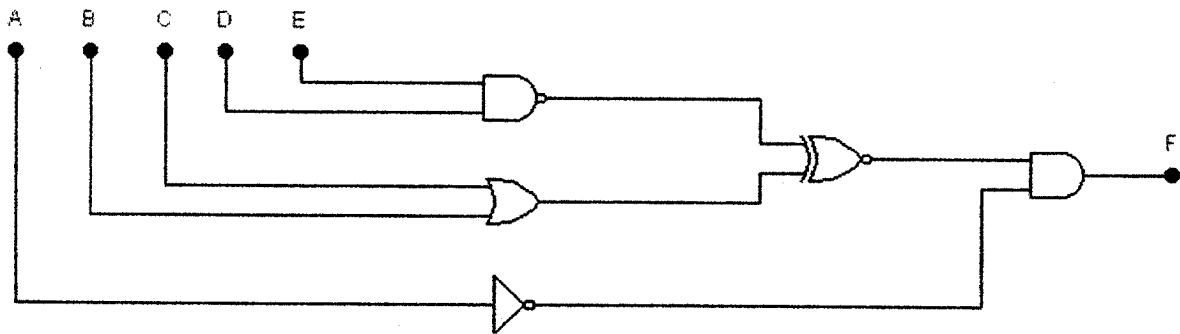
Using the input signal (A, B, C, D and E) below, determine the output signal F for each of the digital circuit diagrams 1, 2 and 3. [35 Marks]



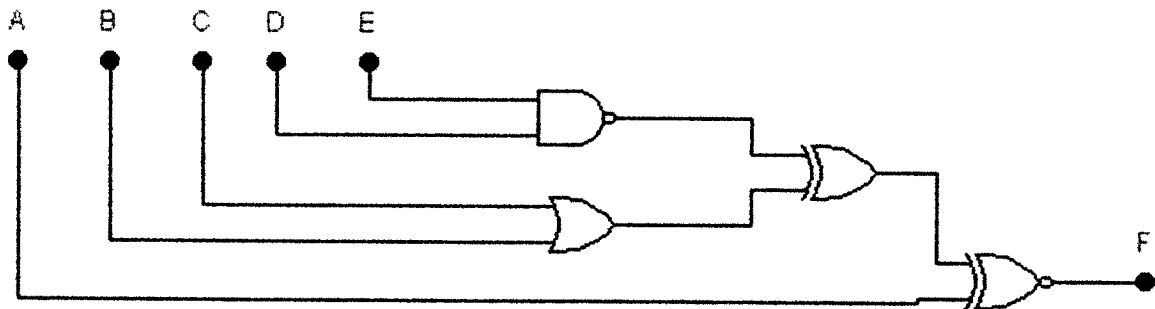
1



2



3



End of Exam!

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

**2011 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS  
GEO 5702: ADVANCED QUANTITATIVE TECHNIQUES IN GEOGRAPHY II**

**TIME:**                      **Three hours**

**INSTRUCTIONS:**    **Answer any THREE questions**  
                              **All questions carry equal marks**

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1. A popularly held belief about university professors is that they do not work very hard and that the higher their rank, the less work they do. A statistics student decided to determine whether the belief is true. She took a random sample of 20 university academic staff in each of the faculties of business, engineering, arts and sciences. In each sample of 20, five were instructors, five were assistant professors, five were associate professors, and five were full professors. Each academic member of staff was interviewed and asked to report confidentially the number of weekly hours of work. These data are stored in file Xr14-52 in the following way:

Column B: hours of work for business professors (first five rows = instructors, next five rows = assistant professors, next five rows = associate professors, and last five rows = full professors).

Column C: hours of work for engineering professors (same format as column B).

Column D: hours of work for arts professors (same format as column B).

Column E: hours of work for science professors (same format as column B).

Can we infer that differences exist in weekly hours of work in the different faculties among the different categories of the workers?

2. Answer this question using the data provided in the file helping2.sav. In this file which has *N* of 517, self-efficacy (belief that one has the ability to help effectively) was measured by 15 questions, each paired with an amount-of-help question that measured a particular type of helping.

There were three categories of help represented in the 15 questions: six questions were intended to measure empathic types of helping; four questions were intended to measure informational types of helping; four questions were intended to measure ("doing things")

types of helping; and the fifteenth question was open-ended to allow any additional type of help to be inserted.

Conduct factor analysis on the 15 self-efficacy questions (effect1 to effect15) to determine the number of factors that would be obtained. Use the Varimax rotation option and you are required to conduct Parallel Analysis.

To aid in the interpretation of the rotated factor matrix the three categories of efficacy each efficacy variable was intended to test are listed below:

[Emot]	Efficacy for emotional types of helping
[Inf]	Efficacy for informational types of helping
[Instr]	Efficacy for instrumental types of helping
[-----]	The open-ended question

3. A developer who specializes in summer cottage properties is considering purchasing a large tract of land adjoining a lake. The current owner of the tract has already subdivided the land into separate building lots by removing some of the trees. The developer wants to forecast the value of each lot. From previous experience, she knows that the most important factors affecting the price of the lot are size, number of mature trees, and distance to the lake. From a nearby area, she gathers the relevant data for 60 recently sold lots. The data are stored in file Xr18-01. (Column A = price in thousands of dollars, column B = lot size in thousands of square feet, column C = number of mature trees, and column D = distance to the lake in feet.

Conduct a regression analysis and interpret your results.

4. Applicants to law schools take the Law School Admission Test (LSAT). There are several companies that offer assistance in preparing for the test. To determine whether they work, and if so, which one is best, an experiment was conducted. Several hundred law school applicants were surveyed and asked to report their LSAT score and which if any LSAT preparation course they took. The scores are stored in file Xr14-12 using the following format:

Column A: LSAT score for applicants with preparatory course A  
Column B: LSAT score for applicants with preparatory course B  
Column C: LSAT score for applicants with preparatory course C  
Column D: LSAT score for applicants with no preparatory course

Do these data allow us to infer that there are differences between the four groups of LSAT scores?

5. Use data provided in Table 1 to smooth time series to determine the time series for precipitation for a 15 month period.

**Table 1: Precipitation (millimeters) for a period of 15 months**

Month	Precipitation	Total	Running Mean	Period
January	360			
February	368			
March	1428			Jan - May
April	904			Feb - June
May	1428			Mar - July
June	776			Apr - Aug
July	1168			May - Sept
August	1348			June - Oct
September	848			July - Nov
October	284			Aug - Dec
November	692			Jan - May
December	580			
January	376			
February	837			
March	410			
April	376			
May	1012			

- a) Calculate the running means for the five months periods for data provided in Table 1.
- b) Use precipitation data for each month as well as for the running means to plot precipitation data.
- c) Interpret your diagram and explain why the analysis you have conducted above does not represent a Zambian scenario.

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END OF EXAMINATION