

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2017/~~2018~~ ACADEMIC YEAR

1. C 2615 BASIC PHYSICAL CHEMISTRY
2. CHE 2522 FUNCTIONAL GROUP AND ARENE CHEMISTRY
3. CHE 4102 BIOCHEMISTRY RESEARCH TECHNIQUES
4. CHE 4211 ANALYSIS OF INORGANIC COMPOUNDS
5. CHE 4511 SYNTHETIC REACTIONS, NEIGHBOURING GROUPS AND
CHEMOTHERAPEUTIC AGENTS
6. CHE 4822 INORGANIC INDUSTRIAL CHEMISTRY II
7. CSC 2901 DISCRETE STRUCTURES
8. GES 1310 INTRODUCTION TO GEOGRAPHY
9. GES 2130 THE GEOGRAPHY OF AFRICA WITH SPECIAL REFERENCE TO
ZAMBIA
10. GES 3262 BIOGEOGRAPHY
11. GES 4342 ENVIRONMENT AND NATURAL RESOURCE MANAGEMENT
12. GES 4451 CARTOGRAPHY
13. GES 4461 LAND RESOURCES SURVEY
14. ICT 1110 COMPUTER SYSTEMS AND ARCHITECTURE
15. MAT 1100 FOUNDATION MATHEMATICS
16. MAT 3110 ENGINEERING MATHEMATICS II
17. MAT 3300 REAL ANALYSIS
18. MAT 3622 LINEAR REGRESSION

19. MSE 9040 ADVANCED BIOLOGY TEACHING METHODS
20. PHY 2112 ATOMIC PHYSICS, MAGNETISM IN MATTER
21. PHY 2522 ANALYTICAL MECHANICS AND SPECIAL THEORY OF
RELATIVITY

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

**2017 ACADEMIC YEAR
FINAL EXAMINATIONS**

**BIO 1401: BIOMOLECULES AND CELLS
THEORY PAPER**

TIME: THREE HOURS

Instructions:

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

DO NOT TURN OVER UNTIL YOU ARE TOLD TO DO SO.

1. Choose the **correct** statement.
 1. An atomic orbital can have a maximum of two shells.
 2. An atomic shell can have a maximum of two atomic orbitals.
 3. The second atomic shell can have a maximum of eight electrons.
 4. The first atomic shell can be occupied by a maximum of three orbitals.
 5. The 's' orbital has higher energy than the 'p' orbital of the same shell.
 6. I do not know.

2. Choose the **correct** statement.
 1. The first atomic orbital to be filled by electrons is the '1p'.
 2. The first three electrons in the 'p' orbitals of the second shell will be unpaired.
 3. The '1s' atomic orbital can have a minimum of two protons.
 4. The function of neutrons is to neutralise electrons in the atom.
 5. The hydrogen atom has two electrons in its shell.
 6. I do not know.

3. Determine the maximum number of electrons in the second shell of an atom.
 1. Two
 2. Four
 3. Six
 4. Eight
 5. Ten
 6. I do not know.

4. Determine the number of valence electrons in an atom with an atomic number of seventeen?
 1. Three
 2. Four
 3. Five
 4. Six
 5. Seven
 6. I do not know.

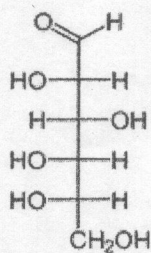
5. Choose the **correct** statement.
 1. Nitrogen gas contains two atoms linked together through covalent double bonds.
 2. Water contains one oxygen atom linked to two hydrogen atoms through hydrogen bonds.
 3. Carbon dioxide has a carbon atom linked to two oxygen atoms through ionic double bonds.
 4. Sodium chloride contains sodium linked to a chloride through an ionic bond.
 5. A hydrogen bond can only be formed between two water molecules.
 6. I do not know.

6. A double covalent bond refers to sharing of ... electron(s).
 1. one
 2. two
 3. three
 4. four
 5. five
 6. I do not know.

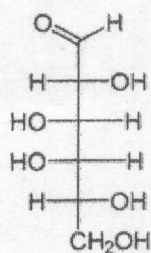
7. In a water molecule, the non-bonding electron(s) in oxygen is/are ...
1. one.
 2. two.
 3. three.
 4. four.
 5. five.
 6. I do not know.
8. Which of the following statements describes a covalent bond between carbon and oxygen.
1. The electrons are shared equally between carbon and oxygen atoms.
 2. Electrons in the bond are closer to the carbon nucleus.
 3. Each atom in the molecule keeps its electrons.
 4. Electrons in the bond are closer to the oxygen nucleus.
 5. The electrons in the molecule are evenly distributed.
 6. I do not know.
9. Identify the **correct** description of a hydrogen bond.
1. A bond between oxygen and hydrogen atoms of the same water molecule.
 2. A bond between oxygen of water and nitrogen of other molecules like ammonia.
 3. A bond between oxygen and hydrogen of different water molecules.
 4. A bond between two hydrogen atoms of different molecules.
 5. Options 2 and 3 above are correct.
 6. I do not know.
10. Choose the statement which distinguishes liquid water from ice.
1. In liquid water, each molecule is surrounded by four other molecules.
 2. In liquid water, molecules are more densely packed.
 3. In liquid water, the molecules are arranged in a regular pattern.
 4. In ice the hydrogen bonds between molecules constantly make and break.
 5. In liquid water, molecules are less densely packed.
 6. I do not know.
11. Capillarity of water in a vessel depends on ...
1. adhesion.
 2. water's density properties.
 3. cohesion.
 4. 1 and 2 above.
 5. 1 and 3 above.
 6. I do not know.
12. The meniscus of water in a narrow tube...
1. curves upwards due to high cohesive forces between water molecules.
 2. is flat because of the force of gravity.
 3. curves downwards due to cohesive forces between water molecules.
 4. is flat because of the high surface tension.
 5. curves downwards due to adhesive forces between water molecules and the tube wall.
 6. I do not know.

13. Which of the following statements is true about water?
1. Hydrogen bonds are a result of electrical attraction between water molecules.
 2. Water is capable of sticking to the sides of glass using cohesive forces.
 3. Water molecules form spheres on a polar surface.
 4. Water is a polar molecule because the electrons on oxygen and hydrogen are equally shared.
 5. Adhesive forces help water to stick together.
 6. I do not know.
14. Which of the following statements is **not true** about water?
1. When water boils covalent bonds are broken.
 2. Water molecules are hydrophilic.
 3. A water molecule is not linear.
 4. Water is an excellent solvent for polar substances.
 5. Water has a very high latent heat of vaporisation.
 6. I do not know.
15. Choose the statement that is **correct** in relation to isomerism in monosaccharides.
1. D and L galactose are structural isomers of each other.
 2. Glucose and fructose are optical isomers of each other.
 3. Alpha glucose and beta galactose are stereoisomers of each other.
 4. The open chain and ring form of glucose are optical isomers of each other.
 5. Galactose and fructose are stereoisomers of each other.
 6. I do not know.
16. Choose the statement that is **correct** in relation to ring formation in monosaccharides.
1. Carbon 4 combines with carbon 1 of the ribose open chain to form a pyranose ring.
 2. Carbon 4 combines with carbon 1 of the glucose open chain to form a furanose ring.
 3. Carbon 2 combines with carbon 1 of the galactose open chain to form a pyranose ring.
 4. Carbon 4 combines with carbon 1 of the fructose open chain to form a pyranose ring.
 5. Carbon 4 combines with carbon 1 of the deoxyribose open chain to form a furanose ring.
 6. I do not know.
17. The formula $C_3H_6O_3$ represents...
1. a disaccharide.
 2. a hexose sugar.
 3. glyceraldehyde.
 4. deoxyribose.
 5. fructose
 6. I do not know.
18. Which of the following molecules is used for the synthesis of nucleic acids?
1. Disaccharides
 2. Oligosaccharides
 3. Polysaccharides
 4. Tetroses
 5. Pentoses
 6. I do not know

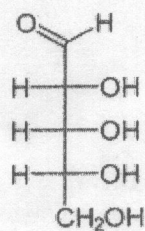
19. Study structures A, B and C and then choose the option that gives the **correct** match between the structure and its name.



A



B



C

#	Structure A	Structure B	Structure C
1	α -Galactose	β -Glucose	β -Ribose
2	β -Glucose	L-Fructose	L-Deoxyribose
3	L-Glucose	D-Galactose	D-Ribose
4	D-Galactose	D-Deoxyribose	L-Glucose
5	L-Ribose	β -Glucose	α -Fructose
6	I do not know		

20. Identify the carbon with a polar bond in dihydroxyacetone?
- One
 - Two
 - Three
 - Four
 - Six
 - I do not know.
21. Choose the statement that is **correct** in relation to the structure of disaccharides.
- Maltose is composed of β -glucose and α -glucose.
 - Sucrose has a glycosidic bond between C-1 of glucose and C-4 of fructose.
 - Lactose is composed of two α -glucose molecules.
 - Sucrose is composed of α -glucose and β -fructose.
 - Maltose is composed of α -glucose and β -fructose.
 - I do not know.
22. Choose the **correct** statement.
- Maltose is a non-reducing sugar because of the 1, 2 glycosidic bond.
 - Sucrose is a reducing sugar because it contains only two monosaccharides.
 - Lactose is a non-reducing sugar because it is animal milk.
 - Sucrose is a non-reducing sugar because of its 1, 2 glycosidic bond.
 - Options 1 and 2 are correct.
 - I do not know.

23. The most suitable molecule for translocation of carbohydrates in plants is ...
1. sucrose.
 2. cellulose.
 3. galactose.
 4. glycogen.
 5. starch.
 6. I do not know.
24. Milk sugar is made from ...
1. maltose and fructose.
 2. sucrose and galactose.
 3. glucose and fructose.
 4. glucose and galactose.
 5. galactose and galactose.
 6. I do not know.
25. Choose the **correct** statement.
1. Branching is important in the function of structural polysaccharides.
 2. An energy storage polysaccharide should be fibrous in nature.
 3. Amylopectin is highly branched and hence more difficult to digest than cellulose.
 4. The structure of glycogen is similar to that of amylopectin.
 5. Amylose gives a blue-black colour with iodine solution.
 6. I do not know.
26. Choose the **correct** statement.
1. Amylose has α -1, 4 and β -1, 4 glycosidic bonds.
 2. Amylopectin has α -1, 4 and β -1, 6 glycosidic bonds.
 3. Cellulose has α -1, 4 and β -1, 4 glycosidic bonds.
 4. Amylose has α -1, 4 and β -1, 4 glycosidic bonds.
 5. Amylose has α -1, 6 glycosidic bonds.
 6. I do not know.
27. The complete hydrolysis of amylopectin yields ...
1. amylose.
 2. galactose.
 3. glucose
 4. fructose.
 5. starch
 6. I do not know.
28. Which of the following statements is **true**?
1. Polysaccharides are chemically reactive substances.
 2. Amylose is a starch.
 3. Carbon one is the asymmetric carbon in glucose.
 4. Starch, glycogen and cellulose are oligosaccharides.
 5. Sucrose has its asymmetric carbon free for further chemical reactions.
 6. I do not know.

29. The hydrolysis of lipids produces ...
1. glucose.
 2. glycerol.
 3. fatty acids.
 4. amino acids.
 5. (2) and (3) above
 6. I do not know.
30. How many electrons are there in the third shell of the atom with atomic number 23?
1. 8
 2. 13
 3. 03
 4. 10
 5. 11
 6. I do not know.
31. The number of electrons in the highest energy level of calcium, atomic number is 20.
1. 8
 2. 6
 3. 5
 4. 4
 5. 2
 6. I do not know.
32. Water is liquid at room temperature because of ... of water.
1. the high boiling point
 2. the high melting point
 3. the high heat of vaporisation
 4. adhesive forces
 5. both 1 and 2.
 6. I do not know.
33. Polar molecules can readily dissolve in water because...
1. polar molecules can form hydrogen bonds with water
 2. polar molecules can replace water-water interaction with more energy provided
 3. water can interact with charged solute molecules
 4. all molecules form solutions with water.
 5. of both options 1 and 3.
 6. I do not know
34. The most important reason for the unique shape of water is ...
1. the covalent bonding pattern in water molecules.
 2. the bond angle between the two hydrogen atoms in water.
 3. the presence of a lone pair of electrons in water.
 4. that water can be ionised at room temperature.
 5. All options above are correct.
 6. I do not know.

35. Hydrogen bonds can be expected to form only between hydrogen and ...
1. carbon.
 2. hydrogen.
 3. oxygen.
 4. nitrogen.
 5. Options 3 and 4.
 6. I do not know.
36. Adhesive forces lead to ... which is the process through which water is absorbed into roots of plants.
1. surface tension
 2. polarity
 3. formation of a tough film of water
 4. elasticity of water
 5. capillary action
 6. I do not know.
37. Which one of the following represents functional groups in carbohydrates?
1. Alcohol and Carboxyl groups
 2. Aldehyde and Ketone groups
 3. Hydroxyl and hydrogen groups
 4. Carboxyl and amine groups
 5. Carbon and hydrogen groups
 6. I do not know.
38. Which of the following is a **true** statement about glucose?
1. It is used for storage of energy.
 2. It has four asymmetric carbon atoms.
 3. It is stored as starch in animals.
 4. It has six asymmetric carbon atoms.
 5. It is oxidized to form fructose.
 6. I do not know.
39. Which of the following is a carbohydrate with six carbon atoms and a keto group as its functional group?
1. Glyceraldehyde
 2. Dihydroxyacetone
 3. Galactose.
 4. Fructose
 5. Ribose
 6. I do not know
40. Choose the **correct** statement(s).
1. Collagen is a globular protein consisting of three polypeptide chains.
 2. The beta-pleated sheet is found in fibrous proteins.
 3. Haemoglobin is a fibrous protein with a quaternary structure.
 4. Statements 1 and 3 are correct.
 5. Statements 2 and 3 are correct.
 6. I do not know.

41. The peptide bond in a dipeptide is located between the ... group and the ...
1. amine/ α carbon.
 2. alkyl group /C=O group.
 3. carboxylic/ alkyl group.
 4. C=O/ N-H group.
 5. carboxylic/ α carbon.
 6. I do not know.
42. Hydrogen bonding between neighbouring beta pleated sheets is between ... and ...
1. oxygen/ an alkyl group.
 2. nitrogen/ hydrogen.
 3. hydrogen/ oxygen.
 4. hydrogen/ an alkyl group.
 5. hydrogen/ hydrogen.
 6. I do not know.
43. Choose the true statement.
1. All enzymes have the same optimum pH and temperature.
 2. All enzymes have the same optimum pH but different optimum temperatures.
 3. All enzymes have different optimum pH values but the same optimum temperature.
 4. Enzymes have different optimum pH values and different optimum temperatures.
 5. Some enzymes have optimum temperature and pH values while others do not.
 6. I do not know.
44. The effect of a reversible competitive inhibitor can be nullified by ...
1. decreasing the product concentration.
 2. increasing the substrate concentration.
 3. increasing the temperature.
 4. decreasing the temperature.
 5. increasing pH.
 6. I do not know.
45. Study Figure 1 below and answer the question that follows.

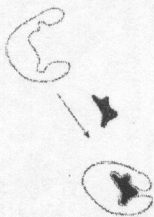


Figure 1. Model of the enzyme active site.

Choose the statement which is **false** about the model in Figure 1.

1. Figure 1 shows the induced-fit model.
2. The active site fits the substrate tightly after binding.
3. In this model, the enzyme is the 'lock' while the substrate is the 'key'.
4. The structure of the active site changes slightly as it binds the substrate.
5. The active site can bind a number of different but closely related substrates.
6. I do not know.

46. Study Figure 1 below and answer the question that follows.

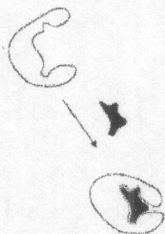


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 5. The active site can bind a number of different but closely related substrates.
 6. I do not
47. Which of the following statements is **true**?
1. DNA bases vary from one species to another.
 2. DNA bases change with the age of the organism.
 3. DNA bases are different in different tissues of an organism.
 4. All cells are made up of the same type of DNA bases.
 5. All the above statements are true.
 6. I do not know.
48. DNA is a polyanion because of the presence of ...
1. carboxylic groups.
 2. deoxyribose sugars.
 3. purine bases.
 4. pyrimidine bases.
 5. phosphate groups.
 6. I do not know.
49. The condensation of a nitrogenous base with a pentose sugar results in a ...
1. **nucleoside.**
 2. nucleotide.
 3. nucleic acid.
 4. ribonucleic acid.
 5. 3 and 4 above.
 6. I do not know.
50. A nucleotide has a ...
1. pentose sugar, a phosphate and an amino acid.
 2. glycosidic bond and a phosphoester bond.
 3. pentose sugar, a phosphate and a lipid.
 4. pentose sugar, an amino acid and a nitrogenous base.
 5. glycosidic bond and a phosphodiester bond.
 6. I do not know.

51. Choose the **correct** statement(s).
1. Purines are single ringed structures.
 2. Pyrimidines are two ringed structures.
 3. Adenine and thymine are examples of pyrimidines.
 4. Uracil, cytosine and thymine are examples of pyrimidines.
 5. All the above statements are correct.
 6. I do not know.
52. The reaction between a pentose sugar and nitrogenous base results in the formation of a(n) ...
1. nucleotide.
 2. ester bond.
 3. nucleic acid.
 4. glycosidic bond.
 5. 1 and 3 above.
 6. I do not know.
53. The sedimentation coefficient of a complete ... ribosome is ... while its large subunit is...
1. eukaryotic/70S/50S.
 2. prokaryotic/50S/20S.
 3. eukaryotic/80S/60S.
 4. prokaryotic/80S/50S.
 5. eukaryotic/60S/40S.
 6. I do not know.
54. During synthesis of a DNA strand, the incoming nucleotide attaches at the...
1. phosphate end of the nucleotide.
 2. 5' end of the growing chain.
 3. 3' end of the nucleotide.
 4. 2' end of the growing chain.
 5. phosphate end of the growing chain.
 6. I do not know.
55. In the DNA molecule ... normally pairs with ... through a ... hydrogen bond.
1. thymine/adenine/triple
 2. uracil/adenine/double bond
 3. guanine/cytosine/double
 4. adenine/guanine/triple
 5. thymine/adenine/double
 6. I do not know.
56. Choose the **false** statement.
1. RNA can be used for temporal storage of genetic material.
 2. DNA is used for long-term storage of genetic material.
 3. RNA is a single strand of nucleotide units.
 4. Transfer RNA carries a codon.
 5. Messenger RNA carries codons.
 6. I do not know.

57. The sugar in RNA is ..., whereas the sugar in DNA is ...
1. deoxyribose/ribose.
 2. ribose/deoxyribose.
 3. ribose/phosphate.
 4. ribose/fructose.
 5. glycerol/cholesterol.
 6. I do not know.
58. The ... end of tRNA is used by the acceptor arm to receive its amino acids.
1. 1'
 2. 2'
 3. 3'
 4. 4'
 5. 5'
 6. I do not know.
59. Which of the following is **not** a characteristic of eukaryotes?
1. DNA
 2. Cell membrane
 3. Cell wall
 4. Endoplasmic reticulum
 5. Plasmid
 6. I do not know.
60. In bacteria, respiration is performed by the ... membrane.
1. vesicle
 2. lysosomal
 3. ribosomal
 4. plasma
 5. mitochondrial
 6. I do not know.
61. Choose the **correct** statement.
1. Bacterial cells use flagella to stick to other bacterial cells.
 2. Bacteria use pili for movement.
 3. Plasmids are DNA on their own.
 4. Lysosomes control all metabolic activities of a cell.
 5. Bacteria do not have a true nucleus but have a structure called a nucleolus.
 6. I do not know.
62. The bacterial cell wall is made up of ...
1. chitin.
 2. cellulose.
 3. wax.
 4. peptidoglycan.
 5. cellulose and chitin.
 6. I do not know.

63. The rough endoplasmic reticulum is abundant in cells that synthesize...

1. carbohydrates.
2. lipids.
3. enzymes.
4. cholesterol.
5. nucleic acids.
6. I do not know

64. The smooth endoplasmic reticulum is abundant in cells that synthesize...

1. carbohydrates.
2. proteins.
3. enzymes.
4. lipids.
5. nucleic acids.
6. I do not know.

65. Which of the following correctly matches an organelle with its function?

#	Organelle	Function
1	mitochondrion	photosynthesis
2	nucleus	cellular respiration
3	ribosome	storage
4	lysosome	digestion
5	central vacuole	manufacture of lipids
6	I do not know	

66. The location where eukaryotic ribosomal RNA is produced is called ...

1. nucleoid.
2. nuclear membrane.
3. nucleolus.
4. Golgi complex.
5. centriole.
6. I do not know.

67. Choose the **false** statement.

1. Animal cells have mitochondria but no chloroplasts.
2. Animal cells have both mitochondria and Golgi body.
3. Plant cells have chloroplasts but no mitochondria.
4. Animal cells have ribosomes and lysosomes.
5. Plant cells have large vacuoles.
6. I do not know.

68. The functions of the central vacuole of plant cells include ...

1. regulating turgor pressure.
2. storing waste materials.
3. storing products of metabolism.
4. absorbing excess water.
5. All the functions above are correct.
6. I do not know.

69. The plasma membrane consists of ...
1. two layers of phospholipids with embedded proteins.
 2. a protein bilayer with embedded phospholipids.
 3. a phospholipid single layer with embedded proteins.
 4. a phospholipid bilayer with glycoproteins in between.
 5. two layers of lipoproteins with phospholipids in between.
 6. I do not know.
70. Choose the **correct** statement.
1. All life is made of cells.
 2. Cells are the smallest units of life.
 3. New cells come from pre-existing cells.
 4. Cells must remain small for them to be successful in the environment.
 5. All the statements above are correct.
 6. I do not know.
71. Chlorophyll is located in the ... of chloroplasts.
1. membrane
 2. cristae
 3. matrix
 4. cell wall
 5. in between the outer and inner membranes
 6. I do not know.
72. The backbone of DNA is...
1. hydrophilic.
 2. hydrophobic.
 3. neutral.
 4. both hydrophilic and hydrophobic.
 5. None of the above.
 6. I do not know
73. Thymidine 5' monophosphate ...
1. is a nucleotide of DNA.
 2. is replaced by uridine 5' monophosphate in RNA.
 3. normally forms two hydrogen bonds with adenosine 5' monophosphate.
 4. forms three hydrogen bonds with adenosine 5' monophosphate.
 5. The options 1, 2 and 3 are correct
 6. I do not know
74. Which molecule carries amino acids to ribosomes?
1. rRNA
 2. **tRNA**
 3. mRNA
 4. DNA
 5. RNA
 6. I do not know

75. Given that the sequence for one DNA strand is 5' TTCAGTACATTG 3', determine the sequence of the complementary strand.
1. 3' UUGCUTGTUUC 5'
 2. 3' AAGTCATGTAAC 5'
 3. 3' CCTUCCUTUAAAC 5'
 4. 5' CAATGTAAGTAA 3'
 5. 5' AAGTCATGTAAC 3'
 6. I do not know.
76. Choose the **correct** statement.
1. All cells are enclosed in a membrane that keeps internal conditions different from their environment.
 2. All cells can synthesise organic molecules.
 3. All cells have DNA as the genetic material.
 4. All cells can produce energy.
 5. All statements above are correct.
 6. I do not know.
77. Which of the following is a common feature of all cells?
1. Organelles
 2. Plasma membrane
 3. Nuclear membrane
 4. Centrioles
 5. Chloroplasts
 6. I do not know.
78. Which of the following statements is **true**?
1. Eukaryotic cells are simple while prokaryotic cells are complex.
 2. Eukaryotic cells do not have a nucleus while prokaryotic cells do.
 3. Prokaryotic cells are larger than eukaryotic cells.
 4. Prokaryotic cells existed before eukaryotic cells.
 5. Eukaryotic cells do not have lysosomes while prokaryotic cells do.
 6. I do not know.
79. Carbon has four (4) valence electrons because...
1. the electrons in the four '2p' orbitals are unpaired.
 2. the second shell has four '2s' orbitals.
 3. the electrons occupy the '2s' and '2p' orbitals.
 4. it has a total 8 electrons.
 5. it always forms four single bonds with other atoms.
 6. I do not know.
80. Which of the following is the correct order for filling electrons in orbitals?
1. 1s, 2s, 2p
 2. 2p, 2s, 1s
 3. 2s, 2p, 1s
 4. 1s, 2p, 2s
 5. 2p, 1s, 2s
 6. I do not know.

81. The number of orbitals in the second shell of an atom is ...
1. 1
 2. 2
 3. 3
 4. 4
 5. 5
 6. I do not know.
82. Which of the following statements is **true** regarding the electronegativity of atoms in a water molecule?
1. Hydrogen is more electronegative than oxygen.
 2. Hydrogen is less electronegative than oxygen.
 3. Electronegativity of hydrogen and oxygen is the same.
 4. Neither oxygen nor hydrogen is electronegative.
 5. None of the above.
 6. I do not know.
83. The formula $C_6H_{12}O_6$ represents ...
1. glycerol.
 2. lactose.
 3. maltose.
 4. sucrose.
 5. alpha and beta glucose.
 6. I do not know.
84. The structural difference in disaccharides is due to the...
1. number of hydrogen atoms.
 2. arrangement in its atoms.
 3. number of carbon atoms.
 4. number of oxygen atoms.
 5. Options 1 and 2 above.
 6. I do not know.
85. Which of the following is a storage polysaccharide?
1. Glycogen
 2. Wax
 3. Starch
 4. Cellulose
 5. Options 1 and 3 above.
 6. I do not know.
86. Which of the following is similar to starch?
1. Cellulose
 2. Glycogen
 3. Glucose
 4. Sucrose
 5. Wax
 6. I do not know.

87. Identify the bond associated with cellulose.
1. β (1-2) linkage
 2. β (1-4) linkage
 3. α (1-4) linkage
 4. α (1-2) linkage
 5. α (1-6) linkage
 6. I do not know
88. The following substances are lipid in nature except ...
1. glycerides.
 2. wax.
 3. cholesterol.
 4. fatty acids.
 5. insulin.
 6. I do not know.
89. Lysosomes are especially abundant in ... cells.
1. actively respiring
 2. protein synthesising
 3. secretory
 4. lipid synthesising
 5. carbohydrate synthesising
 6. I do not know.
90. Lysosomes...
1. destroy harmful bacteria engulfed by white blood cells.
 2. help to digest worn-out or damaged cellular particles.
 3. are double membrane organelles.
 4. can hydrolyse food in vacuoles.
 5. All the options above are correct.
 - 6 I do not know.
91. Many bacteria adhere to surfaces by structures called ...
1. cilia.
 2. mitochondria.
 3. flagella.
 4. pili.
 5. microtubules.
 6. I do not know
92. In eukaryotic cells, internal membranes ...
1. provide additional area for metabolic processes.
 2. form membrane-bound compartments called organelles.
 3. contain proteins essential for metabolic processes.
 4. increase a cell's total membrane area.
 5. All of the above are correct.
 6. I do not know.

93. The function of mitochondria is ...
1. intracellular transport of proteins.
 2. photosynthesis.
 3. intracellular digestion.
 4. cellular respiration.
 5. lipid synthesis.
 6. I do not know.
94. What is the main difference between prokaryotes and eukaryotes?
1. Prokaryotes do not reproduce.
 2. Prokaryotes do not have membrane-bound internal compartments.
 3. Prokaryotes have no DNA.
 4. Prokaryotes have no cytoplasm.
 5. Prokaryotes have no lysosomes.
 6. I do not know.
95. Which pyrimidine base contains an amino group at Carbon 4?
1. Thymine
 2. Cytosine
 3. Uracil
 4. Guanine
 5. Adenine
 6. I do not know.
96. At which carbon in the pentose sugar of a nucleotide is a base attached?
1. At the oxygen bridge
 2. At carbon 5
 3. At carbon 3
 4. At carbon 1
 5. At carbon 2
 6. I do not know.
97. The forces which hold two strands of DNA together are ...
1. electrostatic bonds.
 2. van der Waals.
 3. hydrogen bonds.
 4. covalent bonds.
 5. phosphodiester bonds.
 6. I do not know.
98. Which of the following is **true** about tRNA?
1. It carries the genetic code.
 2. It is a component of ribosomes.
 3. Some of its portions are double stranded
 4. It consists of two arms.
 5. It is a double helix.
 6. I do not know.

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

**2017 ACADEMIC YEAR
FINAL EXAMINATIONS**

**BIO 1412: MOLECULAR BIOLOGY AND GENETICS
THEORY PAPER**

TIME: THREE HOURS

INSTRUCTIONS

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

1. Choose the relationship which is true regarding the central dogma of molecular biology.
 1. DNA -- transcription → RNA -- translation → DNA -- replication → Protein.
 2. DNA -- replication → DNA -- transcription → RNA -- translation → Protein.
 3. RNA -- transcription → DNA -- translation → Protein -- modification → DNA
 4. RNA -- replication → RNA -- transcription → DNA -- translation → Protein.
 5. DNA -- transcription → RNA -- translation → Protein -- modification → DNA.
 6. I do not know.

2. During DNA replication nucleotides are added ...
 1. to both the 5' end and the 3' end of the DNA primer.
 2. either to the 5' end or to the 3' end of the RNA primer.
 3. to the 5' end of the RNA primer.
 4. to the 3' end of the RNA primer.
 5. to the 3' end of the DNA primer.
 6. I do not know.

3. The stages of DNA replication can be represented by the following order:
 1. Initiation, separation of daughter DNA, , proof reading, elongation.
 2. Separation of daughter DNA, initiation, elongation, proof reading.
 3. Initiation, separation of daughter DNA, elongation, proof reading.
 4. Elongation, initiation, separation of daughter DNA, proof reading.
 5. Initiation, elongation, proof reading, separation of daughter DNA.
 6. I do not know.

4. Choose the statement which is **false**.
 1. After replication, each daughter DNA contains one old strand and one new strand.
 2. In their experiment, Meselson and Stahl used *E.coli* cells.
 3. Meselson and Stahl initially grew *E.coli* cells in a medium containing nitrogen 15 isotope for many generations.
 4. Meselson and Stahl initially grew *E.coli* cells in a medium containing nitrogen 14 isotope for many generations.
 5. Meselson and Stahl analysed DNA samples using caesium chloride density-gradient equilibrium centrifugation.
 6. I do not know.

5. Choose the molecule which opens the DNA, creating a replication fork.
 1. DNA helicase
 2. DNA ligase
 3. DNA polymerase
 4. Single strand binding protein
 5. Topoisomerase
 6. I do not know.

6. At the end of the lagging strand DNA synthesis, ...
 1. phosphodiester bonds between adjacent nucleotides break.
 2. bonds between the nitrogen base and deoxyribose sugar break .
 3. the leading strand produces Okazaki fragments.
 4. hydrogen bonds between the nucleotides of the two strands break.
 5. DNA ligase catalyses the sealing of the gap between adjacent DNA fragments.
 6. I do not know.

7. Bacterial cells grown in a heavy nitrogen isotope and allowed to replicate three times in a culture of a light nitrogen isotope will show the following results:
 1. 100% heavy DNA
 2. 100% light DNA
 3. 50% hybrid and 50% heavy DNA
 4. 25% hybrid and 75% light DNA.
 5. 25% light, 25% heavy and 50% hybrid.
 6. I do not know.

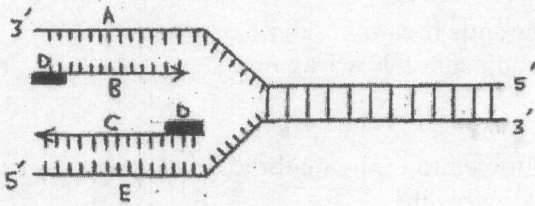
8. Choose the enzyme which is correctly matched with its function.

1	Topoisomerase	Causes the initial strand separation of template DNA
2	dnaA protein	Removes supercoiling from DNA
3	Helicase	Produces RNA primers
4	Primase	Separates the two DNA strands
5	Single strand binding protein	Prevents separated DNA strands from rejoining
6	I do not know.	

9. Which reaction in DNA replication is catalyzed by DNA ligase?
 1. Addition of new nucleotides to the lagging strand.
 2. Addition of new nucleotides to the leading strand.
 3. Base pairing of the template and the newly formed DNA strand.
 4. Formation of a phosphodiester bond between the 3' OH of one Okazaki fragment and the 5' phosphate of the next on the lagging strand.
 5. Synthesis of a short RNA primer complementary to DNA.
 6. I do not know.

10. The elongation of the leading strand during DNA synthesis
 1. progresses away from the replication fork.
 2. occurs in 3'→5' direction.
 3. produces Okazaki fragments.
 4. uses a DNA primer.
 5. depends on the action of DNA polymerase.
 6. I do not know.

11. The diagram given below shows the process of DNA replication at a replication fork. Study it and then answer the question that follows.



The strand labeled B is the

1. template strand.
 2. lagging strand.
 3. leading strand.
 4. Okazaki fragment.
 5. RNA primer.
 6. I do not know.
12. The first amino acid to be translated in prokaryotes is ...
1. methionine.
 2. valine.
 3. adenine.
 4. formyl methionine.
 5. cytosine.
 6. I do not know.
13. The last amino acid to be translated in prokaryotes is ...
1. methionine.
 2. formyl methionine.
 3. dependent on the mRNA sequence.
 4. dependent on the tRNA anticodon.
 5. the stop codon
 6. I do not know.
14. If the sequence of bases in non-template DNA is TAGC, then the corresponding sequence of bases in the transcribed RNA will be...
1. ATCG.
 2. TAGC.
 3. UAGC.
 4. AUGC.
 5. AUCG.
 6. I do not know.

15. Which of the following occurs in both eukaryotic and bacterial transcription?

1. 5' capping
2. Poly A tail
3. Promoter
4. Splicing
5. Nucleotide deletion
6. I do not know

16. Which of the following is **not** part of RNA processing in eukaryotes?

1. Addition of a 5' cap.
2. Addition of poly A tail
3. Intron removal.
4. Addition of an RNA primer.
5. Joining exons together.
6. I do not know

17. Choose the statement which represents the degeneracy of the genetic code.

1. The genetic code is very unstable.
2. The genetic code is the same for all organisms.
3. Two or more codons may specify one amino acid.
4. Two or more amino acids may be specified by one codon.
5. Each codon consists of three nucleotides.
6. I do not know.

18. Which position of a codon is said to wobble?

1. First
2. Second
3. Third
4. Fourth
5. 1 and 2
6. I do not know.

19. Which of the following is **not** a property of the genetic code?

1. Triplet
2. Degenerate
3. Non-overlapping
4. Universal
5. Ambiguous
6. I do not know.

20. Of the different possible codons of the genetic code,specify amino acids and signal stop.
1. 20, 17, 3
 2. 64, 20, 3
 3. 64, 61, 3
 4. 61, 60, 1
 5. 64, 20, 1
 6. I do not know.
21. During the process of translation the ...
1. first amino acid binds to the A site of the ribosome.
 2. first amino acid binds to the P site of the ribosome.
 3. second amino acid binds to the P site of the ribosome.
 4. second amino acid binds to the elongation factor.
 5. last amino acid binds to the stop codon.
 6. I do not know.
22. Identify the complex that is formed when tRNA binds to an amino acid.
1. Aminoacyl synthetase
 2. Aminoacyl tRNA complex
 3. 70S initiation complex
 4. 30S initiation complex
 5. 40S initiation complex
 6. I do not know.
23. During translation, the ... site of the ribosome holds the growing polypeptide chain while the ... site holds the next amino acid to be to be added to the chain.
1. A, P
 2. P, A
 3. A, B
 4. B, A
 5. None of the above
 6. I do not know
24. A messenger RNA is 336 nucleotides long, including the start and stop codons. The number of amino acids in the protein translated from this mRNA is
1. 110
 2. 111
 3. 112
 4. 330
 5. 999
 6. I do not know

25. Which of the following steps is **correct** for the formation of a peptide bond between the two amino acids in the ribosome?
1. The first amino acid is transferred to the NH₂ terminus of the second amino acid in the A site.
 2. The first amino acid is transferred to the NH₂ terminus of the second amino acid in the P site.
 3. The first amino acid is transferred to the COOH terminus of the second amino acid in the A site.
 4. The first amino acid is transferred to the COOH terminus of the second amino acid in the P site.
 5. The tRNA with the first amino acid shifts from the P site to the A site.
 6. I do not know.
26. Identify the role of the enzyme peptidyl transferase during translation.
1. Transfer of phosphate group.
 2. Amino acid activation.
 3. Peptide bond formation between adjacent amino acids
 4. binding of ribosome subunits to mRNA.
 5. Dissociation of ribosome subunits.
 6. I do not know.
27. The *Lac* operon is a group of genes involved in the metabolism of ...
1. galactose.
 2. permease.
 3. glucose.
 4. lactase.
 5. lactose
 6. I do not know.
28. The *Lac* operon is switched **on** when ...
1. the repressor molecule binds the operator.
 2. glucose is present.
 3. lactose is absent.
 4. RNA polymerase binds to the operator site.
 5. the repressor molecule binds to lactose.
 6. I do not know.
29. What is the function of the permease enzyme in the *lac* operon?
1. Hydrolysis of lactose
 2. Entry of lactose into the cell
 3. Attachment of lactose to the lac repressor protein
 4. Breakdown of lactose
 5. Exit of lactose from the cell
 6. I do not know.

30. The *Lac* repressor dissociates from the operator site when it binds to the ...
1. promoter.
 2. operator.
 3. inducer.
 4. structural genes.
 5. regulator gene.
 6. I do not know.
31. In the *Lac* operon, binding of the repressor to the operator site will ...
1. facilitate transcription of structural genes.
 2. inhibit the enzymatic activity of RNA polymerase.
 3. stimulate the enzymatic activity of RNA polymerase.
 4. inhibit transcription of the structural genes.
 5. increase glucose concentration.
 6. I do not know
32. Which of the following contains all the hereditary information passed on from one generation to next generation.
1. messenger RNA.
 2. transfer RNA.
 3. ribosomal RNA.
 4. messenger RNA and transfer RNA.
 5. DNA.
 6. I don't know.
33. A dividing cell has 19 chromosomes, each consisting of two sister chromatids. Choose the stage(s) of cell division in which this cell is.
1. Prophase II of meiosis.
 2. Telophase of meiosis I.
 3. Prophase I of meiosis.
 4. Options 1 and 2.
 5. Options 2 and 3.
 6. I do not know.
34. Which of the following statements is **false**?
1. Chromosomes divide into two equal parts during mitosis.
 2. Sister chromatids are identical.
 3. Sister chromatids undergo crossing-over during cell division.
 4. Homologous chromosomes are always of the same length.
 5. Chromosomes are in form of chromatin fibres before cell division.
 6. I do not know.

35. Which of the following statements is false?
1. The chromosomal theory agrees with Mendel's laws of inheritance.
 2. Homologous chromosomes separate during meiosis.
 3. Sorting of homologous pairs of chromosomes into gametes is random.
 4. Gametes contain the same number of parental chromosomes.
 5. Gametes combine during fertilisation.
 6. I do not know.
36. How many autosomal chromosomes are present in the human egg cell?
1. 22
 2. 46
 3. 23
 4. 44
 5. 24
 6. I do not know.
37. Choose the statement which is **true**.
1. The phase of the cell cycle in which DNA replicates is the S phase.
 2. The phase of the cell cycle in which the cell divided is designated G₁ phase.
 3. The phase of the cell cycle in which DNA replicates is designated M phase.
 4. Proteins and enzymes are synthesized during the S phase of the cell cycle.
 5. Organelles replicate during the M phase of the cell cycle.
 6. I do not know.
38. Choose the cells which undergo meiosis.
1. Cells found in muscles.
 2. Cells found in somatic cells.
 3. Brain cells.
 4. Cells found in the skin.
 5. Cells found in gonads.
 6. I do not know.
39. What is the purpose of G₁ phase?
1. Cell rests and does not need to divide.
 2. Cell grows and checks for mistakes in DNA.
 3. Cell grows and prepares to replicate DNA.
 4. DNA is replicated.
 5. The cell divides.
 6. I do not know.

40. How many phases constitute the cell cycle?

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

41. Which pair is correct?

1. M phase, cell growth.
2. G₁ phase, DNA replication.
3. S phase, cell division.
4. G₂ phase, DNA replication.
5. G₂ phase, preparation for mitosis.
6. I do not know

42. Choose the genetic term which matches with the corresponding description

	Genetic term	Description
1	Haploid	Any chromosome other than the sex chromosome
2	Meiosis	Number of chromosomes in the gamete
3	Cytokinesis	Division of the nucleus
4	Autosomal chromosomes	Reduction division
5	Centromere	Site on the chromosome to which spindle fibres attach
6	I do not know.	

43. In which phase of cell cycle are chromosomes visible under the microscope for the first time?

1. Interphase
2. Prophase
3. Metaphase
4. Anaphase
5. Telophase
6. I do not know.

44. During mitosis the nuclear membrane disappears at

1. prophase
2. metaphase
3. anaphase
4. telophase
5. cytokinesis
6. I do not know.

45. Mitosis is similar to
1. Meiosis I
 2. Meiosis II
 3. Synapsis
 4. Both I and II
 5. None of the above
 6. I do not know.
46. What is the role of the spindle during mitosis?
1. It makes the chromosomes visible.
 2. It breaks down the nuclear membrane.
 3. It duplicates DNA.
 4. It helps to separate the chromosomes.
 5. It duplicates the centromere.
 6. I do not know
47. Chiasmata are clearly visible in a cell during ...
1. interphase of meiosis.
 2. prophase of meiosis.
 3. prophase of mitosis.
 4. metaphase of mitosis.
 5. metaphase of meiosis.
 6. I do not know.
48. Choose the **correct** statement.
1. The cells from which gametes are produced are haploid.
 2. Meiosis is a source of genetic variation.
 3. The male reproductive organs are called gametes.
 4. The female reproductive organs are called ova.
 5. Gametes are produced from somatic cells.
 6. I do not know.
49. Choose the **false** statement.
1. Meiosis is a reductional division.
 2. Synapsis takes place during meiosis.
 3. Meiosis produces two haploid daughter cells.
 4. Mitosis produces daughter cells with identical chromosomes.
 5. Through meiosis daughter cells with recombinant chromosomes may be produced.
 6. I do not know.

50. Study the Figure 1 below and then choose the correct statement.

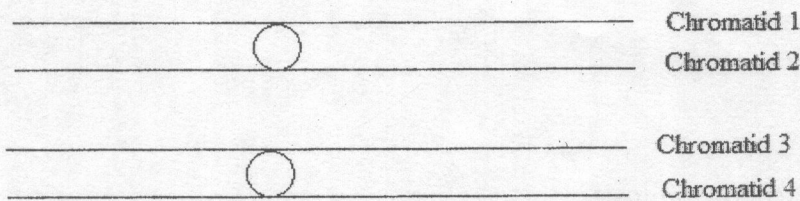


Figure 1: A tetrad of two homologous chromosomes

1. Crossing over can take place between chromatids 1 and 2.
 2. Crossing over can take place between chromatids 1 and 3.
 3. Crossing over can take place between chromatids 2 and 3.
 4. Crossing over can take place between chromatids 3 and 4.
 5. Statements 2 and 3 are correct.
 6. I do not know.
51. Which of the following is **not** a characteristic of meiosis? -
1. Chromosomes arrange themselves in pairs.
 2. Daughter cells with half the normal number of chromosomes produced.
 3. One cell undergoing two cell divisions, one after the other.
 4. Division of somatic cells.
 5. Recombination of alleles in the daughter cells.
 6. I do not know.
52. A test cross is carried out to confirm whether the ...
1. F_1 individual is homozygous or not.
 2. F_1 individual is heterozygous or not.
 3. test cross individual with a dominant phenotype is heterozygous or not.
 4. test cross individual with a recessive phenotype is heterozygous or not.
 5. test cross individual with a dominant phenotype is recessive or not.
 6. I do not know.
53. Choose the **false** statement.
1. Genetics is the study of how characteristics are passed on from one generation to the next.
 2. Genetics can be applied to produce improved crops and livestock.
 3. Mendel showed that each genetic characteristic is controlled by two alternative factors.
 4. Multiple alleles control quantitative traits.
 5. Two alternative forms of a gene occupy a specific locus in homologous chromosomes.
 6. I do not know.

54. Choose the term which **correctly** describes the alleles responsible for blood groups A and B.
1. Dominant
 2. Codominant
 3. Recessive
 4. Incompletely dominant
 5. Lethal
 6. I do not know.
55. A gene
1. can be described as a unit of heredity.
 2. contains information to produce a particular protein.
 3. affects traits at the cellular level.
 4. can exist in many forms
 5. All of the above.
 6. I do not know.
56. An F₂ phenotypic ratio of 2:1 in a monohybrid cross suggests that ...
1. there was sex linkage.
 2. a recessive allele is involved.
 3. a colour blindness trait is involved.
 4. a lethal allele is involved.
 5. Options 1 and 2 above.
 6. I do not know.
57. Which of the following is (are) true about lethal alleles?
1. They cause the death of an organism that carries them.
 2. They are usually a result of mutations in genes.
 3. They may be recessive.
 4. They may be dominant.
 5. All of the above.
 6. I do not know.
58. When Mendel crossed pure breeding tall pea plants with pure breeding short pea plants, the progeny plants were all tall. This was because the ...
1. alleles for tallness and shortness were codominant.
 2. alleles for tallness were in the homozygous state.
 3. alleles for tallness and shortness were assorting independently.
 4. allele for shortness was recessive.
 5. alleles for shortness were in the homozygous state
 6. I do not know.

59. The monohybrid F_2 phenotypic ratio of a trait with co-dominant alleles is ...
1. 1:1.
 2. 3:1
 3. 1:2:1
 4. 1:1:1:1
 5. 9:3:4
 6. I do not know.
60. In pea plants, the allele for yellow flowers is dominant to the allele for green flowers. If a heterozygous yellow-flowered plant is crossed with a green flowered plant, what is the expected progeny phenotypic ratio?
1. All yellow
 2. 1 yellow: 1 green
 3. 1 yellow: 2 pink: 1 green
 4. 3 yellow: 1 green
 5. 2 yellow: 1 green
 6. I do not know.
61. The alleles in the gametes of an F_1 individual in monohybrid cross are in the ratio
1. 1:1
 2. 1:2
 3. 1:1:1:1
 4. 9:3:3:1
 5. 1:2:1
 6. I do not know
62. Mendel verified true-breeding pea plants for certain traits before undertaking his experiments. The term "true-breeding" refers to
1. genetically pure lines.
 2. organism that have a high rate of reproduction.
 3. organism that will produce identical copies of themselves upon reproduction.
 4. organism that are homozygous for all possible traits.
 5. 1 and 3 above.
 6. I do not know
63. In one experiment, Mendel studied the inheritance pattern of two traits (seed shape and seed colour). Mendel's aim was to find out whether the ...
1. two traits are linked to each other or not.
 2. genes of the two alleles are inherited together or separately.
 3. alleles of the two traits are inherited together or separately.
 4. alleles of the two traits segregate or not.
 5. traits of the two alleles segregate or not.
 6. I do not know.

64. If a cross between two sheep with black coat colour produced a white offspring, which of the following statements is true about this cross?
1. The genotype of both parents is homozygous black.
 2. The genotype of both parents is heterozygous black.
 3. The alleles for coat colour are incompletely dominant to each other.
 4. The allele for white coat colour is dominant.
 5. The alleles for coat colour are codominant to each other.
 6. I do not know.
65. In a cross between a tall violet plant with the genotype $TTVv$ and short white plant, what phenotypic ratio of the progeny would be expected from this cross?
1. All tall violet.
 2. 1 tall violet: 1 short violet.
 3. 1 tall violet: 1 tall white: 1 short violet: 1 short white.
 4. 1 tall violet: 1 tall white.
 5. All short white.
 6. I do not know.
66. A farmer mates a homozygous tall, red tomato plant ($TTRR$) with a heterozygous tall, red tomato plant ($TtRr$). What is the percent chance that the offspring will be short plants with yellow fruits?
1. 0%
 2. 25%
 3. 50%
 4. 75%
 5. 100%
 6. I do not know.
67. If the genotype of a dominant phenotype is not known, choose the cross which can be used to determine that genotype.
1. $RR \times rr$
 2. $R_ \times rr$
 3. $Rr \times rr$
 4. $RR \times RR$
 5. $rr \times rr$
 6. I do not know.
68. The progeny of a dihybrid test cross is expected to have ... phenotypes.
1. 2
 2. 3
 3. 4
 4. 5
 5. 8
 6. I do not know.

69. Choose the expected dihybrid test cross progeny phenotypic ratio.
1. 3:1
 2. 1:1:1:1
 3. 1:2:1
 4. 9:3:3:1
 5. 1:1
 6. I do not know.
70. If all the progeny of a monohybrid test cross have a dominant phenotype, it means the individual being tested is
1. heterozygous dominant.
 2. homozygous recessive.
 3. homozygous dominant.
 4. heterozygous recessive.
 5. None of the above.
 6. I do not know
71. Choose the statement that is **correct** in relation to linked genes.
1. Alleles of linked genes assort independently.
 2. Genes which are linked are found on different chromosomes.
 3. The number of parental phenotypes is the same as the number of recombinants among the dihybrid test cross progeny.
 4. The dihybrid test cross progeny phenotypes are in the ratio 1:1:1:1
 5. **The test cross progeny consist of both parental and recombinant phenotypes.**
 6. I do not know.
72. Autosomal gene linkage
1. reduces the chances of segregation.
 2. prevents independent assortment.
 3. reduces the number of parental types in the F_2 generation.
 4. increases the number of recombinants in the F_2 generation.
 5. prevents synapsis.
 6. I do not know
73. Crossing over in diploid organisms is responsible for
1. co-dominance of alleles.
 2. Incomplete dominance of alleles.
 3. independent assortment alleles of unlinked genes.
 4. recombination of alleles of linked genes.
 5. linkage between genes
 6. I do not know.

Use the information below to answer questions 74- 77.

One type of red flower colour in pea plants is controlled by two alleles R and r. The dominant allele R is responsible for red colour while the recessive allele r is responsible for white colour. A cross was carried out between two heterozygous red plants. The progeny plants consisted of 165 red flowered plants and 35 white flowered plants. A chi-squared test was carried out on the results of the progeny phenotypes.

74. The expected Mendelian progeny phenotypic ratio of this cross is ...
1. 1:1
 2. 3:1
 3. 4:1
 4. 1:2:1
 5. 9:3:3:1
 6. I do not know.
75. The calculated χ^2 value is ...
1. 1.5
 2. 3.84
 3. 4.5
 4. 6.0
 5. 0.05
 6. I do not know.
76. The tabulated χ^2 value at 0.05 probability is ...
1. 1.5
 2. 3.84
 3. 4.5
 4. 6.0
 5. 0.05
 6. I do not know.
77. From the results of the chi-squared test it can be concluded that ...
1. the calculated χ^2 value is not significant.
 2. the difference between the observed ratio and the expected ratio is not significant.
 3. there are 2 degrees of freedom.
 4. the two alleles are linked.
 5. the progeny phenotypes are not in the expected Mendelian ratio.
 6. I do not know.

78. If the blood group of a child is O, which of the following couples could not be biological parents of the child?
1. Mother group A and father group B.
 2. Both mother and father group A.
 3. Mother group AB and father group O.
 4. Mother group B and father group O.
 5. Mother group A and father group O.
 6. I do not know.
79. The trait for plant height that Mendel studied in peas exhibited variation.
1. continuous
 2. discontinuous
 3. quantitative
 4. qualitative
 5. 2 and 4 above.
 6. I do not know
80. When heterozygous parents with recessive epistasis are crossed the progeny phenotype ratio is ...
1. 9:1:1:3
 2. 9:3:1
 3. 9:3:4
 4. 9:3:3:1
 5. 12:3:1
 6. I do not know.
81. A typical dihybrid F_2 phenotypic ratio is ...
1. 9:3:3:1
 2. 1:1:1:1
 3. 3:1
 4. 9:3:2
 5. 9:2:2:1
 6. I do not know.
82. A man suffering from haemophilia is married to a homozygous normal woman for the condition. Their offspring will ...
1. all be haemophiliac.
 2. consist of haemophiliac boys only.
 3. consist of haemophiliac girls only.
 4. consist of 50% haemophiliac children and 50% normal children.
 5. all be normal.
 6. I do not know.

83. A female who is homozygous normal for colour vision marries a man who is colour blind. Choose the statement which is true about their offspring.
1. All the children will be colour blind.
 2. All the children will have normal colour vision.
 3. All the sons will be colour blind.
 4. Half of the daughters will be carriers of colour blindness.
 5. Options 2 and 4 above are correct.
 6. I do not know.
84. The sex chromosomes of human females are and while the sex chromosomes for males are
1. YY, XX
 2. XX, XY
 3. XX, YY
 4. XY, XY
 5. XX, XO
 6. I do not know
85. Haemophilia is more common in males because it is a
1. recessive character carried by the Y chromosome.
 2. dominant character carried by the Y chromosome.
 3. dominant trait carried by the X chromosome.
 4. recessive trait carried by the X chromosome.
 5. mutant allele in males than in females.
 6. I do not know.
86. If a man and his son are both hemophiliac, but his wife is normal, her genotype must be
1. $X^h X^h$
 2. $X^H X^h$
 3. $X^H X^H$
 4. $X^H Y$
 5. XY
 6. I do not know
87. Choose the principle of heredity that Gregor Mendel **did not** use in his work.
1. Dominance
 2. Recessive
 3. Gene interaction
 4. Independent assortment
 5. Test cross
 6. I do not know.

88. Albinism is a condition in which the affected individual lacks skin and eye pigmentation due to an autosomal recessive allele. If a homozygous normal male is married to a heterozygous female ...
1. all their children will be homozygous normal.
 2. all their children will be heterozygous.
 3. 50% of their male children will be heterozygous.
 4. 50% of their female children will be albino.
 5. all their children will be albino.
 6. I do not know.
89. Long radishes crossed with round radishes result in all oval radishes. The shape of radishes is controlled by
1. two genes.
 2. multiple alleles.
 3. dominant alleles.
 4. codominant alleles
 5. incompletely dominant alleles.
 6. I do not know
90. The ABO blood group trait in humans is controlled by ...:
1. two alleles.
 2. incompletely dominant alleles.
 3. codominant alleles
 4. multiple alleles.
 5. 3 and 4 above.
 6. I do not know
91. A cross was made between blue flowered, short stalked plants and white flowered, long stalked plants. The results were as follows:
- 400 blue, short
 - 400 white, long
 - 100 blue, long
 - 100 white, short

Which of the above phenotypes are recombinants?

1. blue, short
2. white, short
3. white, long
4. blue, long
5. 2 and 4 above
6. I do not know.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 2002: STATISTICAL ANALYSIS OF BIOLOGICAL DATA
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. ILLUSTRATE YOUR ANSWER WHERE NECESSARY. A FORMULAE SHEET AND TWO STATISTICAL TABLES, THE NORMAL DISTRIBUTION AND THE t DISTRIBUTION ARE PROVIDED.

1. (a) Define the following terms:
 - i. Inferential statistics.
 - ii. Measures of variation.
 - iii. Correlation.
 - iv. Type I error.(b) Briefly describe how the following samples are obtained.
 - i. Systematic random sample.
 - ii. Cluster sample.(c) Summarise the properties and uses of the mean, the median and the mode.

2. A group of women underwent an operation as part of cervical cancer treatment and urinary tract infection was observed in 12 of the subjects. The number of postoperative days until diagnosis of the urinary tract infection are shown below.

16, 8, 10, 19, 49, 11, 15, 22, 6, 13, 15, 17

Using the data set provided compute the following:

- (a) Mean.
- (b) Sample variance.
- (c) Sample standard deviation.
- (d) Coefficient of variation.
- (e) Interquartile range.

TURN OVER

3. Milligrams (mg) of sodium obtained by a dietician interested in comparing the sodium content of real eggs with the sodium content of artificial eggs are shown in below.

Artificial eggs (mg of sodium): 38, 16, 18, 24, 12, 30, 35, 32, 31, 30, 24, 35

Real eggs (mg of sodium): 26, 15, 12, 18, 24, 32, 14, 18, 16, 18, 22, 12

- Using the data provided construct two box plots on one graph.
 - State which of the two has a higher content of sodium between artificial eggs and real eggs.
 - Comment on the variability of the distribution of milligrams of sodium in real eggs and artificial eggs.
4. The number of grams of carbohydrates in a 340 milligrams serving of a regular soft drink for a random sample of soft drinks is shown below.

48	37	52	40	43	46	41	38
41	45	45	33	35	52	45	41
30	34	46	40				

- Calculate the point estimate of the mean number of carbohydrates in all brands of soft drinks.
 - Determine which distribution between the z and t distributions should be used to find the confidence interval and explain why.
 - Given that the sample variance, s^2 is 35.9, find the 95% confidence interval of the true mean.
 - Explain why an interval estimate is better than a point estimate of a parameter.
5. (a) A survey of 500 men found that 60 of them were infected with athlete's foot, a contagious fungal infection that affects the skin on the feet. Find the 95% confidence interval of the true proportion of adults infected with athlete's foot.
- (b) A researcher wishes to estimate the proportion of fish in Goma lakes infected with monogenean parasites. She wants to be 90% confident that her estimate is within 5% of the true proportion. Determine the sample size that should be taken if in a sample of 300 fish, 30 were infected with monogenean parasites.

PROCEED TO NEXT PAGE

6. A physician claims that joggers' maximal volume oxygen uptake is greater than the average of all adults. A sample of 15 joggers has a mean of 40.6 millilitres per kilogram (ml/Kg) and a standard deviation of 6ml/kg.
- State the hypotheses and identify the claim.
 - Given that the average of all adults is 36.7ml/Kg, compute the appropriate test value.
 - Determine whether there is enough evidence to support the physician's claim at $\alpha = 0.05$.
7. A student of Microbiology hypothesizes that the average number of coliform counts for male toilet floors are greater than the average number of coliform counts for female toilet floors. The student then collects 50 samples from male toilets and 50 samples from female toilets. She then processes the samples and obtains the following results:
- Mean coliform count for male toilets $\bar{X}_1 = 8.6$ and the sample standard deviation $s_1 = 3.3$.
 Mean coliform count for females toilets $\bar{X}_2 = 7.9$ and the sample standard deviation $s_2 = 3.3$.
- State the hypotheses and identify the claim.
 - Compute the appropriate test value.
 - Determine whether there is enough evidence to support the student's claim at $\alpha = 0.10$.
8. Data obtained from a study of age(x) and systolic blood pressure(y) of 6 randomly selected subjects is shown in Table 1 below.

Table 1: Age and systolic blood pressure of a random sample of 6 individuals.

Subject	Age x	pressure y
A	43	128
B	48	120
C	56	135
D	61	143
E	67	141
F	70	152

- Compute the correlation coefficient for the data.
- Determine the relationship between age and blood pressure.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2017 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 2302: BASIC MICROBIOLOGY
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER ANY **FIVE** QUESTIONS. ILLUSTRATE YOUR ANSWER WHERE NECESSARY. USE SEPARATE ANSWER BOOKS FOR EACH SECTION.

SECTION A

1. State three major methods of classification of culture media.
2. Describe Kochi's postulates.
3. Describe the process of endospore formation in two bacterial genera.
4. (a) Explain the function of the following in the bacterial cell:
 - (i) Cell membrane.
 - (ii) Cell wall.(b) Explain importance of the functions of cell membrane to the growth and persistence of prokaryotes.

SECTION B

5. Discuss types of virus symmetry.
6. Describe the replication process of a retrovirus.
7. (a) Discuss genome and mRNA formation in DNA viruses.
(b) Discuss groups of viral proteins.
8. Summarise **each** of the following:
 - (a) Mechanical transmission of plant viruses.
 - (b) Ambiviruses.
 - (c) Disease symptoms of plants infected by tobacco mosaic virus (TMV).
 - (d) Viroid structure.

END OF EXAMINATION

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

**2017 ACADEMIC YEAR
FINAL EXAMINATIONS**

**BIO 2701: BASIC PHYSIOLOGY
THEORY PAPER**

TIME: THREE HOURS

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

SECTION A: Plant Physiology

1. Summarise the light reactions of photosynthesis in oxygen-evolving organisms.
2. (a) List the inorganic nutrient elements essential for plant growth and development, distinguishing macronutrient elements and micronutrient elements.
(b) For each nutrient element listed above state two functions of the inorganic nutrient element in plants.
3. (a) Discuss the chemiosmotic mechanism for polar auxin transport in stems and coleoptiles.
(b) Outline the Cholodny-Went model for auxin action in phototropism.
4. Compare and contrast the actions of auxin and gibberellin in regard to stem elongation.

SECTION B: Animal Physiology

5. Discuss the roles of brainstem and receptors in the control of respiration in a human.
6. Summarise each of the following:
 - (a) Feeding behavior.
 - (b) Diabetes mellitus.
 - (c) Parthenogenesis.
 - (d) Oogenesis.
7. (a) Describe the digestive functions of the pancreas.
(b) With reference to two specific examples, explain how homeostasis is achieved in animals.

TURN OVER

8. (a) Explain the role of Schwann cells and myelination in nerve fibres.
(b) Discuss the transmission of action potentials from pre-synaptic to post-synaptic neurons.

END OF EXAMINATION

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

2017 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 2812: DIVERSITY OF ANIMALS
THEORY PAPER

TIME: THREE HOURS

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

SECTION A: INVERTEBRATES

1. Describe the general characteristics of the phylum Sarcomastigophora.
2. Discuss the evolutionary theories on the origin of Metazoa.
3. Outline the major distinguishing characteristics of classes Polyplacophora, Gastropoda, Bivalvia and Cephalopoda.
4. Summarise each of the following:
 - (a) Reproduction in protozoans.
 - (b) Filter-feeding body forms in the phylum Porifera.
 - (c) Habitat adaptations by free-living and parasitic Platyhelminthes.
 - (d) Parasitism of nematodes.

SECTION B: VERTEBRATES

5. Summarise each of the following:
 - (a) Cephalochordata.
 - (b) Petromyzontiformes.
 - (c) Sarcopterygii.
 - (d) Tetrapoda.
 - (e) Artiodactyla.
6. Compare and contrast classes Cyclostomata and Chondrichthyes.
7. Illustrate how the class Amphibia is representative of subphylum Gnathostomata.
8. Describe the subclasses of class Mammalia, giving examples of each subclass.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3011: BIOLOGICAL DATA ANALYSIS AND EXPERIMENTAL DESIGN
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS

-
1. Data for a completely randomized design experiment with 3 treatments and 4 replications per treatment are shown in Table 1 below. The data represent protein percentage in maize at 2, 4 and 9 weeks (= treatments) after December 1 (2017) in Lusaka Province for the 2017/18 crop-growing season. Test the null hypothesis that there are no significant differences among the treatment means.

Table 1. Protein percentage in maize at different periods of growth.

Replications	Weeks after December 1, 2017 (= Treatments)		
	2	4	9
1	38	16	13
2	24	20	7
3	26	18	9
4	29	14	13

2. A group of strawberry plants ($n = 8$) was grown in pots in a green house and the following measurements were taken on crop yield in grams and the corresponding level of nitrogen in parts per million present in the leaf at the time of harvesting.

Nitrogen (X): 2.50 2.55 2.54 2.56 2.68 2.55 2.62 2.57
Yield (Y): 247 245 266 277 284 251 275 241

Calculate the correlation coefficient between X and Y and test the significance of the correlation.

TURN OVER

3. The measurements in Table 2, of the antennal length of 10 males and 10 females of the 6th developmental stage of the Armoured ground cricket, *Acanthopplus speiseri* Brancsik, were collected by a researcher.

Table 2. Measurements of length (mm) of antennae of the Armoured ground cricket.

Sex	Length of Antennae (mm)									
	Male	76.1	70.0	61.0	62.5	53.0	52.0	37.4	62.0	89.0
Female	77.6	57.4	66.0	65.0	65.6	44.3	66.0	58.0	65.0	93.9

Assuming that population variances are equal, test the null hypothesis (NH) that the sexes have antennae of the same length.

4. A scientist studied the effect of auxin concentration (gm^{-2}) on root length on two genotypes, A and B of *Arabidopsis thaliana*, a model species commonly used in biological research, measured after 10 days exposure on growth media. The raw data is as presented in Table 3.

Table 3. Effect of Auxin on root length of *Arabidopsis thaliana* genotypes.

Auxin concentration (gm^{-2})	Root Length (mm)	
	Genotype A	Genotype B
1	2.8	5.2
2	2.4	5.4
3	3.1	6.1
4	2.5	4.4
5	3.5	10.8
6	3.6	9.1
7	6.7	8.1
8	8.6	11.0
9	5.3	14.5
10	10.1	12.4

Test the Null hypothesis that there is no significant difference in mean root length between genotypes A and B.

PROCEED TO NEXT PAGE

5. The yields (Kg) of a crop in an experiment with three randomized blocks are shown in Table 4 below. The yield of crop D in block 1 was missing. Estimate the missing yield value and then conduct an ANOVA and test for the significance of the differences among yields.

Table 4. Crop yield in a Randomized Block Design experiment involving different crop varieties.

Crop variety	BLOCK		
	1	2	3
A	34.0	34.3	35.0
B	33.0	36.3	35.8
C	34.3	35.3	32.3
D	-	29.8	28.0

6. Results of an automobile exhaust emission study to compare the efficiency of four petrol additives (A, B, C & D) in reducing the amount of oxides emitted in exhaust gases are presented in Table 5.

Table 5. Amounts of nitrogen oxides emitted in automobile exhaust gases.

Driver	CAR			
	1	2	3	4
I	A = 28	B = 26	D = 20	C = 25
II	D = 23	C = 27	-	B = 27
III	B = 16	D = 13	C = 16	A = 19
IV	C = 17	A = 15	B = 20	D = 20

- Indicate the additive with a missing value in the table and estimate the missing value.
 - Test the null hypothesis that there are no significant differences in efficiency among the additives.
7. The results of a survey in a rural area in Central Africa to compare the prevalence of infection with *Schistosoma mansoni*, a bilharzia parasite, among different occupations are presented in a 2x4 contingency Table 6. Test the N.H. that there was no association between risk of infection and occupation.

TURN OVER

Table 6. Risk of infection with *Schistosoma mansoni*, a bilharzia parasite in different occupations in a rural area in Central Africa.

<i>Schistosoma mansoni</i>	OCCUPATION				Total
	Fishermen	Farmers	Traders	Craftsmen	
Positive	22	21	17	15	75
Negative	13	22	41	14	90
Total	35	43	58	29	165

8. Display data presented in Table 7 in a scatter diagram and:
- Fit a regression line to the scatter diagram and
 - Test the significance of the departure of rho from zero.

Table 7. Regression analysis data.

X	1	2	4	5	8	10	12	15
Y	5	10	16	18	35	40	46	58

END OF EXAMINATION

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

**2017 ACADEMIC YEAR
FINAL EXAMINATIONS**

**BIO 3022: BIOLOGY OF SEED PLANTS
THEORY PAPER**

TIME: THREE HOURS

**INSTRUCTIONS: ANSWER FIVE QUESTIONS. ILLUSTRATE YOUR ANSWER
WHERE NECESSARY. USE SEPARATE ANSWER BOOKS FOR EACH SECTION.**

SECTION A

1. Discuss the occurrence of stomata in eudicots, monocots and conifers, and the significance of leaf stomatal positions in relation to the epidermal layer and side of leaf.
2. Explain the distinction between C₃ and C₄ grasses based on the structure of the parenchyma bundle sheath.
3. Compare and contrast structure and function of the characteristic tissue types of seed plants.
4. Describe the phenomena of sapwood, heartwood and annual or growth rings in perennial seed plants.

SECTION B

5. Discuss the genetic control of pollination self-incompatibility in angiosperms.
 6. Discuss the contribution of auxin and cytokinins to the formation and maintenance of the root apical meristem in angiosperms.
 7. Discuss genetic determination of floral organ identity in the floral meristem following flowering induction.
 8. Summarise the development, structure and function of endosperm types found in angiosperm seeds.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2017 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3132: COMMUNITY ECOLOGY
THEORY PAPER

TIME: THREE HOURS

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

1. Describe the full sequence of an ecological succession after a terrestrial volcanic eruption.
 2. Summarise each of the following:
 - (a) Significance of first and second laws of thermodynamics in community ecology.
 - (b) Energy flow in an ecosystem.
 - (c) Species diversity.
 - (d) Trophic structure.
 3. Explain the theories of Climax community.
 4. Discuss the Intermediate Disturbance Hypothesis.
 5. Discuss the factors which affect primary production in aquatic ecosystems.
 6. Compare and contrast the concept of dominance and species diversity in community organisation.
 7. "Competition and predation are two forms of species interactions in a community that influence the co-existence of species". Discuss the validity of this statement.
 8. Give a concise description of the impact of changes to a natural ecosystem system on species diversity.
-

END OF EXAMINATION

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

**2017 ACADEMIC YEAR
FINAL EXAMINATIONS**

**BIO 3412: GENETICS
THEORY PAPER**

TIME: THREE HOURS

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

SECTION A

1. Describe the lytic and lysogenic life cycles in bacteriophage.
2. Summarise each of the following:
 - (a) Down syndrome.
 - (b) Marfan Syndrome.
3. Explain the genetic cause, symptoms and inheritance pattern of cystic fibrosis.
4. Explain genetic exchange in bacterial cells.

SECTION B

5. (a) Explain how you can distinguish unlinked genes from completely linked and partially linked genes.
 - (b) Explain how the Poisson distribution can be used to convert genetic distances in map units into distances in centiMorgans.
 - (c) Explain the weaknesses of estimating genetic distance in map units.
 - (d) Describe four types of genetics maps.

TURN OVER

6. Three genes of maize (*Zea mays*) R, D and Y lie on chromosome 8. The genetic distance between genes R and D is 15 map units and that between genes D and Y is 25 map units.
- Draw the genetic map of chromosome 8 if the longest distance is between R and Y.
 - Write the genotypes of the double crossover progeny.
 - If the three genes were mapped based on 1000 progeny of a trihybrid testcross;
 - Estimate the number of double crossover plants that would be expected if there was no interference.
 - Estimate the number of double crossover plants that would be expected if the coefficient of coincidence was 0.7.
 - Express the distance between genes R and Y in map units and in centiMorgans.
7. A randomly mating human population has the following allele frequencies at the ABO blood group locus: $I^A = 0.152$ and $I^O = 0.719$. The I^A and I^B alleles are co-dominant with respect to each other, and both alleles are dominant over the I^O allele.
- Express the Hardy Weinberg equilibrium formula for the ABO gene.
 - If you sample one thousand persons from this randomly mating population, calculate the number of persons that would fall into each of the following phenotypic categories:
 - Blood group A
 - Blood group B
 - Blood group AB
 - Blood group O
 - Explain how the ABO blood group gene deviates from Mendel's monohybrid cross results.
8. Growth rate (body mass gained per day) and food conversion ratio (body mass gained per unit mass of feed taken) are very important polygenic characters in fish farming. Table 1 shows the variance estimates based on growth rate and food conversion ratio in a population of male Nile tilapia fish raised in a fish pond.

Table 1: Variance estimates on growth rate and food conversion ratio in male Nile tilapia fish.

Component of variance	Growth rate (grams/day)	Food conversion ratio (gram/gram)
V_A	52	43
$V_D + V_I$	9	6
V_E	39	51

- Using the results in Table 1, calculate the narrow-sense and broad-sense heritabilities for:
 - Growth rate.
 - Food conversion ratio.
- Explain the importance of growth rate and food conversion ratio to a fish farmer.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3412: GENETICS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER QUESTION ONE AND ANY OTHER THREE QUESTIONS.
A CHI-SQUARED TABLE IS PROVIDED.

SECTION A - COMPULSORY

1. In a triple test cross starting with parental types AABBCc and aabbcc, the testcross progeny phenotypes and their numbers are shown in Table 1.

Table 1: Results of a trihybrid test cross involving genes A, B and C

Phenotype	ABC	abc	Abc	aBC	ABc	abC	AbC	aBc
Progeny number	1761	1773	97	89	182	138	8	6

Study Table 1 and:

- Establish whether the three genes are linked or not
- Estimate the map distances in map units
- Estimate the map distances in centimorgans
- Calculate the value of interference

SECTION B – ANSWER ANY THREE QUESTIONS

2. In man the gene which controls the ability to taste the chemical phenyl thiocarbamide (PTC) has two alleles **T** and **t**. Tasting ability is conferred by the dominant allele **T** while the recessive allele **t** is for inability to taste. In one study, a group of 200 people were tested and it was found that 140 were tasters and 60 were non-tasters.

Determine:

- Genotype frequencies
- Allele frequencies

3. Describe the three major mechanisms of gene transfer in bacteria.
4. (a) List the assumptions made in the HWE.
(b) Explain two applications of the Hardy-Weinberg Equilibrium.
(c) Describe effective population size.
5. In a study of the genetic structure of a sample of 1000 humans, the frequencies of the ABO alleles were determined to be: $I^A = 0.43$; $I^B = 0.38$
Use the results to estimate the number of individuals with each of the following blood groups:
(a) Group A
(b) Group B
(c) Group AB
(d) Group O
6. Supposing the mean height of the current population of eucalyptus trees is = 16.5m; variance = 2.5; Narrow sense heritability = 0.35. If the aim is to improve the height of these trees by breeding using the top 5%* of the current population to produce the next improved generation, estimate the following:
(a) The intensity of selection, i
(b) Selection coefficient, S
(c) Response to selection, R
(d) Mean of the offspring of select 5%.

*The Z value consistent with 5% is 0.103

END OF EXAMINATION

CHI SQUARED TABLE

		PROBABILITY										
		0.01	0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
DEGREES OF FREEDOM	1	6.6	3.8	2.7	1.6	1.1	0.71	0.45	0.27	0.15	0.064	0.016
	2	9.2	6.0	4.6	3.2	2.4	1.83	1.39	1.02	0.71	0.446	0.211
	3	11.3	7.8	6.3	4.6	3.7	2.95	2.37	1.87	1.42	1.005	0.584
	4	13.3	9.5	7.8	6.0	4.9	4.04	3.36	2.75	2.19	1.649	1.064
	5	15.1	11.1	9.2	7.3	6.1	5.13	4.35	3.66	3.00	2.343	1.610
	6	16.8	12.6	10.6	8.6	7.2	6.21	5.35	4.57	3.83	3.070	2.204
	7	18.5	14.1	12.0	9.8	8.4	7.28	6.35	5.49	4.67	3.822	2.833
	8	20.1	15.5	13.4	11.0	9.5	8.35	7.34	6.42	5.53	4.594	3.490
	9	21.7	16.9	14.7	12.2	10.7	9.41	8.34	7.36	6.39	5.380	4.168

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3601: PARASITOLOGY
THEORY PAPER

TIME: THREE HOURS

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

SECTION A

1. (a) Describe the life cycle and pathogenesis of *Trypanosoma rhodesiense*.
(b) Describe the basic differences between Gambian and Rhodesian trypanosomiasis.
2. Describe the life cycle and pathogenesis of *Babesia bovis* in cattle.
3. Summarise the each of the following;
 - (a) Transmission of *Toxoplasma gondii*.
 - (b) Immunity in African trypanosomiasis.
 - (c) Complications associated with severe falciparum malaria.
 - (d) Prevention and control of leishmaniasis.
4. Illustrate and briefly describe the life cycles of the following organisms;
 - (a) *Balantidium coli*.
 - (b) *Plasmodium* species.

SECTION B

5. Discuss with examples the general characteristics of helminths.
6. Summarise each of the following with the aid of labelled diagrams:
 - (a) The morphology of different eggs of human *Schistosoma* species
 - (b) *Taenia solium* adult worm
 - (c) Miracidium larva of *Fasciola hepatica*
7. Describe the life cycle of *Schistosoma haematobium* and indicate the sequences in the life cycle that could easily be broken to prevent and control the disease caused by this parasite.

TURN OVER

8. (a) With the aid of labelled diagrams describe the following stages in the life cycle of *Fasciola hepatica*.
- (i) Reproductive stages
 - (ii) Resistant stages
- (b) Describe the transmission of the cysticercus of *Taenia solium* to the primary host.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
INSTITUTE OF DISTANCE EDUCATION
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR
FINAL EXAMINATION

BIO 3721: PLANT PHYSIOLOGY
THEORY PAPER

TIME: THREE HOUR

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS.

1. Compare and contrast NADP⁺-me and NAD⁺-me subtypes of C4 photosynthesis.
2. Summaries adaptations of treachery elements of water conduction in plants.
3. Discuss the principle of the shed avoidance and how it relates to auxin facilitated growth.
4. Summaries the following:
 - (b) The role of phytochromes in flowering of short and long day plants.
 - (c) Signal transduction events leading to de-etiolation.
5. Summaries the role of auxins:
 - (a) In tropisms through the regulation of differential growth patterns;
 - Geotropism using the statoliths hypothesis.
 - Phototropism.
 - Thigmotropism
 - (b) Their application in agriculture:
 - Auxins as herbicides.
 - Auxins to control apical dominance.
 - Auxins and gibberellins to stimulate fruit development.

TURN OVER

6. Explain photoperiodic regulation of flowering in angiosperms. In your answer provide a model for the phytochrome pigment (Pr/Pfr) to demonstrate its role in flowering of:
- (a) Long-day plants and Short-day plants.
 - (b) Given below are phytochrome data for two experimental plants. Predict and explain if they were grown under red or far red light.

Plant A: Pfr/total phytochrome = 0.03. Total phytochrome = 50 mg/kg dry weight

Plant B: Pfr/total phytochrome = 0.86. Total phytochrome = 1 mg/kg dry weight

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3841: EVOLUTIONARY BIOLOGY
THEORY PAPER

TIME: THREE HOURS

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

SECTION A

1. Explain how the Galápagos Islands finches illustrate Charles Darwin's four postulates of biological evolution.
2. Describe the type of selection occurring in the Lake Tanganyika cichlid fish *Perissodus microlepis* with regard to mouth shape polymorphism.
3. With the help of an empirical example, explain the evolutionary significance of inversions.
4. Describe how the incidence of retinitis pigmentosa on Tristan da Cunha Island illustrates the founder effect.

SECTION B

5. Discuss the phenomenon of heterosis, giving at least two applications in which the phenomenon has been utilised.
6. In Labrador dogs (commonly called Labs), black coat colour is dominant to brown. Assume that the skin colour is controlled by two alleles B and b. For a Lab to have brown coat the genotype must be 'b,b' (chocolate labs). For the pigment to be deposited, it is influenced by a dominant allele symbolized by E. If the lab is homozygous recessive for the second locus (e,e) then the coat is yellow regardless of the genotype at the black/brown locus.
 - (a) How would you describe the gene at locus E/e?
 - (b) Work out the genotypes of the F2 generation from a heterozygous cross BbEe x BbEe.
 - (c) What are the possible phenotypic ratios of the cross?
7. Give a brief description of the prezygotic barriers that may impede members of two species from interbreeding and producing fit off-springs.
8. Explain the differences between allopatric and sympatric speciation.

END OF EXAMINATION

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

**2017 ACADEMIC YEAR
FINAL EXAMINATIONS**

**BIO 4060: VERTEBRATE BIOLOGY
PRACTICAL PAPER**

TIME: ONE HOUR THIRTY MINUTES

INSTRUCTIONS: ANSWER ALL QUESTIONS.

1. Examine specimens **A1** to **A5**. For each specimen:
 - (a) State the name.
 - (b) Draw and label all the parts.
 - (c) State its function(s).
 - (d) Describe its nature in non-crocodilian reptiles.

 2. Examine slide preparations for specimens **B1** to **B5**. For each specimen:
 - (a) State the name.
 - (b) Draw and label all the parts.
 - (c) State its function(s).

 3. Examine specimens **C1** to **C5**. For each specimen:
 - (a) State the name.
 - (b) Draw and label all the parts.
 - (c) State how a similar structure in Class Aves is differently adapted.
-

END OF EXAMINATION

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

**2017 ACADEMIC YEAR
FINAL EXAMINATIONS**

**BS 4182: WILDLIFE AND RANGELAND MANAGEMENT
PRACTICAL PAPER**

TIME: THREE HOURS

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

1. Study specimens labeled **A1** to **A5**. For each specimen:
 - (a) State the scientific name.
 - (b) Describe the habitat in which the species is co-dominant

2. Examine specimens labeled **B1** to **B10**. For each specimen:
 - (a) State the scientific name.
 - (b) Describe the habitat in which it is commonly found.
 - (c) Describe sex dimorphism of the species.
 - (d) Describe breeding habits
 - (e) Describe external features

3. An ecologist has carried out an assessment of range condition to determine the grazing capacity of the Lupande Game Management Area. The study shows that the range is suitable for Impala, Zebra, Wildebeest, Kudu and Buffalo. Ten per cent (10%) of the range is a steep hill and in addition about 40% of the range is within 6.5 km from water. Furthermore, results indicate that the production of key forage species averages about 3,000kg/ha of dry matter biomass per year. The estimated grazing area of the GMA is 10,000 ha in size. Assuming that allowable use is 45% of the total biomass, and that the daily dry matter intake is 2% of the animal body weight,
 - (a) Calculate the number of 685 Kgs buffaloes you would allow as your base herd in the area.
 - (b) Calculate the number of hectares you would need to stock 200 zebras of 350 kg weight each per year in this Game Management Area.
 - (c) Discuss assumptions associated with this method.
 - (d) Discuss limitations of this method in estimating stocking rate of a wildlife species.

TURN OVER

4. Results of a study of habitat selection in Kafue National Park are presented in Figure1. The study was carried out during the rainy season. Study the figure and answer the following questions:
- Discuss the results of habitat selection in Kafue National Park by the three wildlife species.
 - Draw possible conclusions from these results.
 - Discuss possible limitations and assumptions in determining wildlife habitat preference.

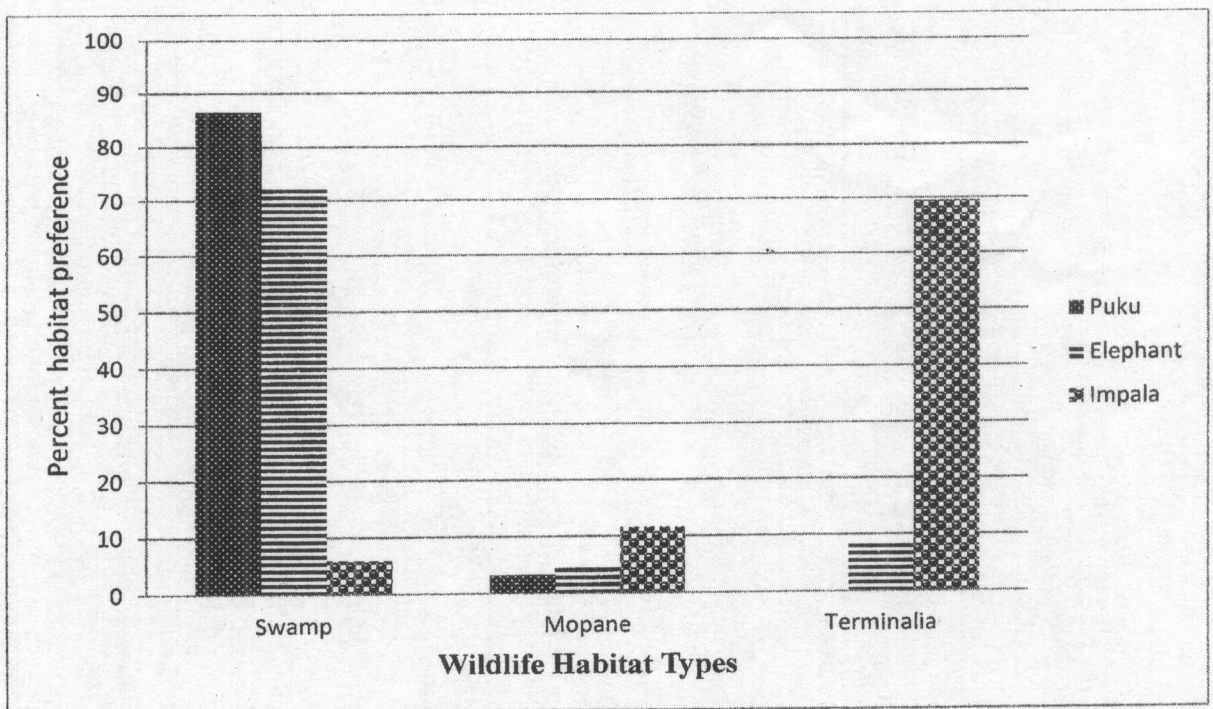


Figure1: Results of wildlife species habitat selection in Kafue National Park.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 4182: WILDLIFE AND RANGELAND MANAGEMENT
THEORY PAPER

TIME: THREE HOURS

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

1. Compare and contrast the concepts of carrying capacity and stocking rate in the management of wildlife species.
2. Summarise each of the following:
 - (a) Kidney/ Fat ratio.
 - (b) King census method.
 - (c) Limitations of the Cap-Chur gun.
 - (d) Point- intercept method.
3.
 - (a) Describe the appropriate procedure for estimating production of grazing dry matter biomass.
 - (b) Discuss the protected area system in Zambia.
4. Discuss the following:
 - (a) Threats to wildlife conservation in Zambia.
 - (b) Harvesting strategies in wildlife management.
5.
 - (a) Discuss characteristics of a wildlife habitat.
 - (c) Describe the *Taurotragus oryx* (Pallas, 1767) in relation to:
 - (i) External features.
 - (ii) Sex dimorphism.
 - (iii) Feeding habits.
 - (iv) Distribution in Zambia.
6.
 - (a) Describe methods used to determine $1 - e^{-H}$ for the purpose of exploiting wildlife populations.
 - (b) Contrast chemical and mechanical capture methods in wildlife management.

TURN OVER

7. Discuss any **two** of the following:

- (a) Methods used in wildlife habitat improvement in a semi-arid environment.
- (b) Limitations of the Maximum Sustainable Yield concept.
- (c) Describe methods used in the restoration of a *Tragelaphus spekii* habitat.

8. Discuss the following:

- (a) Characteristics and effects of bush fires in a range land ecosystem.
- (b) Difficulties associated with the translocation and restocking operations in a game reserve.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 4341: INDUSTRIAL MICROBIOLOGY
THEORY PAPER

TIME: THREE HOURS

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

SECTION A

1. (a) Describe growth phases of a microbe growing on a suitable growth medium.
(b) Describe three primary and three secondary metabolites produced during the growth of a microbe in relation to their function.
2. Discuss biopolymer types synthesized by microbes and their uses.
3. Discuss biofertilizers with reference to types and function.
4. Discuss *Phanerochaete chrysosporium* with reference to its industrial application.

SECTION B

5. Discuss filamentous fungi as sources of enzymes and their significance in the production of high quality paper.
6. Discuss the role of four named enzymes of *Bacillus* spp. used in the production of detergents.
7. Explain with examples the significance of microbe-derived pectinases in the production of fruit juices.
8. Explain the importance of starter cultures of named microbes in the production of cheese.

END OF EXAMINATION

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THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 4621: ECOLOGY AND EPIDEMIOLOGY OF PARASITIC DISEASES
THEORY PAPER

TIME: THREE HOURS

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

SECTION A

1. Discuss the roles of various stages of *Fasciola hepatica* in the overall life cycle of the parasite.
2. Explain the release mechanism of *Capillaria hepatica* from the fine structure of the liver of an infected host.
3. Discuss the daily periodicity of *Loa loa* that coincide with the periodic feeding habits of its vector.
4. Discuss the release mechanism employed by the adult female worm *Dracunculus medinensis* as an ecological adaptation for its larvae to gain access to next host without depending on a blood-sucking vector.

SECTION B

5. Explain how microparasite and macroparasite abundance is regulated in nature.
6. Discuss the various ways in which climatic factors influence the epidemiology of most parasitic diseases of humans.
7. Discuss the epidemiology of *Giardia lamblia*.

TURN OVER

8. Summarise each of the following:

- (a) Breakpoints in transmission of parasites
- (b) Factors that generate underdispersion and overdispersion of parasites in host populations.
- (c) Uses, advantages and disadvantages of cohort and case-control study designs.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 4641: IMMUNOLOGY
THEORY PAPER

TIME: THREE HOURS

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

1. Compare and contrast each of the following:
 - (a) Innate and acquired immunity.
 - (b) Humoral and cell-mediated immunity.
 - (c) T-cell receptor and B-cell receptor.
2. Explain how lysozyme secretion is able to destroy the cell wall of Gram-positive bacteria.
3. Contrast the properties of the different professional Antigen Presenting Cells (APCs) that affect their abilities to present antigen that induce T-cell activation.
4. Explain the classical pathway of complement activation in killing microbes.
5. Describe the structure, function and classes of antibodies.
6. Discuss the composition and role of Major Histocompatibility Complex (MHC) in the recognition of different antigens.
7. Explain the role of interferons in the prevention of viral replication in a virus infected cell.
8. Explain how hematopoiesis gives rise to the various cells that make the immune system function.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR MID-YEAR EXAMINATIONS
CHE 2001: AGRICULTURAL AND VETINARY CHEMISTRY

INSTRUCTIONS TO CANDIDATES:

Time: three (3) hours

All questions carry equal marks (20 marks each)

Answer **any Five (5)** questions

Write your computer number on all answer booklets

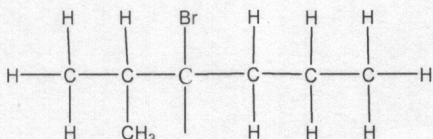
This examination consists of six (6) questions and FOUR (45) printed pages and the DATA sheet

QUESTION 1

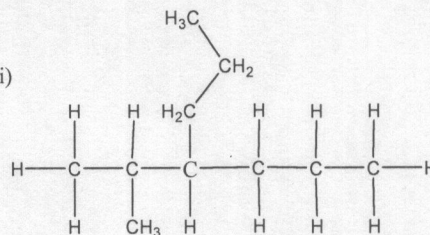
Name the following compounds

- a) Provide the IUPAC name for each of the following compounds and draw the bond line structures for each of the two [4 marks]

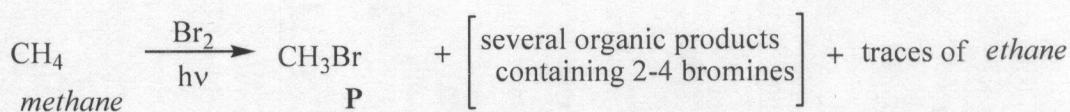
i)



ii)



- b) Consider the following reaction:



- (i) Name the type of reaction. [1 marks]
- (ii) Provide detailed reaction mechanisms for formation of **P** from methane. [6 marks]
- (iii) Propose a possible mechanism to account for the traces of ethane found in the reaction mixture. [2 marks]
- c) Consider a compound **X**, with molecular formula, C₅H₁₀.
- (i) Define the term structural isomerism [2 marks]
- (ii) Define the terms saturated and unsaturated hydrocarbon [4 marks]
- (iii) Write four (4) possible structural isomers of **X** and translate them into (line formulae). [4 marks]
- (iv) What is meant by the term esterification. [2 marks]

QUESTION 2

- a) Write a note on SN₂ reaction. In your discussion include the following aspects of the
- I. nature of the substrate [2 marks]
 - II. The rate law [2 marks]
 - III. Give an example of a solvent used in the reaction [1 marks]
 - IV. Give a detailed mechanism of SN₂ reaction [5 marks]

- b) Write a note on the electrophilic addition reaction. In your discussion include the following aspects:
- | | | |
|------|---|-----------|
| I. | Nature of the reactants | [2 marks] |
| II. | State the Markovinkov rule | [2 marks] |
| III. | A detailed mechanism of SN1 reaction | [6 marks] |
| IV. | Give an example of solvent used in the reaction | [1 marks] |
- c) Write the chemical reaction equation to represent the esterification reaction [4 marks]

QUESTION 3

- a) A solution has concentration of hydroxide ions, $[\text{OH}^-] = 2.0 \times 10^{-3} \text{ M}$ at 25°C . What is the concentration of the hydrogen ion in this solution? Is the solution acidic or basic? [6 marks]
- b) The pH scale is used to determine acidity or alkalinity of a solution.
- What does it mean for a solution to be acidic or alkaline?
 - What is the pH of a 0.2 M solution of nitric acid (HNO_3)?
 - What is the concentration of hydrogen ions $[\text{H}^+]$ present in a solution of $\text{pH} = 14$?
 - A solution has $\text{pH} = 13$, what type of solution is this based on this pH value? [8 marks]
- c) Write expressions for the autoionization (autoprotolysis) of the following substances:
- H_2O
 - CH_3OH
 - CH_3NH_2
- [6 marks]

QUESTION 4

- a) What is the conjugate base of the following?
- HCl
 - HNO_3
- [6 marks]
- b) A solution has concentration of hydroxide ions, $[\text{OH}^-] = 3.0 \times 10^{-6} \text{ M}$ at 25°C . What is the concentration of the hydrogen ion in this solution? Is the solution acidic or basic? [6 marks]
- c) Write the equilibrium constant expression for the acid dissociation (K_a) for the following reaction:



[8 marks]

QUESTION 5

- a) Classify each of the following processes as endothermic or exothermic. In each case, draw an energy diagram to illustrate the heat content (enthalpy), reactants or products.
- I. combustion of natural gas
 - II. condensation of water vapor
- [4 marks]**
- b) 1674 J of heat are absorbed by 25.0 mL of an aqueous solution of NaOH ($\rho = 1.10 \text{ g/mL}$, specific heat = $4.10 \text{ J/g } ^\circ\text{C}$). The temperature of the solution goes up how many degrees?
- [6 marks]**
- c) 50.0 g of iron that has an initial temperature of $225 \text{ }^\circ\text{C}$ and 50.0 g of gold that has an initial temperature of $25.0 \text{ }^\circ\text{C}$ are brought into contact with one another. Assuming no heat is lost to the surroundings, what will be the temperature when the two metals reach thermal equilibrium? The specific heat capacity of iron = $0.449 \text{ J/g}^\circ\text{C}$ and gold = $0.128 \text{ J/g}^\circ\text{C}$.
- [10 marks]**

QUESTION 6

- a) Describe four conditions that affect the rate of a reaction and use the principles of the collision theory to explain why each factor affects the rate as it does.
- [4marks]**
- b) The rate expression for a particular reaction is $\text{Rate} = [\text{A}][\text{B}]^2$. If the initial concentration of B is increased from 0.1 M to 0.3 M, the initial rate will increase by what factor?
- [6 marks]**
- c) A reaction has the experimental rate law of $\text{Rate} = k[\text{A}]^2$.
- I. What happens to the rate if the concentration of A is tripled?
 - II. What happens to the rate if the concentration of A is reduced to one third the initial concentration?
- [10 marks]**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR DEFFERED FINAL EXAMINATIONS
CHE 2112: INTRODUCTORY BIOCHEMISTRY

INSTRUCTIONS TO CANDIDATES:

Time: Three (3) hours

All questions carry **equal marks** (20 marks each)

Answer **any Five (5)** questions

Write your computer number on all answer booklets

This examination consists of SIX (6) questions and SIX (6) printed pages

QUESTION 1

- a) What is the **significance** of hydrogen bonding on the properties of water? [2 marks]
- b) The K_a of formic acid (HCOOH) is 1.77×10^{-4} at 25°C . What is the pH of a 0.01 M solution of formic acid in water? [6 marks]
- c) You were introduced to the acetic acid- acetate buffer as part of the laboratory experiments. Suppose a buffer solution was 0.2 M in acetic acid and acetate. If the buffer species are **equimolar**,
- Calculate** the change in pH upon adding 1.0 ml of 0.1 M HCl to 10 ml of this solution. [8 marks]
 - What **assumption did** you make in **part c** (i) to arrive at a mathematically correct estimate? (K_a of acetic acid is 1.75×10^{-5}) [1 mark]

Question 2

- a) Using a sketch of a graph, **show** what most likely happens to the rate of reaction of a human enzyme when temperature is gradually raised from 15°C to 90°C . Briefly **explain** your answer. [6 marks]
- b) Starting with any four (4) basic assumptions, **derive** the Michaelis-Menten equation. [12 marks]
- c) The following data was obtained in a study of an enzyme known to follow Michaelis -Menten kinetics:

V_0 ($\mu\text{mol}/\text{min}$)	Substrate added (mmol/L)
215	0.5
320	2.0
430	4.8
490	5.9
650	1,000.0

Without plotting a graph, **calculate** the K_m for this enzyme. Show all your steps (reasoning) clearly. [2 marks]

Question 3

- a) Given the following peptide "LNGRSEAI".
- List** the full names of the amino acids in this peptide. [2 marks]
 - Identify** which are polar or non-polar. [2 marks]
 - What** is the net charge of this peptides shown above at pH 2.7? [4 marks]
- b) A particular polypeptide chain containing 105 amino acids residues:
- Calculate** its length if It exists entirely in α - helical form. [3 marks]
 - Calculate** its length if the backbone bonds are fully extended and linear. [3 marks]
- c) A mixture of amino acids can be separated by paper chromatography and electrophoresis. Ninhydrin is used to locate the position of amino acids on chromatograms. It reacts with ammonia, primary and secondary amine.
- Explain** in two to three sentences the principles underlying electrophoresis. [2 marks]
 - What** is the colour of the complex formed when ninhydrin reacts with proline? [1 mark]
 - Draw** the chemical structure of D-threonine and **calculate** the number of stereoisomers of threonine. [3 marks]

Question 4

The table below refers to some enzymes involved in the digestion of carbohydrates in the human digestive system.

- a) **Copy** and **complete** the table by writing the correct word(s) for the site of secretion. For products of reaction, draw the respective chemical structures.

Name of enzyme	Name of substrate	Products of reaction
lactase		
sucrase		
maltase		

[3 marks]

- b) **Draw** the Haworth projections of products formed by the action of sucrase in the table above. [4 marks]

- c) Starch and cellulose are high molecular weight polysaccharides.

i. **Which** hexose sugar forms their basic unit? [1 mark]

ii. **What** is the essential structural difference between starch and cellulose?

[2 marks]

iii. **Describe** mutarotation using glucose as an example [6 Marks]

iv. In a **tabular format**, list the reagents, colour produced, and sugars specific for the following reactions:

(a) Barfoeds test

[1 Mark]

(b) Benedicts test

[1 Mark]

(c) Molisch test

[1 Mark]

(d) Seliwanoff test

[1 Mark]

Question 5

Nucleic acids are macromolecules that are essential for life. The major nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

- a) List two difference in composition between DNA and RNA **[1 Marks]**
- b) A sample of double – stranded DNA was found to have thymidylate as 21% of the nucleotide resides. If its percentage of thymidylate was increased to 33% would you expect the melting temperature of this strand to increase or decrease? Justify your answer. **[5 Marks]**
- c) Adenosine triphosphate is a nucleotide.
- i. **Draw** the chemical structure of Adenosine triphosphate **[3 Marks]**
 - ii. **Name** and **label** the chemical linkage joining adenine to ribose, ribose to phosphate, and linkages joining various phosphate in the Adenosine triphosphate. **[4 Marks]**
 - iii. **Draw** the chemical structure of any Adenosine nucleoside analogue used in treatment of HIV. **[3 Marks]**
 - iv. **Explain** how such a nucleoside analogue works in the treatment of HIV. **[4 Marks]**

Question 6

- a) Lipids are molecules that are generally insoluble in water and soluble in non-polar solvents. Most lipids have fatty acids as their building blocks.
- What** is meant by rancidity of lipids? [2 marks]
 - Write** short notes on polyunsaturated lipids. (Hint: not more than five lines). [2 marks]
 - Give the **systematic name, common name** and the **skeletal structure** for the following fatty acid given by the following notations: C18:3 cis $\Delta^{9,12,15}$ [4 marks]
- b) **What** is the redox potential of the system NAD^+/NADH against hydrogen electrode, if the standard redox potential E_0' is -0.32 V and ratio NAD^+/NADH is 10:1? (25°C , $R = 8.3143\text{ J K}^{-1}\text{ mol}^{-1}$, $F = 96\,487\text{ J V}^{-1}\text{ mol}^{-1}$)[12 marks]

END OF EXAMINATIONS

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

**2017 ACADEMIC YEAR
MID YEAR EXAMINATIONS**

CHE 2511: BASIC ORGANIC CHEMISTRY

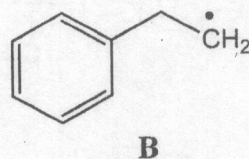
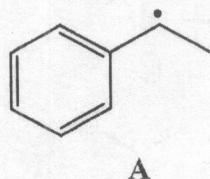
INSTRUCTIONS TO CANDIDATES:

TIME ALLOWED: THREE (3) HOURS

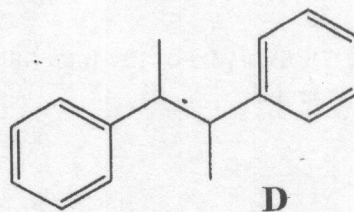
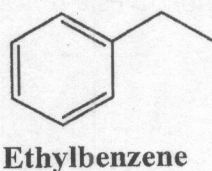
1. This paper contains **five questions** and has six (6) printed pages. Please ensure that you have all printed pages.
2. **Answer any four (4) questions.**
3. Questions carry equal marks, **twenty five (25).**
4. Write your **TG number** (example: TG 9) on the cover page of each answer booklet.
5. **Please** be reminded of the need to present your answers in a **neat and logical manner**, try to be to the point.

QUESTION 1

- (a) Draw the possible stereochemical structures for the saturated chiral carboxylic acid, containing five carbon atoms and give the IUPAC name for any one of them. (4 marks)
- (b) The radical **A** is more stable than radical **B**. State why? (1 mark)



- (c) Ethylbenzene was reacted with NBS in carbon tetrachloride in presence of the UV light at room temperature. The major organic product, **C**, isolated from the reaction mixture was found to be optically inactive. Traces of compound **D**, shown below, were also detected in the reaction mixture.

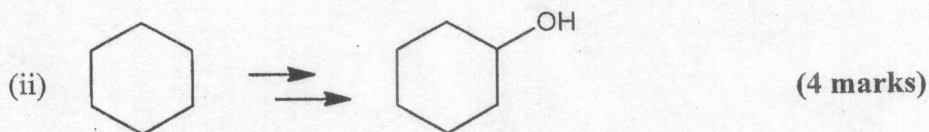
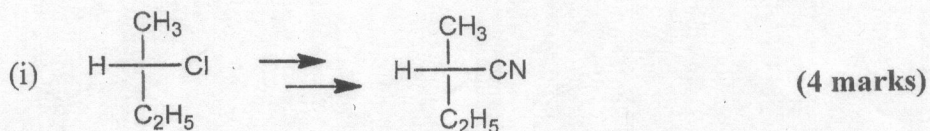


- (i) Identify the product **C** and give reaction mechanism. (7 marks)
- (ii) Provide a mechanistic explanation to account for the optical inactivity of the isolated product **C**. (5 marks)
- (iii) Suggest a plausible mechanism for formation of the trace amount of **D** in this reaction. (2 marks)

- (d) A hydrocarbon **E** reacts with hydrogen iodide to form **F** which reacts with aqueous potassium hydroxide to give compound **G**. Oxidation of **G** with Jones reagent gives propanone. What are the structural formulas of **E**, **F**, and **G**? Show your reasoning. (6 marks)

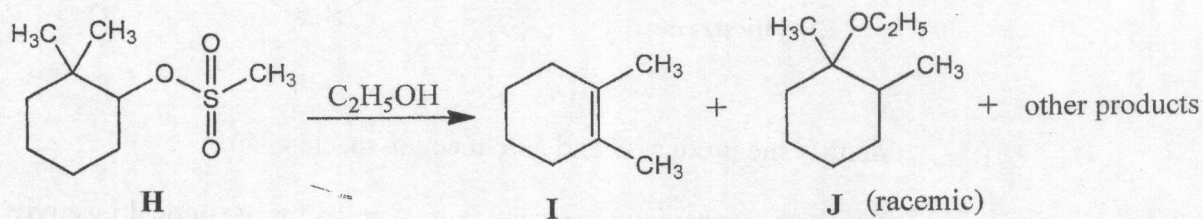
QUESTION 2

- (a) Suggest the shortest synthetic schemes for each of the following transformations. More than one step is required in each case. Show the reagents, solvents, reaction conditions, and intermediates for each step clearly. Please do not write reaction mechanisms.



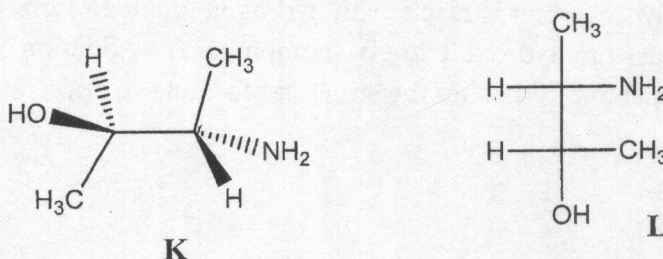
- (b) Propose the stereochemical structure of the alkyl halide that gives only *E*-3-methyl-2-phenyl-2-pentene by E2 elimination. (3 marks)

- (c) Solvolysis of the mesylate **H** in aqueous ethanol gives a mixture of products, including **I** and **J**.



Propose plausible reaction mechanisms to account for the products **I** and **J**.

- (d) State the relationship between the compounds **K** and **L** as either identical, structural isomers, enantiomer, diastereomers or meso compound. Show your reasoning clearly. (6 marks)



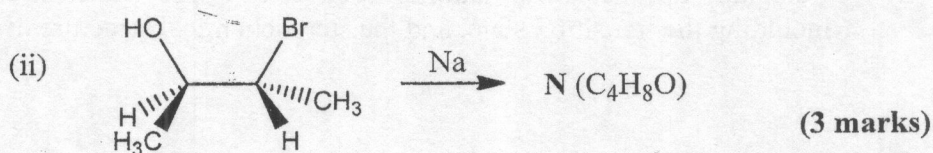
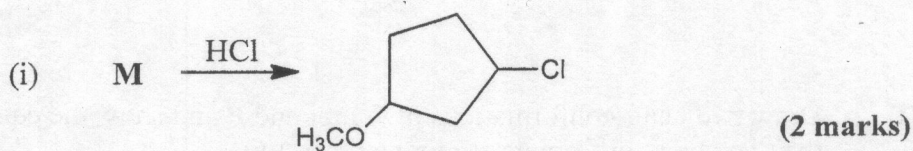
QUESTION 3

(a) Sighting the (R)-2-methylbutane molecule along the C2-C3 bond:

- (i) Draw the Newman projections for all possible conformers. (4 marks)
- (ii) Draw a qualitative graph of potential energy versus angle of rotation about the C2-C3 bond. (4 marks)
- (iii) Given the "energy costs" in the table below, calculate and assign the quantitative energy values to your graph. (6 marks)

Interaction	Energy Cost kJ.mol ⁻¹	Interaction	Energy Cost kJ.mol ⁻¹
CH ₃ -CH ₃ gauche	3.8	H-CH ₃ eclipsed	6.0
H-H eclipsed	4.0	CH ₃ -CH ₃ eclipsed	11.0

(b) Provide the structures, including stereochemistry, where pertinent, of the compounds M and N.



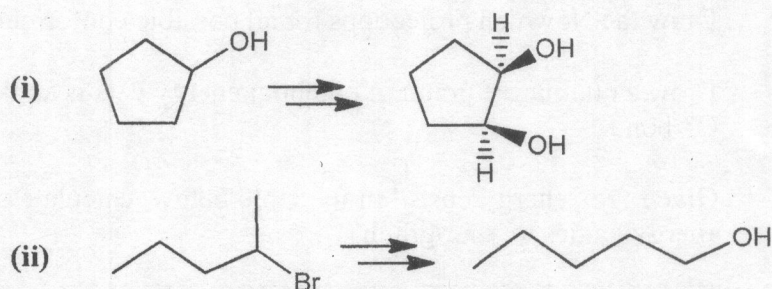
(c) Identify the product and give mechanism of the reaction of (S)-2-butanol with thionyl chloride in presence of pyridine. (6 marks)

QUESTION 4

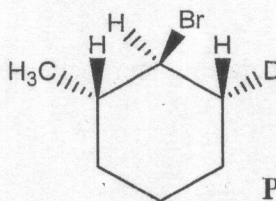
(a) Outline how you would make the following transformations. Show all steps clearly.

Please *do not* write reaction mechanisms.

(8 marks)



(b) Upon heating with sodium ethoxide in ethanol, the compound **P** gave the product **Q**.



(i) Draw two chair conformations of compound **P** and show the equilibrium between the two chair conformers at room temperature. (3 marks)

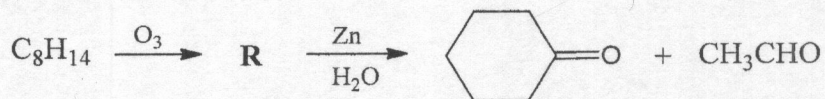
(ii) Using appropriate conformational structure of **P**, provide the reaction mechanism, including the transition state, and the stereochemical structure of **Q**. (5 marks)

(c) Explain why 1-alkynes are acidic in nature.

(2 marks)

(d) (i) Determine the structure of the unknown compound, C_8H_{14} , from the following reaction.

(2 marks)

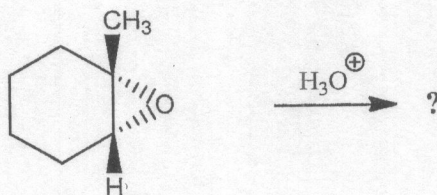


(ii) Provide the structure of **R** and the mechanism of its formation.

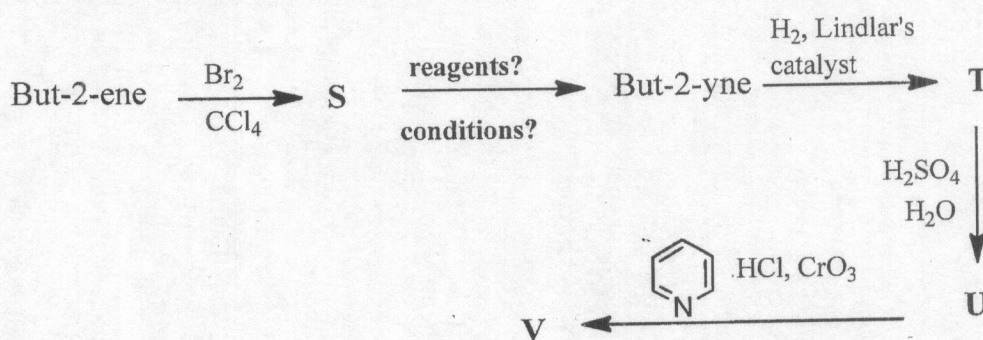
(5 marks)

QUESTION 5

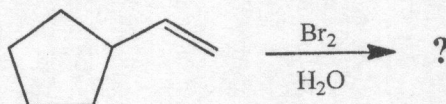
- (a) Identify the product of the following reaction, showing the pertinent stereochemistry. (3 marks)



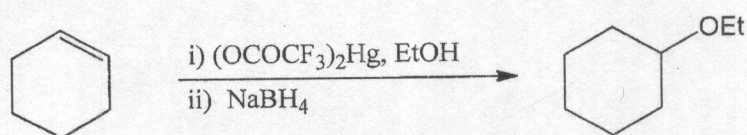
- (b) (i) Provide the missing intermediates S, T, U, the product V, reaction conditions and reagents for the following synthesis. (8 marks)



- (ii) Give the composition of Lindlar's catalyst. (2 marks)
- (c) Predict the major product and give a mechanism for the following reaction. (7 marks)



- (d) Suggest a mechanism to account for the following ether synthesis. (5 marks)



**END OF EXAMINATION
GOOD LUCK!**

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

**2017 ACADEMIC YEAR
DEFERRED FINAL EXAMINATIONS**

CHE 2511: BASIC ORGANIC CHEMISTRY

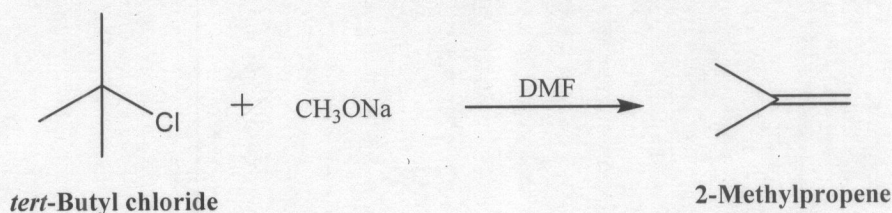
TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS:

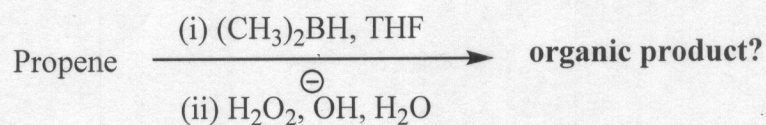
1. Answer any four (4) questions.
2. Each question carries 25 marks.
3. Write your TG number (example: TG 9) on the cover page of each answer booklet.
4. Present your answers in a logical manner.
5. Begin each question on a new page.
6. Ensure that you have 5 printed pages and five (5) questions in this question paper.

QUESTION 1

- (a) A CHE 2511 student attempted to prepare *tert*-butyl methyl ether, $(\text{CH}_3)_3\text{COCH}_3$, by Williamson ether synthesis by reacting *tert*-butyl chloride with sodium methoxide, but instead of the ether, she obtained an alkene, 2-methylpropene.

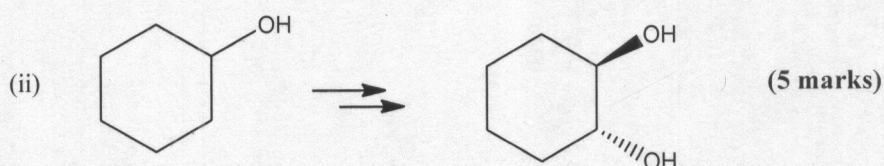


- (i) Briefly explain why *tert*-butyl methyl ether was not obtained. (2 marks)
 - (ii) Give a mechanism to account for the 2-methylpropene product. (2 marks)
 - (iii) Show how you would prepare *tert*-butyl methyl ether by Williamson ether synthesis. (3 marks)
- (b) Predict the major organic product and give the mechanism of the following reaction:



(8 marks)

- (c) Suggest how the following transformations can be achieved. More than one step are required, show all steps clearly. Reaction mechanisms are NOT required.

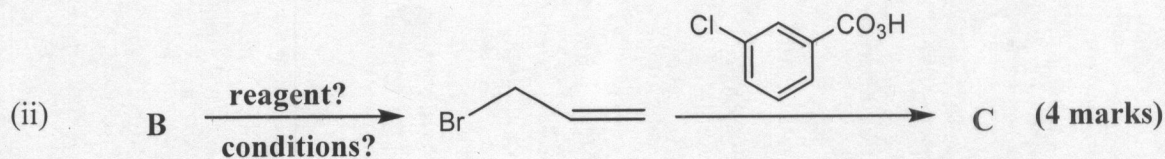
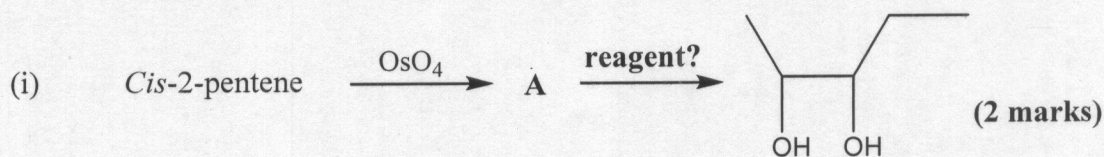


QUESTION 2

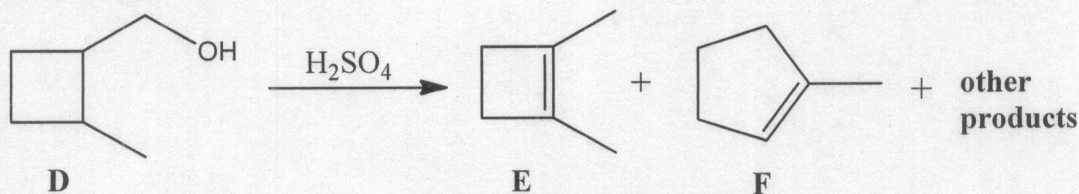
- (a) Use Fischer projections to draw all the stereoisomers of 3-amino-2-butanol. Give the complete names for **any two** of the stereoisomers. (9 marks)
- (b) Predict the product and give the mechanism of the reaction of propene with NBS in presence of sunlight. (6 marks)
- (c) Draw the following: (2 marks each)
- A stable butterfly conformer for methylcyclobutane.
 - A stable envelope conformer for ethylcyclopentane.
 - A stable chair conformer for cis-1,3-diisopropylcyclohexane.
- (d) Give the structures of the products from the following reactions. Reaction mechanisms are **not** required to be shown. (2 marks each)
- Treatment of 1-methylcyclohexene with cold alkaline potassium permanganate.
 - Treatment of methylcyclopentene with hydrogen chloride.

QUESTION 3

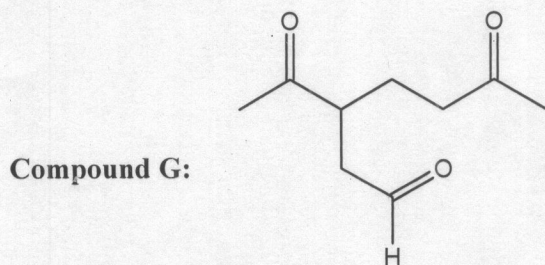
- (a) Provide the missing starting materials/reagents/solvents/conditions/products of the following reactions. Show the stereochemistry of reactants/products, where required.



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



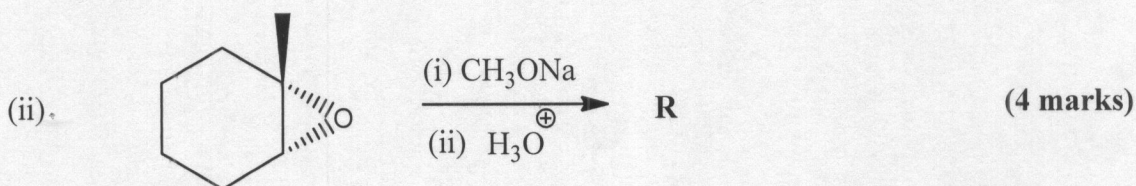
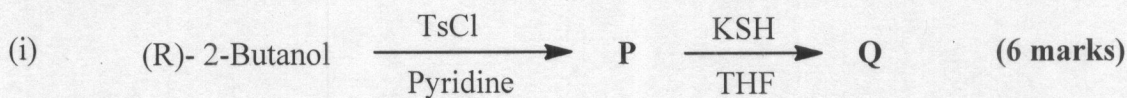
- (c) Limonene, $\text{C}_{10}\text{H}_{16}$, is a terpene found in lemon and orange oils. Upon treatment with excess hydrogen over a platinum catalyst, limonene gives 1-isopropyl-4-methyl-cyclohexane. Upon treatment with ozone and then with zinc and acetic acid, limonene gives methanal and a compound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



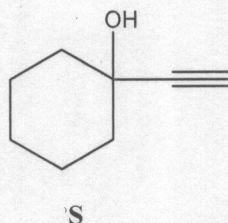
- (i) Calculate IHD of limonene and interpret it. (2 marks)
- (ii) Propose a structure for limonene that is consistent with these experimental results. Justify your answer. (7 marks)
- (iii) Provide the IUPAC name for compound **G**. (1 mark)

QUESTION 4

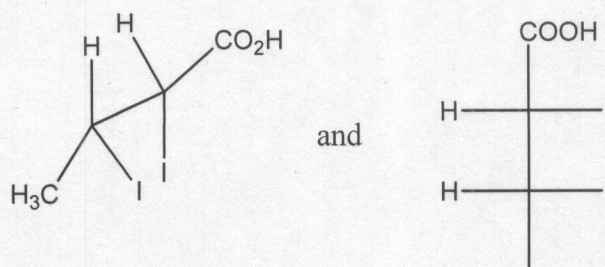
- (a) Suggest the structure of an alkyl halide that gives only *E*-3-methyl-2-phenyl-2-pentene and none of the *Z*-isomer upon E2 elimination. Show the reaction. (4 marks)
- (b) Identify the organic product(s), including pertinent stereochemistry, and give mechanisms of the following reactions:



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



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



QUESTION 5

- (a) Draw the Newman projections for staggered and eclipsed conformers of butane along the C2-C3 bond and arrange them in increasing order of energy. (6 marks)
- (b) Predict the organic product of the following reactions. Do not write reaction mechanisms. (2 marks each)
- Reaction of 1-butyne with aqueous sulphuric acid in presence of mercuric ions.
 - Reaction of cyclohexene with CH_2N_2 in presence of uv radiation.
- (c) Propose a Grignard synthesis of 3-hexanol from 1-propanol as the only source of carbon atoms and any needed reagents. Show all steps clearly, including the reagents, solvents, conditions and intermediates for each step. DO NOT write reaction mechanisms. (8 marks)
- (d) Write the mechanism for the reaction of (*S*)-2-pentanol with phosphorous tribromide. (7 marks)

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

**2017 ACADEMIC YEAR
FINAL EXAMINATIONS**

CHE 2522: FUNCTIONAL GROUP AND ARENE CHEMISTRY

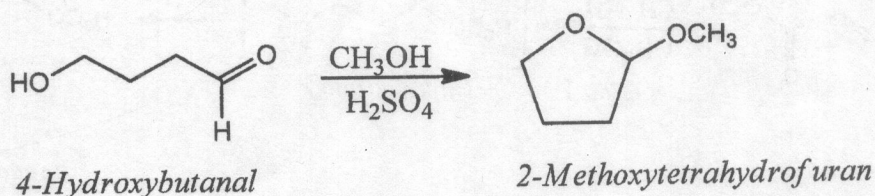
TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS:

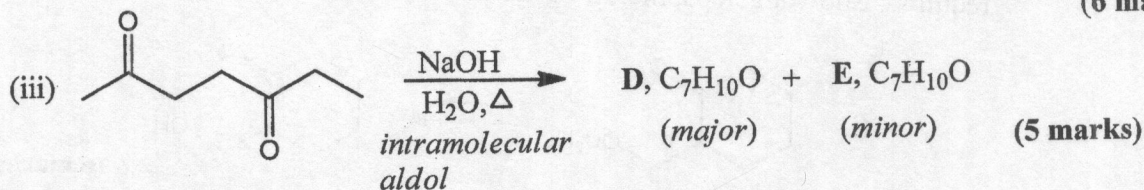
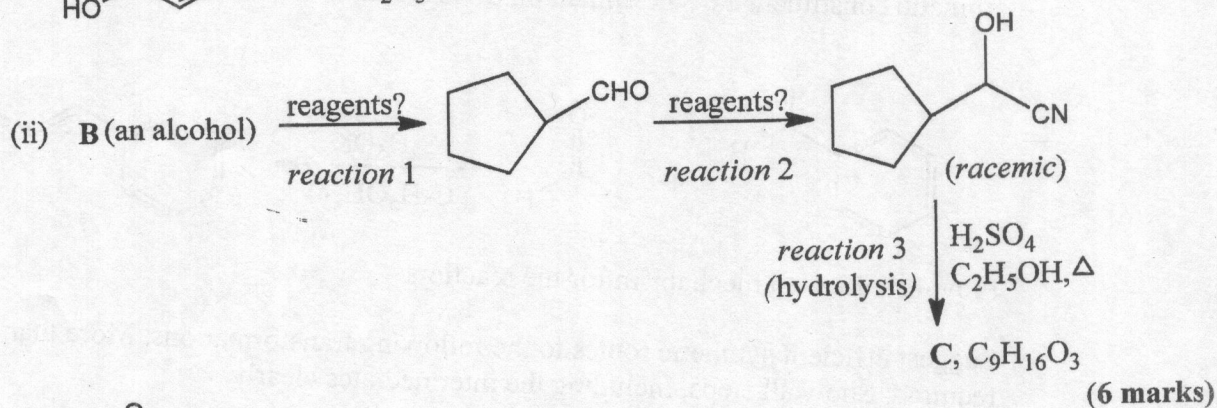
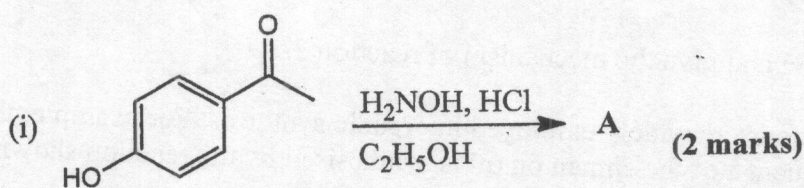
1. Answer any FOUR (4) questions.
2. Present your answers in a logical manner.
3. Write your TG number (example: TG 9) on the cover page of each answer booklet.
4. Begin each new question on a new page.
5. Ensure you have six (6) printed pages containing five (5) questions.

QUESTION ONE

- (a) Upon treatment with methanol in the presence of a strong proton acid, 4-hydroxybutanal gives 2-methoxytetrahydrofuran. Propose a plausible mechanism for the transformation. (6 marks)



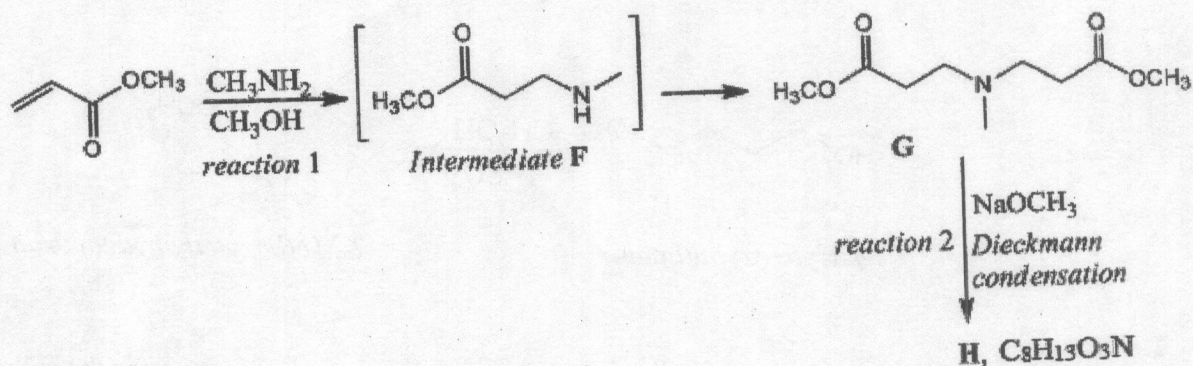
- (b) Provide the missing starting materials/products/reagents/conditions for the following reactions. Do not write reaction equations or mechanisms. (13 marks)



- (c) Suggest a synthesis of butanoic acid ($\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$) from propanoic acid ($\text{CH}_3\text{CH}_2\text{COOH}$). Show all steps clearly, including the reagents, conditions and intermediates for each step. Do not write reaction mechanisms. (6 marks)

QUESTION TWO

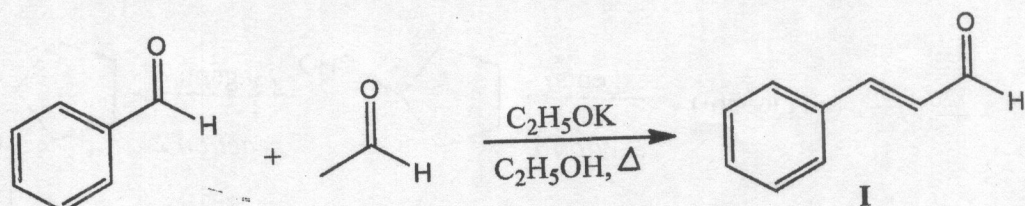
(a) Two steps of a procedure for the synthesis of 4-oxopiperidones are shown below:



(i) Provide a plausible mechanism to account for the formation of the intermediate F in reaction 1. (4 marks)

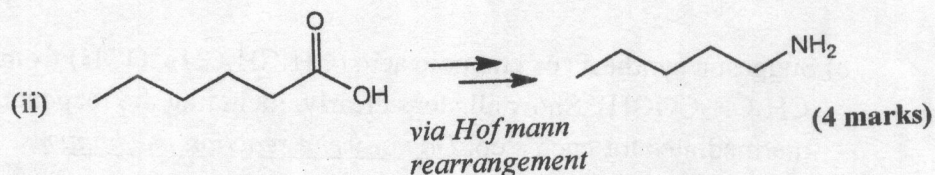
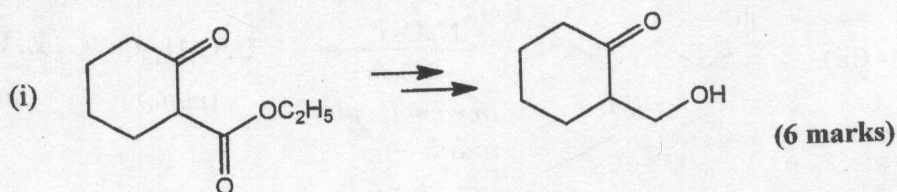
(ii) Identify H and give the mechanism of reaction 2. (4 marks)

(b) Aldol condensations are widely employed in organic synthesis. For example, the aromatic constituent I of the cinnamon oil is synthesised by the reaction shown below:



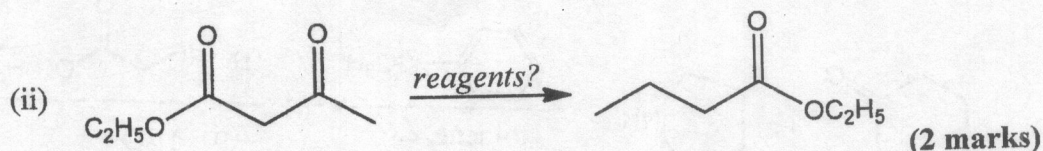
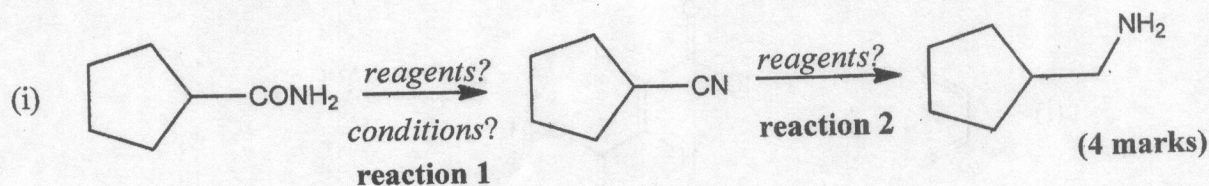
Provide a detailed mechanism for the reaction. (7 marks)

(c) Suggest efficient synthetic routes to the following transformations. More than one step is required. Show all steps, including the intermediates clearly. (10 marks)

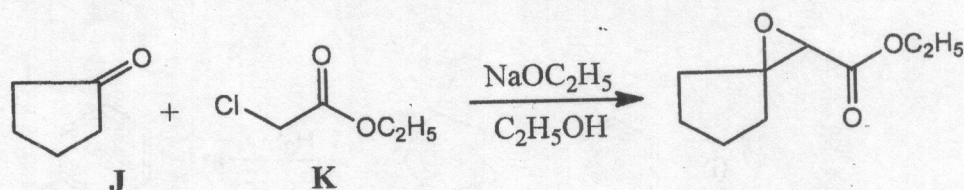


QUESTION THREE

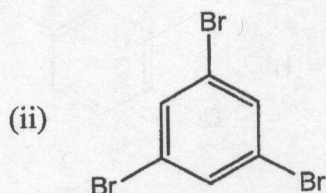
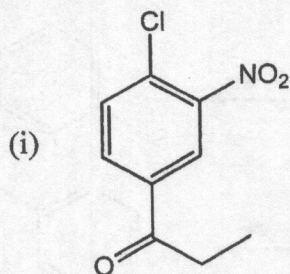
- (a) Provide the reagents and conditions for the following transformations. Please do not write reaction equations. (6 marks)



- (b) Base catalyzed condensation of ethyl chloroacetate **K** with a ketone gives an epoxy ester. The reaction is called Darzens condensation, an example is shown below:

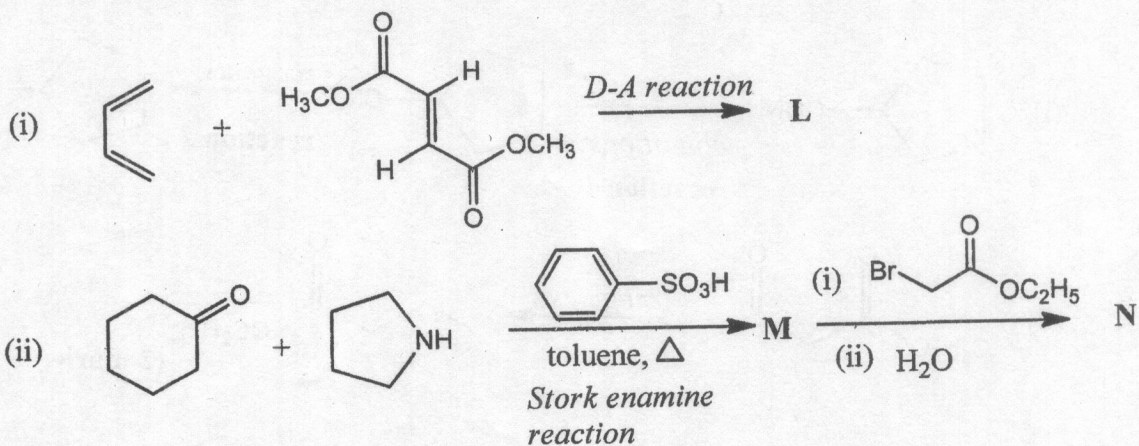


- (i) The α -hydrogens of compound **K** are more acidic than those of compound **J**. Explain why. (2 marks)
- (ii) Darzens condensation involves two steps, the first step is a nucleophilic addition reaction and the second step is an intramolecular $\text{S}_{\text{N}}2$ reaction. On this basis, provide the mechanism of the Darzens condensation shown above. (5 marks)
- (c) Propose the most efficient route for the synthesis of the following compounds starting from benzene. Show all steps clearly. Do not write mechanisms. (12 marks)

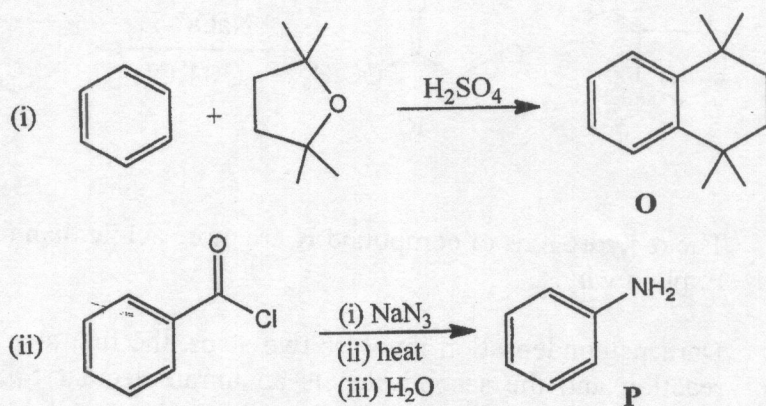


QUESTION FOUR

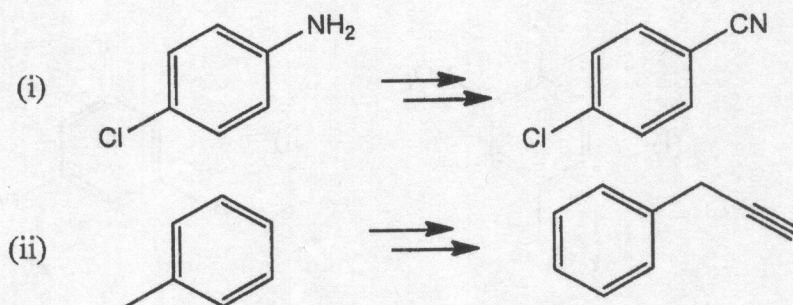
- (a) Provide the structures, including the stereochemistry, where relevant, of the products L-N of the following reactions. Do not write mechanisms. (6 marks)



- (b) Provide plausible mechanisms to account for the products of the following reactions: (12 marks)

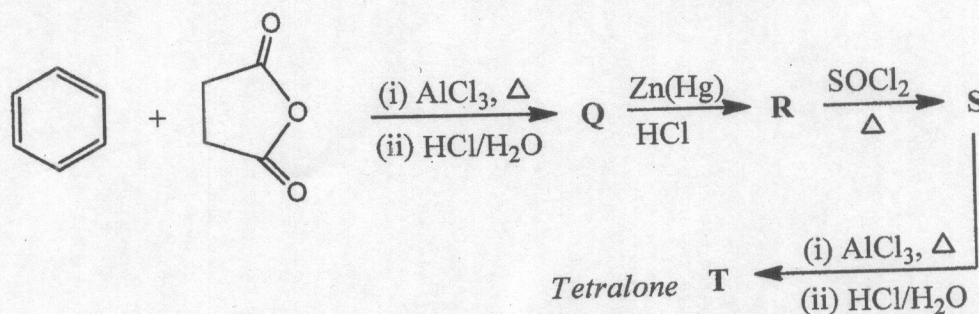


- (c) Suggest the shortest synthesis for each of the following transformations. Show all steps, including the intermediates clearly. Do not write reaction mechanisms. (7 marks)

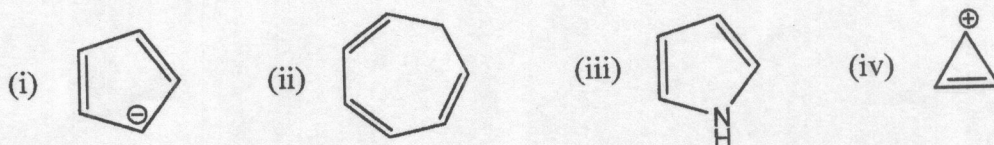


QUESTION 5

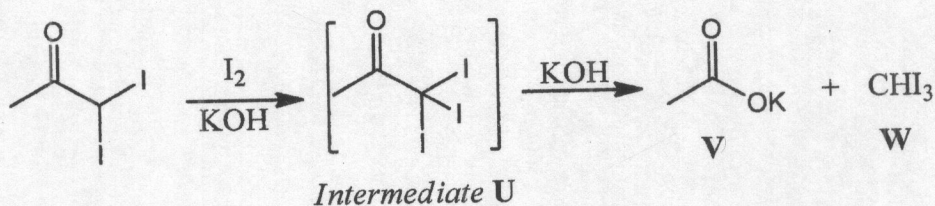
- (a) Benzene is a starting point in the synthesis of many aromatic compounds. Tetralone can be synthesized using the following schemes of reactions. Provide the structures for the products, Q-T, of the following reactions. (5 marks)



- (b) Draw the π -molecular orbitals of the 1,3-pentadienyl anion and label the HOMO and LUMO (7 marks)
- (c) Consider the following molecules and state, with a reason, which ones are aromatic, non-aromatic, or antiaromatic. (6 marks)



- (d) Provide a mechanistic explanation to account for the intermediate U and the products V and W of the iodoform reaction shown below. (7 marks)



**END OF EXAMINATION
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**THE UNIVERSITY OF ZAMBIA
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**2017 ACADEMIC YEAR
UNIVERSITY DEFERRED EXAMINATIONS**

CHE 2522: FUNCTIONAL GROUP AND ARENE CHEMISTRY

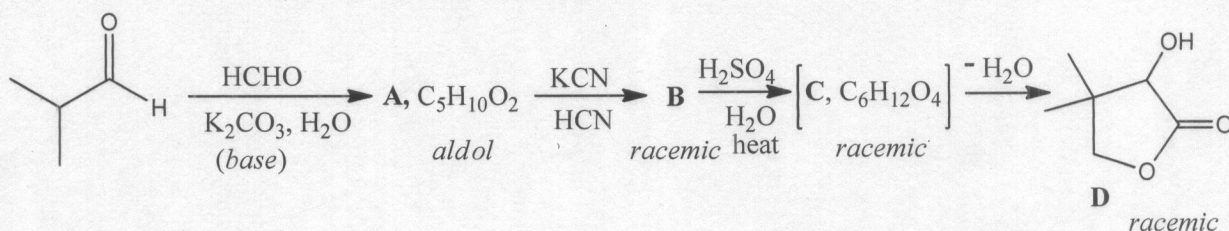
TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS:

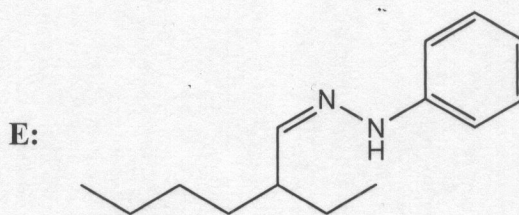
1. Answer any FOUR (4) questions.
2. Present your answers in a logical manner.
3. Write your TG number (example: TG 9) on the cover page of each answer booklet.
4. Begin each new question on a new page.
5. Ensure you have 7 printed pages containing five (5) questions.

QUESTION ONE

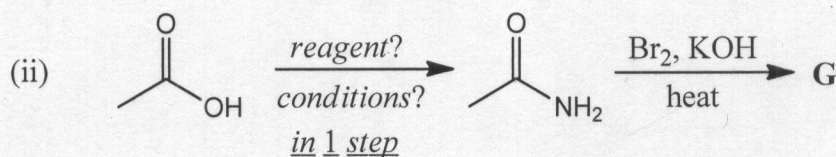
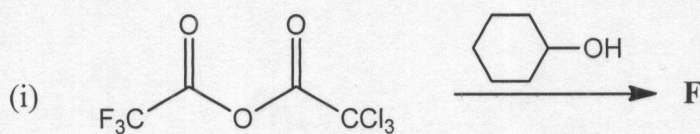
- (a) The compound **D**, an important intermediate in the synthesis of pantothenic acid, vitamin B5, was prepared by the route shown below:



- (i) Identify the intermediates **A-C** in the above synthesis. **(4 marks)**
 (ii) Give the mechanism for the formation of **D** from **C**. **(5 marks)**
- (b) Propose a synthesis of the compound **E** shown below, from any alcohols via an aldol condensation. Show all steps, including the intermediates clearly. *Do not write reaction mechanisms.* **(6 marks)**

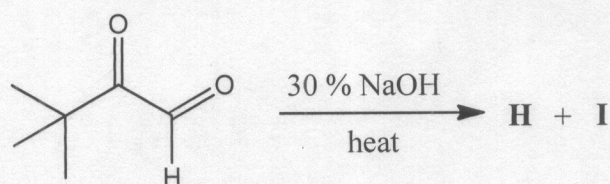


- (c) Provide the missing reagents, conditions and the products **F** and **G** of the following reactions: **(4 marks)**



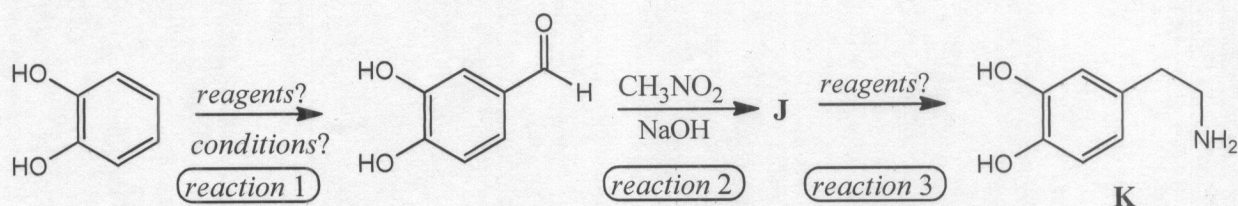
(d) Predict the products and give mechanism of the following reaction:

(6 marks)



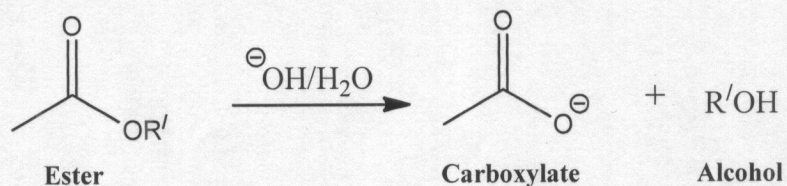
QUESTION TWO

(a) Consider the following synthesis of the neurotransmitter **K**.

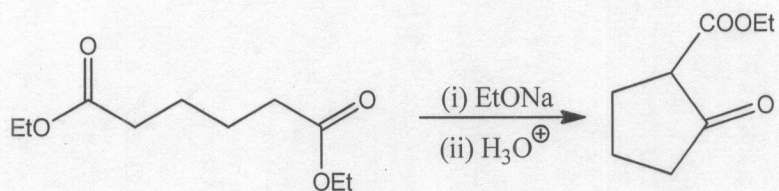


- (i) Provide the reagents and conditions for reaction 1. (2 marks)
(ii) Identify the intermediate **J** and give the mechanism of the reaction 2. (7 marks)
(iii) Give the reagents for reaction 3. (1 mark)

(b) The carboxylic acid group is often protected as a *tert*-butyl ester in organic synthesis. Unlike methyl and ethyl esters, which are easily hydrolysed by aqueous bases, *tert*-butyl esters, RCOOC(CH₃)₃, are resistant to alkaline hydrolysis.

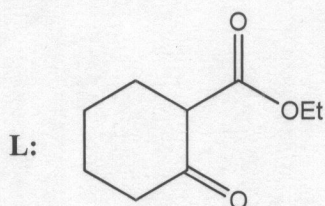


- (i) Write the mechanism of alkaline hydrolysis of esters, RCOOR', indicating the rate determining step. (4 marks)
(ii) Based on the hydrolysis mechanism you wrote, briefly explain why *tert*-butyl esters are resistant to alkaline hydrolysis. (2 marks)
- (c) (i) Dieckmann condensation is used for synthesis of a variety of cyclopentanone and cyclohexanone derivatives. An example is shown below:



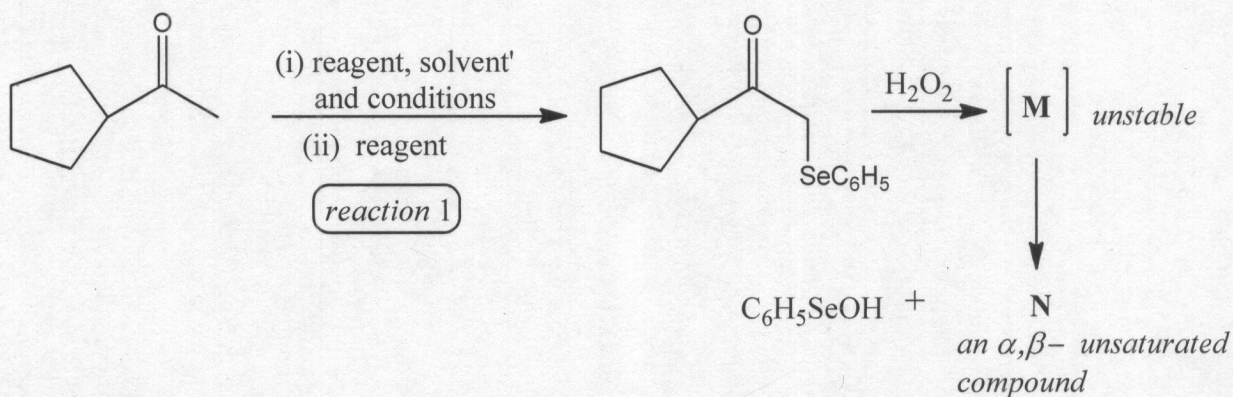
Provide a detailed mechanism for the reaction, including the resonance stabilisation of the anion intermediates. **(8 marks)**

(ii) What starting material would you use to prepare **L** by Dieckmann condensation? **(1 mark)**



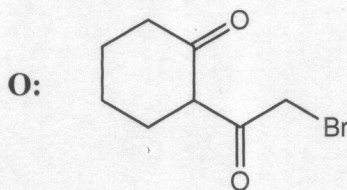
QUESTION THREE

(a) α -Selenylation is frequently used for the synthesis of the α,β -unsaturated carbonyl compounds. An example is shown below:

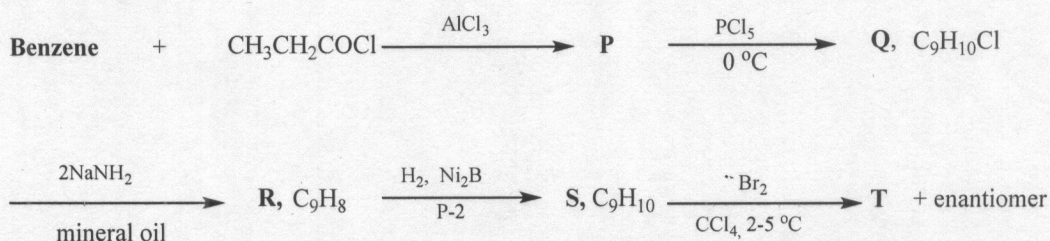


- (i) Provide the reagents and conditions for the reaction 1. **(3 marks)**
 (ii) Identify the intermediate **M** and the final product **N**. **(2 marks)**
 (iii) Show the mechanism of the reaction for the transformation of **M** into **N**. **(2 marks)**

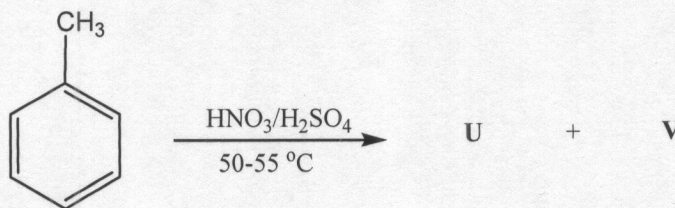
- (b) Suggest a synthesis of the compound **O**, shown below, starting from any alcohols as the only source of carbons via Stork enamine reaction. Show all steps, including the intermediates clearly. Please do not write reaction mechanisms. (7 marks)



- (d) Give the structures, including stereochemistry where appropriate for the Compounds; **P-T.** (5 marks)



- (e) Write the mechanism of the following reaction which proceeds by electrophilic aromatic substitution mechanism. Identify the products **U** and **V.** (6 marks)

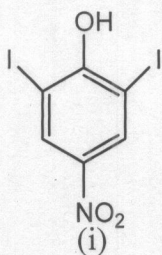


QUESTION FOUR

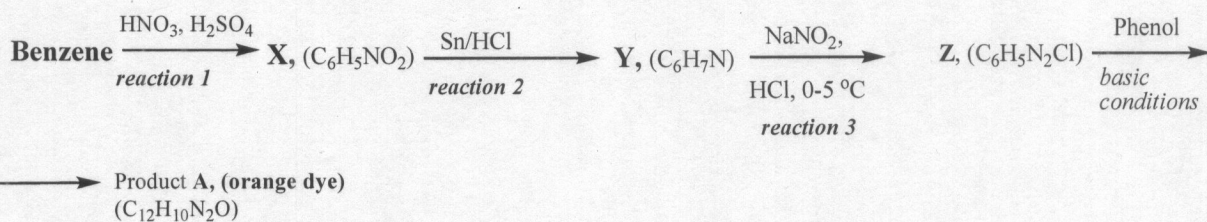
- (a) Draw the structures of the following compounds: (4 marks)

- (i) 1-(4-Bromo-3-nitro-phenyl) ethanoate
- (ii) 2,4-Difluoro-3-propylphenol

- (b) Provide the systematic name for the following compounds: (4 marks)



(c) The following reaction sequence is of valuable synthetic utility. Consider the chemistry, starting with benzene and ending with an azo compound A.



(i) Provide the structures X, Y, Z and A (4 marks)

(ii) Write the reaction mechanism for reaction 3, the formation of diazonium salt. (7 marks)

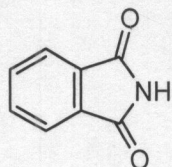
(d) Define the following terms

(i) Aromaticity (4 marks)

(ii) Huckel's $(4n+2)$ rule (2 marks)

QUESTION FIVE

(a) Phthalimide, structure shown below, used in the Gabriel synthesis, is prepared by the reaction of ammonia with phthalic acid.

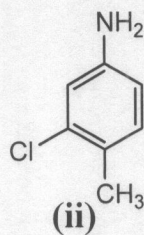
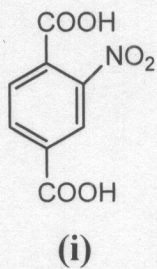


Phthalimide

(i) Propose a reaction mechanism for the synthesis. (8 marks)

(ii) When phthalimide obtained in (a)(i) above is treated with isopropyl iodide in the presence of aqueous potassium hydroxide, what products would you expect to obtain? Suggest the mechanism for this reaction. (7 marks)

(b) Outline the methods for the preparation of the following compounds in a reasonably pure state and good yield from benzene by electrophilic aromatic substitution. **(10 marks)**



END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR FINAL DEFERRED EXAMINATIONS

CHE 3111: CELLULAR BIOCHEMISTRY

INSTRUCTIONS TO CANDIDATES:

Time: Three (3) hours

All questions carry **equal marks** (20 marks each)

Answer any **Five (5)** questions

Write your computer number on all answer booklets

This examination consists of **SIX (6)** questions on **FIVE (5)** printed pages

QUESTION 1

- i. Quite often in biochemistry, we use spectrophotometry (optical density or absorbance) to measure amount of protein in a sample. **What** molecular feature(s) in protein are responsible for absorbance measurements?
[5 marks]
- ii. The absorbance of a protein solution containing 1 mg/ml albumin was measured using a 1 cm light path and was found to be 0.550 and 0.199 absorbance units at 279 nm and 290 nm respectively. Assuming that tyrosine and tryptophan are the only amino acids that absorb appreciably at these wavelengths, **calculate** the number of these two amino acids in a molecule of the protein given that:
- a) MW of albumin is 65 000 dalton.
 - b) The molar extinction coefficient of tyrosine is 1.1×10^3 l/mol.cm at 279 nm and 0.28×10^3 l/mol.cm at 290 nm.
 - c) The molar extinction coefficient of tryptophan is 5.2×10^3 l/mol.cm at 279 nm and 4.3×10^3 l/mol.cm at 290 nm.

[15 marks]

Question 2

- a) Using a neat table, **compare** and **contrast** myoglobin and haemoglobin.
[10 marks]
- b) Using a neat diagram, briefly **discuss** the probable molecular mechanism for the sigmoidal oxygen dissociation curve of haemoglobin.
[10 marks]

PLEASE TURNOVER THE PAGE

Question 3

a) With a neat diagram, **explain** the whole process of metabolism.

[8 marks]

b) **True or False. If False, write the correct statement.** There are 2 major types of non-linear metabolic pathways.

[4 marks]

c) Using chemical structures, explain the process of glycogen synthesis starting from glucose-6-phosphate, naming all enzymes involved in the linking of the first six residues.

[8 marks]

Question 4

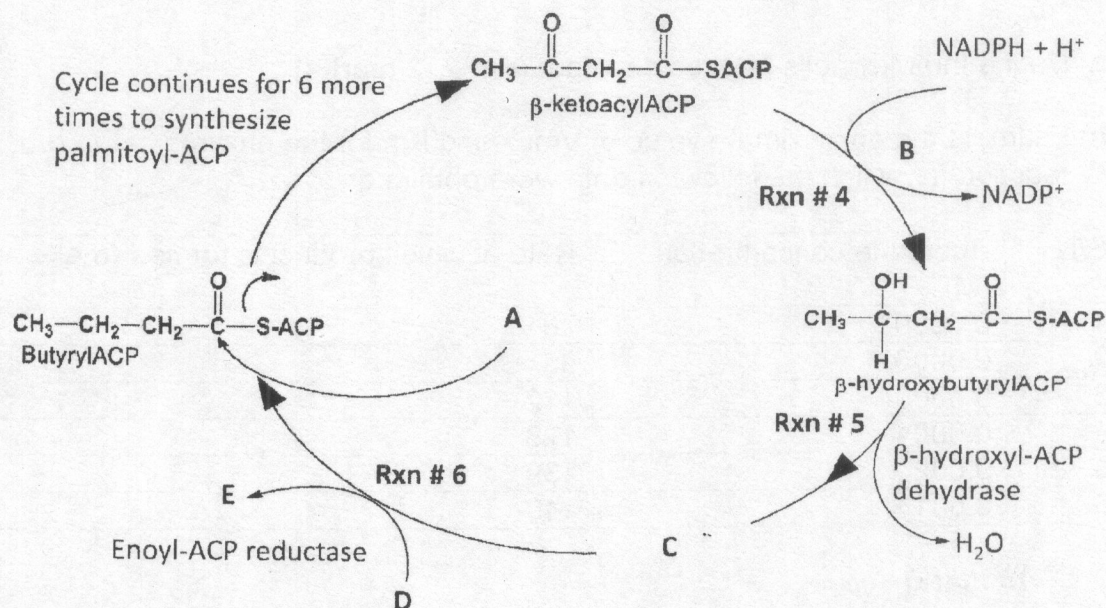
a) **Which** of the two under aerobic conditions, yields more ATP per gram, Hexanoic acid or glucose? Prove your answer by biochemically by applying mathematical reasoning. (*Hint: molecular masses are 116 and 180 respectively*)

[12 marks]

PLEASE TURNOVER THE PAGE

b) **Copy and complete** the following diagram clearly providing structures and names from A to E.

[8 marks]



Question 5

a) **What** is the source of atoms in urea formed by the urea cycle?

[4 marks]

b) With the help of biochemical reactions, **explain** the mitochondrial part of the urea cycle.

[12 marks]

c) **What** is the difference between CPS I and CPS II?

[4 marks]

Question 6

There are various mechanisms of action used by enzymes. Michaelis-Menten's equation tries to characterize the kinetic features of enzyme catalysis. Chymotrypsin and some antiretroviral drugs such as saquinavir are protease inhibitors

- (a) Define the Michaelis-Menten constant (K_m)? [2 marks]
- (b) Estimate the approximate value of V_{max} and K_m for the enzyme catalyzed reaction for which the following data were obtained

S/N	Substrate concentration {M}	Rate at which product is formed {mole/min}
1	0.00001	70
2	0.00002	95
3	0.00004	112
4	0.0001	128
5	0.002	139
6	0.001	140

[9 mark]

- (c) Outline the detailed mechanism of action chymotrypsin. [8 marks]
- (d) Name the mechanism of action used by saquinavir (1marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR FINAL EXAMINATIONS
CHE 3122: ENERGY TRANSDUCTION SYSTEMS

INSTRUCTIONS TO CANDIDATES:

Time: **THREE (3)** hours

All questions carry **equal marks** (20 marks each)

Answer any **FIVE (5)** questions

Write your student identification number (ID) on **ALL** answer booklets

This examination consists of **SIX (6)** questions on **FIVE (5)** printed pages

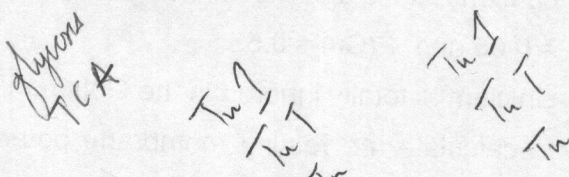
Question1

a) Copy and complete the following table:

[10 marks]

Component/molecule/ion:	Role/function:
Creatine	
Troponin	
Ca ²⁺ ions	
Myosin	
Actin	

b) Briefly **discuss** the statement: "Muscle contraction does not mean shortening of muscle proteins". **Include** a neat diagram [10 marks]



QUESTION 2

- a) Write briefly about any three (3) ways how ATP can be generated in a muscle fibre? [6 marks]
- b) What is muscle fatigue? [2 marks]
- c) Name any three (3) causes of muscle fatigue. [6 marks]
- d) Give any two (2) characteristics of the 3 kinds of muscle fibres. [6 marks]

lactic acidosis

2

*creatine
TCA
glycolysis*

Question 3

a) **How** do the following alterations in the structures of fatty acids affect the membrane physical properties? **[3 marks]**

- i) Increasing the chain lengths of saturated fatty acids.
- ii) Increasing the number of double bonds in unsaturated fatty acids.
- iii) Changing a cis double bond in a fatty acid to a trans double bond.

b) Consider the following information about a giant squid neuron.

Ion	Axoplasmic side	Exoplasmic side
Potassium	400 mM	12 mM
Sodium	55 mM	450 mM
Calcium	0.0001 mM	10 mM
Chloride	56 mM	550 mM



i) Assuming a temperature of 20 °C, $R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}$ and $F = 96,485 \text{ JV}^{-1}\text{mol}^{-1}$, **calculate** the Nernst equilibrium potential for **each** of the above ions. **[8 marks]**

ii) **State** the Goldman equation and hence **calculate** the membrane potential (V_m) for the giant squid neuron, using the above ion concentrations and the following ion permeabilities: $P(\text{K}^+) = 1.0$; $P(\text{Na}^+) = 0.05$ and $P(\text{Cl}^-) = 0.55$ **[8 marks]**

iii) Calcium is totally ignored in the Goldman equation which was designed to calculate the resting membrane potential. **Explain** why, this is so. **[1 mark]**

Handwritten calculations for the Goldman equation:

$$V_m = \frac{RT}{F} \ln \left(\frac{P_{\text{K}^+}[\text{K}^+]_{\text{out}} + P_{\text{Na}^+}[\text{Na}^+]_{\text{out}} + P_{\text{Cl}^-}[\text{Cl}^-]_{\text{in}}}{P_{\text{K}^+}[\text{K}^+]_{\text{in}} + P_{\text{Na}^+}[\text{Na}^+]_{\text{in}} + P_{\text{Cl}^-}[\text{Cl}^-]_{\text{out}}} \right)$$

Substituting values from the table:

$$V_m = \frac{RT}{F} \ln \left(\frac{1.0(12) + 0.05(450) + 0.55(56)}{1.0(400) + 0.05(55) + 0.55(550)} \right)$$

Handwritten work shows the following steps:

- Top numerator: $1(12) + 0.05(450) + 0.55(56) = 12 + 22.5 + 30.8 = 65.3$
- Bottom denominator: $1(400) + 0.05(55) + 0.55(550) = 400 + 2.75 + 302.5 = 705.25$
- Ratio: $\frac{65.3}{705.25} \approx 0.0926$
- Final calculation: $V_m = \frac{26 \text{ mV}}{\ln(10)} \ln(0.0926) \approx 26 \times (-1.08) \approx -28 \text{ mV}$

Handwritten notes at the bottom of the page:

- $\frac{26 \text{ mV}}{2.3}$
- 3
- 4 $P[\text{Na}^+]$
- 1 mV

Question 4

- a) **What** key observations support the chemiosmotic hypothesis? [3 marks]
- b) **Explain** using a neat diagram the F-type ATPase [12 marks]
- c) **Show** with a clear arrow the direction of flow of protons if the pump in part (b) works as a synthase [1 mark]
- d) In bullet form, **give** an account of the physiologic changes that occur in the pump during ATP synthesis [4 marks]

Question 5

- 10
12
- a) **Explain** in less than 100 words and with the **help** of a neat diagram the FRAP experiment. [6 marks]
- b) Transport across membranes is broadly divided into two classes; passive and active transport. Give one example and function of any of the passive transporters and one example and function of any of the active transporters. [2 marks]
- c) With reference to the erythrocyte, **explain** membrane asymmetry with respect to phosphatidyl choline, phosphatidyl serine, phosphatidyl inositol and sphingomyelin. [2 marks]
- d) The membrane composition of *E.coli* is 25% phospholipid and 75 % protein while the human myelin sheath is 30% phospholipid and 30% protein (all percentages are mass by mass). **Explain** using biochemical and evolutionary knowledge why such a differential distribution of membrane components occur in these two organisms. [4 marks]
- e) **Explain** (less than 150 words) the molecular basis of the onset of cystic fibrosis. [6 marks]

Cystic fibrosis
CFTR
transmembrane
regulator

energy
metabolism
concern

4

membranes

Phospholipid
NB DI
Cl⁻ channels
desorp h₂O

Question 6

- a) Compare and contrast the mitochondrial and nuclear genetic code. [5 marks]
- b) Illustrate using a diagram that the mitochondrial genome is degenerate. [6 marks]
- c) In not more than five sentences illustrate that the Mitochondrial genome is diverse [3 marks]
- d) In the mitochondria, gamma DNA polymerase is selectively affected by Emtricitabine a drug used in HIV treatment
- i. List three side effects arising as a result of the aforementioned fact. [3 marks]
- ii. Explain how these side effects are biochemically caused. [3 marks]

END OF EXAMINATION

Universal ✓
non ambiguous ✓
non punctuation ✓
~~no comma~~ non overlap
degeneracy ✓

myo pathy
lipid trophy

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR DEFERRED FINAL EXAMINATIONS

CHE 3122: ENERGY TRANSDUCTION SYSTEMS

INSTRUCTIONS TO CANDIDATES:

Time: Three (3) hours

All questions carry **equal marks** (20 marks each)

Answer any **Five (5)** questions

Write your computer number on all answer booklets

This examination consists of **SIX (6)** questions on **FOUR (4)** printed pages

QUESTION 1

Using a neat diagram, **explain** skeletal muscle contraction. In what sense do muscles proteins actually contract i.e., do muscle proteins actually shorten? **Explain.**
[20 marks]

QUESTION 2

- a) The Ca^{2+} ion is one of the main players in skeletal muscle contraction. Using a neat diagram, **explain** in detail its role in muscle contraction. [15 marks]
- b) **What** is the source of Ca^{2+} ions in skeletal muscles? **Mention** any two. [5 marks]

QUESTION 3

- a) When an *E. coli* cell is cultured at 10 °C, 20 °C, 30 °C and 40 °C, respectively, what is the general trend in fatty acid composition of the cell membrane with respect to myristic acid and palmitoleic acid? [4 marks]
- b) Explain with the help of a neat diagram, the major types of integral membrane protein classes. [6 marks]
- c) Calculate the free energy needed to move 1 mol of Na^+ ions from outside the cell (where $[\text{Na}^+] = 150 \text{ mM}$) to the inside (where $[\text{Na}^+] = 5 \text{ mM}$) when the membrane potential is 70 mV and the temperature is 37°C. $R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}$ and $F = 96,485 \text{ JV}^{-1}\text{mol}^{-1}$ [10 marks]

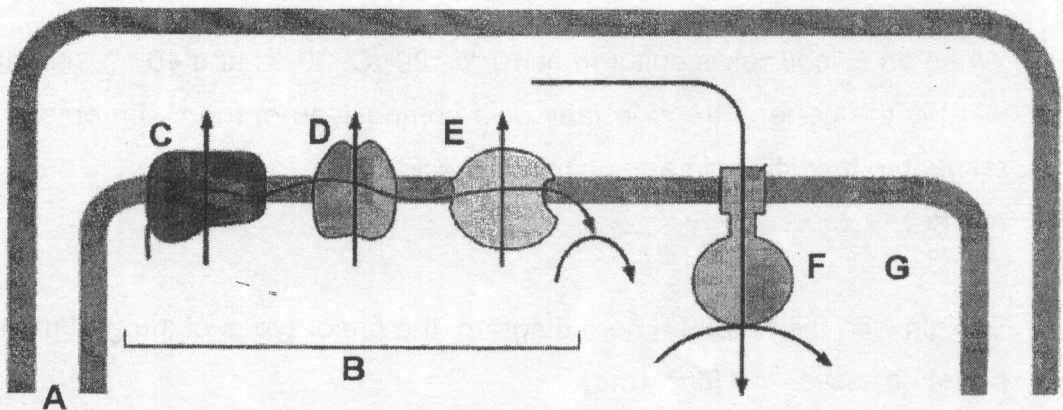
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QUESTION 4

- a) Explain detail how ions and glucose move with respect to the Na^+/K^+ ATPase and the $\text{Na}^+/\text{Glucose}$ transporter in the intestinal epithelial cells. [15 marks]
- b) How is carbon dioxide effectively removed from respiring tissue? Explain with the help of an appropriate diagram. [5 marks]

QUESTION 5

- a) Copy and fill in the missing details of the diagram below. [15 marks]



- b) For each of the following, state the part of the electron transport chain inhibited.
- i) Rotenone ii) Azide iii) Oligomycin [3 marks]
- c) How many ATP molecules will be synthesized if only 7 protons are translocated from the intermembrane space? [2 marks]

PLEASE TURNOVER THE PAGE

QUESTION 6

- a) Compare and contrast the mitochondrial and nuclear genome. [10 marks.]
- b) In not more than five sentences illustrate that the Mitochondrial genome is diverse [4marks]
- c) In the mitochondria, gamma DNA polymerase is selectively affected by Emtricitabine and not Abacavir. Both drugs are used in HIV treatment
- i. List three side effects caused by Emtricitabine arising as a result of the aforementioned fac and explain how these side effects are biochemically caused. [3 marks].
 - ii. Explain why Emtricitabine affect gamma DNA polymerase but Abacavir does not. [3 marks].

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Chemistry

2017 Academic year Term 2 Final Exam

CHE3422

Organometallics and Inorganic Reaction Mechanism

Instructions: Answer any four questions

All questions carry equal marks

Duration: 3 hours

QUESTION 1.

- (a) From the knowledge of chemical properties, speculate on why cerium and Europium were the easiest lanthanides to be isolated before the development of ion-exchange chromatography?
- (b) Actinides form oxocations but lanthanides don't. Explain
- (c) Account for the electrolytic conductivity of a solution of alkali metal in liquid ammonia.

QUESTION 2.

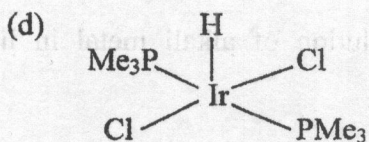
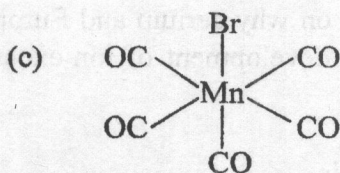
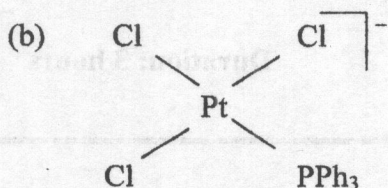
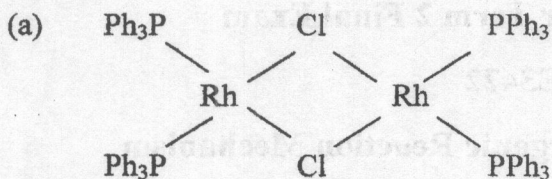
- (a) What is the principle behind atom bomb? How does it differ from hydrogen bomb?
- (b) What is meant by critical mass in relation with nuclear reactor. Why does it vary?
- (c) Draw a diagram to illustrate how binding energy per nucleon varies with mass number. Comment on the shape of the curve.

QUESTION 3.

- (a) Extraction of Uranium involves both chemical and physical separation techniques. Briefly outline the steps involved in the separation of nuclear grade uranium from its ore.
- (b) Compare and contrast the electronic spectra of lanthanide ions with those of transition metal ions.
- (c) Comment on the behaviour of HNO_3 in solvents:
 - (i) liquid ammonia
 - (ii) acetic acid
 - (iii) H_2SO_4

QUESTION 4.

For each organometallic complex below, determine the oxidation state of the metal, d-electron count of the metal, total number of metal electrons and justify any unsaturation or saturation.

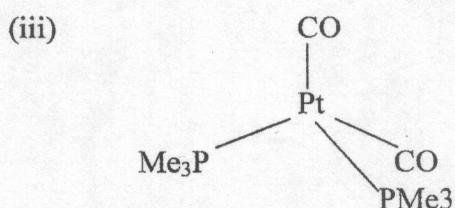
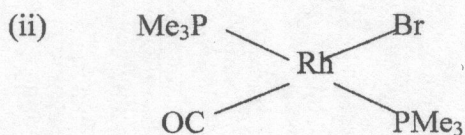
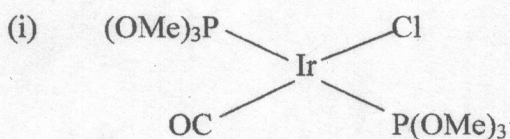


QUESTION 5.

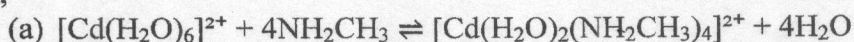
- $\text{V}(\text{CO})_6$ and $[\text{V}(\text{CO})_6]^-$ are both octahedral organometallic complexes. Which of the two should have the shorter C-O bond? Briefly explain
- Which of the two should have the shorter V-C bond? Briefly explain
- Which organo complex, $(\text{CH}_3)\text{Tc}(\text{CO})_5$ or $(\text{F})\text{Re}(\text{CO})_5$, will have the weakest M-CO bonding? Explicitly explain your answer.

QUESTION 6.

- What does an oxidative addition reaction involve?
 - State THREE general features of an oxidative addition reaction.
- To which of the following organo complexes will H_2 most readily undergo oxidative addition and Why?



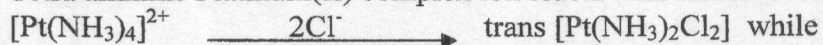
(c) (i) Stability/Formation constants for the reactions of $[\text{Cd}(\text{H}_2\text{O})_6]^{2+}$ with NH_2CH_3 and en,



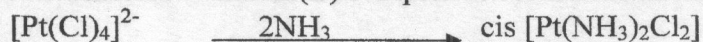
(b) $[\text{Cd}(\text{H}_2\text{O})_6]^{2+} + 2\text{en} \rightleftharpoons [\text{Cd}(\text{H}_2\text{O})_2(\text{en})_2]^{2+} + 4\text{H}_2\text{O}$ are $\log \beta_4 = 6.6$ and $\log \beta_2 = 10.6$ respectively. Explain why we have $\log \beta_4$ in (C) (i) a and $\log \beta_2$ in (C) (i) b.

(ii) Why is $\log \beta_2$ higher than $\log \beta_4$?

(iii) Tetra ammine Platinum(II) complex ion reacts with chloride ions as follows:



Tetrachloride Platinum(II) complex ion reacts with ammonia as follows:



Why do different isomers form?

END OF EXAMINATION

PERIODIC TABLE OF THE ELEMENTS

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

KEY

Atomic number
X
Atomic mass
Name of the element X

1 H 1.01 Hydrogen	2 He 4.00 Helium	3 Li 6.94 Lithium	4 Be 9.01 Beryllium	5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon	11 Na 23.00 Sodium	12 Mg 24.31 Magnesium	13 Al 26.98 Aluminum	14 Si 28.09 Silicon	15 P 30.99 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.88 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 71.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc 97.91 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 Tellurium	53 I 126.90 Iodine	54 Xe 131.29 Xenon
55 Cs 132.91 Cesium	56 Ba 137.33 Barium	57-71 Lanthanum 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	86 Rn 222.02 Radon
87 Fr (223.02) Francium	88 Ra 226.03 Radium	89-103	104 Uuq 261.11	105 Uup 262.11	106 Uub 263.12	107 Uuq 262.12	108 Uuo 265.00	109 Uue 265	110 Uuq 265	111 Uuh 265	112 Uuq 265	113 Uuq 265	114 Uuq 265	115 Uuq 265	116 Uuq 265	117 Uuq 265	118 Uuo 265

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

The University Of Zambia
School of Natural Sciences
Department of Chemistry
2017 Academic Year Final Examination

CHE3422: Organometallics and Reaction Mechanisms

Instructions:

Answer any four (4) questions

All questions carry equal marks

Time: Three (3) hours

QUESTION 1

- (a) Lanthanides exhibit +3 oxidation state whereas actinides exhibit +2 to +7 oxidation states. Why is this so?
- (b) Lanthanide contraction is the steady decrease in size by lanthanides from La (atomic radius $r = 188\text{pm}$) to Lu (atomic radius $r = 173\text{pm}$). Deduce why this happens.
- (c) Spectroscopy of d-block metals is governed by crystal field splitting whereas crystal field splitting is insignificant in lanthanides. State what governs lanthanide spectroscopy and why spectra of Ln^{3+} ions contain large number of absorptions.
- (d) Compare and differentiate between absorption bands of d-d transitions and 4f-5d transitions. Explain the differences.
- (e) Determine the ground state term symbols for Ce^{3+} and Er^{3+} .

QUESTION 2

- (a) Briefly discuss how lanthanide metals are extracted from monazite and bastanite ores and how they are separated into from each other.
- (b) (i) Define alpha - decay.
(ii) Describe how α -decay is used in smoke detectors.
- (c) Define β^- -decay and β^+ -decay with examples.
- (d) (i) What is fission?
(ii) How is fission used to generate power?
(iii) State common problems and solutions for using nuclear power.
- (e) After 500 years, a sample of radium-226 decayed to 80.4% of its original mass. Find the half life of radium-226.

QUESTION 3

- (a) (i) What sub atomic particles are present in nuclei?
(ii) What are their charges?
(iii) Are these sub particles naturally attracted to each other?
(iv) What holds nuclei together?
(v) What is mass defect?
- (b) The mass of ^{19}F is 18.9984 amu. Given that the mass of a hydrogen atom (1 proton and 1 electron) is 1.007825 amu and a neutron is 1.008665 amu, find the mass defect in ^{19}F .
- (c) State and describe the self ionization of liquid SO_2 , liquid H_2SO_4 and liquid NH_3 . State a neutralization reaction in liquid ammonia.
- (d) Liquid H_2SO_4 has a very long liquid range making for wide use as a non aqueous solvent but its use is limited. Explain why.
- (e) Solutions of ammonium halides in ammonia are used as acids in preparation of silane and arsane. Give equations by which silane and arsane are produced.

QUESTION 4

- (a) All organometallic complexes are diamagnetic except Vanadium hexacarbonyl which is paramagnetic. Explain
- (b) Calculate the EAN for $\text{V}(\text{CO})_6$.
- (c) How is the C-O bond order related to the C-O stretching frequencies in metal carbonyls?
- (d) Discuss the preparation, properties and structure of dicobalt octacarbonyl.

QUESTION 5

- (a) Explain the applications of "trans-effect" using synthesis of Pt (II) complexes.
- (b) Describe the $\text{S}_{\text{N}}1\text{CB}$ mechanism involved in base hydrolysis of Co(III) ammine complexes.
- (c) Give the steps involved in the formation of cis & trans isomers by treating $[\text{PtCl}_4]^{2-}$ ion with NH_3 .
- (d) Compare and contrast the mechanism of $\text{S}_{\text{N}}1$ and $\text{S}_{\text{N}}2$ reactions in octahedral complexes.

END OF EXAMINATION

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1 H 1.01 Hydrogen	2 He 4.00 Helium																	
3 Li 6.94 Lithium	4 Be 9.01 Beryllium																	
11 Na 23.00 Sodium	12 Mg 24.31 magnesium																	
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.88 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 71.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton	
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc 97.91 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 Tellurium	53 I 126.90 Iodine	54 Xe 131.29 Xenon	
55 Cs 132.91 Caesium	56 Ba 137.33 Barium	57 - 71 Lanthanum 138.91	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantalum	74 W 183.84 Tungsten	75 Re 186.21 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.97 Gold	80 Hg 200.59 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po 208.98 Polonium	85 At 209.99 Astatine	86 Rn 222.02 Radon	
87 Fr (223.02) Francium	88 Ra 226.03 Radium	89 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		

KEY

Atomic number X
Atomic mass
Name of the element X

USEFUL DATA

Avogadro's constant, N_A	$6.022 \times 10^{23} \text{ mol}^{-1}$
Molar volume of gas at S.T.P	$22.4 \text{ dm}^3 \text{ mol}^{-1}$
Planck Constant, h	$6.626 \times 10^{-34} \text{ Js}$
Rydberg constant, R_H	$1.097 \times 10^7 \text{ m}^{-1}$
Speed of light in vacuum, c	$3.00 \times 10^8 \text{ ms}^{-1}$
Mass of an electron	$9.11 \times 10^{-31} \text{ kg}$
1 electron volt (1 eV)	$1.602 \times 10^{-19} \text{ J}$

$$1 \text{ Joule} = 1 \text{ J} = 1 \text{ kg m}^2 \text{ s}^{-2} = 1 \text{ Pa m}^3$$

Universal Gas constant R

$8.3145 \text{ J mol}^{-1} \text{ K}^{-1}$
$8.314 \text{ k Pa L K}^{-1} \text{ mol}^{-1}$
$0.083145 \text{ L bar mol}^{-1} \text{ K}^{-1}$
$0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$
$62.364 \text{ L torr mol}^{-1} \text{ K}^{-1}$
$62.364 \text{ L mmHg mol}^{-1} \text{ K}^{-1}$

Pressure

$$\begin{aligned} 1 \text{ atm} &= 1.01325 \times 10^5 \text{ Pa} \\ &= 1.01325 \times 10^5 \text{ N m}^{-2} \\ &= 760 \text{ torr} \\ &= 760 \text{ mmHg} \\ &= 1.01325 \text{ bar} \\ 1 \text{ bar} &= 1.00000 \times 10^5 \text{ Pa} \\ &= 1.00000 \times 10^5 \text{ N m}^{-2} \end{aligned}$$

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

**2017 ACADEMIC YEAR
FINAL EXAMINATIONS**

**CHE 3522
POLYFUNCTIONAL COMPOUNDS, MOLECULAR REARRANGEMENTS
AND ORGANIC SYNTHESIS**

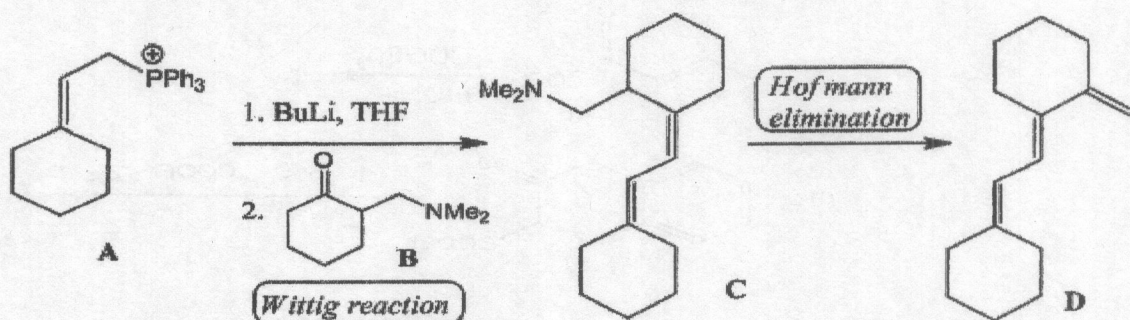
TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS:

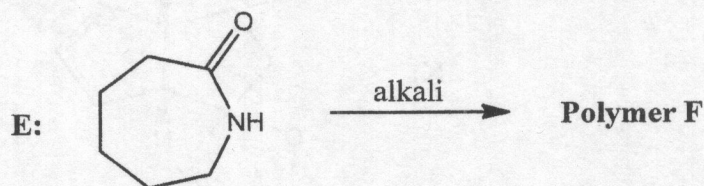
1. Answer any four (4) questions.
2. Each question carries 25 marks.
3. Please present your answers in a neat and logical manner.
4. Ensure you have six (6) printed pages containing five (5) questions.

QUESTION ONE

- (a) Consider the following synthesis of the triene, **D**, which was designed as a model for synthesis of vitamin D.



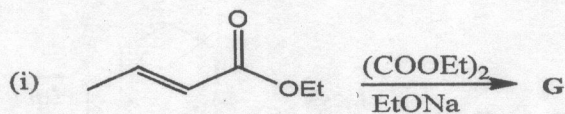
- (i) Provide the reagents and conditions for the Hofmann elimination step. (2 marks)
- (ii) Suggest a synthesis of the Wittig reagent **A** from acetylene, cyclohexanone and triphenyl phosphine (PPh₃) and any needed reagents. (5 marks)
- (iii) Give the reaction equation for preparing **B** from cyclohexanone by Mannich reaction and provide a detailed mechanism of the reaction. Assume that all needed reagents are available. (7 marks)
- (b) The polymer **F** (fibers), required by textile industry, is made by alkaline polymerization of the lactam **E**.



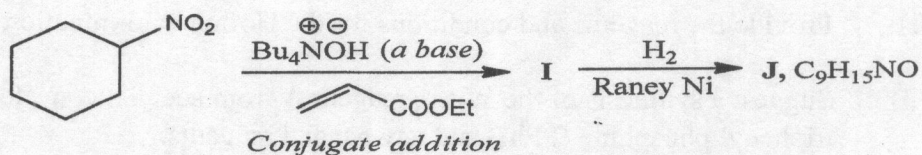
- (i) What is the structure of the polymer **F**? (2 marks)
- (ii) Explain the reactions underlying the polymerization and give reaction mechanisms. (6 marks)
- (c) Would you expect D-glucaric acid to be optically active? Briefly explain. (3 marks)

QUESTION TWO

- (a) Identify the major organic products **G** and **H**, including pertinent stereochemistry, where relevant, of the following reactions: (4 marks)

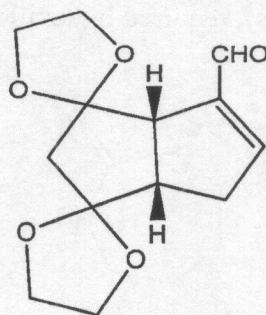


- (b) Provide the structures for the compounds **I** and **J** in the following synthesis. (5 marks)



- (c) Applying the disconnection approach, propose a synthesis for the key intermediate in prostaglandin synthesis, **K**, shown below, from readily available starting materials. Show clearly the retrosynthetic analysis, and all steps of the proposed synthesis, stating the reagents, conditions and intermediates for each step. Please do not write reaction mechanisms. (12 marks)

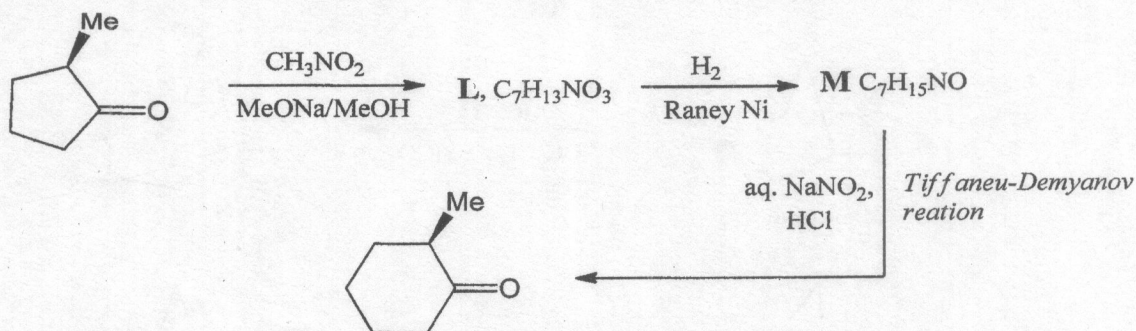
K:



- (d) Two of the four aldopentoses yield D-threose on Ruff degradation. What are their structures? (4 marks)

QUESTION THREE

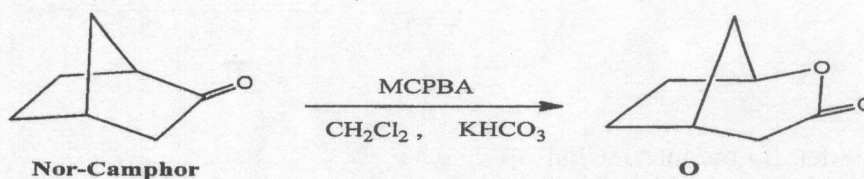
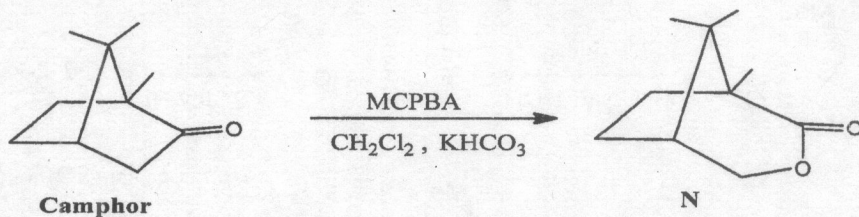
- (a) A general method for homologation of cyclic ketones is shown below. The last step of the reaction sequence is known as Tiffaneu-Demyanov reaction, a variant of Pinacol rearrangement.



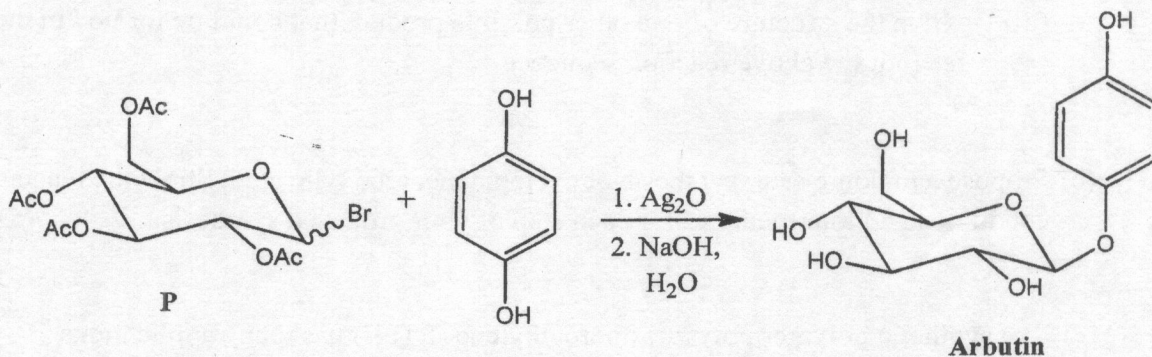
- (i) Identify the intermediates **L** and **M** (2 marks)
- (ii) Suggest the most likely mechanism for the Tiffaneu-Demyanov reaction. shown above. (8 marks)
- (iii) Give the structure of one other possible product that could be formed in the last step of the above reaction sequence (2 marks)
- (b) Propose a malonic ester synthesis of cyclobutanecarboxylic acid. Show the reagents, conditions and intermediates for each step of your proposed synthesis. (5 marks)
- (c) The synthetic polymer polytetrafluoroethylene (PTFE) has many applications.
- (i) Provide the structures of PTFE and the monomer required to make it. (3 marks)
- (ii) What type of polymer is PTFE? (1 mark)
- (iii) PTFE is used as non-stick coating for cookware. Provide a scientific rationale for this use. (2 marks)
- (iv) Neither water nor water-containing substances wet PTFE. Briefly explain why. (2 marks)

QUESTION FOUR

- (a) Baeyer Villiger oxidation of camphor gave an unexpected product, **N** in 30 % yield; whereas norcamphor gives the expected product **O** as shown below. Provide a mechanistic explanation for these experimental results. (10 marks)



- (b) Bearberry leaf extract is used in skin lightening treatments designed for long term and regular use. The active ingredient of the extract, *arbutin*, is commercially prepared by Koenigs-Knorr reaction:

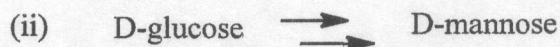
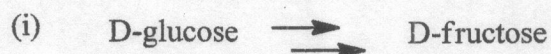


- (i) What classes of compounds are **P** and *arbutin*? (2 marks)
- (ii) Identify the aglycon in *arbutin*. (1 mark)
- (iii) Both α - and β - anomers of **P** yield *arbutin* in good yield. Propose a mechanistic explanation to account for these results. (6 marks)
- (c) α -Amino acids, are synthesised in many ways. Describe the synthesis of Leucine using the Strecker method. (6 marks)

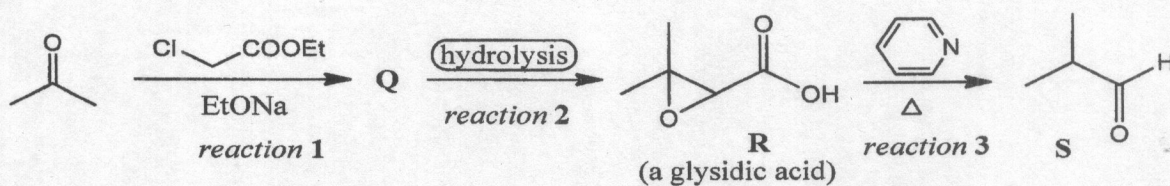
QUESTION FIVE

(a) Show how you would carry out the following transformations,

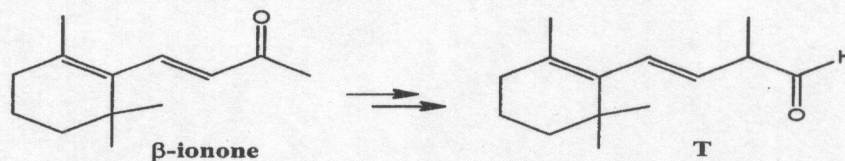
(12 marks)



(b) A general method for conversion of a ketone to an aldehyde with one carbon more is outlined below.



- Identify the glycidic ester **Q** and suggest a plausible mechanism for the reaction 1 (Darzens condensation). (5 marks)
- Propose the most likely mechanism for the decarboxylation reaction 3. (4 marks)
- Using this method, propose a synthesis of the aldehyde **T**, a key intermediate in an industrial synthesis of vitamin A. (4 marks)



**END OF EXAMINATION
GOOD LUCK!**

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR FINAL EXAMINATIONS
CHE 4102: BIOCHEMICAL RESEARCH TECHNIQUES

INSTRUCTIONS TO CANDIDATES:

Time: three (3) hours

All questions carry **equal marks** (20 marks each)

Answer **any Five (5)** questions

Write your computer number on all answer booklets

This examination consists of SIX (6) questions on FOUR (4) printed pages

Question 1

The human liver hosts two types of reactions that deal with foreign chemicals that come into the body.

- a) **Give** the general expressions for these two types reactions in the liver and provide specific examples. **[10 marks]**
- b) **What** is the ultimate aim of these two reactions? **[5 marks]**
- c) **Do** these reactions always result in desirable results? Explain. **[5 marks]**

Question 2

Consider the human kidney:

- i) Using a neat diagram, **describe** the anatomy of the human kidney. **[10 marks]**
- ii) **Discuss** in detail the role of the human kidney in dealing with xenobiotics. **[10 marks]**

Question 3

Write short notes (maximum 4 sentences) on:

[10 marks]

- a) Agonist vs antagonist
- b) Innate immunity vs adaptive immunity
- c) Biochemical explanation for the development of cholera
- d) Natural killer cell cells vs phagocytic cells
- e) Interferons vs complement system

Question 4

- a) Explain the following terms: [4 marks]
- i) Primary cell culture
 - ii) Senescence
 - iii) Cell viability (using a formula)
 - iv) EMEM
- b) What are the sources of the following cell lines? [2 marks]
- i) HeLa cells
 - ii) Sf9
 - iii) MCF-7
 - iv) Cos-7
- c) i) Using mouse B cells producing anti-insulin antibody and HeLa cells, **explain** how hybridomas are formed. [7 marks]
- ii) How can **select** the positive hybrid cells in part c) i)? [7 marks]

Question 5

Regulation of metabolic pathways could be effected by phosphorylation and dephosphorylation of enzymes. The levels of glucose in the human blood is usually maintained at a near constant level.

- a) One-way glucose levels are maintained at this near constant level is through glycogenolysis and glycogenogenesis. **State** the normal level of glucose in human blood [1 mark]
- b) **What** is meant by the term glycogenolysis? [1 mark]
- c) **Explain** in detail how glycogenolysis and glycogenogenesis is regulated (*Hint: include both positive and negative regulation*). [18 marks]

Question 6

- a) **Compare and contrast** in the table form catabolism and anabolism
[5 marks]
- b) Using a diagram, **illustrate** that catabolism of carbohydrate, protein and lipids is **convergent** in character.
[5 marks]
- c) **Explain** the gene regulation of lactose metabolism *E.coli*. [10 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR MID-YEAR DEFERRED EXAMINATIONS
CHE 4111: INFORMATION STORAGE AND BIOCHEMICAL GENETICS

INSTRUCTIONS TO CANDIDATES:

Time: Three (3) hours

All questions carry **equal marks** (20 marks each)

Answer **any Five (5)** questions

Write your computer number on all answer booklets

This examination consists of SIX (6) questions and THREE (3) printed pages

QUESTION 1

Write a critical essay on:

"Dangers (and precautions against) of recombinant DNA technology – facts versus myths" [20 marks]

QUESTION 2

- a) Why do restriction enzymes not hydrolyze the DNA of the organism that produces it? [5 marks]
- b) What are the key differences between a DNA library and cDNA library? [10 marks]
- c) Why is it a large undertaking to construct a DNA library? [5 marks]

QUESTION 3

- a) **Describe** the general composition of eukaryotic nucleosomes [8 marks]
- b) Write a note on the various levels of DNA packaging from the double strand duplex to the chromosome. (*Hint: use a diagram to help you explain*) [12 marks]

QUESTION 4

1 bp of DNA is approximately 0.34 nm in length. A bacterial chromosome is about 4 million bp in length and is organized into about 100 loops that are about 40,000 bp in length each.

- a) If it was stretched out linearly, **how** long (in micrometers) would one loop be? [5 marks]
- b) If a bacterial chromosomal loop is circular, what would be its diameter? (Note: Circumference = πD , where D is the diameter of the circle.) [5 marks]
- c) **Explain** the complementation test experiment in detail using appropriate examples [10 marks]

QUESTION 5

- a) The survival of the human race partly depends prevention and minimising mutations. **Explain** briefly how DNA polymerase participates in the prevention and minimising of mutations. **[10 marks]**
- b) Humans carry out transcription in three stages, initiation elongation and termination. **Describe** the detailed the process of initiation of transcription. **[10 marks]**

QUESTION 6

Reverse transcription is observed in HIV particles and is catalysed by reverse transcriptase.

- a) **Outline** the enzymatic activities of HIV reverse transcriptase. **[8 marks]**
- b) **Name** one nucleotide analogue that can inhibit the above process. **[2 marks]**
- c) **Discuss** how the nucleotide analogue named in part (b) can inhibit the reverse transcription (*Hint use biochemical reactions to discuss with chemical structures*) **[5 marks]**
- d) **Explain** the biochemical advantage of nucleotide analogue over most nucleoside analogue when used as antiretroviral drugs **[5 marks]**

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR FIRST TERM FINAL EXAMINATIONS

CHE4211 ANALYSIS OF INORGANIC COMPOUNDS

TIME: THREE HOURS

INSTRUCTIONS

- 1 There are **five** questions in this paper.
 - 2 Answer any **four** questions.
 - 3 Questions carry equal marks.
-

Question 1

- (a) There are generally two methods on which air sampling is based. **State** these two general methods employed in the sampling of air for analysis of contaminants and describe air sampling protocol using an impinger.
- (b) Mention seven (7) organoleptic and physical parameters determined during water analysis.
- (c) (i) Define what is meant by Dissolved Oxygen and state two methods that may be employed for its determination.
- (ii) Mention two main sources of dissolved oxygen and two main processes that use it up in natural water bodies.
- (d) (i) Most labs use the **Hach Method** to measure chemical oxygen demand (COD). Define chemical oxygen demand and State the conditions employed in the **Hach** method for determination of COD.
- (ii) In this method, the catalyst use can form a precipitate with chloride ions if present. How would this interference prevented?

Question 2

- (a) Compare and contrast the methods of Hutchinson and MacLennan to that of Tinsley, Taylor and Moore with respect to sample digestion and final limestone content.
- (b) Dissolution for the analysis of rocks and minerals may be achieved using fusion. What is fusion technique in mineral analysis? Give two examples each, of acidic and basic fluxes used; and name one disadvantage of fusion.

- (c) A sample of potassium is analyzed by FES using the standard addition method. Two 0.5 mL aliquots are added to 5.0 mL portions of water. To one portion is added 10 μ L 0.05 M KCl solution. The net emission signals in arbitrary units are 32.1 and 58.6. What is the concentration of potassium?
- (d) Phosphorus content of soils was determined by gravimetry using quinolinium phosphomolybdate agent. A 3.1 g precipitate of quinolinium phosphomolybdate (C_9H_7N)₃PMo₁₂O₄₀ was obtained from a 1.0 g sample. Using atomic weights P = 31; O = 16; N = 14 and Mo = 96, calculate:
- %P
 - % P₂O₅

Question 3

- (a) Define the following terms **in brief**.
- Quick-release fertilizers
 - Slow-release fertilizers
 - Biochemical oxygen demand
 - Hard water
 - Soft water
 - Aerosols
 - Dusts
 - Fumes
 - Smokes
- (b) State two physical parameters used to assess quality of fertilizer
- (c) The Karl Fischer is one analytical technique used to measure the moisture (water) content in solids, liquids or gases. Mention three advantages and three disadvantages associated with this analytical technique.
- (d) Mention four possible points where and when water samples should be collected to assess domestic water quality. For each, state the reason for the stated assessment.

Question 4

- (a) Define the terms TEB and CEC; and name three components of TEB, and two components of CEC as the terms are used in soil analysis. On which part of the sample are TEB and CEC determined?
- (b) Chromic oxide, (Cr_2O_3), a green pigment is often produced by the reaction between sodium dichromate and ammonium chloride to yield chromic oxide, nitrogen gas, and other products. What type of reaction is this? Calculate how much pigment (in mg) can be produced from 0.010 kg of sodium dichromate.

- (c) (i) Malachite, $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$, is used as a decorative stone when cut and polished. Use malachite to define what is meant by the term 'mineral'.
- (ii) Determine the carbon content in 1.00 g of a copper ore that contains 10% malachite, giving your answer in milligramme, correct to two significant figures.
- (d) Describe briefly how you would analyze the different components in an ordinary Portland cement (OPC).

Question 5

- (a) Iron is found in ores such as haematite (Fe_2O_3); limonite ($\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$); and, magnetite (Fe_3O_4), which is the most magnetic of all the naturally occurring minerals on Earth. Most of these ores are acid soluble. Give a brief description of an appropriate method for:
- (i) Sample digestion using aqua regia
- (ii) If you are to determine iron content by redox method, how would you prepare the sample aliquot from the digestate?
- (b) Some minerals like NaCl , MgSO_4 and $\text{FeSO}_4 \cdot 2\text{H}_2\text{SO}_4$ may be water soluble. However, to achieve complete dissolution it is necessary to add another solvent. Suggest, giving reasons which mineral acid you would choose.
- (c) A 0.5 g soil sample was intimately mixed with 0.6 g potassium dichromate in order to analyse for its carbon content using the chromic acid oxidation method. The mixture was heated with concentrated sulphuric acid; then the excess chromate was titrated against a solution of iron (II) sulphate requiring 12.5 mL. The iron (II) sulphate was standardised against 0.4 g potassium dichromate requiring 20.0 mL. Calculate the carbon content (%) of the soil sample.
- (d) Major mineral groups in the earth's crust include silicates which occur widely in nature. This phenomenon can be explained by the fact that the earth's crust contains approximately 50% (46.6%) oxygen and almost 30% (27.7%) silicon. Define the following terms which are used in the analysis of silicates. Give an example of each one.
- (i). Major constituents
- (ii). Minor constituents
- (iii). Traces

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

Department of Chemistry

2017 Academic year Term 2 Final Exam

CHE4422

Metal Chemistry and its application to Organometallics and Catalysis

Duration: 3 hours

- Instructions:**
1. This exam paper consists of **five (5)** questions
 2. Attempt **any four (4)** questions
 3. All questions carry **equal marks**
 4. Answer each question in a **separate** answer booklet
 5. You are reminded of the necessity for **tidy and orderly presentation** of your work.

Some Useful Data

Planck's constant = $6.6 \times 10^{-34} \text{ Js}$

Speed of light = $3 \times 10^8 \text{ m/s}$

Avogadro number = $6.02 \times 10^{23}/\text{mol}$

Boltzmann Constant, $K = 1.380 \times 10^{-16} \text{ erg/K}$

1 eV = $1.6 \times 10^{-19} \text{ joules}$

1 BM = $0.927 \times 10^{-20} \text{ erg/gauss}$

Magnetic field strength, $\beta = 9.27 \times 10^{-24} \text{ J/T}$

Question One

Many organometallic compounds function as "homogeneous catalysts" for significant chemical transformations. An understanding of these catalysts depends upon concepts such as

- (a) ligand association and/or dissociation,
- (b) oxidative-addition,
- (c) reductive-elimination, and
- (d) migratory-insertion reaction.

Briefly explain, with examples, each one of those processes and, then explain **in detail** (using labelled catalytic cycles), the roles of homogeneous catalysts in **TWO** of the following processes:

- (i) the Monsanto acetic acid synthesis from methanol.
- (ii) the rhodium-catalyzed hydroformylation of propene.
- (iii) The Wacker olefin oxidation process (ethylene to ethanal).

In your catalytic cycles, clearly indicate the name of each step, and the electron count of each species postulated to be involved.

Question Two

Write brief, but concise notes, on **any four (4)** of the following:

- (a) Asymmetric synthesis using homogeneous catalysis.
- (b) Tennessee–Eastman acetic anhydride process using homogeneous catalysis.
- (c) BASF and Cativa processes for the manufacture of acetic acid.
- (d) Comparison of conditions and selectivities of the BASF, Monsanto and Cativa processes for the manufacture of acetic acid
- (e) Tennessee–Eastman acetic anhydride process

Question Three

- (a) Discuss the *isolobal concept* as enunciated by the 1981 Chemistry Nobel Laureate **Roald Hoffmann**.
- (b) "The isolobal analogy can be extended to any molecular fragment having frontier orbitals of suitable size, shape, symmetry, and energy. The realization of these analogies inspired research by suggesting target molecules that can appear unorthodox on first inspection."

In the light of that statement, and limiting yourself to the ligand CO and first-row transition metals, state at least one organometallic fragment that is isolobal with each of the following hydrocarbon fragments:

CH_3 , CH_2 , CH , CH_3^- , CH_2^- , CH^- , CH_3^+ , CH_2^+ , and CH^+ .

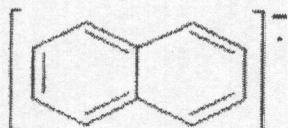
- (c) Isolobal analogies find tremendous utility in suggesting new compounds. Formation of metal-metal bonds differ from others in the use of *d* orbitals on both atoms, in addition to the usual *s*- and *p*- bonds.

For the species, $[\text{Re}_2\text{Cl}_8]^{2-}$,

- (i) State the bond order
- (ii) Show the bonding interactions between metal *d orbitals*, and hence
- (iii) Show the relative energies of orbitals formed from *d*-orbital interactions

Question Four

- (a) What are metastable ion peaks? Calculate the metastable peak for $\text{Ni}(\text{CO})_4^+$ and represent it in a diagram.
- (b) Predict the ESR spectrum of Naphthalene radical anion.



Represent the hyperfine splitting using a stick diagram and predict the intensities using Pascals triangle.

- (c) The energy difference between $^{57}\text{Fe}^*$ & ^{57}Fe is 14.4 KeV. In a Mossbauer experiment if the relative velocity of source and the absorber is 100 ms^{-1} , calculate the shift in frequency.

Question Five

- (a) N_2 gas molecule at 298 K, molar magnetic susceptibility, χ_m being $-1.24 \times 10^{-5} \text{ cm}^3/\text{mol}$, calculate μ_M , magnetic moment and its number of unpaired electrons.
- (b) Calculate the spin only moment, μ_s , and μ_{s+L} of Lanthanide ion, Pm^{3+} and compare with the experimental moment, μ_{exp} 3.6 Bohr Magnetons. Justify your answer.
- (c) Predict the mass spectrum of CH_2Br_2 , given that $\text{Br}^{79} = 50\%$ and $\text{Br}^{81} = 50\%$

END OF CHE4422 EXAMINATION for 2017/2018 ACADEMIC YEAR

The Periodic Table of Elements

1 2 3 4 5 6 7 0 (8)

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

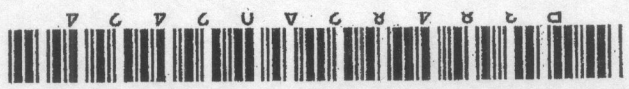
1.0
H
hydrogen
1

4.0
He
helium
2

(1) 6.9 Li lithium 3	(2) 9.0 Be beryllium 4	(3) 45.0 Sc scandium 21	(4) 47.9 Ti titanium 22	(5) 50.9 V vanadium 23	(6) 52.0 Cr chromium 24	(7) 54.9 Mn manganese 25	(8) 55.8 Fe iron 26	(9) 58.9 Co cobalt 27	(10) 58.7 Ni nickel 28	(11) 63.5 Cu copper 29	(12) 65.4 Zn zinc 30	(13) 10.8 B boron 5	(14) 12.0 C carbon 6	(15) 14.0 N nitrogen 7	(16) 16.0 O oxygen 8	(17) 19.0 F fluorine 9	(18) 20.2 Ne neon 10	
23.0 Na sodium 11	24.3 Mg magnesium 12	40.1 Ca calcium 20	88.9 Y yttrium 39	87.6 Sr strontium 38	88.9 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	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 rosgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated							

* Lanthanide series
* Actinide series

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



THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR
MID YEAR EXAMINATIONS

**CHE 4511: SYNTHETIC REACTIONS, NEIGHBOURING GROUPS
AND CHEMOTHERAPEUTIC AGENTS**

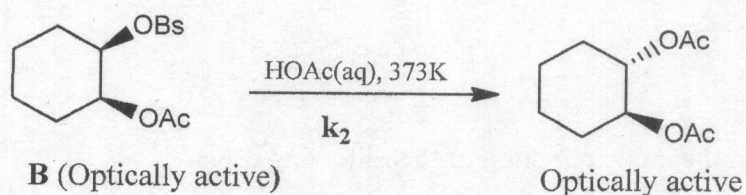
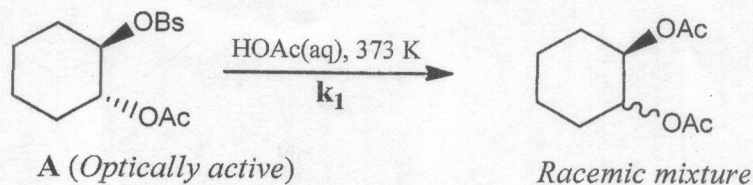
INSTRUCTIONS TO CANDIDATES:

TIME: THREE (3) HOURS

1. THIS PAPER HAS FIVE (5) QUESTIONS.
 2. ANSWER **ANY FOUR (4)** QUESTIONS.
 3. EACH QUESTION CARRIES **25 MARKS**.
 4. PLEASE PRESENT YOUR ANSWERS IN A **LOGICAL** MANNER.
 6. ENSURE THERE ARE **FIVE (5)** PRINTED PAGES.
-

QUESTION 1

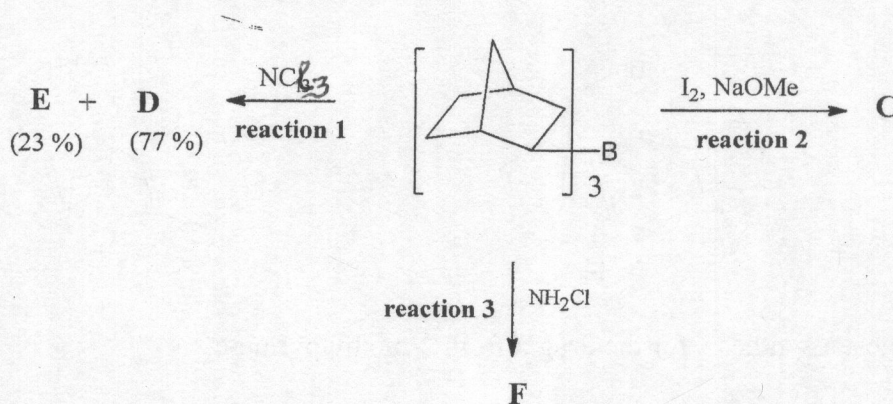
- (a) Acetolysis of *syn*- and *anti*-brosylates **A** and **B** at 373 K, structures shown below, was found to proceed as follows:



Kinetics data: $k_1 = 1.9 \times 10^{-4}$ $k_2 = 2.9 \times 10^{-7}$

- (i) Give a mechanistic explanation for the above experimental results. (8 marks)
- (ii) What product or products could be isolated that would support your explanation if the above reactions were run in aqueous ethanol. (3 marks)

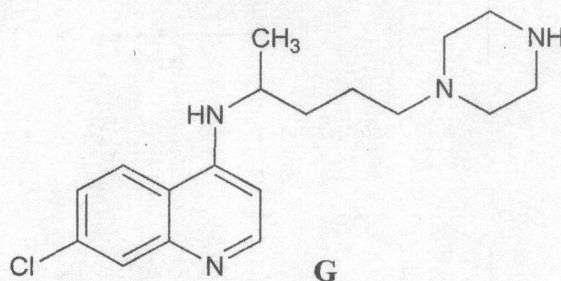
- (b) Consider the following reaction scheme:



- (i) Provide the stereochemical structures of the products **C-F**. (7 marks)
- (ii) Give mechanism for the reaction 3. (5 marks)
- (c) Define the terms 'bacteriostatic' and 'bactericidal' drugs. (2 marks)

QUESTION 2

- (a) Suggest a synthesis of the antimalarial drug, **G**, from readily available non-heterocyclic starting materials and reagents. Show all steps of your proposed synthesis clearly, stating the reagents, solvents, special conditions if any, and intermediates. (14 marks)

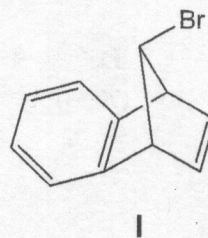
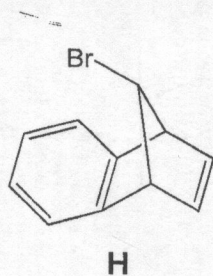


- (b) Explain the mode of action of the following drugs: (11 marks)

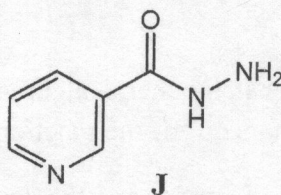
- (i) Trimethoprim
- (ii) Artemisinin

QUESTION 3

- (a) Although there is a substantial difference in the rate at which **H** and **I** solvolyze (**H** reacts 4.4×10^4 times faster than **I** in acetic acid), both compounds give products of completely retained configuration. Briefly explain the difference in reaction rate and mechanistically account for the observed stereochemistry. (6 marks)

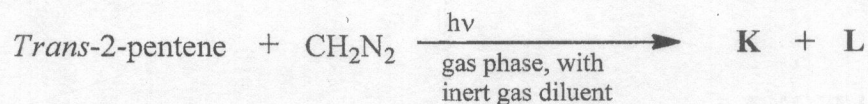


- (b) Suggest a synthesis for the drug **J** from 2-methylpyridine. (5 marks)



- (c) (i) What are carbenes? (2 marks)
 (ii) Give classification for carbenes. (2 marks)
 (iii) Provide three methods for generation of carbenes. (6 marks)

(d) Identify the products of the following reaction and show their stereochemistry. (4 marks)



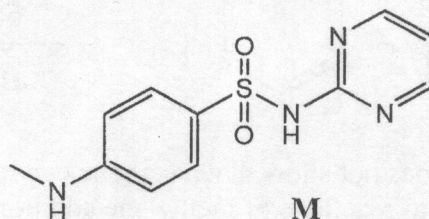
QUESTION 4

(a) Provide one example (structures and name) of each of the following drugs. (8 marks)

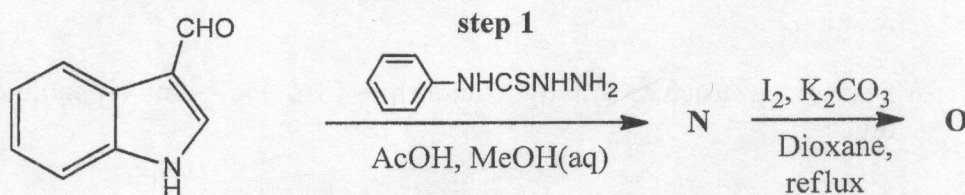
- (i) Anti-fungal drug
 (ii) Fluoroquinolone antibacterial drug
 (iii) Non-nitrogenous antimalarial drug
 (iv) Antimicrobial cephalosporin

(b) Propose a synthesis of the drug **M** from 4-acetamidobenzenesulfonyl chloride and any needed non-heterocyclic reagents. Show all steps, including the intermediates clearly.

(6 marks)

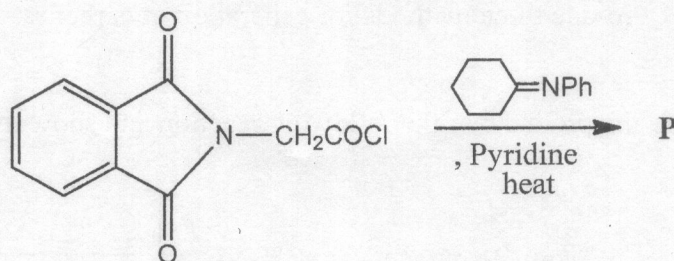


(c) (i) Deduce the structure of the biologically active molecule **O** from the following synthesis and state its principal biological action. (4 marks)



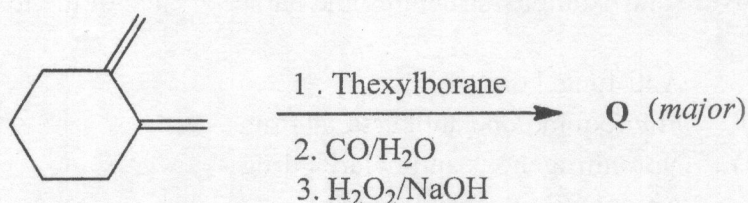
(ii) How would you make the thiosemicarbazide used in step 1? (3 marks)

- (d) Identify the antimicrobial agent **P** and give mechanism of the following reaction. (4 marks)

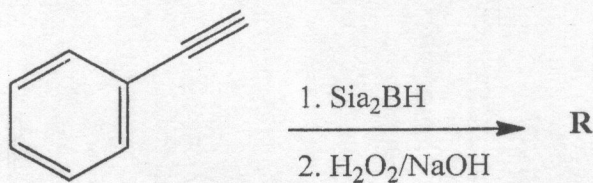


QUESTION 5

- (a) Predict the major product and give the mechanism of the following reaction. (8 marks)



- (b) Provide the stereochemical structure of the product of the following reaction. (2 marks)



- (c) Spectroscopy does not show that a carbene can react either as a singlet or a triplet. With reference to reactions of methylene addition across a double bond, show how you would differentiate a carbene that reacts as a singlet from a carbene that reacts as a triplet. (6 marks)
- (d) The carbene generated from dichloromethane and methyl lithium were reacted with 3-methylindole, what product would you expect to obtain? Show the mechanism for the reaction. (5 marks)
- (e) Discuss the structure-activity relationships (SAR) in 4-aminoquinoline antimalarial drugs. (4 marks)

**END OF EXAMINATION
GOOD LUCK!**

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

**2017 ACADEMIC YEAR
FINAL EXAMINATIONS**

**CHE 4522
PHYSICAL ORGANIC CHEMISTRY AND NATURAL PRODUCTS
CHEMISTRY**

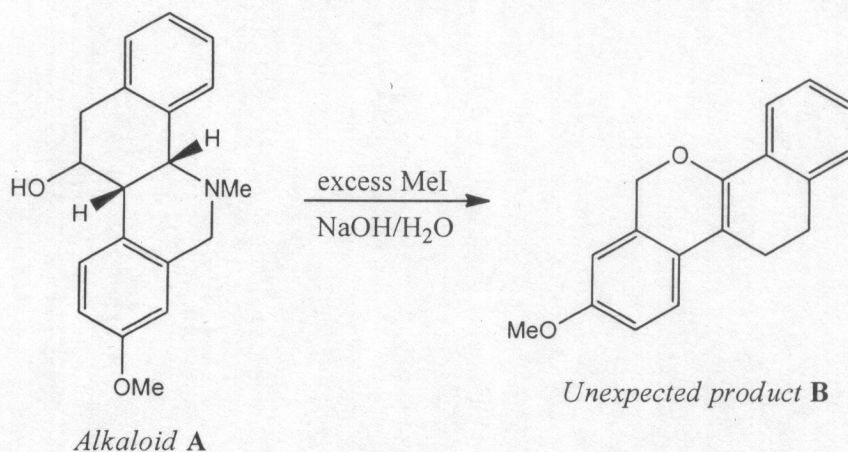
TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS:

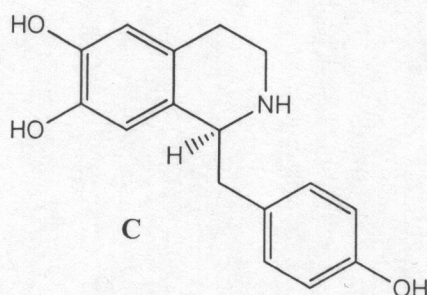
1. Answer any FOUR (4) questions.
3. Each question carries 25 marks.
3. Present your answers in a concise and logical manner
4. Ensure you have seven (7) printed pages and five questions.

QUESTION ONE

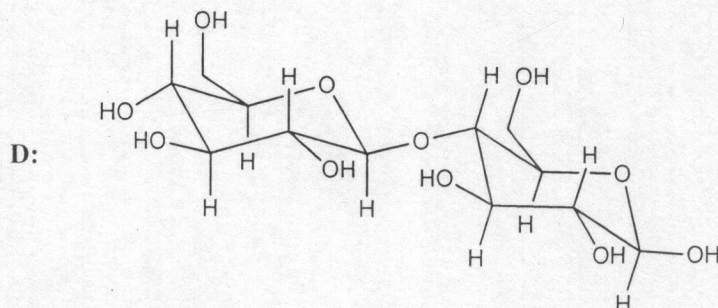
- (a) Hofmann degradation of the alkaloid **A** with excess methyl iodide and aqueous sodium hydroxide unexpectedly gave a compound **B** in good yield. Propose a plausible mechanistic explanation to account for the unexpected product **B**. (8 marks)



- (b) Isotopic labeling experiments have shown that the alkaloid **C**, an intermediate in the biosynthesis of the protoberberine alkaloids in plants, is derived from the amino acid *L*-tyrosine. On this basis suggest the most likely biosynthetic pathway for **C**, showing all steps clearly. (8 marks)

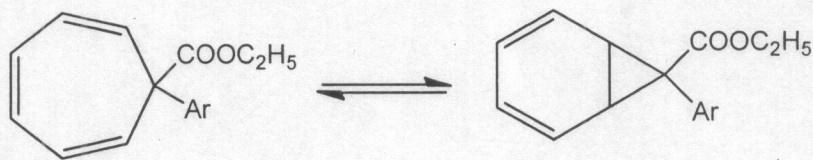


- (c) Propose a scheme for the synthesis of the disaccharide **D**, from D-glucose and methyl 2,3,6-tri-O-acetyl- β -D-glucopyranoside and provide a systematic name for it. (9 marks)



QUESTION TWO

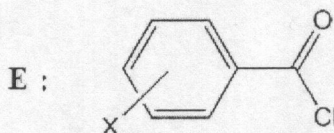
- (a) Cycloheptatriene are often in rapid equilibrium with an isomeric bicyclo[4.1.0]heptadiene.



The thermodynamics of the isomerization has been studied and some of the data are given below.

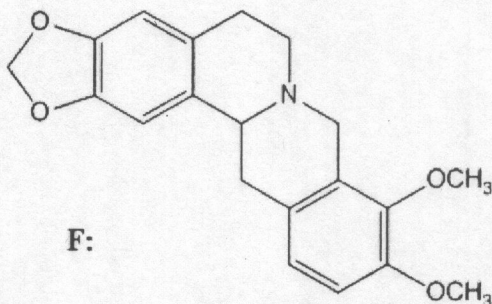
Ar	ΔH (kJ/mol)	ΔS kJK ⁻¹ mol ⁻¹
Phenyl	-22.60	-0.160
p-Nitrophenyl	-14.23	-0.110
p-Methoxyphenyl	-9.62	-0.074

- (i) Calculate the equilibrium constant for each case at 298 °K. (3 marks)
 - (ii) Calculate the temperature at which $K=1$ for each system. (3 marks)
 - (iii) Are the signs of enthalpy and entropy as you would expect them to be? Briefly explain. (4 marks)
 - (iv) Explain the pattern of substituent effects that emerge from the above data. (5 marks)
- (b) Experimental studies on the hydrolysis of substituted benzoyl chlorides, **E**, in moist acetonitrile (a neutral nucleophilic reagent) gave a ρ of 1.20 from the Hammett σ plot. When the same studies were conducted in the presence of perchloric acid (an acid and a highly polar reagent), a correlation with σ^+ was obtained with a ρ of -3.90. Explain these observations. (10 marks)



QUESTION THREE

- (a) Using the disconnection approach, propose an efficient synthesis for the alkaloid **F** shown below. Show all steps clearly, including the reagents, conditions and the intermediates for each step. *Please do not write any reaction mechanism.* Assume that 1,2-dihydroxy- and 1,2-dimethoxy benzenes are available. (14 marks)

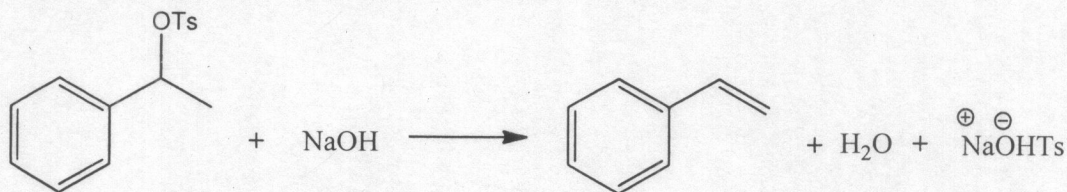


- (b) Interpret the data on the rare disaccharide **G**, $C_{12}H_{22}O_{11}$, isolated from saffron and deduce its structure.
- The disaccharide **G** gives positive Tollens test, undergoes mutarotation and forms a phenylosazone.
 - Reaction of **G** with a large excess of iodomethane and silver iodide gives an octamethyl derivative, which upon acidic hydrolysis gives 1 equivalent of 2,3,4,6-tetra-*O*-methyl-D-glucose and 1 equivalent of 2,3,4-tri-*O*-methyl-D-glucose.
 - The coupling constant, $^3J_{H1,H2}$ for the hydrogen at the anomeric carbon of the glycosidic linkage in **G** was found to be 4.1 Hz.

(11 marks)

QUESTION FOUR

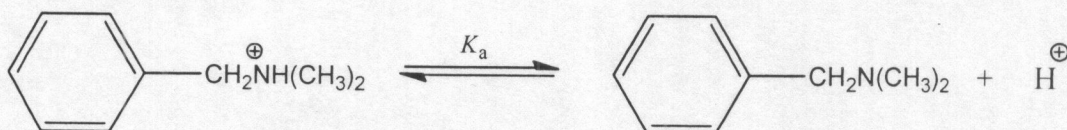
(a) Consider the elimination reaction shown below:



You are required to confirm whether it is an E1 or E2 reaction using the kinetic isotope effect methods.

- Briefly describe what is meant by 'kinetic isotope effect'. (2 marks)
- Design an experiment describing how you could go about testing the proposed mechanism. (4 marks)
- Briefly discuss how your results could answer the question under investigation. (7 marks)

(b) The basicity of a series of substituted benzyldimethylamines was studied and the data is given in the table below:



X	pKa	X	pKa
p-CH ₃ O	9.32	m-NO ₂	8.19
p-CH ₃	9.22	p-NO ₂	8.14
p-F	8.94	p-Cl	8.83
H	9.03	m-Cl	8.67

- Determine graphically whether the data correlates with the Hammett equation. (5 marks).
- What is the value of ρ ? (2 marks)
- Interpret the observed ρ value obtained from the graph. (5 marks)

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR
FINAL EXAMINATIONS

CHE4522: PHYSICAL ORGANIC AND NATURAL PRODUCTS CHEMISTRY

SOME USEFUL PHYSICAL CONSTANTS

Substituent	σ	σ^-	σ^+
H	0.00	0.00	0.00
p-NO ₂	0.78	1.23	0.79
m-NO ₂	0.71		0.67
m-CH ₃	-0.07		-0.07
p-CH ₃	-0.17		-0.31
m-Br	0.39		
p-Br	0.23		0.15
m-Cl	0.37		
m-COOEt	0.37		
p-OCH ₃	-0.27	-0.27	
p-COOEt	-0.45	0.68	0.48
m-OCH ₃	0.10		0.05
p-CN	-		0.66
m-CN	-		0.56

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Chemistry

2017 Academic year Term 2 Final Exam

CHE4822

Inorganic Industrial Chemistry II

Instructions: Answer any four questions

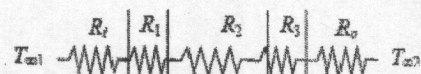
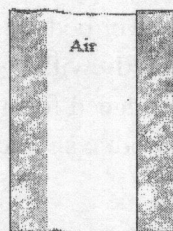
Question 1 carries 20 marks

Questions 2 to 5 carry 15 marks each

Duration: 3 hours

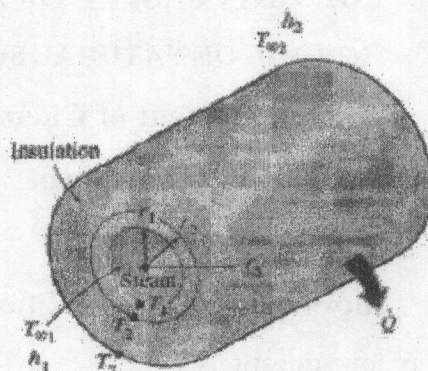
QUESTION 1.

- a) List the three basic mechanisms of heat transfer and explain the mode of heat transfer in each of the three cases and State Fourier's Law of heat for each case.
- b) Consider a 0.8 m high and 1.5 m wide double-pane window consisting of two 4mm thick layers of glass ($k = 0.78 \text{ W/mK}$) separated by a 10 mm wide stagnant air space ($k = 0.026 \text{ W/mK}$). Determine the steady rate of heat transfer through this double pane window and the temperature of its inner surface for a day during which the room is maintained at 20°C while the temperature of the outdoors is 10°C . Given that the Convection heat transfer coefficients on the inner and outer surface of the window is



$h_1 = 10 \text{ W/m}^2\text{K}$ and $h_2 = 40 \text{ W/m}^2\text{K}$. Use a sketch to illustrate your answer.

- c) Steam at $T_{\infty 1} = 320^\circ\text{C}$ flows in a cast Iron pipe $K = 80 \text{ W/mK}$ whose inner and outer diameters are $D_1 = 5 \text{ cm}$ and $D_2 = 5.5 \text{ cm}$, respectively. The pipe is covered with 3 cm thick glass wool insulation with $k = 0.05 \text{ W/mK}$. Heat is lost to the surroundings at $T_{\infty 2} = 5^\circ\text{C}$ by natural convection and radiation, with a combined heat transfer coefficient of $h_2 = 18 \text{ W/m}^2\text{K}$. Given that the heat transfer coefficient inside the pipe to be $h_1 = 60 \text{ W/m}^2\text{K}$. Determine the rate of heat loss from the steam per unit length of the pipe and calculate the temperature drops across the pipe shell and the insulator.



QUESTION 2

- (a) The CONTACT PROCESS for the manufacture of sulfuric acid did not come into widespread use until the importance of the following points was realised:
- There must be excess air in the air/SO₂ mixture.
 - The temperature of the reacting gases must be kept as low as is practical.
- (i) Why is excess oxygen used and where in the process units is it added?
- (ii) State the conditions that will favour a high yield of SO₃.
- (b) (i) Even though high pressures will improve the yield of product, why do industries carry out the Contact Process at normal atmospheric conditions?
- (ii) Why is it important to ensure complete conversion of SO₂ to SO₃?
- (c) (i) Why is the catalyst spread over beds in the converter?
- (ii) Why isn't SO₃ reacted directly with H₂O to produce H₂SO₄?
- (iii) How then is H₂SO₄ produced from SO₃ in the Contact Process?
- (iv) Name two industrial products which are produced using sulfuric acid?

QUESTION 3

- (a) The HABER PROCESS combines nitrogen from the air with hydrogen derived mainly from natural gas (methane) into ammonia. The reaction is reversible and the production of ammonia is exothermic. State the following conditions for the reaction:
- (i) proportion of nitrogen to hydrogen;
 - (ii) temperature;
 - (iii) pressure;
 - (iv) catalyst;
 - (v) how the ammonia is removed from the equilibrium mixture.

(b) The choice of conditions you gave the question 2 (a) above affects the process in a number of ways. These conditions have an effect on:

- the position of equilibrium,
- on the rate of the reaction,
- the economics of the process.

Explain how each of the conditions you gave in question 2(a), i.e. temperature, pressure and the catalyst affects:

- (i) the position of equilibrium,
- (ii) the rate of the reaction,
- (iii) the economics of the process.

QUESTION 4

- (a) With the help of a process diagram, describe the production of weak nitric acid.
- (b) With the help of a process diagram, describe the production of high strength nitric acid.
- (c) Discuss emissions from nitric acid production and how to control them.

QUESTION 5

- (a) Describe how you would make 1 ton of hydrochloric acid by synthesis from molecular hydrogen (H_2) and molecular chlorine (Cl_2).
- (b) State the necessary conditions for the reaction between H_2 and Cl_2 to proceed. Explain with the help of a process diagram.
- (c) The reaction that produces HCl from H_2 and Cl_2 in Q. 1 above is highly exothermic and this heat energy would set off the reverse reaction thus breaking up HCl back into H_2 and Cl_2 . This is undesirable because it would lead to low HCl yields. How are high yields of HCl assured?

END OF EXAMINATION

PERIODIC TABLE OF THE ELEMENTS

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

1 H 1.01 Hydrogen	2 He 4.00 Helium																										
3 Li 6.94 Lithium	4 Be 9.01 Beryllium	5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon																				
11 Na 23.00 Sodium	12 Mg 24.31 Magnesium	13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.99 Phosphorus	16 S 32.07 Sulphur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon																				
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.88 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 71.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton										
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc 97.91 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 Tellurium	53 I 126.90 Iodine	54 Xe 131.29 Xenon										
55 Cs 132.91 Caesium	56 Ba 137.33 Barium	57-71 Lanthanum series	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantalum	74 W 183.84 Tungsten	75 Re 186.21 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.97 Gold	80 Hg 200.59 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po 209 Polonium	85 At 209 Astatine	86 Rn 222 Radon										
87 Fr (223.02) Francium	88 Ra 226.03 Radium	89-103 Actinium series	104 Rf 261.11 Rutherfordium	105 Db 262.11 Dubnium	106 Sg 266 Seaborgium	107 Bh 264 Bohrium	108 Hs 277 Hassium	109 Mt 266 Meitnerium	110 Ds 271 Darmstadtium	111 Rg 272 Roentgenium	112 Cn 277 Copernicium	113 Nh 284 Nihonium	114 Fl 289 Flerovium	115 Lv 293 Livermorium	116 Lv 293 Livermorium	117 Ts 294 Tennessine	118 Og 294 Oganesson										

KEY

Atomic number
X
Atomic mass
Name of the element X

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

USEFUL DATA

Avogadro's constant, N_A	$6.022 \times 10^{23} \text{ mol}^{-1}$
Molar volume of gas at S.T.P	$22.4 \text{ dm}^3 \text{ mol}^{-1}$
Planck Constant, h	$6.626 \times 10^{-34} \text{ Js}$
Rydberg constant, R_H	$1.097 \times 10^7 \text{ m}^{-1}$
Speed of light in vacuum, c	$3.00 \times 10^8 \text{ ms}^{-1}$
Mass of an electron	$9.11 \times 10^{-31} \text{ kg}$
1 electron volt (1 eV)	$1.602 \times 10^{-19} \text{ J}$

$$1 \text{ Joule} = 1 \text{ J} = 1 \text{ kg m}^2 \text{ s}^{-2} = 1 \text{ Pa m}^3$$

$$1 \text{ Faraday (F)} = 96485 \text{ C mol}^{-1}$$

Universal Gas constant R

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

$$8.314 \text{ k Pa L K}^{-1} \text{ mol}^{-1}$$

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

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

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

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

Pressure

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

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

$$= 760 \text{ torr}$$

$$= 760 \text{ mmHg}$$

$$= 1.01325 \text{ bar}$$

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

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017 ACADEMIC YEAR
FINAL EXAMINATIONS

MAT2602 INTRODUCTION TO STATISTICS

Time Allowed: Three (3) Hours

- Instructions:
1. Answer any **Five (5)** Questions
 2. Show All Essential Working
 3. Statistical Tables are provided
 4. Calculators are Allowed
-

1. (a) Define the following:
 - (i) sample of convenience.
 - (ii) response bias.

- (b) A study was conducted to compare the failure rates for maths and history students. Out of a sample of 150 history students, 18 students failed to complete their programme on time while a sample of 250 maths students showed that 50 failed to complete on time.
 - (i) Test whether the proportion of history students who fail to complete their studies on time is higher than 0.08. Use $\alpha = 0.02$.
 - (ii) Construct a 99% confidence interval for the proportion of maths students not completing on time.
 - (iii) Is the failure rate higher among maths students compared to history students? Test at the 5% level of significance.

- (c) A company claims there is no difference in the mean lifespans of the two brands of bulbs it produces. A random sample of 22 brand A bulbs had a mean lifespan of 1.8 years while a sample of 15 brand B bulbs had a mean lifespan of 1.3 years. The lifespans for the bulbs are normally distributed with standard deviations 0.54 years and 0.82 years for brands A and B respectively.
 - (i) Test whether the company's claim is valid at the 5% level of significance.
 - (ii) How large a sample is required if we want to be 90% confident that our estimate of the brand B mean lifespan is within 0.16 years of the true value?

2. (a) Define the following:
- stratified sample.
 - descriptive statistics.
- (b) The following data represent marks of 30 students in a mathematics entry examination at a certain university:

58	42	71	23	11	55	20	53	81	14
63	9	33	98	57	13	77	86	31	28
66	72	5	62	51	25	54	43	40	20

- Construct an ordered stem and leaf plot for the marks.
 - Describe the distribution of the marks.
 - Find the percentile rank of 62.
 - Construct a boxplot for the marks and identify outliers if any.
- (c) Weights of Grade 5 pupils at a certain school are normally distributed with a mean of 45kg and a standard deviation of 5kg.
- Find the probability that a randomly chosen pupil weighs more than 42kg.
 - Find the probability that the mean weight of 24 randomly chosen pupils lies between 42.2kg and 44.8kg.
 - If probability that the total weight of 9 randomly chosen pupils exceeds k is 0.0082, find the value of k .
3. (a) (i) State the central limit theorem.
(ii) Define a statistical hypothesis.
- (b) A school principal claims that more than 30% of the pupils in the school are left handed. To test the claim, a sample of 200 pupils is taken and the claim is accepted if more than 70 pupils are found to be left handed.
- Explain how one can commit a type II error in this context.
 - Find the probability of committing a type I error.
 - Find the probability of committing a type II error assuming that the proportion of left handed pupils is 0.4.
- (c) Speeds of 10 cars (in km/h) passing through a residential area are captured as follows:
- | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|----|
| 28 | 45 | 15 | 32 | 33 | 20 | 42 | 25 | 35 | 40 |
|----|----|----|----|----|----|----|----|----|----|
- Determine whether the mean speed is significantly lower than the speed limit of 40km/h. Use $\alpha = 0.05$.
 - Construct a 98% confidence interval for the standard deviation of the speeds of the cars.
 - Is the standard deviation of the cars significantly different from 6km/h? Explain.
 - State the assumption(s) required for (i), (ii) and (iii) to be valid.

4. (a) State two properties of the
- (i) linear correlation coefficient.
 - (ii) normal curve.
- (b) A director at the Ministry of Tourism claims that 32% of the visitors to the Victoria Falls are Europeans, 24% are Americans, 15% are Asians, 10% are Africans and the rest are from other parts of the world. The following distribution was obtained from a sample of 250 visitors:

European	75
American	50
Asian	42
African	36
Others	47

Test whether the director's claim is valid at the 5% level of significance.

- (c) An experiment was conducted to compare the number of bags of maize obtained per acre for different varieties of maize. The experiment compared 4 varieties of maize in 5 different locations. The following results were obtained:

		Location					Total
		1	2	3	4	5	
Variety	1	34	41	26	50	38	189
	2	40	44	28	46	42	200
	3	62	48	44	50	52	256
	4	58	46	42	48	54	248
Total		194	179	140	194	186	893

(Additionally $\sum_i \sum_j y_{ij}^2 = 41409$)

- (i) Explain why a randomized block design is suitable for this study.
- (ii) Taking varieties to be treatments and locations to be blocks, write down a model for the experiment. Explain the meaning of all the terms in the model and state all the assumption(s).
- (iii) Prepare an ANOVA table for the experiment.
- (iv) Is there a significant difference among the maize varieties? Test at the 5% level of significance.
- (v) Does location have an effect on the yield? Use a 5% level of significance.

5. (a) Define the following:
- simple random sample.
 - sampling distribution.
- (b) To study the effect of speed (in km/h) on the number of kilometres covered per litre of petrol, an investigation involving 9 hybrid cars was carried out and the following results were obtained:

Speed (x)	126	121	116	118	114	118	132	141	108
Number of km per litre (y)	4.3	4.5	5.9	5.6	6.1	5.2	3.8	2.1	7.5

(You may use the following: $\sum_{i=1}^9 x_i = 1094$, $\sum_{i=1}^9 y_i = 45$
 $\sum_{i=1}^9 x_i^2 = 133786$, $\sum_{i=1}^9 y_i^2 = 244.26$, $\sum_{i=1}^9 x_i y_i = 5348.2$)

- Estimate the simple linear regression line.
- Explain the meaning of the estimated slope parameter in (i).
- Estimate the number of kilometres covered per litre at the speed of 110 km/h.
- Copy and complete the following ANOVA table:

Source	SS	df	MS	F*
Regression				
Error			0.116189	
Total				

- Test whether there is a significant negative linear relationship between speed and fuel consumption. Use $\alpha = 0.05$.
 - Compute the coefficient of determination.
 - Explain the meaning of the coefficient in (vi).
 - Compute the correlation coefficient.
6. (a) Define the following:
- type II error.
 - parameter.

- (b) A study was conducted to determine whether level of education and economic status are related. The following results were obtained from a survey of 250 people.

		Education level			
		None	Primary	Secondary	College
Economic Status	Rich	14	29	41	51
	Poor	21	26	27	41

Test at the 10% level of significance whether level of education and economic status are independent.

- (c) A worker has two possible routes she can use to get to work. A sample of 13 times she used route 1 had a mean time of 32 minutes with a standard deviation of 5.4 minutes and a sample of 10 trips on route 2 had a mean of 40 minutes with a standard deviation of 7.2 minutes. Assume that the times it takes to drive to work are normally distributed.
- (i) Is there sufficient evidence to indicate that route 1 is faster than route 2? Test at the 1% level of significance assuming equal variances.
 - (ii) Construct a 95% confidence interval for the ratio of the two population standard deviations.
 - (iii) Is the assumption of equal variances made in (i) valid? Explain.

END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF MATHEMATICS & STATISTICS**

2017 Academic Year Final Examinations
MAT 3200 Abstract Algebra

7th December, 2018

Total time allowed: Three (3) hours

Instructions:

- There are seven questions in this paper; answer any five (5).
 - All questions carry equal marks.
 - Show detailed working to earn full marks.
 - Marks are indicated in square brackets at the end of each part of the question.
-

1. (a) (i) Define the order of an element a in a group G . [3]
(ii) State Sylow's First Theorem. [3]
(b) Consider the dihedral group

$$D_6 = \{1, r, r^2, r^3, r^4, r^5, s, sr, sr^2, sr^3, sr^4, sr^5\}.$$

Find all the distinct conjugacy classes for this group. [5]

- (c) (i) List all the distinct left cosets of the cyclic subgroup $K = \langle 6 \rangle = \{0, 6, 12, 18\}$ in the group \mathbb{Z}_{24} . [2]
(ii) Find the order of the elements $14 + K$ and $15 + K$ in the factor group \mathbb{Z}_{24}/K . [2]
(iii) Find the inverse of the element $8 + K$ and the inverse of the element $9 + K$ in the factor group \mathbb{Z}_{24}/K . [2]
(d) Let $\delta = (1243)(24567)$ be a permutation in the symmetric group S_7 . Find the order of δ and determine whether δ is even or odd. [4]
2. (a) (i) Define an even permutation. [2]
(ii) State The Fundamental Theorem of Cyclic Groups. [2]

- (b) Find $\gcd(253, 189)$ and then find integers m and n such that the equation $253m + 189n = \gcd(253, 189)$ is satisfied. [5]
- (c) (i) List the elements of $U(15)$, the group of units modulo 15. [2]
(ii) Given that $H = U_5(15)$, list all the elements of the factor group $U(15)/H$. [2]
(iii) Construct the Cayley table for the factor group $U(15)/H$. [2]
- (d) State and prove Lagrange's Theorem. [5]
3. (a) (i) Let G be a group of permutations of a set S . Then define the stabilizer of an element a in S . [2]
(ii) State Cauchy's Theorem For Abelian Groups. [3]
- (b) Use the Division Algorithm to find the quotient and remainder when -369 is divided by 8 and hence express -369 in the form $-369 = 8q + r$, where q is the quotient and r is the remainder. [4]
- (c) Let $A = \{a, b, c, d, e, f, g\}$ and consider the permutation $\beta = (a\ b\ c\ e)(f\ g)$ in the symmetric group S_A . By writing your final answer in array notation find β^{-6} . [5]
- (d) Let ϕ be the group homomorphism from \mathbb{Z}_{16} to \mathbb{Z}_{12} defined by $\phi(x) = 3x$. Then find the following:
(i) the image of ϕ , [2]
(ii) the kernel of ϕ , [2]
(iii) $\phi^{-1}(K)$, given that $K = \{0, 6\}$. [2]
4. a) Let D be an integral domain. What does it mean that
(i) $x \in D$ is unit? [2]
(ii) a polynomial $f(x) \in D[x]$ is irreducible? [2]
- b) (i) Let R be a commutative ring with unity and let I be an ideal of R . Prove that $I = R$ if and only if I contains a unit. [3]
(ii) Show that $2 + 3i$ is a unit in $\mathbb{Z}[i]$. [3]
- c) Let $\phi : R \rightarrow S$ be a ring isomorphism. Show that
(i) if $r \in R$ is a unit, then $\phi(r)$ is a unit in S . [2]
(ii) if R is a field, then S is also a field. [2]
- d) i) Let F be a field. Prove that if $f(x) \in F[x]$ has degree 2 or 3, then $f(x)$ is reducible if and only if $f(x)$ has a zero in F . [4]
ii) Hence or otherwise, determine whether or not $f(x) = x^3 + 2x^2 + x + 2$ is reducible over \mathbb{Q} . [2]

5. a) Define the following
- (i) a Euclidean domain, [2]
 - (ii) a unique factorization domain (UFD). [2]
- b) Show that \mathbb{Z} with norm $N(x) = |x|, x \in \mathbb{Z}$ is a Euclidean domain. [4]
- c) i) Show that $\mathbb{Z}[\sqrt{-3}]$ is not a UFD. [2]
- ii) Prove that any two elements in a UFD have a greatest common divisor (gcd). [5]
- d) Find the greatest common divisor of $-4 + 7i$ and $1 + 7i$ in $\mathbb{Z}[i]$. [4]
6. a) Define the following
- (i) a field extension, [2]
 - (ii) the minimum polynomial of linear operator T . [2]
- b) i) Let F be a field and $f(x)$ be a non-constant polynomial in $F[x]$. Prove that F has an extension field E in which $f(x)$ has a zero. [6]
- ii) Find the splitting field over \mathbb{Q} of $x^4 - x^2 - 2$ [3]
- c) Prove that the minimum polynomial of T is unique. [3]
- d) Let $T : \mathbb{R}^4 \rightarrow \mathbb{R}^4$ be a linear operator defined by $T(x_1, x_2, x_3, x_4) = (x_1 - x_2, 2x_2, x_3, 2x_4)$. Find the minimum polynomial of T . [4]
7. a) Define
- (i) a linear operator T , [2]
 - (ii) an adjoint T^* of a linear operator T on an inner product space V . [2]
- b) i) State the Cayley-Hamilton Theorem. [2]
- ii) Verify the Cayley-Hamilton Theorem for $T : \mathbb{R}^3 \rightarrow \mathbb{R}^3$ defined by $T(x, y, z) = (x - y, y, 2z)$. [4]
- c) i) Show that Kernel of T is T -invariant. [2]
- ii) Show that the image of T is T -invariant. [2]
- d) Let T_1 and T_2 be linear operators on an inner product space V . Show that
- i) $(T_1 + T_2)^* = T_1^* + T_2^*$. [3]
 - ii) $(T_1 T_2)^* = T_2^* T_1^*$. [3]

END OF EXAM