

# THE UNIVERSITY OF ZAMBIA

## SCHOOL OF NATURAL SCIENCE

### 2018/2019 ACADEMIC YEAR EXAMS

- |              |   |
|--------------|---|
| 1. BIO 1412  | MOLECULAR BIOLOGY GENETICS  |
| 2. BIO 2302  | BASIC MICROBIOLOGY  |
| 3. BIO 3011  | BIOLOGICAL DATA ANALYSIS AND EXPERIMENTAL DESIGN<br>(THEORY PAPER)        |
| 4. BIO 3132  | COMMUNITY ECOLOGY   |
| 5. BIO 3412  | GENETICS  |
| 6. BS 1401   | BIOMOLECULES AND CELLS  |
| 7. CHE 1000  | INTRODUCTION TO CHEMISTRY   |
| 8. CHE 2001  | AGRICULTURAL AND VETERINARY   |
| 9. CHE 2112  | INTRODUCTORY BIOCHEMISTRY   |
| 10. CHE 2511 | BASIC ORGANIC CHEMISTRY   |
| 11. CHE 2522 | FUNCTIONAL GROUP AND ARENE CHEMISTRY                                      |
| 12. CHE 3122 | ENERGY TRANSDUCTION SYSTEMS   |
| 13. CHE 3222 | INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS                                 |
| 14. CHE 3411 | MAIN GROUP CHEMISTRY AND TRANSITION METAL<br>COMPLEXES                    |
| 15. CHE 3422 | ORGANOMETALLICS AND REACTION MECHANISM                                    |
| 16. CHE 3522 | POLYFUNCTIONAL COMPOUNDS, MOLECULAR RERANGEMENTS<br>AND ORGANIC SYNTHESIS |
| 17. CHE 4102 | BIOCHEMICAL RESEARCH TECHNIQUES   |
| 18. CHE 4211 | ANALYSIS OF INORGANIC COMPOUNDS   |
| 19. CHE 4222 | FOOD, DRUG, PESTICIDES AND DETERGENT ANALYSIS                             |
| 20. CHE 4522 | PHYSICAL ORGANIC CHEMISTRY AND NATURAL PRODUCTS                           |
| 21. CHE 4822 | INORGANIC INDUSTRIAL CHEMISTRY II   |
| 22. CSC 2000 | COMPUTER PROGRAMMING I  |
| 23. CSC 2000 | COMPUTER PROGRAMMING II   |
| 24. CSC 2101 | COMPUTER SYSTEMS (DEFERRED)   |
| 25. CSC 2111 | COMPUTER ARCHITECTURE   |
| 26. CSC 2111 | COMPUTER ARCHITECTURE (DEFERRED)  |

27. CSC 2202	OPERATING SYSTEMS I
28. CSC 2202	OPERATING SYSTEMS II
29. CSC 2702	DATABASE AND INFORMATION MANAGEMENT SYSTEMS
30. CSC 2702	DATABASE AND INFORMATION MANAGEMENT SYSTEMS
31. CSC 2901	DISCRETE STRUCTURES I
32. CSC 2901	DISCRETE STRUCTURES II
33. CSC 2912	NUMERICAL ANALYSIS I
34. CSC 2912	NUMERICAL ANALYSIS II
35. CSC 3120	DIGITAL ELECTRONICS
36. CSC 3202	ARTIFICIAL INTELLIGENCE
37. CSC 3600	SOFTWARE ENGINEERING
38. CSC 3742	INFORMATION AND NETWORK SECURITY I
39. CSC 3742	INFORMATION AND NETWORK SECURITY II
40. CSC 3750	MANAGEMENT INFORMATION SYSTEMS
41. CSC 4130	ADVANCED HARDWARE DESIGN AND IMPLEMENTAION I
42. CSC 4130	ADVANCED HARDWARE DESIGN AND IMPLEMENTAION II
43. CSC 4630	ADVANCED SOFTWARE ENGINEERING I
44. CSC 4630	ADVANCED SOFTWARE ENGINEERING II
45. CSC 4642	SOFTWARE QUALITY ASSURANCE
46. CSC 4722	DISTRIBUTED SYSTEMS
47. CSC 4792	FUNDAMENTALS OF DATA MINING AND WARE HOUSING
48. CSC 4812	CLOUD AND HIGH PERFORMANCE COMPUTING
49. CSC 4822	ROUTING AND SWITCHING TECNOLOGIES
50. CSC 4822	ROUTING AND SWITCHING TECNOLOGIES
51. CSC 4842	CLOUD AND HIGH PERFORMANCE COMPUTING
52. CSC 3120	DIGITAL ELECTRONICS
53. GES 2411	MAPPING AND FIELD TECHNIQUES IN GEOGRAPHY
54. GES 3151	REGIONAL PLANNING AND DEVELOPMENT
55. GES 3241	CLIMATOLOGY
56. GES 3262	BIOGEOGRAPHY
57. GES 3330	ENVIRONMENTAL AND DEVELOPMENT
58. GES 3352	SPATIAL DIMENSION OF DISEASES AND HEALTH CARE SERVICES PROVISION
59. GES 3441	REMOTE SENSING
60. GES 4181	URBAN GEOGRAPHY AND PLANNING
61. GES 4172	RURAL LAND USE AND LAND SCAPES
62. GES 4192	GEOGRAPHICAL DIMENSION SETTLEMENTS
63. GES 4342	ENVIRONMENT AND NATURAL RESOURCE MANAGEMENT
64. GES4372	TOURISM ENVIRONMENT AND DEVELOPMENT

65. MAT 1100	FOUNDATION MATHEMATICS
66. MAT 1110	FOUNDATION MATHEMATICS AND STATISTICS FOR SOCIAL SCIENCES
67. MAT 2012	ECONOMICS FOR ACTUARIAL SCIENCE
68. MAT 2100	ANALYTIC GEOMETRY AND CALCULUS
69. MAT 2100	ANALYTIC GEOMETRY AND CALCULUS
70. MAT 2110	ENGINEERING MATHEMATICS I
71. MAT 2110	ENGINEERING MATHEMATICS
72. MAT 2200	LINEAR ALGEBRA I
73. MAT 2200	LINEAR ALGEBRA II
74. MAT 2602	INTRODUCTION TO STATISTICS
75. MAT 3011	PRINCIPLES OF FINANCE AND FINANCIAL REPORTING
76. MAT 3011	PRINCIPLES OF FINANCE AND FINANCIAL REPORTING
77. MAT 3022	INVESTMENT ANALYSIS AND POTFOLIO MANAGEMENT
78. MAT 3100	ADVANCED CALCULUS
79. MAT 3110	ENGINEERING MATHEMATICS II
80. MAT 3300	REAL ANALYSIS
81. MAT 4022	PENSION DESIGN VALUATION
82. MAT 4032	FINANCIAL ENGINEERING
83. MAT4119	ENGINEERING MATHEMATICS III
84. MAT4300	ELEMENTS OF FUNCTIONAL ANALYSIS
85. MAT4615	NONPARAMETRIC STATISTICS
86. MAT4622	CATEGORICAL DATA ANALYSIS
87. PHY 1010	INTRODUCTORY PHYSICS
88. PHY 2112	ATOMIC PHYSICS AND MAGNETISM IN MATTER
89. PHY 2611	ELECTRICITY AND MAGNETISM
90. PHY 2712	OPTICS
91. PHY 3032	COMPUTATIONAL PHYSICS I
92. PHY 3411	ANALOGUE ELECTRONICS I
93. PHY 3531	INTRODUCTION TO QUANTUM MECHANICS
94. PHY 4021	MATHEMATICAL METHODS FOR PHYSICS
95. PHY 4221	SOLID STATE PHYSICS I
96. PHY 4221	SOLID STATE PHYSICS II
97. PHY 4442	DIGITAL ELECTRONICS
98. PHY 4535	QUANTUM MECHANICS II

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

**2018 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 statement which is **true**.
  1. After replication, half the daughter DNA contains two new strands.
  2. In their experiment, Meselson and Stahl proved that DNA replication is conservative.
  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 one generation.
  5. Meselson and Stahl analysed DNA samples using caesium chloride preparative centrifugation.
  6. I do not know.
  
2. Bacterial cells grown in a heavy nitrogen isotope and allowed to replicate once 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.
  
3. The Meselson-Stahl experiment to study DNA replication had three layers settled in the centrifuge tubes according to their weight. Which layer had the nitrogen 14 isotope?
  1. Top layer
  2. Middle layer
  3. Bottom layer
  4. Both 1 and 2 above.
  5. Both 1 and 3 above.
  6. I do not know.
  
4. The normal replication of DNA involves ...
  1. A pairing with G.
  2. leading stranding and lagging strand synthesis.
  3. daughter DNA having one old strand and one new strand.
  4. A pairing with U.
  5. parental DNA having one old strand and one new strand.
  6. I do not know.
  
5. 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 -- translation → RNA -- transcription → Protein.
  3. RNA -- transcription → DNA -- translation → Protein -- modification → DNA
  4. RNA -- replication → RNA -- transcription → DNA -- translation → Protein.
  5. Protein ← translation -- RNA transcription -- DNA ← replication -- DNA.
  6. I do not know.

11. Which reaction in DNA replication is catalysed by helicase?
1. Addition of new nucleotides to the lagging strand.
  2. Separation of the strands of DNA double helix.
  3. Addition of new nucleotides to the leading strand.
  4. Base pairing of the template and the newly formed DNA strand.
  5. Synthesis of a short RNA primer complementary to DNA.
  6. I do not know.

12. During DNA replication, separation of DNA strands requires ...

1. hydrolysis of phosphodiester bonds.
2. DNA ligase activity.
3. hydrolysis of GC and AT bonds.
4. complementary base-pairing.  $\times$
5. topoisomerase activity.
6. I do not know

13. If the sequence of bases on a non-template DNA is 5'- TAGT - 3', then the corresponding sequence of bases in the transcribed RNA will be...

1. 5'- ATCG- 3'.
2. 5'- TAGC- 3'.
3. 3'-UAGC-5'.
4. 3'-AUGC- 5'.
5. 3'-UAGU- 5'.
6. I do not know.

A U C A  
A T C A    A U C A  
U A G U

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

1. 5' capping
2. Poly A tail
3. Nucleolus
4. Splicing
5. RNA synthesis
6. I do not know.

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

1. Addition of a 5' cap. ✓
2. Lagging strand synthesis
3. Addition of poly A tail ✓
4. Intron removal. ✓
5. Joining exons together. ✓
6. I do not know

6. Which of the following contains the genetic information for the synthesis of one specific protein?

1. messenger RNA.
2. transfer RNA.
3. ribosomal RNA.
4. messenger RNA and transfer RNA.
5. DNA.
6. I don't know.

7. During DNA replication, new nucleotides are added to the ...

1. phosphate group of carbon 5 of the deoxyribose
2. OH group of carbon 3 of the deoxyribose
3. phosphate group of carbon 5 of the ribose
4. OH group of carbon 3 of the ribose
5. phosphate group on the 3' end of the RNA primer.
6. I do not know.

8. The stages of DNA replication can be represented by the following reverse order:

1. Initiation, separation of daughter DNA, proof reading, elongation.  $\alpha$
2. Separation of daughter DNA, proof reading, elongation, initiation.  $\beta$
3. Initiation, separation of daughter DNA, elongation, proof reading.
4. Elongation, initiation, separation of daughter DNA, proof reading.  $\alpha$
5. Initiation, elongation, proof reading, separation of daughter DNA.  $\alpha$
6. I do not know.

9. 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. a number of Okazaki fragments are produced.
4. hydrogen bonds between the nucleotides of the two strands break.  $\alpha$
5. helicase catalyses the sealing of the gap between adjacent DNA fragments.  $\alpha$
6. I do not know.

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

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

16. Choose the statement which represents the universality 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.
17. Which position(s) of a codon is(are) said to wobble?
1. First and second
  2. Second and third
  3. First
  4. Second
  5. Third
  6. I do not know.
18. Which of the following is **not** a property of the genetic code?
1. Triplet
  2. Degenerate
  3. Overlapping
  4. Universal
  5. Unpunctuated
  6. I do not know.
19. The total number of possible codons of the genetic code is  $6^4$  out of which  $3^3$  are stop codons.
1. 20, 3
  2. 21, 3
  3. 64, 21
  4. 64, 3
  5. 64, 20
  6. I do not know.
20. During the process of translation, the ...
1. first amino acid binds to the A site and the second amino acid binds to the P site.
  2. first amino acid binds to formyl methionine.
  3. first amino acid binds to the P site and the second amino acid binds to the A site.
  4. last amino acid binds to the stop codon.
  5. last amino acid binds to the release factor.
  6. I do not know.

21. Identify the complex that is formed when mRNA binds to a ribosomal subunit.
1. Aminoacyl synthetase
  2. Aminoacyl tRNA complex
  3. 70S initiation complex
  4. 30S initiation complex
  5. 40S initiation complex
  6. I do not know.
22. A messenger RNA is 300 nucleotides long, excluding the start and stop codons. The number of amino acids in the protein translated from this mRNA is ....
1. 98
  2. 100
  3. 300
  4. 30
  5. 302
  6. I do not know
23. Identify the role of the enzyme peptidyl transferase during translation.
1. Transfer of peptide from the P site to the A site.
  2. Transfer of peptide from the A site to the P site.
  3. Breakdown of peptide bonds between neighbouring amino acids.
  4. Synthesis of tRNA.
  5. Formation of peptide bonds between neighbouring amino acids
  6. I do not know.
24. The nucleolus is the site where ...
1. mRNA poly A tail is added. *no*
  2. rRNA is synthesised in prokaryotes.
  3. mRNA is synthesised in prokaryotes.
  4. mRNA is translated.
  5. rRNA is synthesised in eukaryotes.
  6. I do not know
25. The poly-A tail is added to the ...
1. 3' end of tRNA. *x*
  2. 5' end of mRNA. *x*
  3. 5' end of any RNA. *x*
  4. 3' end of any RNA. *✓*
  5. 3' end of mRNA. *x*
  6. I do not know

26. During RNA processing ...

1. exons are removed and hydrolysed. ✗
2. RNA molecules are converted to DNA. ✗
3. mRNA molecule is translated into a protein molecule. ✗
4. the different types of RNA are synthesised from the DNA template. ✗
5. the different RNA primary transcripts are converted to mature RNA. ✓
6. I do not know

27. Which one of the following molecules contains introns?

1. Primary mRNA transcript of prokaryotic cells.
2. Primary mRNA transcript of eukaryotic cells.
3. Primary tRNA transcript of eukaryotic cells.
4. Primary rRNA transcript of prokaryotic cells.
5. Processed prokaryotic mRNA. ✓
6. I do not know

28. Because there are more codons than amino acids, ...

1. each amino acid is specified by more than one codon.
2. some codons specify more than one amino acid.
3. some codons do not specify any amino acid.
4. some amino acids do not have matching codons.
5. Both 1 and 3 above are correct.
6. I do not know

29. Given the DNA sequence CAT-AAG-GGC, AAG-GGC-CAT which of the following polypeptides would be the result?

1. Val-Phe-Pro
2. Gln-Asn-Gly
3. Val-Ser-Pro
4. Phe-Pro-Val
5. Gly-Leu-Pro
6. I do not know.

GUA - UUA - CCG  
UUC - CCG - GUA

30. All the following materials are required in translation except ...

1. all the types of RNA.
2. amino acids.
3. the RNA primer.
4. elongation factors.
5. ribosomes.
6. I do not know

31. Identify the sequence on the amino acid attachment arm of t-RNA.

1. 3' CAC 5'<sup>α</sup>
2. 3' CCA 5'
3. 5' CCA 3'
4. 3' ACA 5'<sup>α</sup>
5. 3' ACC 5'<sup>α</sup>
6. I do not know

32. The end of translation is signalled by a/an ... which binds a protein called the ...

1. anticodon, initiation factor
2. stop codon, release factor
3. start codon, initiation factor
4. stop codon, stop factor
5. stop codon, nonsense codon.
6. I do not know.

33. During the process of translation ...

1. all incoming tRNA molecules must first bind to the P-site.<sup>α</sup>
2. initiation begins with the binding of the ribosome to the start anticodon. ✓
3. the message on mRNA is translated into a polypeptide. ✓
4. termination is achieved by the binding of methionine to the stop codon.
5. the growing polypeptide is passed from the A-site to the P-site.
6. I do not know.

<sup>α</sup> 34. The role of messenger mRNA is to ...

1. act as a catalyst during protein synthesis.
2. help in the assembly of the ribosome.
3. provide the genetic information for protein synthesis
4. translate the genetic code into other tRNA molecules.
5. modify tRNA molecules before protein synthesis.
6. I do not know.

35. During prokaryotic translation the start codon specifies the amino acid...

1. methionine.
2. valine.
3. glycine.
4. formyl methionine.
5. tryptophan.
6. I do not know.

36. The enzyme amino acyl-tRNA synthetase....

1. attaches an amino acid to the 30s ribosomal subunit.
2. attaches an amino acid to its tRNA.
3. removes tRNA from its amino acid.
4. attaches an amino acid to its mRNA.
5. helps tRNA synthesize amino acids.
6. I do not know.

37. The ribosome reads the message on ...

1. mRNA in the 5' to 3' direction.
2. mRNA in the 3' to 5' direction.
3. mRNA in both directions.
4. tRNA in the 5' to 3' direction.
5. tRNA in the 3' to 5' direction.
6. I do not know

38. Which one of the following sequences does **not** belong to the genetic code?

1. AAA GGC AAG CAC
2. CCC GGG AAA GCA
3. AUA GGC AUG CAC
4. GGT CCC GCC GTG
5. CAA UGA ACA CCA
6. I do not know.

39. If the sequence of bases on template DNA is ATCG, then the sequences of bases on the RNA transcript will be ...

1. ATCG
2. TAGC
3. AUCG
4. AUCG
5. UACG
6. I do not know.

UAGC

TAGC

AUCG

40. The stages of translation arranged in chronological order are ...

1. Initiation, elongation, activation, termination.
2. Initiation, activation, elongation, termination.
3. Elongation, initiation, activation, termination.
4. Activation, initiation, elongation, termination.
5. Activation, elongation, initiation, termination.
6. I do not know.

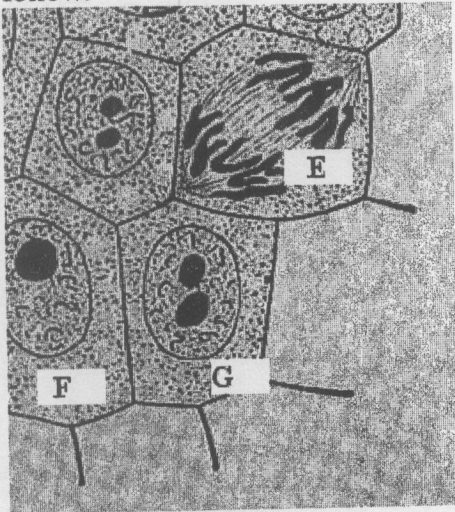
41. Choose the type(s) of RNA involved in translation.
1. tRNA
  2. mRNA
  3. rRNA
  4. tRNA and mRNA
  5. all the three types of RNA.
  6. I do not know
42. The codon, anticodon and DNA sequence for methionine are ....., ..... and ..... respectively.
1. UAG, AUC, ATC
  2. AUG, AUC, ATC
  3. UAG, UAC, TAC
  4. AUG, AUC, CTA
  5. AUG, UAC, TAC
  6. I do not know
- AUG  
- UAC  
- TAC
43. The *Lac* operon is a group of genes involved in the metabolism of ...
1. galactose.
  2. lactose
  3. permease.
  4. glucose.
  5. lactase.
  6. I do not know.
44. 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. glucose is absent.
  6. I do not know.
45. What is the function of the permease enzyme in the *lac* operon?
1. Hydrolysis of lactose
  2. Attachment of lactose to the lac repressor protein
  3. Breakdown of lactose
  4. Entry of lactose into the cell
  5. Exit of lactose from the cell
  6. I do not know.

46. The *Lac* repressor dissociates from the operator site when it binds to ...
1. lactose.
  2. the operator.
  3. the repressor.
  4. glucose.
  5. the regulator gene.
  6. I do not know.
47. In an operon, the function of the promoter is to ...
1. code for the repressor protein.
  2. bind to the repressor.
  3. code for the regulator gene.
  4. bind with RNA polymerase.
  5. All of the above are correct.
  6. I do not know
48. Choose the item which is **not** part of the lac operon.
1. Inducer.
  2. Regulator.
  3. Operator.
  4. Promoter.
  5. Structural genes.
  6. I do not know.
49. What is the function of  $\beta$ -galactosidase enzyme in the *lac* operon?
1. Entry of lactose into the cell.
  2. Synthesis of lactose.
  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.
50. The repressor becomes inactive when it binds to ...
1. the promoter.
  2. the operator.
  3. the regulator.
  4. glucose.
  5. lactose.
  6. I do not know.

51. What is an operon?
1. A part of ribosome.
  2. A part of RNA.
  3. A unit made up of linked genes that code for proteins needed to do a specific task.
  4. A special gene used in regulation of gene expression.
  5. A set of unrelated genes located close by on a chromosome.
  6. I don't know.
52. Proteins responsible for compact packaging of chromosomal DNA are called ...
1. haemoglobin.
  2. histones.
  3. myoglobin.
  4. collagen.
  5. glycoprotein.
  6. I don't know
53. What is the name of the sequence of DNA that determines one specific form of a trait?
1. Allele
  2. Genotype
  3. Centromere
  4. Phenotype
  5. RNA
  6. I don't know
- ∞ 54. The number of pairs of autosomal chromosomes in humans are ....
1. 23.
  2. 46.
  3. 44.
  4. 48.
  5. 22.
  6. I do not know.
55. What happens during the G<sub>2</sub>-phase of the cell cycle?
1. Cell rests and does not need to divide.
  2. Cell grows and synthesizes enzymes and other proteins.
  3. Cell grows and synthesizes organelles in preparation for division.
  4. DNA is replicated.
  5. The whole cell divides.
  6. I do not know.

56. Cytoplasmic division of a cell is called...
1. S-phase
  2. Cytokinesis
  3. Mitosis
  4. Synapsis
  5. G-phase
  6. I don't know
57. What is the role of the centromere during mitosis?
1. It makes the chromosomes visible.
  2. It holds chromosomes in place.
  3. It holds non-sister chromatids together.
  4. It duplicates DNA.
  5. It holds sister chromatids together.
  6. I do not know
58. During the process of \_\_\_\_\_, two daughter cells will be produced with identical DNA.
1. Mitosis
  2. Protein Synthesis
  3. Meiosis
  4. DNA Replication
  5. Interphase
  6. I don't know.
59. Choose the **false** statement.
1. Meiosis is a reductional division.
  2. Synapsis takes place during meiosis II.
  3. Meiosis produces four haploid daughter cells.
  4. Meiosis is a source of genetic variation.
  5. Through meiosis daughter cells with recombinant chromosomes may be produced.
  6. I do not know.
60. 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 diploid mother cells.
  5. Recombination of alleles during prophase II.  $\alpha$
  6. I do not know.

Study the diagrams below which show some stages of mitosis and answer the questions that follow.



61. Identify the stage labelled E.

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

∝ 62. Differentiate between F and G.

1. F is metaphase while G is prophase.
2. F is interphase while G is metaphase.
3. F is interphase while G is telophase.
4. F is interphase while G is prophase.
5. F is prophase while G is metaphase.
6. I do not know.

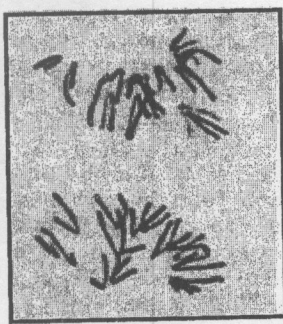
*1 pmat*

63. The exchange of segments of 2 non-homologous pair of chromosomes is called...

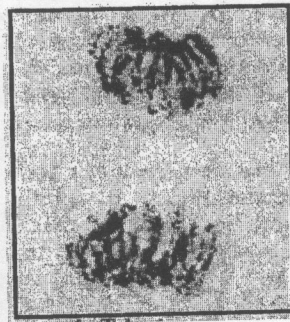
1. Recombination ∝
2. Linkage
3. Chiasma ∝
4. Metaphase ∝
5. Telophase ✓
6. I don't know.

64. During which of these stages do chromatids separate and move to the poles of the spindle?
1. Metaphase of mitosis and metaphase 1 of meiosis.
  2. Anaphase of mitosis and anaphase 2 of meiosis.
  3. Telophase 1 and 2 of meiosis.
  4. Prophase of mitosis only.
  5. Cytokinesis.
  6. I don't know.

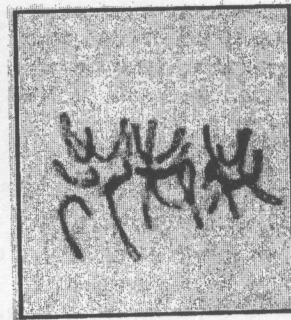
Study the diagrams below which show some stages of mitosis and answer the question that follows.



X



Y



Z

metaphase

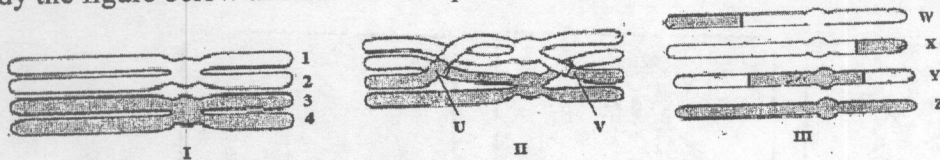
pmat

65. Identify the stages labelled X, Y and Z.
1. X is anaphase, Y is telophase, Z is metaphase
  2. X is telophase, Y is interphase, Z is prophase  $\times$
  3. X is prophase, Y is telophase, Z is anaphase  $\times$
  4. X is anaphase, Y is interphase, Z is metaphase  $\times$
  5. X is interphase, Y is telophase, Z is metaphase
  6. I do not know.
66. Crossing over between chromatids takes place during ...
1. interphase of meiosis.
  2. prophase II of meiosis.
  3. prophase of mitosis.
  4. metaphase of mitosis.
  5. prophase I of meiosis.
  6. I do not know.
67. Synapsis is a process ...
1. during mitosis whereby chromosomes exchange their material.
  2. during meiosis whereby sister chromatids exchange their material.
  3. whereby daughter cells with half the genetic material of the parent cell are produced.
  4. whereby homologous chromosomes separate and migrate to opposite poles.
  5. homologous chromosomes become closely associated.
  6. I don't know.

68. Crossing-over occurs during ....

1. prophase
2. interphase
3. prophase I
4. prophase II
5. metaphase I.
6. I do not know

Study the figure below and answer the question that follows.



69. The letter U in diagram II represents ...

1. a chiasma between chromatids 1 and 2.
2. the behaviour of chromosomes during metaphase.
3. a chiasma between chromatids 1 and 3.
4. the behaviour of chromosomes during anaphase.
5. recombinant gametes.
6. I do not know.

70. The structures in diagram III represent...

1. a chiasma between chromatids 1 and 2. ✗
2. the behaviour of chromosomes during metaphase. ✗
3. a chiasma between chromatids 1 and 3.
4. the behaviour of chromosomes during anaphase.
5. recombinant gametes.
6. I do not know.

71. Which one of the following statements is **not** a characteristic of homologous chromosomes?

1. They have the same length. ✓
2. They have the same centromere position. ✓
3. They carry genes that control any given trait at the same location. ✗
4. They always have the same type of alleles that code for the exact same type of a trait.
5. They pair up during meiosis I. ✓
6. I do not know. ✓

72. Choose the **correct** statement.

1. The genotype is the physical appearance of an individual.  $\alpha$
2. The phenotype is the allelic combination of an individual.  $\alpha$
3. An allele contains two or more genes.  $\alpha$
4. A dominant allele is one expressed only in a homozygous individual.  $\alpha$
5. Codominant alleles are both expressed in a heterozygous individual. ✓
6. I do not know.

73. Which alleles are responsible for the A and O blood groups?

1. Dominant and recessive alleles.
2. Codominant alleles.
3. Codominant and recessive alleles.
4. Incompletely dominant alleles.
5. Dominant alleles.
6. I do not know.

74. Choose the statement which is **not true** about an individual that is homozygous for an allele?

1. The individual is true-breeding with respect to that allele.
2. Each of the individual's cells possesses two copies of that allele.
3. The parents of the individual have to be homozygous for that allele.
4. Each of individual's gametes contains one copy of that allele.
5. The allele can be passed to the individual's offspring.
6. I do not know.

75. Alternative forms of a gene occupying the same position on a pair of homologous chromosomes are known as ...

1. double strands.
2. templates.
3. nucleosomes.
4. alleles.
5. histones.
6. I do not know.

76. The allelic combination of an individual is described as the ...

1. phenotype.
2. genotype.
3. nucleus.
4. chromosomes.
5. genes.
6. I do not know.

77. A test cross is a cross between ...

1. two F<sub>1</sub> individuals.
2. two recessive phenotypes
3. a dominant phenotype and a recessive phenotype.
4. two dominant phenotypes.
5. a dominant genotype and a recessive genotype.
6. I do not know

78. Mendel's second law states that ...

1. alleles of different genes assort independently.
2. genes of different alleles assort independently.
3. alleles of a gene segregate in equal numbers.
4. genes of an allele segregate in equal numbers.
5. genes of an allele segregate in unequal numbers.
6. I do not know

79. If two organisms are crossed and the trait being studied displays incomplete dominance, one may expect the following monohybrid phenotypic ratio in the offspring:

1. 3:1
2. 1:2:2
3. 1:2:1
4. 9:3:3:1
5. 1:1
6. I do not know.

80. In a monohybrid cross the ...

1. dominant phenotype disappears in the F<sub>1</sub> generation.
2. dominant phenotype disappears in the F<sub>2</sub> generation.
3. recessive phenotype re-appears in the F<sub>1</sub> generation.
4. recessive phenotype re-appears in the F<sub>2</sub> generation.
5. co-dominant phenotype disappears in the F<sub>1</sub> generation.
6. I do not know.

81. In a cross between red-flowered and white-flowered parental plants, the offspring had red flowers with white spots, indicating that the alleles for flower colour exhibit...

1. complete dominance.  $\times$
2. recessive behaviour.  $\times$
3. incomplete dominance.
4. codominance.
5. dominant and recessive behaviour.  $\times$
6. I do not know.

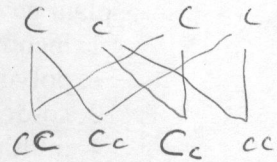
82. In monohybrid inheritance ...

1. two characters, controlled by two alleles are considered.
2. one character, controlled by one allele is considered.
3. two characters, controlled by one gene are considered.
4. one character, controlled by two alleles is considered.
5. two characters, controlled by two genes are considered.
6. I do not know.

Human albinism is determined by homozygosity for the recessive allele  $c$  while normal pigmentation is determined by the dominant allele  $C$ . If a normally pigment couple, each of whom has an albino parent are married and have two children, answer the questions that follow.

83. What is the probability that one of the children will be an albino child?

1.  $\frac{1}{2}$
2.  $\frac{1}{3}$
3.  $\frac{1}{4}$
4.  $\frac{1}{8}$
5.  $\frac{1}{16}$
6. I do not know.



$$\frac{10}{4} = 0.25$$

84. What is the probability that both the children will be albino?

1.  $\frac{1}{2}$
2.  $\frac{1}{3}$
3.  $\frac{1}{4}$
4.  $\frac{1}{8}$
5.  $\frac{1}{16}$
6. I do not know.

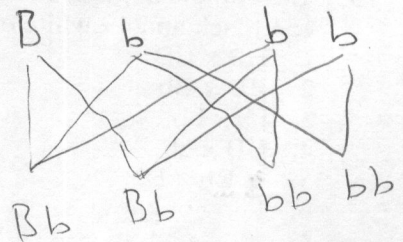
cc

85. Choose the option which best represents a monohybrid testcross.

1.  $TT/tt \times TT$
2.  $Tt/TT \times Tt$
3.  $TT/Tt \times TT$
4.  $TT/Tt \times tt$
5.  $TT/tt \times Tt$
6. I do not know

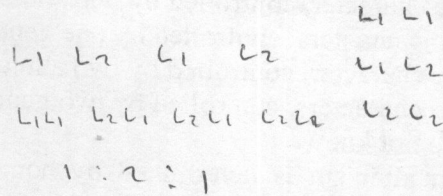
86. In guinea pigs black coat is a dominant trait and white is a recessive trait. When a heterozygous black guinea pig is crossed to a white one, what fraction of the  $F_2$  is expected to be heterozygous?

1.  $\frac{1}{4}$
2.  $\frac{2}{3}$
3.  $\frac{1}{3}$
4.  $\frac{3}{4}$
5.  $\frac{1}{2}$
6. I do not know.



87. Root shape in radishes is a result of two alleles in which  $L_1L_1$  produces long roots.  $L_1L_2$  produces oval root shape and  $L_2L_2$  produces round root shape. What genotypic ratio would you expect in the  $F_2$  generation?

1. 1:1
2. 3:1
3. 9:3:3:1
4. 1:2:1
5. 3:0
6. I do not know

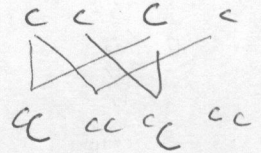


88. A cross between a pure breeding red-flowered plant and a pure breeding white-flowered plant gave a progeny of pink-flowered variety only. This example illustrates ...

1. incomplete dominance.
2. polygenic inheritance.
3. co-dominance.
4. multiple alleles.
5. complete dominance.
6. I do not know

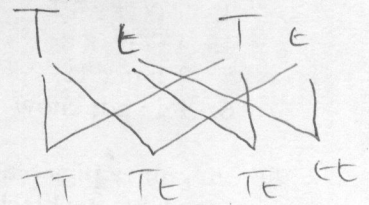
89. Albinism is due to a recessive allele. If an albino male is married to a heterozygous normal female, the children produced will be ...

1. 100% normal homozygous
2. 100% normal heterozygous
3. 50% albino: 50% normal heterozygous
4. 50% normal homozygous: 50% heterozygous
5. None of the above
6. I do not know.



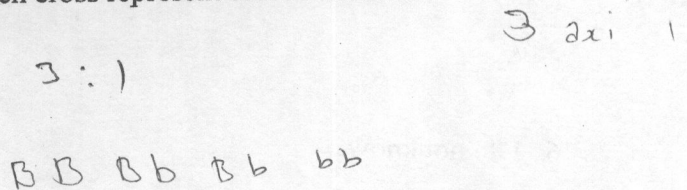
90. In pea plants, axial flowers are dominant over terminal flowers. What phenotypic ratios would you expect in offspring from a cross between two heterozygous axial-flowered plants?

1. 3 axial: 1 terminal
2. 3 terminal: 1 axial
3. 1 axial: 1 terminal
4. All axial.
5. All terminal.
6. I do not know



91. Several black guinea pigs were crossed among themselves and they produced a mixture of 151 black and 49 white offspring. Which cross represent these results?

1.  $BB \times BB$
2.  $BB \times Bb$
3.  $bb \times bb$
4.  $BB \times bb$
5.  $Bb \times Bb$
6. I do not know



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 166 red flowered plants and 34 white flowered plants. A chi-squared test was carried out on the results of the progeny phenotypes. Use the information below to answer questions that follow.

92. The expected Mendelian progeny phenotypic ratio of this cross is ...
1. 1:1
  2. 4:1
  3. 1:2:1
  4. 9:3:3:1
  5. 3:1
  6. I do not know.
93. The calculated  $\chi^2$  value is ...
1. 1.71
  2. 5.12
  3. 3.8
  4. 6.8
  5. 5.0
  6. I do not know.
94. The tabulated  $\chi^2$  value at 0.05 probability is ...
1. 1.7
  2. 5.1
  3. 3.8
  4. 6.8
  5. 5.0
  6. I do not know.
95. From the results of the chi-squared test it can be concluded that ...
1. the calculated  $\chi^2$  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 progeny phenotypes are in the expected Mendelian monohybrid ratio.
  5. the progeny phenotypes are not in the expected Mendelian monohybrid ratio.
  6. I do not know.

96. Short hair in rabbits is governed by a dominant gene (L) and long hair by its recessive allele (l). Black hair results from the action of its dominant allele (B) and brown from the recessive allele (b). What are the expected genotypic ratios from the cross LLBb x llbb?
1. 1:2
  2. 3:1
  3. 1:1:1:1
  4. 1:1:2:2
  5. 9:3:3:1
  6. I do not know.

Use the information below to answer the questions that follow.

A cross was carried out between two plants; YyRr (yellow, round seeds) x yyrr (green, wrinkled seeds). Out of 500 progeny, the following results were obtained:

Yellow round	200
Yellow wrinkled	49
Green round	51
Green wrinkled	200

A chi-squared test was then carried out to test the results of the progeny.

97. The calculated chi-squared value is...
1. 45
  2. 46.2
  3. 180.
  4. 43.8.
  5. 7.8.
  6. I do not know.
98. The degrees of freedom are...
1. 2.
  2. 3.
  3. 4.
  4. 9.
  5. 16.
  6. I do not know.
99. The results of this cross suggest that...
1. The gene with alleles R, r and the gene for Y, y are on different chromosome.
  2. The four genes are on different chromosomes.
  3. The two genes are linked.
  4. The three genes are on the same chromosomes.
  5. The three genes are controlled by multiple alleles.
  6. I do not know.

100. If the blood group of a child is A, 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.



**CHI-SQUARED TABLE FOR UP TO FOUR DEGREES OF FREEDOM**

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

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END OF EXAMINATION

**THE UNIVERSITY OF ZAMBIA**  
**SCHOOL OF NATURAL SCIENCES**  
**2018 ACADEMIC YEAR**  
**FINAL EXAMINATIONS**

**BIO 2302: BASIC MICROBIOLOGY**  
**THEORY PAPER**

**TIME: THREE HOURS**

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

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**SECTION A**

1. Discuss the significance of the microbial growth curve in determining soil fertility.
2. State five methods of sterilization and discuss the sterilization of septrin (Co-trimoxazole) tablets at the point of manufacturing.
3. State four methods used for measuring the effectiveness of anti-microbial agents and describe two of them in detail.
4. (a) Summarise the classification of bacteria and fungi.  
(b) Describe in detail how you would prepare 105 culture plates of nutrient agar, each holding 8mls of the agar (35g = 1litre)

**SECTION B**

5. Describe methods used for quantification of animal and bacterial viruses.
6. Discuss the following in relation to tobacco mosaic virus (TMV).
  - (a) Virus structure.
  - (b) Viral symptoms.
  - (c) Viral transmission methods.
7. Discuss the consequences of virus infection in bacterial cells.
8. Summarise four of the following:
  - (a) Viroid structure.
  - (b) Viral envelope.
  - (c) Viral symmetry.
  - (d) Genomic diversity among viruses.
  - (e) Features of the retroviral genome.

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**END OF EXAMINATION**

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

2018 ACADEMIC YEAR  
DEFERRED FINAL EXAMINATIONS

BIO 3011: BIOLOGICAL DATA ANALYSIS AND EXPERIMENTAL DESIGN  
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS

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1. Two Biostatistics classes comprising 10 students each were given a lab test and the scores out of 10 are presented in Table 1.

Table 1. Results of lab tests for two Biostatistics classes.

Class A: 4.00	9.50	6.30	4.50	7.00	7.00	2.00	9.50	6.50	8.00
Class B: 3.50	4.00	7.50	4.00	5.25	6.25	2.00	5.50	5.25	6.00

- (a) Determine the location and scatter of the scores of each class.  
(b) Test the null hypothesis that there was no significant difference in the performance of the two classes in the lab test.
2. Table 2 shows the number of years women spent on higher education and the number of children they had. Test whether or not there was a correlation between the number of years spent on higher education and the number of children they had.

Number of years spent on higher education	Number of Children
0	4
9	1
5	0
2	2
4	3
1	5

TURN OVER

3. The results of a Randomized Block Design experiment are set out in Table 3.

Table 3. Results of a Randomized Block Design experiment in centimeters.

Block	Treatments			
	1	2	3	4
1	8.460	27.000	21.000	11.430
2	18.000	39.965	25.000	23.000
3	10.000	26.000	22.000	14.000

Conduct an ANOVA of the results and if the null hypothesis is rejected, separate the means using LSD statistics.

4. The Energy Regulation Board of Zambia tested four different blends of petrol for fuel efficiency according to a Latin Square Design in order to control variability of four different drivers and four different models of cars. Fuel efficiency was measured as kilometers per liter after driving cars over a standard course. The data are given in Table 4.

Table 4. Fuel efficiency test results (in kilometers per liter) for four blends of petrol using four car models by the Energy Regulation Board of Zambia.

Driver	Car Model			
	I	II	III	IV
1	D = 15.50	B = 33.90	C = 13.20	A = 29.00
2	B = 16.30	C = 26.60	A = 19.40	D = 22.80
3	C = 10.80	A = 31.10	D = 17.10	B = 30.30
4	A = 14.70	D = 34.00	B = 19.70	C = 21.60

Test the Null hypothesis that there are no significant differences in fuel efficiency among the four blends of petrol tested.

5. A scientist studied the effect of auxin concentration ( $\text{gm}^{-2}$ ) measured after 10 days exposure on growth media, on root length on two genotypes, **A** and **B** of *Arabidopsis thaliana*. The raw data is as presented in Table 5.

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Table 5. Effect of Auxin on root length of *Arabidopsis thaliana* genotypes.

Auxin concentration ( $\text{gm}^{-2}$ )	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.

6. Measurements of the length (mm) of the prothorax and the diameter of the compound eye of 10 adult females of the armoured ground cricket, *Acanthopplus speiseri* Brancsik, collected from the surroundings of the university of Zambia's Samora Machelo School of Veterinary Medicine are presented in Table 6.

Table 6. Prothorax length and compound eye diameter of adult armoured ground cricket females.

Prothorax length:	13.20	14.00	14.00	13.00	13.00	12.60	13.00	12.50	13.30	11.45
Compound eye diameter:	1.75	1.70	1.85	1.70	1.80	1.80	1.80	1.70	1.70	1.90

- (a) Calculate the product moment correlation coefficient for these two measurements.  
 (b) Test the significance of the association.

7. Two samples of the Kafue weed, with 6 plants each, were collected from two locations on the Kafue River between Mazabuka and Kafue Gorge Dam. The lengths of the root systems of the plants (in cm) are given in Table 7.

TURN OVER

Table 7. Lengths of the root systems (cm) of the Kafue weed plants collected between Mazabuka and Kafue Gorge Dam.

SAMPLE 1	SAMPLE 2
97	88
104	101
17	87
101	67
31	65
98	43

- (a) Examine the significance of the difference between the mean root lengths, assuming that population variances are equal.
- (b) Indicate what your conclusion would be regarding the difference between the mean root lengths, if population variances were unequal.
8. The results of a survey in a rural area in Central Africa to compare the prevalence of infection of *Schistosoma mansoni*, a bilharzia parasite, among different occupations are presented in a 2x4 contingency Table 8. Test the Null hypothesis that there was no association between risk of infection and occupation.

Table 8. 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

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END OF EXAMINATION

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

2018 ACADEMIC YEAR  
FINAL EXAMINATIONS

BIO 3011: BIOLOGICAL DATA ANALYSIS AND EXPERIMENTAL DESIGN  
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS

---

1. The numbers of external parasites (mites) found on bodies of 25 specimens in each sample of a given species of ground beetle collected from different regions of a country are presented in Table 1.

Table 1. The numbers of external parasites found on the bodies of a given species of ground beetle.

SAMPLE 1	SAMPLE 2
5, 3, 7, 5, 7,	3, 3, 7, 3, 3,
5, 1, 4, 2, 5,	7, 7, 7, 3, 7,
8, 3, 6, 5, 7,	3, 7, 3, 7, 7,
5, 8, 3, 6, 5,	5, 3, 3, 7, 3,
5, 5, 5, 4, 2.	7, 3, 3, 7, 7.

- (a) Provide a picture of each of the sample data and determine its:  
i. location and  
ii. scatter.
- (b) Test the equality of the scatters of the two samples.
2. Twenty-five students were tested for their reaction times (sec) to a stimulus and gave the following results:

6.4 3.8 6.4 16.5 3.7 13.1 25.0 7.6 2.3 2.8 15.4 4.3 8.5  
9.5 10.8 1.4 19.7 3.4 7.5 6.2 26.3 6.4 12.1 6.0 4.8

- (a) Test the Null hypothesis that the median reaction time is 7.8 sec.
- (b) Calculate the mean reaction time and comment on the result.

TURN OVER

3. A plant ecologist wishes to test the hypothesis that the height (cm) of plant species X depends on the type of soil it grows in. She measures the height of 3 plants in each of 4 plots representing 4 different soil types. The results are presented in Table 2. Determine whether these results support her hypothesis and if they do, separate the mean heights using the Least Significant Difference (LSD) Statistic.

Table 2. Heights of plant species X growing in 4 different soil types.

Observation	Plots			
	1	2	3	4
1	15	25	17	10
2	9	21	23	13
3	4	19	20	16

4. An experiment consisting of sampling the air quality of homes in Lusaka was conducted. Ten homes each from an unplanned settlement and from a government housing project were randomly sampled. The objective of the experiment was to compare whether there were differences in the number of bacteria colonies per cubic meter of air. The number of bacteria colonies was estimated from petri dishes and the results are summarized in Table 3.

Table 3. The number of bacteria colonies per cubic meter of air in two human Settlements.

Unplanned Settlement	Council Housing Project
37.0	1.0
2.6	5.3
48.6	3.4
47.8	2.3
99.3	5.1
1.4	38.7
2.3	5.0
3.1	50.6
3.0	1.6
0.3	22.7

(a) Determine the following for each sample:

- (i) Sum-of-Squares (SS).
- (ii) Variance.
- (iii) Standard deviation.

(b) Test the Null hypothesis that there is no significant difference in the air quality between the two types of settlements.

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5. Results of a Randomized Block Design (RBD) experiment are presented in Table 4 in which for some unknown reasons, two cells (**a** and **b**) had missing values. Estimate the missing yield values and then conduct an ANOVA to test if there are any significant differences among treatment means.

Table 4. Results of a Randomized Block Design (RBD) experiment.

TREATMENTS	BLOCKS (Replicates)		
	1	2	3
1	11	13	16
2	18	20	<b>b</b>
3	<b>a</b>	29	30
4	29	30	31

6. The Energy Regulation Board of Zambia tested four different blends of petrol for fuel efficiency according to a Latin Square Design in order to control variability of four different drivers and four different models of cars. Fuel efficiency was measured as kilometers per liter after driving cars over a standard course. The data are given in Table 5.

Table 5. Fuel efficiency test results (in kilometers per liter) for four blends of petrol using four car models by the Energy Regulation Board of Zambia.

Driver	Car Model			
	I	II	III	IV
1	D = 15.50	B = 33.90	C = 13.20	A = 29.00
2	B = 16.30	C = 26.60	A = 19.40	D = 22.80
3	C = 10.80	A = 31.10	D = 17.10	B = 30.30
4	A = 14.70	D = 34.00	B = 19.70	C = 21.60

Test the Null hypothesis that there are no significant differences in fuel efficiency among the four blends of petrol tested.

7. Measurements of the length (mm) of the prothorax and the diameter of the compound eye of 10 adult females of the armoured ground cricket, *Acanthopplus speiseri* Brancsik, collected from the surroundings of the university of Zambia's Samora Machelo School of Veterinary Medicine are presented in Table 6.

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Compound eye diameter:	1.75	1.70	1.85	1.70	1.80	1.80	1.80	1.70	1.70	1.90

TURN OVER

- (a) Calculate the product moment correlation coefficient for these two measurements.  
 (b) Test the significance of the association.
8. Two samples of the Kafue weed, with 6 plants each, were collected from two locations on the Kafue River between Mazabuka and Kafue Gorge Dam. The lengths of the root systems of the plants (in cm) are given in Table 7.

Table 7. Lengths of the root systems (cm) of the Kafue weed plants collected between Mazabuka and Kafue Gorge Dam.

SAMPLE 1	SAMPLE 2
97	88
104	101
17	87
101	67
31	65
98	43

- (a) Examine the significance of the difference between the mean root lengths, assuming that population variances are equal.  
 (b) Indicate what your conclusion would be regarding the difference between the mean root lengths, if population variances were unequal.

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END OF EXAMINATION

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

2018 ACADEMIC YEAR  
FINAL EXAMINATIONS

BIO 3132: COMMUNITY ECOLOGY  
THEORY PAPER

TIME: THREE HOURS

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

---

1. Predators and prey in a given ecosystem are involved in a long-term evolutionary arms race to survive and reproduce. Provide evidence of strategies both have evolved to support the arms race concept.
  2. Summarise each of the following:
    - (a) Species diversity.
    - (b) Trophic cascades.
    - (c) Herbivory.
    - (d) Food web.
  3. Discuss a model of an ecosystem after a major disturbance.
  4. Savanna ecosystems have an evolutionary history with fires, which means fires are ~~an~~ a common occurrence in such systems. Discuss the effect of fires on plant and animal communities in Miombo woodland.
  5. Citing examples, discuss the Intermediate Disturbance Hypothesis (IDH).
  6. Summarise each of the following:
    - (a) Facilitation Model.
    - (b) Sigmoid functional response.
    - (c) Community stability.
    - (d) Competition.
  6. Compare and contrast natural ecosystems and agro-ecosystems.
  8. Aquatic biomes are known to have low Net Primary Production (NPP) in comparison to Terrestrial ones and yet have a proportionately higher biomass of animals. Discuss the validity of this statement.
- 

END OF EXAMINATION

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

**2018 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. A CHI-SQUARED TABLE IS PROVIDED.**

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**SECTION A**

1. (a) Explain conjugation in bacteria.  
(b) Explain how Hfr bacteria are formed.  
(c) Explain how can interrupted conjugation be used to create a genetic map in bacteria?
2. (a) Explain with the help of a diagram, the processes of transduction and transformation.  
(b) Explain briefly, the major steps involved in the process of binary fission.
3. (a) Explain either the lytic or lysogenic life cycle in bacteriophage with the help of a diagram.  
(b) Explain the factors which determine the transition of a bacteriophage from lysogenic to lytic cycle.  
(c) Explain briefly how we can experimentally study recombination in bacteriophages.
4. (a) Differentiate auto-polyploidy from allo-polyploidy and aneuploidy.  
(b) Summarise each of the following:
  - (i) Klinefelter syndrome.
  - (ii) Huntington's chorea.
  - (iii) Down syndrome.

**SECTION B**

5. (a) Explain how you can differentiate unlinked genes from completely linked and partially linked genes using a triple test cross.  
(b) Describe the mapping function which relates RF to chiasma frequency.  
(c) Demonstrate how the mapping function in 5(b) above can be used to estimate genetic distance between two genes in centimorgans.

**TURN OVER**

6. A survey was carried out on a human population in order to study its genetic structure based on the albinism trait in which the recessive allele  $c$  causes albinism while the dominant allele  $C$  produces a normal skin pigmentation. Out of a sample of 1, 500 participants, 30 of them were albino.

- Calculate the genotype frequencies.
- Calculate the allele frequencies.
- Estimate the number of individuals who are carriers of the albinism allele in this population.
- Calculate the probability that a 'normal' couple from this population may have an albino child.

7. A population which was known to be in Hardy-Weinberg equilibrium (HWE) was monitored over a period of time. Table 1 shows the initial and the final genetic structures of the population, based on one gene with two alleles 'A' and 'a'.

Table 1. Results of a study of the genetic structure of a population monitored over a period of time

Population description	Number of AA individuals	Number of Aa individuals	Number of aa individuals
Initial generation (in HWE)	25	49	26
Final generation	40	54	6

For this population:

- Calculate the allele and genotype frequencies
- Determine whether the final generation of the population is also in HWE.
- Discuss the results in 7(b) above.

8. A sample of 400 randomly mating humans has allele frequencies  $I^B = 0.45$  and  $I^O = 0.18$  at the ABO blood group locus.

- Calculate the number of person expected to have each of the following blood groups:
  - A.
  - B.
  - AB.
  - O.
- Suggest how the knowledge of the ABO blood group distribution in a population can be used by the local hospital blood bank.

PROCEED TO THE NEXT PAGE

CHI SQUARED TABLE

DEGREES OF FREEDOM	PROBABILITY										
	0.01	0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
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

END OF EXAMINATION

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

**DEPARTMENT OF BIOLOGICAL SCIENCES  
2018 ACADEMIC YEAR**

**FINAL EXAMINATIONS**

**BS 1401: BIOMOLECULES AND CELLS  
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. A blank space carries -1 mark
7. The option "I do not know" carries 0 marks
8. Use ink to record your answers on the answer sheet
9. Cross out a wrong entry and write the correct one by the side
10. Handover both the answer sheet and question paper at the end of the test
11. Any communication with another candidate will lead to disqualification
12. Use of cell phones is not allowed.

1. The atomic number of a given element is ...
  1. the mass of the element.
  2. number of protons.
  3. the number of protons plus neutrons.
  4. number of neutrons.
  5. the number of electrons.
  6. I do not know.
  
2. Isotopes are atoms that have the same..... but different ...
  1. atomic masses, charges
  2. mass numbers, atomic numbers
  3. atomic numbers, mass numbers
  4. charges, atomic masses
  5. mass numbers, charges
  6. I do not know.
  
3. The element which has mass number 12 and atomic number 6 is ....
  1. nitrogen.
  2. carbon.
  3. sulphur.
  4. sodium.
  5. chlorine.
  6. I do not know
  
4. The region of an atom which can be filled with one or two electrons is known as...
  1. a nucleus.
  2. a shell.
  3. a neutron.
  4. an atomic orbital.
  5. proton.
  6. I do not know.
  
5. For the second shell of an atom to be stable, it must have ... electrons.
  1. 2
  2. 4
  3. 6
  4. 8
  5. 16
  6. I do not know.

6. Which of the following substances has a polar covalent bond between its atoms?

1. Sodium chloride (NaCl)
2. Hydrogen molecule (H<sub>2</sub>)
3. Glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>)
4. Methyl group (-CH<sub>3</sub>)
5. Oxygen molecule (O<sub>2</sub>)
6. I do not know.

7. Which of the following substances contains an ionic bond?

1. Carbon dioxide (CO<sub>2</sub>)
2. Fructose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>)
3. Glycine (NH<sub>2</sub>CH<sub>2</sub>COOH)
4. Sodium chloride (NaCl)
5. Water (H<sub>2</sub>O)
6. I do not know.

8. Which of the following is **true** about the type of bonds in liquid water?

1. Water contains ionic and nonpolar hydrogen bonds.
2. Contains hydrogen bonds only.
3. Water contains both polar covalent and hydrogen bonds.
4. Water contains non-polar covalent bonds only
5. Water contains both non-polar covalent and hydrogen bonds.
6. I do not know.

9. Which of the following substances **does not** have hydrogen bonds?

1. Water
2. Glyceride
3. DNA
4. Transfer RNA
5. Polypeptide
6. I do not know

10. Choose the series which is arranged in order of decreasing strength.

1. Covalent bond > Ionic bond > Van der Waals forces > Hydrogen bond
2. Ionic bond > Hydrogen bond > Covalent bond > Van der Waals forces
3. Covalent bond > Ionic bond > Hydrogen bond > Van der Waals forces
4. Hydrogen bond > Ionic bond > Covalent bond > Van der waal's forces
5. Van der Waals forces > Covalent bond > Ionic bond > Hydrogen bond
6. I don't know

11. Compared to the charge and mass of a proton, an electron has ...
1. the same charge and a smaller mass.
  2. the same charge and the same mass.
  3. an opposite charge and a smaller mass.
  4. an opposite charge and the same mass.
  5. an opposite charge and larger mass.
  6. I don't know.
12. Which of the following are isotopes ...
1. Carbon 14 and Nitrogen 14
  2. Oxygen 16 and Oxygen 18
  3. Chlorine 35 and Sulphur 32
  4. 1 and 2 above.
  5. 2 and 3 above.
  6. I don't know
13. The electrons involved in chemical reactions are always found in the ... of an atom.
1. first shell
  2. nucleus
  3. outermost shell
  4. 2p orbital
  5. 1s orbital
  6. I don't know.
14. When oxygen is involved in a chemical reaction, its...
1. atomic number increases.
  2. protons are involved in the chemical reaction.
  3. atomic number decreases.
  4. neutrons are involved in the chemical reaction.
  5. atomic number remains the same.
  6. I don't know.
15. An ion with 15 protons, 16 neutrons and a charge of negative three (-3) has an atomic number of ...
1. 16
  2. 15
  3. 12
  4. 18
  5. 31
  6. I don't know.

16. The maximum number of electrons that can occupy the first shell of an atom is ...

1. 1
2. 2
3. 4
4. 6
5. 8
6. I do not know.

17. The orbitals of the second shell of an atom are ...

1. 1s,2s,2px and 2py
2. 1s,2px,2s and 2pz
3. 2py,2pz,3s and 3px
4. 2s,2px,2py and 2pz
5. 1s,2s,2pz and 3px
6. I do not know.

18. Choose the statement which is **correct**.

1. The carbon dioxide molecule has two covalent single bonds.
2. In the formation of carbon dioxide, electrons are donated by carbon to oxygen.
3. The water molecule has two covalent single bonds.
4. In the formation of water, electrons are donated by hydrogen to oxygen.
5. Both 1 and 3 above are correct.
6. I do not know

19. Choose the property which makes water an effective solvent.

1. Density property.
2. High latent heat of vaporisation.
3. Dipolar nature.
4. High specific heat capacity.
5. Surface tension.
6. I do not know.

20. Ice is able to float on liquid water because...

1. water has a high specific heat capacity.
2. of the high surface tension of liquid water.
3. ice is insoluble in liquid water.
4. water freezes at 4°C
5. the density of liquid water below the ice surface increases.
6. I do not know.

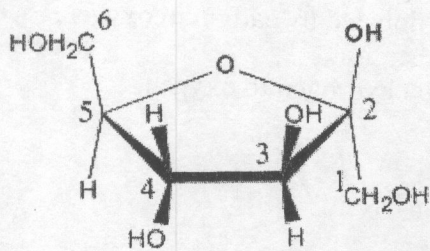
21. The cooling effect of water on plants depends on its ...

1. covalent bonds.
2. ionic bonds.
3. heat of vaporization.
4. capillarity.
5. heat capacity.
6. I do not know.

22. The best explanation of why certain insects can walk on water is ...

1. the effect of surface tension between water and the legs of the insects.
2. because water gets frozen whenever such insects walk over it.
3. the strong effect of cohesion at the water surface.
4. because all such insects have a lower density than that of water.
5. the strong effect of adhesion at the water surface.
6. I do not know.

23. The structure in the figure below represents...

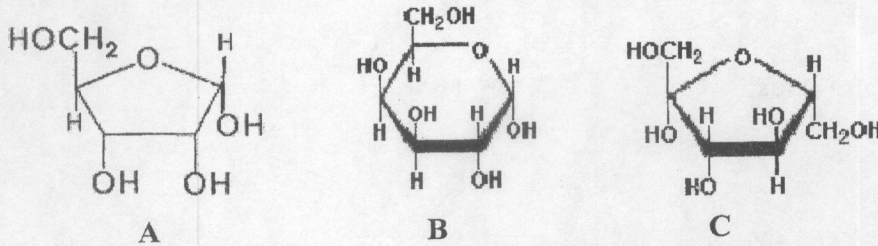


1. an alpha pyranose ring.
2. a beta ribose furanose ring.
3. an alpha pentose sugar ring.
4. a beta furanose ring.
5. an alpha pyranose ring.
6. I do not know.

24. Choose the **incorrect** statement.

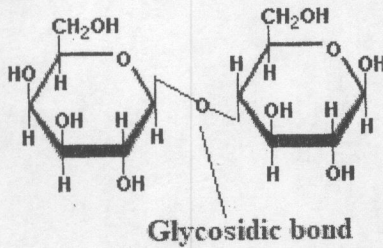
1. Glucose is a structural isomer of galactose.
2. Fructose is a structural isomer of glucose.
3. The most common form of glucose is the D-isomer.
4. Alpha glucose has the OH group on carbon 1 below the ring.
5. Glucose has the OH group on carbon 4 above the ring.
6. I do not know.

25. Study the molecules below and choose the statement which best describes the molecules.



1. A is a deoxyribose, B is  $\alpha$ -glucose and C is a fructose.
2. A is a ribose, B is a fructose and C is  $\alpha$ -galactose.
3. A is a ribose, B is  $\alpha$ -galactose and C is a fructose.
4. A is a deoxyribose, B is a  $\beta$ -glucose and C is a ribose.
5. A is a deoxyribose, B is  $\beta$ -galactose and C is a ribose.
6. I do not know.

26. The structure in the figure below is... and the glycosidic bond is...



#	Structure	Glycosidic bond
1	2 monomers of cellulose	$\beta$ 1,4
2	Lactose	$\alpha$ 1,4
3	Maltose	$\beta$ 1,2
4	Lactose	$\beta$ 1,4
5	Maltose	$\alpha$ 1,4 glycosidic bond.
6	I do not know.	

27. Which of the following statement(s) is(are) true about glycogen and cellulose?

1. glycogen is found in animals while cellulose is found in plants.
2. glycogen is a storage material while cellulose is a structural material.
3. The glycogen polymer is branched while cellulose polymer is unbranched.
4. Glycosidic bonds in glycogen are 1,4 and 1,6 while they are only 1,4 in cellulose.
5. All of the above are true.
6. I do not know.

28. Lipids are ...

1. soluble in water.
2. hydrophilic.
3. polymers of fatty acids.
4. hydrophobic.
5. amphipathic.
6. I do not know.

29. Which statement is **true** about fatty acids (e.g. stearic acid) as compared to carbohydrates (e.g. glucose)?

1. Fatty acids have a higher hydrogen to oxygen ratio.
2. Fatty acids have a lower hydrogen to oxygen ratio.
3. Fatty acids and carbohydrates have the same hydrogen to oxygen ratio.
4. Fatty acids have a lower carbon to oxygen ratio.
5. Fatty acids more polar groups.
6. I do not know.

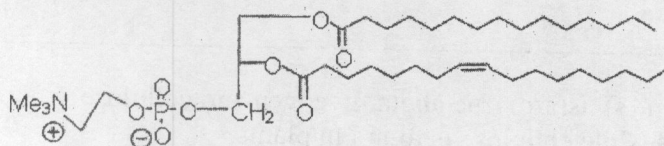
30. Which of the following is **true** about oleic acid?

1. It has a glycerol head.
2. It is polyunsaturated.
3. It has two double bonds.
4. It has one double bond.
5. It is saturated.
6. I do not know.

31. During the formation of an ester bond, ...

1. an H of a carboxylic group reacts with an OH group of an alcohol.
2. a CO of a carboxylic group reacts with an OH group of an alcohol.
3. an OH of carboxylic group reacts with H group of an alcohol.
4. a CO of a carboxylic group reacts with an H group of a lipid.
5. an OH of carboxylic group reacts with an OH group of an alcohol.
6. I do not know.

32. Study the molecule below.



This molecule is a(n) ...

1. fatty acid.
2. triglyceride.
3. wax.
4. oleic acid.
5. phospholipid.
6. I do not know.

33. Essential amino acids ...
1. are the 20 naturally occurring amino acids.
  2. are found only in animal tissues.
  3. can be synthesised by the human body.
  4. cannot be synthesised by the human body.
  5. are found in plants and not in animals.
  6. I do not know.
34. Choose the term that explains the ability of amino acids to function either as acids or bases.
1. Amphipathic
  2. Neutral
  3. Hydrophilic
  4. Amphoteric
  5. Hydrophobic
  6. I do not know.
35. In an acidic medium the amino acid glycine ( $\text{NH}_2\text{—CH}_2\text{—COOH}$ ) will exist as ...
1.  $\text{NH}_2\text{—CH}_2\text{—COOH}$ .
  2.  $\text{NH}_2\text{—CH}_2\text{—COO}^-$ .
  3.  $\text{NH}_2\text{—CH}_3^+\text{—COO}^-$ .
  4.  $\text{NH}_3^+\text{—CH}_2\text{—COOH}$ .
  5.  $\text{NH}_3^+\text{—CH}_2\text{—COO}^-$ .
  6. I do not know.
36. Choose the statement that is **true** about amino acids.
1. Amino acids produced by human cells are called essential amino acids.
  2. Amino acids with two amino groups are called basic amino acids.
  3. Amino acids with two carboxylic groups are called acidic amino acids.
  4. The most common form of amino acids is the D isomer.
  5. 2 and 3 above are true.
  6. I do not know.
37. The primary structure of proteins is maintained by ...
1. hydrogen bonds.
  2. ionic bonds.
  3. phosphodiester bonds.
  4. covalent bonds.
  5. disulphide bonds.
  6. I do not know.

38. In the stomach, proteins are hydrolysed by the enzyme known as...
1. trypsin, whose optimum pH is alkaline.
  2. lipase, whose optimum pH is acidic.
  3. pepsin, whose optimum pH is acidic.
  4. amylase, whose optimum pH is alkaline.
  5. maltase, whose optimum pH is acidic.
  6. I do not know.
39. Choose the statement which is **true** about enzymes.
1. Enzymes do not require co-factors.
  2. Enzymes do affect the amount of activation energy required by the reaction.
  3. Enzymes increase the amount of activation energy required by the reaction.
  4. Enzymes decrease the amount of activation energy required by the reaction.
  5. None of the above statements is true.
  6. I do not know.
40. The "Lock and Key" theory of enzyme action was proposed by...
1. Fischer.
  2. Koshland.
  3. Chargaff.
  4. Watson and Crick.
  5. Rosalind Franklin.
  6. I do not know.
41. The optimum pH of the enzyme trypsin, which is found in the small intestine, is ...
1. acidic.
  2. above pH7.
  3. neutral.
  4. either alkaline or acidic.
  5. below pH6.
  6. I do not know.
42. Any molecule which acts directly on an enzyme to lower its catalytic activity is called ...
1. a co-enzyme.
  2. a co-factor.
  3. an inhibitor.
  4. a substrate.
  5. a product.
  6. I do not know.

43. Which of the following statement is **true**?
1. The type of DNA bases varies from one species to another.
  2. The type of DNA bases changes with the age of the organism.
  3. The type of DNA bases is different in different tissues of an organism.
  4. The type of DNA is the same in all living organisms.
  5. All the above statements are true.
  6. I do not know.
44. The negative charge of DNA is due to the presence of ...
1. sugar, phosphate and amino acids.
  2. a deoxy ribose sugar.
  3. nitrogenous bases specifically adenine.
  4. a phosphate group.
  5. nitrogenous bases specifically guanine.
  6. I do not know.
45. The building blocks of DNA are called ...
1. purine.
  2. nucleosides.
  3. nucleotides.
  4. pyrimidines.
  5. polymers.
  6. I do not know.
46. What is the role of DNA?
1. To store genetic information.
  2. To translate the nucleotide sequence into amino acids.
  3. To transfer nucleotides to ribosomes.
  4. To transfer amino acids to ribosomes.
  5. To synthesis protein molecules.
  6. I do not know.
47. Choose the **correct** statement.
1. Purines are single ringed structures.
  2. Purines are two ringed structures.
  3. Adenine and guanine are pyrimidines
  4. Pyrimidines are two ringed structures.
  5. Adenine and uracil are pyrimidines.
  6. I do not know.

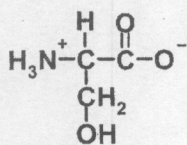
48. Choose the **correct** statement.
1. A nucleoside is a nucleotide without sugar.
  2. A nucleotide is a nucleoside without sugar.
  3. A nucleoside is a nucleotide without a phosphate.
  4. A nucleotide is a nucleoside plus a base.
  5. A nucleotide is a nucleoside plus sugar.
  6. A nucleotide is a nucleoside without a base.
  7. I do not know.
49. Which of the following is **not** a characteristic of prokaryotes?
1. Presence of DNA.
  2. Presence of cell membrane.
  3. Presence of cell wall.
  4. Presence of ribosomes.
  5. Presence of nucleolus.
  6. I do not know.
50. One way in which plants differ from animals is that plants have...
1. an endoplasmic reticulum.
  2. mitochondrial membranes.
  3. thylakoid membranes.
  4. a cell membrane.
  5. Ribosomes.
  6. I do not know.
51. Bacterial ribosomes consists of...and ... subunits.
1. 30s and 50s
  2. 40s and 60s
  3. 30s and 40s
  4. 40s and 50s
  5. 30s and 60s
  6. I do not know
52. The rough endoplasmic reticulum is so named because it has ... on its membrane.
1. an abundance of mitochondria
  2. a thick lipids layer
  3. a thick cellulose layer
  4. many Golgi bodies
  5. many ribosomes
  6. I do not know.

53. The eukaryotic ribosomal RNA is synthesized in the ...
1. cytoplasm.
  2. smooth endoplasmic reticulum.
  3. nucleolus.
  4. Golgi complex.
  5. rough endoplasmic reticulum.
  6. centriole.
  7. I do not know.
54. Water is a liquid at room temperature because of ...
1. its high boiling point.
  2. its high heat of vaporization.
  3. its high specific heat capacity.
  4. its dipolar nature.
  5. All of the above.
  6. I do not know.
55. The most important reason for the unusual properties of water is because of ...
1. the presence of covalent bonds in each water molecule.
  2. its hydrophobic nature.
  3. hydrogen bonding between its molecules.
  4. its ionization at room temperature.
  5. its small molecule size.
  6. I do not know.
56. Why do the atoms of a water molecule attain partial charges?
1. Oxygen donates an electron to hydrogen.
  2. Hydrogen donates an electron to oxygen.
  3. There is an unequal sharing of electrons between oxygen and hydrogen.
  4. Hydrogen is attracted by oxygen.
  5. There is equal sharing of electrons between oxygen and hydrogen.
  6. I do not know
57. Choose the **correct** statement(s) about the arrangement of water around ions of common salt (sodium chloride).
1. Oxygen atoms surround sodium ions.
  2. Hydrogen atoms surround chloride ions.
  3. The ions of common salt separate and clusters of water molecules form around them.
  4. Ions of common salt float on water.
  5. 1-3 above are correct.
  6. I do not know

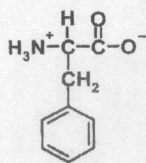
58. Which word best describes the attraction of a molecule to water?
1. Amphipathic
  2. Bipolar
  3. Solvent
  4. Hydrophilic
  5. Amphoteric
  6. I do not know.
59. When a lipid is mixed with water, the two immediately separate because ...
1. the lipid is amphipathic.
  2. the lipid is denser than water.
  3. hydrogen bonds form between water molecules.
  4. the lipid is hydrophilic.
  5. hydrogen bonds form between water molecules and lipid.
  6. I do not know.
60. Which of the following chemical groups is not a component of all amino acids?
1. An amino group.
  2. A carboxylic group.
  3. A side chain (R-group).
  4. An ester group.
  5. Hydrogen atom.
  6. I do not know.
61. The secondary structure of a protein is determined by the ...
1. number and order of its amino acids.
  2. hydrogen bond(s) made between  $\text{-CO-}$  of one peptide bond and the  $\text{-NH-}$  of another peptide bond.
  3. disulphide bonds formed between different sulphur containing amino acids.
  4. non-covalent bonds between R-groups.
  5. association between different polypeptide chains.
  6. I do not know.
62. Which of the following compounds is **not** a polymer?
1. Starch
  2. Lipid
  3. Protein
  4. Nucleic acid
  5. Enzyme
  6. I do not know

63. Which of the following pairs of groups **cannot** form a hydrogen bond with each other? The proposed hydrogen bonds are represented by dotted lines.
1.  $\text{-OH} \dots \text{N} <$
  2.  $\text{-OH} \dots \text{O} -$
  3.  $\text{-NH} \dots \text{O} -$
  4.  $\text{-CH} \dots \text{O} -$
  5.  $\text{-CO} \dots \text{HO} -$
  6. I do not know.
64. What is the role of the SH group of cysteine in the structure of proteins?
1. Forming disulphide bonds between pairs of cysteines in different parts of a polypeptide chain.
  2. Forming disulphide bonds between cysteines and different amino acids.
  3. Forming disulphide bonds through reduction of the SH groups.
  4. Forming disulphide bonds through oxidation of the SH groups.
  5. 1 and 4 are correct.
  6. I do not know.
65. Peptide bonds which covalently link two acids result from the...
1. oxidation of amino acids.
  2. reduction of amino acids.
  3. hydrolysis of amino acids.
  4. condensation of amino acids.
  5. formation of hydrogen bonds between amino acids.
  6. I do not know.
66. Which of the following levels of protein structure describes the three-dimensional folding of a polypeptide chain?
1. Quaternary structure
  2. Secondary structure
  3. Primary structure
  4. Tertiary structure
  5. Both 1 and 4 are correct
  6. I do not know.
67. The attraction between molecules of the same chemical structure is known as ...
1. adhesion.
  2. polar covalent bonding.
  3. non polar covalent bonding.
  4. cohesion.
  5. ionic bonding
  6. I do not know.

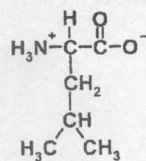
68. Which of the following amino acids has (have) a hydrophobic side chain?



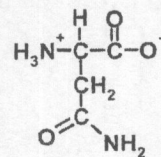
A



B



C



D

1. A and B
2. C and A
3. B and C
4. C and D
5. A and D
6. I do not know

69. The effect of a reversible competitive inhibitor can be cancelled by ...

1. increasing the product concentration.
2. increasing the substrate concentration.
3. increasing the temperature.
4. increasing the inhibitor concentration.
5. decreasing the product concentration.
6. I do not know.

70. The chemical addition of hydrogen to an unsaturated fatty acid to form the corresponding saturated fatty acid would cause it to...

1. become more rigid.
2. gain a bend in its shape.
3. change from a solid to a liquid.
4. form an ester bond.
5. have a lower melting point.
6. I do not know.

71. Which of the following is a co-enzyme?

1. Metal ion
2. Protein
3. Vitamin
4. Purine
5. Lipid
6. I do not know

72. The optimum temperature for most human enzymes is ...
1. 25°C
  2. 30°C
  3. 35°C
  4. 37°C
  5. 100°C
  6. I do not know.
73. In the induced fit model of enzyme activity, ...
1. the substrate changes its shape slightly after binding the enzyme.
  2. the enzyme active site changes its shape slightly after binding the substrate.
  3. both enzyme and substrate change their shapes after binding each other.
  4. none of the enzyme and substrate change their shape after binding each other.
  5. the enzyme and substrate have a perfect fit of each other.
  6. I do not know.
74. The effect of a competitive inhibitor on enzyme activity is such that it ...
1. reversibly increases enzyme activity.
  2. irreversibly stops enzyme activity.
  3. irreversibly increases enzyme activity.
  4. reversibly changes the shape of enzyme active site.
  5. reversibly stops enzyme activity.
  6. I do not know
75. Which of the following statements is **true**?
1. Prokaryotic cells are bigger than eukaryotic cells.
  2. Eukaryotic cells are simple while prokaryotic cells are complex.
  3. The prokaryotic cell wall is made of peptidoglycan while the eukaryotic cell wall is made of cellulose.
  4. Eukaryotic cells do not have a nucleus, prokaryotic cells do.
  5. Eukaryotic cells have genetic material while prokaryotic cells do not have genetic material.
  6. I do not know.
76. The endoplasmic reticulum is involved in the transport of ...
1. proteins.
  2. lipids.
  3. enzymes.
  4. carbohydrates.
  5. Both 1 and 2 above.
  6. I do not know.

77. The DNA of a eukaryotic cell can be found in the ...

1. nucleoid region.
2. ribosome.
3. nucleus
4. vacuole.
5. lysosome.
6. I do not know.

78. Name an organelle which serves as a primary vesicle producing particle of the cell.

1. Mitochondrion
2. Endoplasmic reticulum
3. Golgi apparatus
4. Vacuole
5. Lysosome
6. I do not know.

79. In the DNA double helix, complementary bases pair through ... bonds.

1. covalent
2. glycosidic
3. hydrogen
4. phosphodiester
5. disulphide
6. I do not know.

80. Which of the following was used to determine the structure of DNA?

1. Electrophoresis
2. Chromatography
3. Centrifugation
4. X-ray
5. Light microscopy
6. I do not know.

81. Which pyrimidines and purines are found in nucleic acids?

	Pyrimidines	Purines
1.	Adenine, thymine and cytosine	Adenine and guanine
2.	Guanine, uracil and cytosine	Thymine and adenine
3.	Uracil, cytosine and thymine	Adenine and guanine
4.	Thymine, guanine and uracil	Adenine and cytosine
5.	Cytosine, thymine and guanine	Adenine and uracil
6	I do not know.	

82. A non-competitive or an allosteric inhibitor ...

1. changes the shape of the substrate.
2. binds to the substrate.
3. binds to the enzyme active site.
4. competes with the substrate.
5. does not bind to the enzyme active site.
6. I do not know.

83. Steroid hormones are made from ...

1. amino acids.
2. cholesterol.
3. triglycerides.
4. waxes.
5. fatty acids.
6. I do not know

84. Which of the following is **not** a function of the plant central vacuole?

1. Storage of water
2. Removal of waste
3. Keeping cells rigid
4. Protein transport
5. Maintaining the cell pH
6. I do not know.

85. Which of the following is found in plant cells but not in animal cells?

1. Ribosomes.
2. endoplasmic reticulum.
3. Mitochondria.
4. Cell wall.
5. Golgi apparatus.
6. I do not know.

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

#	Organelle	Function
1	Mitochondrion	Photosynthesis
2	Nucleus	Cellular respiration
3	Endoplasmic reticulum	Water storage
4	Lysosome	Digestion of particles
5	Central vacuole	Movement
6	I do not know	

87. Which of the following structures is present only in animal cell?
1. Cell membrane
  2. Vacuole
  3. Centriole
  4. Ribosome
  5. Endoplasmic reticulum
  6. I do not know
88. Which of the following statements is **not** correct?
1. Lysosomes are able to cause cell suicide.
  2. In bacteria the cell membrane performs most of the functions of eukaryotic organelles.
  3. Ribosomes are the power house of the cell.
  4. Plant cells are more regularly shaped than animal cells.
  5. Most mature plant cells have a large central vacuole.
  6. I do not know.
89. One difference between eukaryotic and prokaryotic cells is that eukaryotic cells have ...
1. nucleic acids.
  2. ribosomes.
  3. a true nucleus
  4. a cell membrane.
  5. cell wall.
  6. I do not know.
90. Choose the statements(s) which explain(s) why enzymes are good biological catalysts.
1. They are consumed in the reaction they catalyze.
  2. They are very specific and their effect is reversible.
  3. They lower the activation energy for the reactions they catalyze.
  4. They are rich in nucleotides.
  5. 2 and 3 above are correct.
  6. I do not know
91. Which of the following statements regarding enzymes is **false**?
1. Enzymes are proteins that function as catalysts.
  2. Enzymes are specific to their substrates.
  3. Enzymes lower the activation energy for reactions.
  4. Enzyme activity cannot be inhibited.
  5. Enzymes may be used many times for a specific reaction.
  6. I do not know.

92. The temporal association between an enzyme and a substrate can best be described as...
1. an enzyme-substrate complex.
  2. a covalent bond association.
  3. one in which the enzyme is changed permanently.
  4. a permanent mutual alteration of structure.
  5. complementary base pairing.
  6. I do not know.
93. The active site of an enzyme...
1. always remains rigid and does not change shape.
  2. is found on the surface of a globular protein.
  3. is the biggest part of the protein molecule.
  4. contains amino acids with the same side chain.
  5. is also called an inhibitor site.
  6. I do not know.
94. Which of the following bonds can be found in enzyme molecules?
1. ionic bond
  2. peptide bonds
  3. disulphide bridges
  4. hydrogen bonds
  5. All of the above are correct.
  6. I do not know.
95. Which of the following statements describes how the substrate fits with the enzyme?
1. The lock and key hypothesis.
  2. The active site changes shape slightly after binding the substrate.
  3. The induced fit hypothesis.
  4. The substrate fits exactly into the enzyme active site.
  5. All of the above.
  6. I do not know.
96. Which relationship is **true** for DNA?
1.  $A + U = G + C$
  2.  $A + C = G + C$
  3.  $A + G = T + C$
  4.  $A + T = G + C$
  5.  $G + A = T + A$
  6. I do not know.

97. Which of the following statements is **not** true about RNA?
1. It is single stranded.
  2. Thymine is present.
  3. Does not obey Chargaff's rules.
  4. The sugar contained in RNA is ribose.
  5. Guanine is present.
  6. I do not know.
98. Which of the following statements is **true** about DNA?
1. The template strand is complementary to its RNA transcript.
  2. The two strands of DNA face in the same direction.
  3. A-T bonds are much more resistant to denaturation than G-C bonds.
  4. The Watson and Crick model of DNA is a double helix.
  5. Both 1 and 4 are correct
  6. I do not know.
99. Which of the following is **not** a component of the nucleic acid backbone?
1. Pentose sugar
  2. Phosphate group
  3. Phosphodiester bond
  4. Purine and pyrimidine
  5. Sugar phosphate
  6. I do not know
100. The pentoses in nucleotides are the ...
1. L- furanose form.
  2. D- furanose form.
  3. L- pyranose form.
  4. D - pyranose form.
  5. Both D and L pyranose forms.
  6. I do not know.

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END OF EXAMINATION

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

**2018/2019 ACADEMIC YEAR  
FINAL EXAMINATIONS**

**CHE1000: INTRODUCTION TO CHEMISTRY**

**TIME: THREE (3) HOURS**

**INSTRUCTIONS TO THE CANDIDATES**

1. Indicate your **student ID number** and **TG number** on **ALL** your answer booklets.
2. This examination paper consists of two (2) sections: **A** and **B**
3. Section **A** has ten (10) short answer questions. Questions carry equal marks.  
(Total marks = 40).

**ANSWER ALL QUESTIONS IN SECTION A IN THE MAIN ANSWER BOOKLET**

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

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

6. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.**
7. Please be reminded that it is your responsibility to **ENSURE** that you have nine (9) printed pages containing questions A1 to A10 and B1 to B5.

**ADDITIONAL INFORMATION TO THE CANDIDATES:**

Useful data is provided on page 10.  
Periodic Table of Elements is on last page.

**SECTION A**  
**ANSWER ALL QUESTIONS IN THIS SECTION IN THE MAIN BOOKLET**

**Question A1**

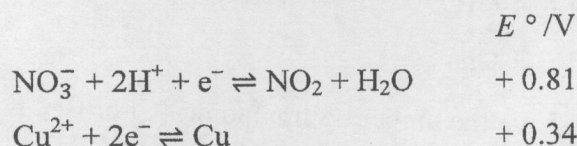
Hemoglobin is the protein that transports oxygen through the blood from the lungs. In doing so, each molecule of haemoglobin combines with four molecules of oxygen. If 1.00 g of haemoglobin combines with  $1.53 \times 10^{-6} \text{ m}^3$  of  $\text{O}_2$  at 310 K and 99059 Pa, what is the molar mass of haemoglobin? **[4 Marks]**

**Question A2**

- (a) Two factors can determine the size (radius) of an atom. State any one of them and explain in *three lines or less*, how it influences the size of an atom.
- (b) Is it more difficult to remove a valence electron from a magnesium atom or a chlorine atom? Explain in *three lines or less*.

**[4 Marks]****Question A3**

The following standard electrode potentials are needed for this question:



Calculate the standard cell emf for the reaction between copper and nitric acid and derive the balanced reaction equation. **[4 Marks]**

**Question A4**

Consider the reaction known to be zero order in A and have a rate constant of  $5.0 \times 10^{-2} \text{ M s}^{-1}$  at 25 °C. An experiment was run at 25 °C, where  $[\text{A}]_0 = 1.0 \times 10^{-3} \text{ M}$ .

- (a) Write the integrated rate law for this reaction.
- (b) Calculate the half-life for this reaction.
- (c) Find the concentration after  $1.0 \times 10^{-3} \text{ s}$  has elapsed.

**[4 Marks]****Question A5**

A solution contains  $1.0 \times 10^{-5} \text{ mol dm}^{-3}$  of  $\text{Na}_3\text{PO}_4$ . What is the required concentration of  $\text{AgNO}_3$  that would cause precipitation of  $\text{Ag}_3\text{PO}_4$  ( $K_{\text{sp}} = 1.8 \times 10^{-18}$ )?

**[4 Marks]**

Please Turn Over

**Question A6**

- (a) The enthalpy of formation of  $\text{NH}_3$  is  $-46 \text{ kJ/mol}$ . Calculate the enthalpy change for the reaction  $2\text{NH}_3(\text{g}) \rightarrow \text{N}_2(\text{g}) + 3\text{H}_2(\text{g})$
- (b) When  $285 \text{ J}$  of heat is added to  $33.6 \text{ g}$  of hexane, ( $M_r. 86.06 \text{ g/mol}$ ), the temperature increases by  $3.74^\circ\text{C}$ . Calculate the molar heat capacity of hexane.

**[4 Marks]****Question A7**

- (a) The vapor pressure above a solution of a nonvolatile solute at  $25.0^\circ\text{C}$  is  $19.3 \text{ mm Hg}$ . What is the mole fraction of the solute? (The vapor pressure of pure water is  $23.8 \text{ torr}$  at  $25.0^\circ\text{C}$ .)
- (b) List the following molecules in order of increasing surface tension:  $\text{C}_3\text{H}_8$ ,  $\text{CH}_4$ ,  $\text{CH}_3\text{COOH}$  and  $\text{C}_2\text{H}_6$ .
- (c) Which substance has the higher vapor pressure:  $\text{C}_{20}\text{H}_{42}$  or  $\text{C}_{30}\text{H}_{62}$ ?

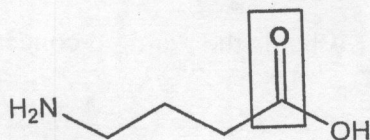
**[4 Marks]****Question A8**

- (a) Identify the strongest intermolecular force present in the following molecules:
- (i)  $\text{CH}_3\text{CH}_2\text{OH}$
- (ii)  $\text{CH}_3\text{CH}_2\text{Cl}$
- (b) Predict which will have the higher boiling point:  $\text{ICl}$  or  $\text{Br}_2$ . Explain your answer in not more than two lines.

**[4 Marks]****Question A9**

- (a) For compound A, 5-isopropyl-2,3-dimethyloct-2-ene:
- (i) Draw a line-bond formula.
- (ii) Give molecular formula.
- (iii) State the number of allylic hydrogens in A.

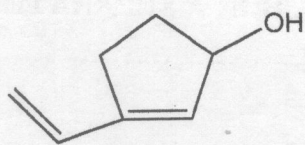
- (b) Classify the molecule shown below and describe the bonding of the group in the box.

**[4 Marks]**

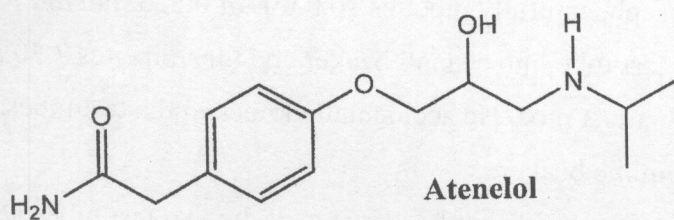
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**Question A10**

(a) Give the **IUPAC** name for the molecule shown below:



(b) Identify all functional groups in the drug atenolol, used for treatment of hypertension (high blood pressure), shown below:



[4 Marks]

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Please Turn Over

**SECTION B**  
**ANSWER QUESTION B1 AND ANY THREE QUESTIONS**  
**EACH IN A SEPARATE BOOKLET**

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**Question B1**

A CHE1000 Student, Lydia, trying to determine the concentration of HCl by titrating it with  $0.525 \text{ mol dm}^{-3}$  NaOH. It takes 83 mL of a  $0.525 \text{ mol dm}^{-3}$  NaOH solution to neutralize 235 mL of an HCl solution.

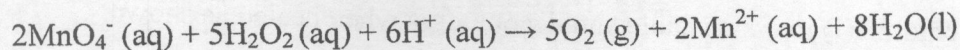
- (a) Another student, Joseph, carefully pipettes 10.0 mL of  $0.525 \text{ mol dm}^{-3}$  NaOH into a test tube. He places the test tube into a small beaker and then pipettes 7.50 mL of  $0.355 \text{ mol dm}^{-3}$  HCl into another test tube. He accidentally knocked the test tubes, while placing, contents combined in the beaker.
- (i) Is the solution formed from the contents of the two test tubes acidic or basic?
- (ii) If he added few drops of Methyl Orange indicator what would be the colour of the solution? (7 marks)
- (b) You are carrying out an acid base titration to determine the concentration of the acid. The endpoint of the neutralization is reached but the stopcock on the burette sticks slightly and allows a few more drops of acid to fall into the solution. Will this small amount of ~~base~~<sup>acid</sup> have any effect on the determined value for the concentration of the acid? If so, how is it affected (*Not more than 4 lines*)? (4 marks)
- (c) A few small drops of water are left in a burette that is then used to titrate a base into an acid solution to determine the concentration of the acid. Will this small amount of water have any effect on the determined value for the concentration of the acid? If so, how is it affected (*Not more than 4 lines*)? (4 marks)

[TOTAL: 15 Marks]

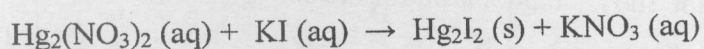
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### Question B2

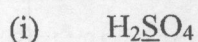
- (a) The active agent in many hair bleaches is hydrogen peroxide. The amount of hydrogen peroxide in 15.8 g hair bleach was determined by titration with a standard potassium permanganate solution:



- (i) How many moles of  $\text{MnO}_4^-$  were required for the titration if 43.2 ml of 0.015 M  $\text{KMnO}_4$  was needed to reach the end point? (1 mark)
- (ii) How many moles of  $\text{H}_2\text{O}_2$  were present in the 15.8 g of hair bleach? (2 marks)
- (iii) How many grams of  $\text{H}_2\text{O}_2$  were present in the hair bleach? (1 mark)
- (iv) What is the mass percent  $\text{H}_2\text{O}_2$  in the hair bleach? (2 marks)
- (v) What is the reducing agent in the redox reaction? (1 mark)
- (b) Consider the following precipitation reaction:



- (i) Balance the reaction. (2 marks)
- (ii) Write the **net** ionic reaction. (2 marks)
- (iii) Identify the spectator ions. (2 marks)
- (c) Determine the oxidation number of the underline atom in each of the following:



(2 marks)

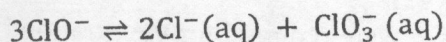
[TOTAL: 15 Marks]

**Question B3**

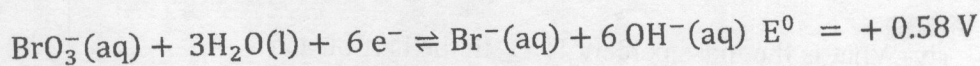
- (a) Use standard electrode potential,  $E^\circ$ , data to calculate the cell potential for the following reaction:



- (b) The chlorate(I) ion is unstable and decomposes when heated as shown.



- (i) Calculate the oxidation number of chlorine in each species. (3 marks)
- (ii) In terms of electron transfer, state what happens to chlorine in the reaction. (1 marks)
- (c) A half-equation involving bromate(V) ions,  $\text{BrO}_3^-$ , and bromide ions is shown.



- (i) An alkaline solution of chlorate (I),  $\text{ClO}^-$ , can be used to oxidise bromide ions to bromate (V) ions. Write the equation for the spontaneous reaction. (2 marks)
- (ii) Draw a cell in which this reaction will occur and label all the parts. (5 marks)
- (iii) Write the shorthand notation for the cell. (2 marks)

[TOTAL: 15 Marks]

**Question B4**

- (a) Calculate the maximum Kinetic Energy (in joules) and velocity (3 significant figures) of an electron ejected from zinc by a 275 nm photon. The threshold energy or work function for Zn = 4.31 eV. (3 marks)
- (b) (i) The nitrogen atom in ammonium ion is  $\text{sp}^3$  hybridized. Use a suitable hybridization scheme to show the hybridization on the nitrogen atom. (3 marks)
- (ii) Show using a sketch diagram that  $\text{NH}_3$  is a polar molecule. (3 marks)

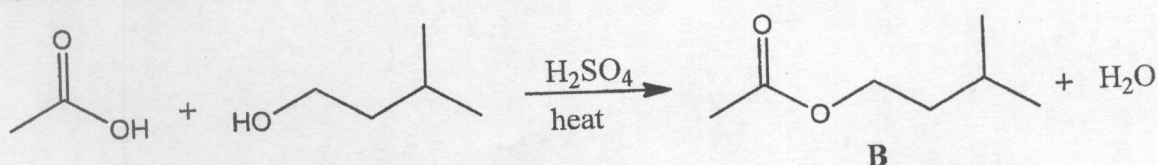
Please Turn Over

- (c) Ethene is a planar shaped molecule. Draw a fully labelled diagram showing the bonding ( $\sigma$  - sigma and  $\pi$  - pie) in the molecule. (3 marks)
- (d) (i) How would you expect the first ionization energy to change as you go across a period in the periodic table. (1 mark)
- (ii) State any two factors that influence the ease of removing an electron from an element. (2 marks)

[TOTAL: 15 Marks]

### Question B5

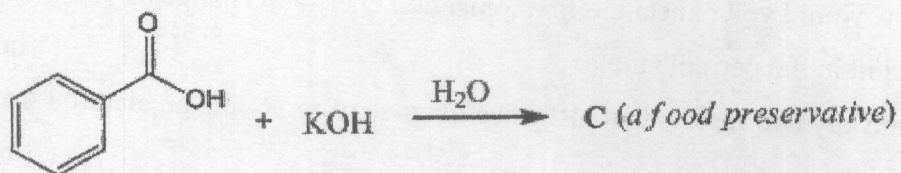
- (a) Several constitutional isomers can be written for molecular formula  $C_4H_7OCl$ .
- (i) Calculate the IHD and state all possible interpretations. (2 marks)
- (ii) Draw line-bond formula and give IUPAC name for an isomer that is a straight chain acyl chloride (acid chloride). (3 marks)
- (iii) Draw line-bond formulae for two (2) isomers with cyclobutane as parent chain and state their isomeric relationship as chain, positional or functional isomers. (3 marks)
- (iv) One of the isomers decolorizes bromine water. Interpret this result and state two (2) other functional groups that could be present in this isomer. (2 marks)
- (b) Esters are pleasant sweet-fruity smelling substances frequently used in perfumery and food industry. One common banana flavor **B** used for candy products is prepared by the reaction shown below:



(i) Name the type of reaction. (1 mark)

(ii) Give the IUPAC name for **B**. (2 marks)

(c) A frequently used food preservative, C, is prepared as shown below:



Identify C (line-bond structure) and circle the most electrophilic center on its structure.

(2 marks)

[TOTAL: 15 Marks]

**END OF EXAMINATION**

Please Turn Over

**USEFUL DATA****Physical constants**

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

**Pressure conversions**

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

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

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

**Other conversion factors**

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

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

	$E^\circ(\text{V})$
$\text{Cl}_2 + 2 \text{ e}^- \rightleftharpoons 2 \text{ Cl}^-(\text{aq})$	+1.36
$\text{ClO}^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) + 2 \text{ e}^- \rightleftharpoons \text{Cl}^-(\text{aq}) + 2\text{OH}^-$	+0.89



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

**2018 ACADEMIC YEAR**

**FINAL DEFERRED EXAMS**

**CHE 2001: AGRICULTURAL AND VETERINARY CHEMISTRY**

**INSTRUCTIONS TO THE 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

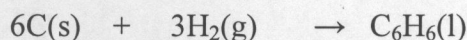
This examination consists of six (6) questions and **FOUR (4)** printed pages and the  
DATA sheet.

## QUESTION 1

- a) The rate law for the decomposition of  $\text{N}_2\text{O}_5$  is  $\text{Rate} = k[\text{N}_2\text{O}_5]$ , where  $k = 5.0 \times 10^{-4} \text{ s}^{-1}$ . What is the concentration of  $\text{N}_2\text{O}_5$  after 1900s, if the initial concentration is 0.56 M? **(6 marks)**
- b) The first order reaction,  $\text{SO}_2\text{Cl}_2 \rightarrow \text{SO}_2 + \text{Cl}_2$ , has a rate constant of  $0.17 \text{ h}^{-1}$ . If the initial concentration of  $\text{SO}_2\text{Cl}_2$  is  $1.25 \times 10^{-3} \text{ M}$ , how many seconds does it take for the concentration to drop to  $0.31 \times 10^{-3} \text{ M}$ ? **(6 marks)**
- c) Cobalt-60 is a radioisotope that decays by first-order kinetics and has a half-life of 5.26 years. The Cobalt-60 in a radiotherapy unit must be replaced when the concentration of Co decreases to 75.0% of its initial value. When does this occur? **(8 marks)**

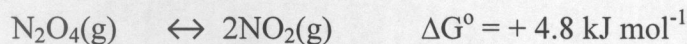
## QUESTION 2

- (a) Calculate the enthalpy of formation of benzene,  $\text{C}_6\text{H}_6$  from the following data: **(6 marks)**



$$\begin{aligned}\Delta H_c^\circ(\text{C}_6\text{H}_6) &= -3267.6 \text{ kJmol}^{-1} \\ \Delta H_f^\circ(\text{H}_2\text{O}) &= -285.9 \text{ kJmol}^{-1} \\ \Delta H_f^\circ(\text{CO}_2) &= -393.5 \text{ kJmol}^{-1}\end{aligned}$$

- (b) Consider the following reaction below:



- (i) Write an expression for the equilibrium constant for the reaction. **(2 marks)**
- (ii) What is the value of the equilibrium constant,  $K_p$ , at 298 K, ( $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ ) **(5 marks)**
- (iii) Which gas is mainly present at equilibrium? **(2 marks)**

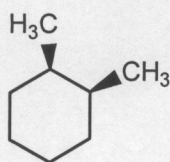
- (c) How much energy is required to heat 80 g of water from  $26^\circ\text{C}$  to  $48^\circ\text{C}$ . The specific heat capacity of water is  $4.184 \text{ J/g C}$ . **(5 marks)**

### QUESTION 3

(a) For each of the following molecules; give the IUPAC name, write the bond-line formula and identify the functional group. **(9 marks)**

- (i)  $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_3$
- (ii)  $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{OH}$
- (iii)  $\text{CH}_3\text{COCH}_2\text{CH}_2\text{CH}_2\text{CH}_3$

(b) Consider *cis*-1,2-dimethylcyclohexane, shown below. It has two possible chair conformations and these are possible through the bond rotations that constitute a ring flip.



*Cis*-1,2-dimethylcyclohexane

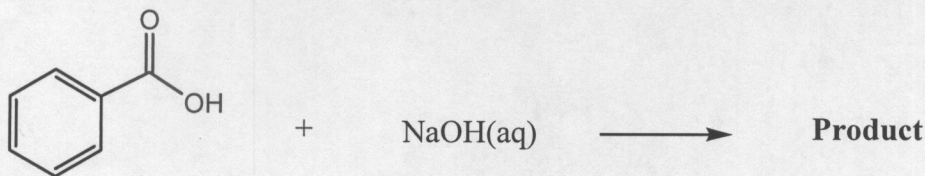
- i) Draw the two chair conformations of *cis*-1,2-dimethylcyclohexane. **(2 marks)**
- ii) Label the bonds where the substituents are as axial or equatorial. **(1 marks)**
- iii) Show the position of equilibrium between the two chair conformers in terms of stability in energy. (*No calculations needed, just use the equilibrium arrows to show this*) **(1 marks)**
- iv) Compare the stability of the conformers and state which one is more stable and explain why. **(1 marks)**

(c) Consider the following molecular formula,  $\text{C}_4\text{H}_7\text{OCl}$ .

- (i) Draw six isomers with this molecular formula. **(6 marks)**

### QUESTION 4

(a) A common food preservative is prepared according to the following reaction:



- (i) Name the type of reaction. **(2 marks)**
- (ii) Draw the structure of the product. **(3 marks)**
- (iii) The product above has an electrophilic carbon, draw a circle to show that. **(2 marks)**

b) Butanoic acid reacts with ethanol in the presence of catalytic amounts of concentrated sulphuric acid to give an **ester** as the product.

- (i) Write an equation to represent this reaction. (4 marks)
- (ii) Name the ester produced. (2 marks)
- (iii) Give a detailed mechanism for the reaction. (7 marks)

### QUESTION 5

(a) Calculate the percent dissociation of acetic acid ( $K_a = 1.85 \times 10^{-5}$ ) in each of the following solutions: (18 marks)

- i) 1.00 M  $\text{CH}_3\text{COOH}$
- ii) 0.100 M  $\text{CH}_3\text{COOH}$

(b) Comment on the calculated percent dissociation values at two different concentrations (2 marks)

### QUESTION 6

(a) Calculate the pH of the following solutions:

- (i) 0.1000 M HCl (3 marks)
- (ii) 0.1000 M NaOH (3 marks)
- (iii) 0.1000 M  $\text{CH}_3\text{COOH}$ ,  $K_a(\text{CH}_3\text{COOH}) = 1.8 \times 10^{-5}$  (7 marks)
- (iv) 0.1000 M  $\text{NH}_3$ ,  $K_b(\text{NH}_3) = 1.8 \times 10^{-5}$  (7 marks)

<b>H</b> Hydrogen 1.00794	<b>4</b> <b>Be</b> Beryllium 9.012182	<b>21</b> <b>Sc</b> Scandium 44.955910	<b>22</b> <b>Ti</b> Titanium 47.867	<b>23</b> <b>V</b> Vanadium 50.9415	<b>24</b> <b>Cr</b> Chromium 51.9961	<b>25</b> <b>Mn</b> Manganese 54.938049	<b>26</b> <b>Fe</b> Iron 55.845	<b>27</b> <b>Co</b> Cobalt 58.933200	<b>28</b> <b>Ni</b> Nickel 58.6934	<b>29</b> <b>Cu</b> Copper 63.546	<b>30</b> <b>Zn</b> Zinc 65.39	<b>31</b> <b>Ga</b> Gallium 69.723	<b>32</b> <b>Ge</b> Germanium 72.61	<b>33</b> <b>As</b> Arsenic 74.92160	<b>34</b> <b>Se</b> Selenium 78.96	<b>35</b> <b>Br</b> Bromine 79.904	<b>36</b> <b>Kr</b> Krypton 83.80	<b>37</b> <b>Rb</b> Rubidium 85.4678	<b>38</b> <b>Sr</b> Strontium 87.62	<b>39</b> <b>Y</b> Yttrium 88.90585	<b>40</b> <b>Zr</b> Zirconium 91.224	<b>41</b> <b>Nb</b> Niobium 92.90638	<b>42</b> <b>Mo</b> Molybdenum 95.94	<b>43</b> <b>Tc</b> Technetium (98)	<b>44</b> <b>Ru</b> Ruthenium 101.07	<b>45</b> <b>Rh</b> Rhodium 102.90550	<b>46</b> <b>Pd</b> Palladium 106.42	<b>47</b> <b>Ag</b> Silver 107.8682	<b>48</b> <b>Cd</b> Cadmium 112.411	<b>49</b> <b>In</b> Indium 114.818	<b>50</b> <b>Sn</b> Tin 118.710	<b>51</b> <b>Sb</b> Antimony 121.760	<b>52</b> <b>Te</b> Tellurium 127.60	<b>53</b> <b>I</b> Iodine 126.90447	<b>54</b> <b>Xe</b> Xenon 131.29	<b>55</b> <b>Cs</b> Cesium 132.90545	<b>56</b> <b>Ba</b> Barium 137.327	<b>57</b> <b>La</b> Lanthanum 138.9055	<b>58</b> <b>Ce</b> Cerium 140.116	<b>59</b> <b>Pr</b> Praseodymium 140.90765	<b>60</b> <b>Nd</b> Neodymium 144.24	<b>61</b> <b>Pm</b> Promethium (145)	<b>62</b> <b>Sm</b> Samarium 150.36	<b>63</b> <b>Eu</b> Europium 151.964	<b>64</b> <b>Gd</b> Gadolinium 157.25	<b>65</b> <b>Tb</b> Terbium 158.92534	<b>66</b> <b>Dy</b> Dysprosium 162.50	<b>67</b> <b>Ho</b> Holmium 164.93032	<b>68</b> <b>Er</b> Erbium 167.26	<b>69</b> <b>Tm</b> Thulium 168.93421	<b>70</b> <b>Yb</b> Ytterbium 173.04	<b>71</b> <b>Lu</b> Lutetium 174.967	<b>72</b> <b>Hf</b> Hafnium 178.49	<b>73</b> <b>Ta</b> Tantalum 180.9479	<b>74</b> <b>W</b> Tungsten 183.84	<b>75</b> <b>Re</b> Rhenium 186.207	<b>76</b> <b>Os</b> Osmium 190.23	<b>77</b> <b>Ir</b> Iridium 192.217	<b>78</b> <b>Pt</b> Platinum 195.078	<b>79</b> <b>Au</b> Gold 196.96655	<b>80</b> <b>Hg</b> Mercury 200.59	<b>81</b> <b>Tl</b> Thallium 204.3833	<b>82</b> <b>Pb</b> Lead 207.2	<b>83</b> <b>Bi</b> Bismuth 208.98038	<b>84</b> <b>Po</b> Polonium (209)	<b>85</b> <b>At</b> Astatine (210)	<b>86</b> <b>Rn</b> Radon (222)	<b>87</b> <b>Fr</b> Francium (223)	<b>88</b> <b>Ra</b> Radium (226)	<b>89</b> <b>Ac</b> Actinium (227)	<b>90</b> <b>Th</b> Thorium 232.0381	<b>91</b> <b>Pa</b> Protactinium 231.03588	<b>92</b> <b>U</b> Uranium 238.0289	<b>93</b> <b>Np</b> Neptunium (237)	<b>94</b> <b>Pu</b> Plutonium (244)	<b>95</b> <b>Am</b> Americium (243)	<b>96</b> <b>Cm</b> Curium (247)	<b>97</b> <b>Bk</b> Berkelium (247)	<b>98</b> <b>Cf</b> Californium (251)	<b>99</b> <b>Es</b> Einsteinium (252)	<b>100</b> <b>Fm</b> Fermium (257)	<b>101</b> <b>Md</b> Mendelevium (258)	<b>102</b> <b>No</b> Nobelium (259)	<b>103</b> <b>Lr</b> Lawrencium (262)	<b>104</b> <b>Rf</b> Rutherfordium (261)	<b>105</b> <b>Db</b> Dubnium (262)	<b>106</b> <b>Sg</b> Seaborgium (263)	<b>107</b> <b>Bh</b> Bohrium (262)	<b>108</b> <b>Hs</b> Hassium (265)	<b>109</b> <b>Mt</b> Meitnerium (266)	<b>110</b> <b>Ds</b> Darmstadtium (269)	<b>111</b> <b>Rg</b> Roentgenium (272)	<b>112</b> <b>Cn</b> Copernicium (277)	<b>113</b> <b>Nh</b> Nihonium (283)	<b>114</b> <b>Fl</b> Flerovium (284)	<b>115</b> <b>Mc</b> Moscovium (285)	<b>116</b> <b>Lv</b> Livermorium (286)	<b>117</b> <b>Ts</b> Tennessine (287)	<b>118</b> <b>Og</b> Oganesson (288)
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<b>5</b> <b>B</b> Boron 10.811	<b>6</b> <b>C</b> Carbon 12.0107	<b>7</b> <b>N</b> Nitrogen 14.00674	<b>8</b> <b>O</b> Oxygen 15.9994	<b>9</b> <b>F</b> Fluorine 18.9984032	<b>10</b> <b>Ne</b> Neon 20.1797	<b>11</b> <b>Na</b> Sodium 22.989770	<b>12</b> <b>Mg</b> Magnesium 24.3050	<b>13</b> <b>Al</b> Aluminum 26.981538	<b>14</b> <b>Si</b> Silicon 28.0855	<b>15</b> <b>P</b> Phosphorus 30.973761	<b>16</b> <b>S</b> Sulfur 32.066	<b>17</b> <b>Cl</b> Chlorine 35.4527	<b>18</b> <b>Ar</b> Argon 39.948
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1995 IUPAC names and Approved Names from <http://www.chem.grow.ac.uk/names/AMW/>  
 names for 107-111 from IUPAC, March 13, 1995, p. 35  
 112 from IUPAC/AMW, p. 183, 184

THE UNIVERSITY OF ZAMBIA  
SCHOOL OF NATURAL SCIENCES

2018/2019 ACADEMIC YEAR 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 SEVEN (7) printed pages

### Question 1

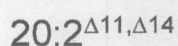
- a) By way of a clear **calculation** (an brief explanation, if any), **show** how you would prepare a 1 litre 0.45 M phosphate buffer at pH 7.4 given that you have at your disposal  $\text{H}_3\text{PO}_4$ ,  $\text{KH}_2\text{PO}_4$ ,  $\text{K}_2\text{HPO}_4$  and  $\text{K}_3\text{PO}_4$  (Rel. Mol. Mass:  $\text{H}_3\text{PO}_4 = 97.994 \text{ g}\cdot\text{mol}^{-1}$ ,  $\text{KH}_2\text{PO}_4 = 136.1 \text{ g}\cdot\text{mol}^{-1}$ ,  $\text{K}_2\text{HPO}_4 = 174.2 \text{ g}\cdot\text{mol}^{-1}$  and  $\text{K}_3\text{PO}_4 = 196.2 \text{ g}\cdot\text{mol}^{-1}$ ). For additional information, see the last page. **[10 marks]**
- b) **Draw** the structure of histidine, and briefly **explain** why it is an appropriate buffer at pH = 6.0. [useful information on the last page of this examination paper] **[5 marks]**
- c) **Why** is histidine an inappropriate (not effective) buffer at pH 12.0? **ONE SHORT SENTENCE ANSWER. [5 marks]**

### Question 2

- a) Secondary structure in proteins include  $\alpha$ -helix and  $\beta$ -pleated sheets.
- i) In point form **describe** salient features of  $\beta$ -pleated sheets. **[5 marks]**
- ii) **Calculate** the axial length of an  $\alpha$ -helix containing 78 amino acyl residues. How long would the polypeptide chain be if it were fully extended? **[10 marks]**
- b) In what order will the following amino acids elute from a chromatographic column packed with Dowex-50 at pH 3.2? ala (pI=6.02), arg(pI=10.76), glu (pI=3.22), ser (pI=5.68) and try (pI=5.88) **[5 marks]**

### Question 3

- a) On hydrolysis a compound X gave the following products: glycerol, palmitic acid, palmitoleic acid and inorganic phosphate and a disaccharide. The compound X, which was extractable into a hexane/methanol mixture, was also observed to be optically active. Draw the possible structure(s) of compound X. **[6 marks]**
- b) The disaccharide in part a was subjected to acid hydrolysis and the two sugars were found to be linked by an  $\alpha$  linkage. Exhaustive methylation of the disaccharide produced equal amounts of 2,3,4,6-tetramethylgalactose and 2,4,6-trimethylglucose. Using Haworth formulas draw the structure of the disaccharide suggested by the above information and show clearly the link between the sugars. **[10 marks]**
- c) Draw skeleton structure of the following fatty acid including its IUPAC name:



**[4 marks]**

#### Question 4

a) Assume that a fragment of B-DNA occurs as a double helix with a total diameter of 20 Å and on average the molecular weight of deoxynucleotide pairs is 618 Daltons.

i) Calculate the length of the double stranded DNA molecule of MW  $3 \times 10^7$ . **[8 marks]**

ii) What is the volume occupied by one molecule of this DNA assuming it's a perfect cylinder? **[4 marks]**

iii) How many helical turns does a molecule of this DNA contain? **[4 marks]**

b) A sample of DNA purified from *Mycobacterium tuberculosis* contains 15.1% adenine on a molar basis. What are the percentages of other bases present? **[4 marks]**

### Question 5

a) **Define** the following terms.

i) Entropy. [1 mark]

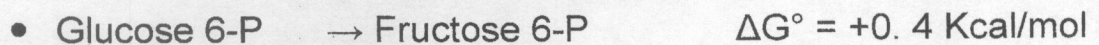
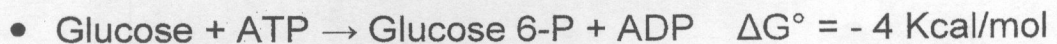
ii) Gibbs free energy [1 mark]

b) i) **State** the second law of thermodynamics. [1 mark]

iii) **Use** the second law of thermodynamics to **derive** the Gibbs - Helmholtz's equation [3 marks]

c) **Using** mathematical expressions **explain** how  $\Delta G^\circ$  is related to the spontaneity of a biological reaction. [5 marks]

d) Given the following reactions



Calculate the standard Gibbs free energy,  $\Delta G^\circ$  for the reaction below



e) i) Draw the detailed structure of adenosine triphosphate [3 marks]

ii) Explain why it is a high energy compound [5 marks]

## Question 6

a) Define the following terms.

i) Apoenzyme. [1 mark]

ii) Coenzyme. [1 mark]

b) Name one coenzyme that you know and draw its chemical structure. [4 marks].

c) Derive the Michealis-Menten equation stating clearly the important assumptions you make. [3 marks]

d) Using the mathematical expression state how  $k_m$  may be found using the  $V_o$  versus  $S_o$  plot when  $V_o =$  half of  $V_{max}$ . [3 marks].

e) State two uses of Michealis-Menten plot. [2 marks].

f) Given the following data for an enzymatic reaction estimate the value of  $k_m$  and  $V_{max}$  without plotting

S/N	Substrate concentration $S_o$ (mol/litre)	Velocity of the reaction $V_o$ (nanomole/minute)
1	0.00000625	15.0
2	0.0000750	56.25
3	0.00010	60.0
4	0.0010	74.9
5	0.010	75.0

[6 marks]

**Useful Information:**

**pka values**

a) Phosphoric acid system

$\text{H}_2\text{PO}_4^-/\text{HPO}_4^{2-}$  pKa = 7.21

$\text{H}_3\text{PO}_4/\text{H}_2\text{PO}_4^-$  pKa = 2.12

$\text{HPO}_4^{2-}/\text{PO}_4^{3-}$  pKa = 12.3

b) Selected amino acids

	<b>pKa1</b>	<b>pKa2</b>	<b>pKa3</b>
Met	2.28	9.21	
Gly	2.34	9.60	
His	1.82	9.17	6.0
Pro	1.99	10.6	
Ala	2.35	9.69	
Arg	2.17	9.04	12.48
Tyr	2.20	9.11	10.07
Val	2.35	9.62	
Ile	2.36	9.68	
Cys	1.71	10.78	8.33

**END OF EXAMINATION**

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

**2018 ACADEMIC YEAR  
MID YEAR EXAMINATIONS**

**CHE 2511: BASIC ORGANIC CHEMISTRY**

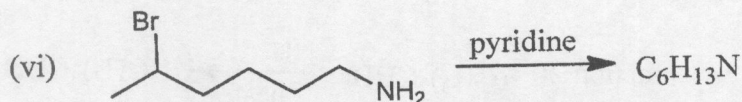
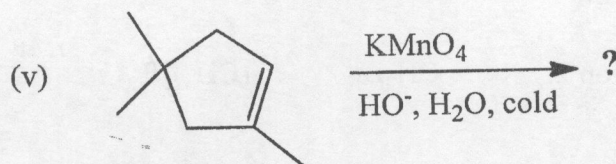
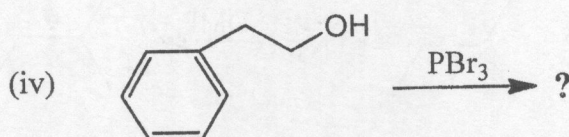
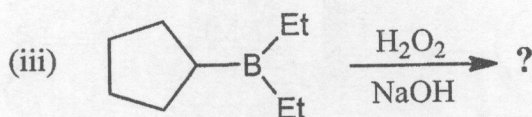
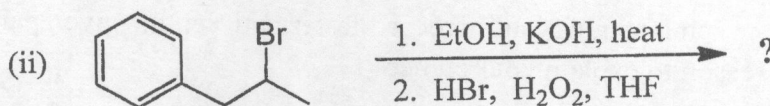
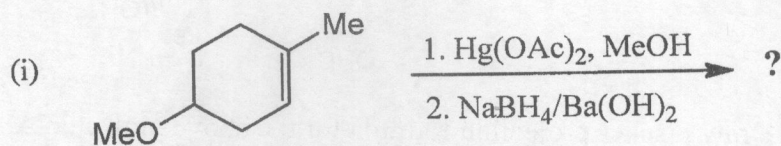
**TIME ALLOWED: THREE (3) HOURS**

**INSTRUCTIONS:**

1. This paper contains **five questions** and has seven (7) 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 logical manner and try to be on point.

## QUESTION 1

- (a) Give the structures of the major organic products, including pertinent stereochemistry, where necessary, of the following reactions. (12 marks)

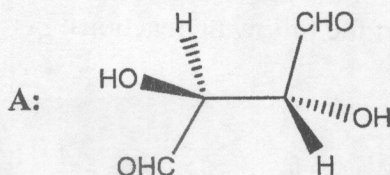


- (b) Provide plausible mechanisms for the reactions numbered (i), (iv) and (vi) in Q1 (a). (13 marks)

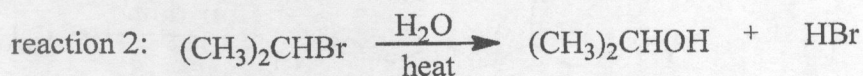
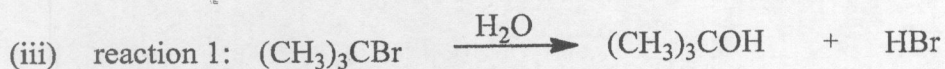
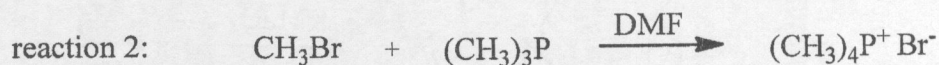
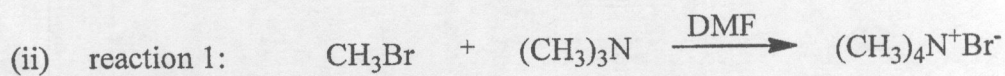
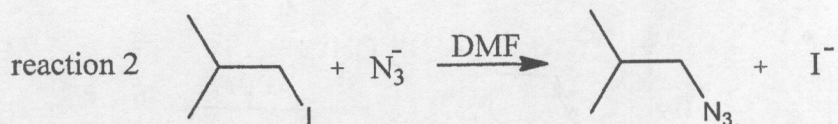
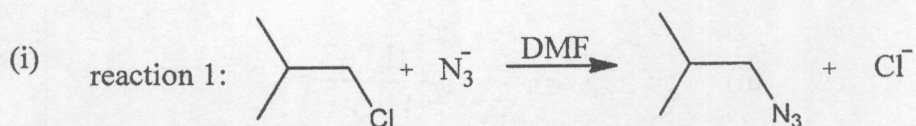
## Question 2

- (a) Provide the stereochemical structures (wedge-dash) for optically active amines with only one stereogenic center represented by the molecular formula  $\text{C}_4\text{H}_{11}\text{N}$  and give a complete IUPAC name for any one enantiomer. (4 marks)

- (b) (i) Assign the configurational label (*R*)- or (*S*)- to all stereogenic centers which may be present in the molecule A, shown below. (2 marks)



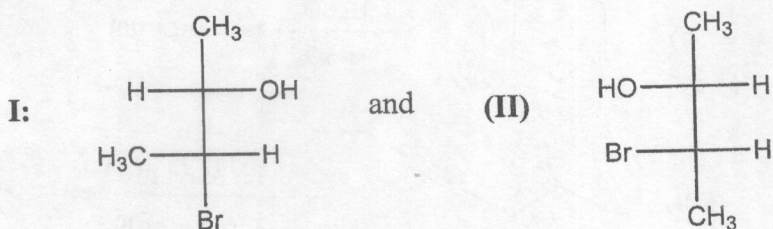
- (ii) Draw Fischer projection formula for the above molecule A. (2 marks)
- (c) Predict which reaction would proceed faster between the given pair of reactions below. Give a reason to explain your choice. (6 marks)



- (d) Attempted Williamson synthesis of *tert*-butyl methyl ether,  $(\text{CH}_3)_3\text{COCH}_3$ , by reacting *tert*-butyl chloride with sodium methoxide ( $\text{NaOMe}$ ), gave 2-methylpropene.

- (i) Propose a mechanism of the reaction leading to formation of 2-methylpropene. (2 marks)
- (ii) Suggest an alternative Williamson synthesis of *tert*-butyl methyl ether where the possibility of elimination products is minimized. (2 marks)

- (e) (i) Identify the relationship between the pair of compounds (I) and (II), shown below, as structural isomers, enantiomers, diastereomers, meso-compounds or identical. Show your reasoning. (5 marks)



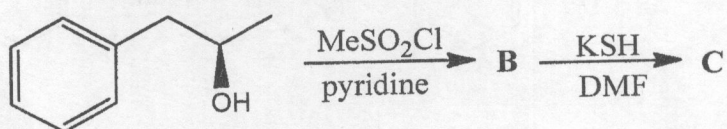
- (ii) Provide a complete IUPAC name for either (I) or (II). (2 marks)

### QUESTION 3

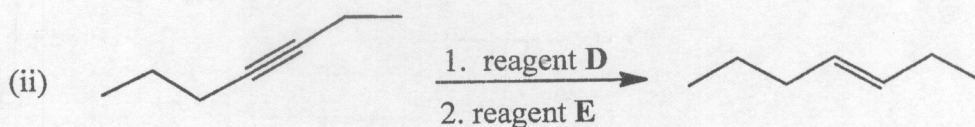
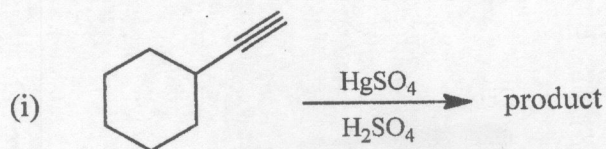
- (a) The optical rotation of a mixture of (*R*)- and (*S*)- 2-butanol at 25 °C was found to be +6.76°. What is the percent enantiomeric composition of the mixture? [Specific rotation of (*S*)-2-butanol is 13.52°] (4 marks)
- (b) (i) Sighting along the C1-C2 bond, construct Newman projections for *anti*, *gauche*, and two *eclipsed* conformations of 1-bromopropane. (4 marks)
- (ii) Using the information below and the fact that barrier to rotation (energy difference between the highest and lowest energy conformers) in 1-bromopropane is 21.0 KJ.mol<sup>-1</sup>, determine the contribution of CH<sub>3</sub>-Br eclipsing interaction. (6 marks)

Eclipsing Interaction	Energy Cost (kJ.mol <sup>-1</sup> )	Gauche Interaction	Energy Cost(kJ.mol <sup>-1</sup> )
H-H	4.0	H-H	0.0
CH <sub>3</sub> -H	6.0	CH <sub>3</sub> -H	1.8
Br-H	7.0	Br-H	0.5
Br-CH <sub>3</sub>	x (calculate)	Br-CH <sub>3</sub>	4.0

- (c) Predict the products B and C and give detailed mechanism of the reactions shown below: (7 marks)

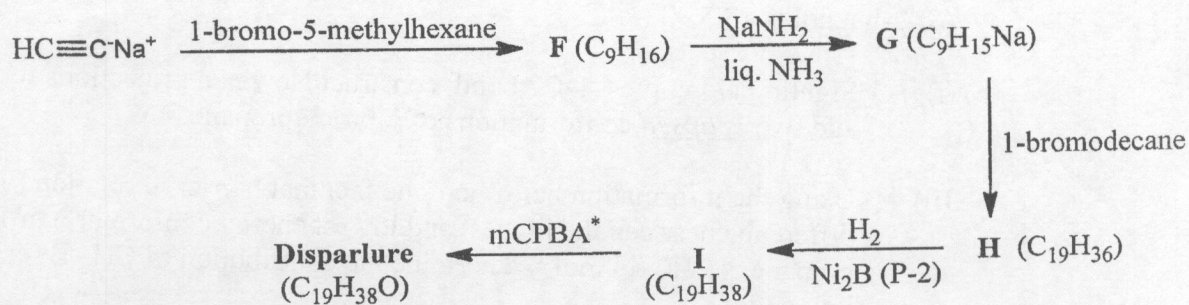


- (d) Predict the major product for reaction (i) and give the reagents needed for reaction (ii).  
(4 marks)



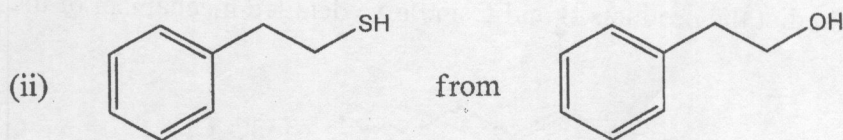
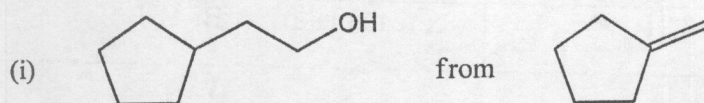
#### QUESTION 4

- (a) Outlined below is a synthesis of the gypsy moth sex attractant *disparlure* (a pheromone).  
Give the structures of *disparlure* and the intermediates F-I. (5 marks)

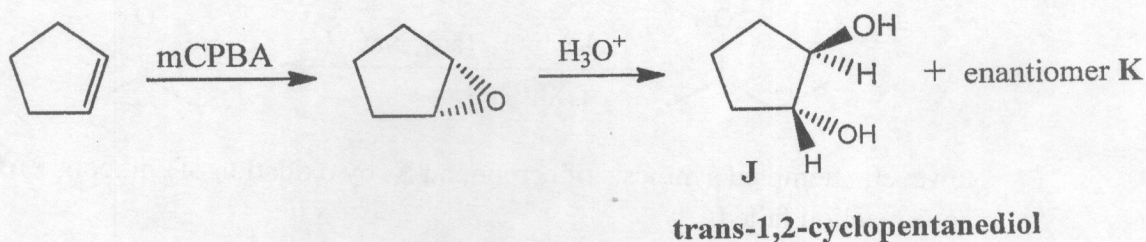


\* metaperoxychlorohezoic acid

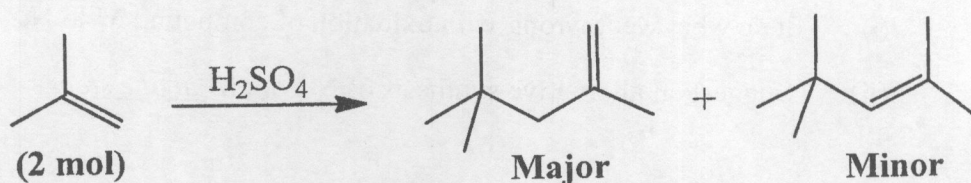
- (b) Provide efficient synthetic routes for the following compounds from the indicated starting materials and readily available reagents. Show all the steps, including all intermediates.  
Do not write any mechanisms. (9 marks)



- (c) Outline mechanisms to show how the enantiomeric forms of *trans*-1,2-cyclopentanediol, **J** and **K**, are formed as given in the scheme below: (6 marks)



- (d) Propose a mechanism to explain the indicated product distribution of the following reaction. (5 marks)



### QUESTION 5

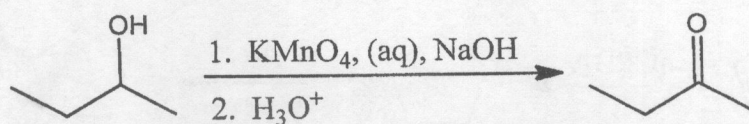
- (a) Consider the molecule **L**, *Cis*-1-bromo-2-methylcyclohexane.

- (i) Draw two chair conformations of **L** and determine their relative steric strain energy (SSE) using the data given below. Show the equilibrium. (6 marks)

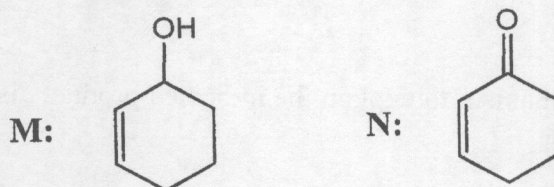
1,3-Diaxial Interaction	Energy Cost (kJ/mol)	Gauche Interaction	Energy Cost (kJ/mol)
H-Br	1.4	H-Br	0.5
H-CH <sub>3</sub>	3.7	H-CH <sub>3</sub>	1.8
Br-CH <sub>3</sub>	7.4	Br-CH <sub>3</sub>	3.2

- (ii) Dehydrohalogenation of **L** by potassium *tert*-butoxide under E2 reaction conditions gives 1-methylcyclohexene as the major product. Only the lower energy **L** conformer can participate in this reaction. Explain why? Illustrate your answer with appropriate transition state. (5 marks)

(b) Secondary alcohols can be oxidized to ketones as shown below:

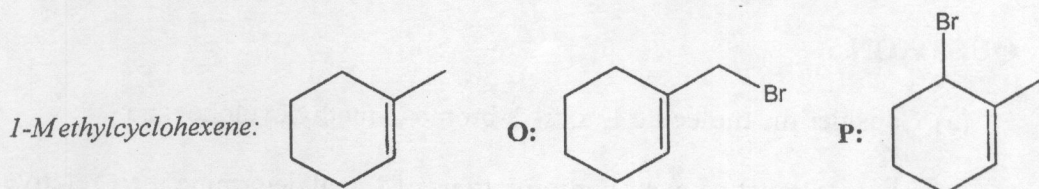


However, attempted synthesis of compound N, by oxidation of compound M using the above reaction failed.



- (i) State what went wrong with oxidation of compound M to N.? (2 marks)
- (ii) Suggest an alternative synthesis of N from M *in one step*. (2 marks)

(c) Upon irradiation with UV light, 1-methylcyclohexene reacts with *N*-bromo-succinimide (NBS) in carbon tetrachloride to give two products O and P, shown below.



- (i) Provide a mechanism to account for the product O. (6 marks)
- (ii) With a reason, state which is the major product. (2 marks)
- (iii) Why is the product P *optically inactive*? Explain. (2 marks)

**END OF EXAMINATION  
GOOD LUCK!**

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

**2018 ACADEMIC YEAR  
UNIVERSITY DEFERRED EXAMINATIONS**

**CHE 2522: FUNCTIONAL GROUP AND ARENE CHEMISTRY**

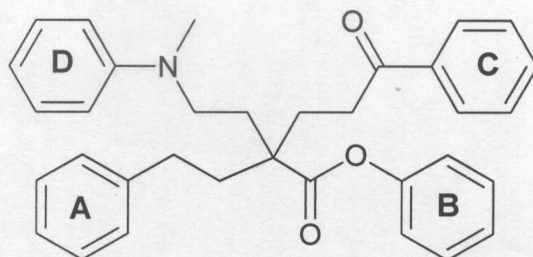
**TIME ALLOWED: THREE (3) HOURS**

**INSTRUCTIONS:**

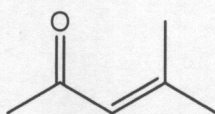
1. Answer any **four (4)** questions.
3. Questions carry equal marks (25).
4. Write your TG number (example: TG 5) on the cover page of each answer booklet.
5. Present your answers in a logical manner.
5. Please ensure that you have six (6) printed pages and five (5) questions.

## QUESTION ONE

- (a) The following compound has four aromatic rings, **A** – **D**. Rank them in terms of increasing reactivity toward electrophilic aromatic substitution. **(3 marks)**

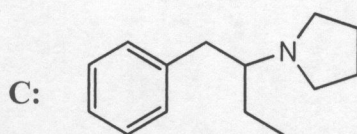


- (b) Upon treatment with hydrogen chloride, acetone gives 4-methylpent-3-en-2-one. Provide the most likely mechanism for this reaction, show all steps clearly. **(11 marks)**



*4-Methylpent-3-en-2-one*

- (c) Suggest a synthesis of an antidepressant drug **A**, shown below, by reductive amination. Do not write reaction mechanisms. **(4 marks)**

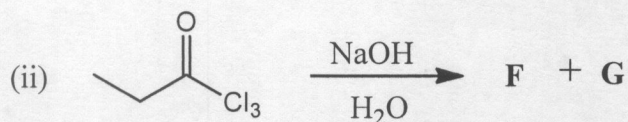
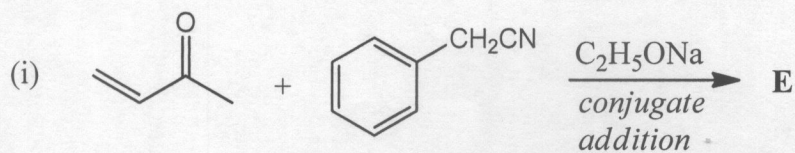


- (d) An unknown compound **D**,  $C_5H_{10}O$ , gives positive Brady's test, negative Tollen's test and positive iodoform test.

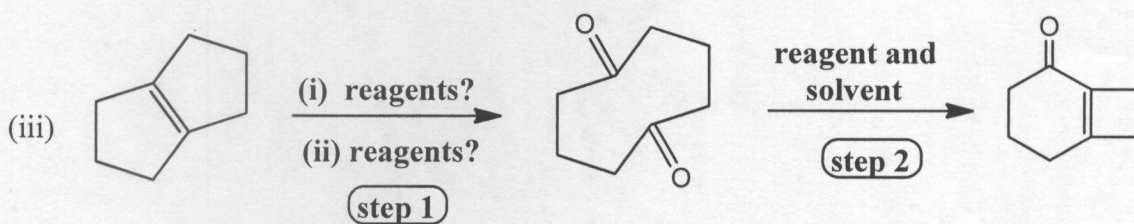
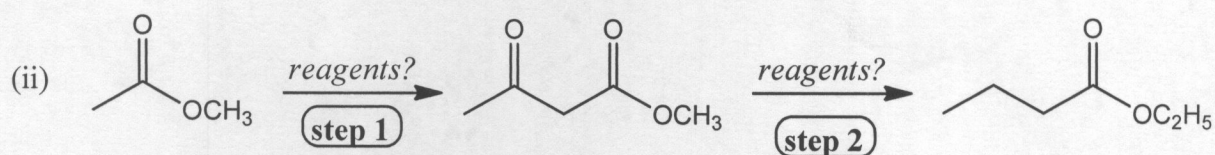
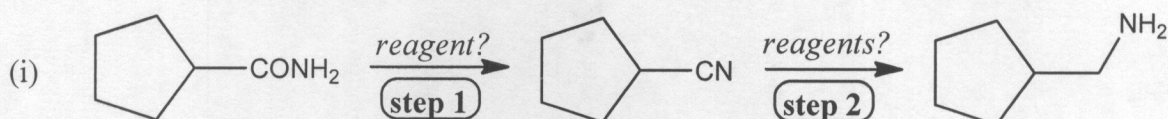
- Calculate IHD for **D** and interpret it. **(2 marks)**
- Interpret the results of all qualitative tests. **(3 marks)**
- Propose possible structure(s) for **D** that are consistent with the given data. **(2 marks)**

## QUESTION TWO

(a) Predict the products and give plausible mechanisms of the following reactions: (13 marks)

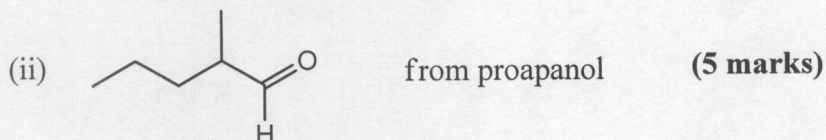
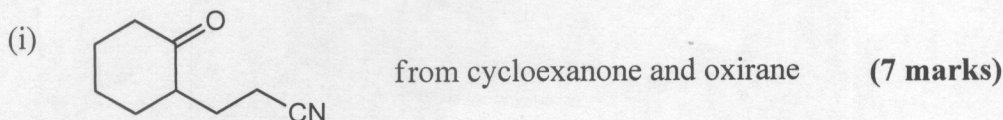


(b) Provide the reagents for the following transformations: (12 marks)



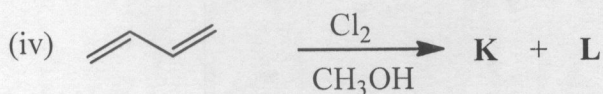
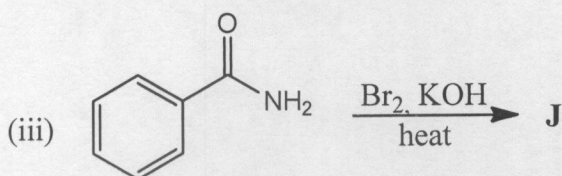
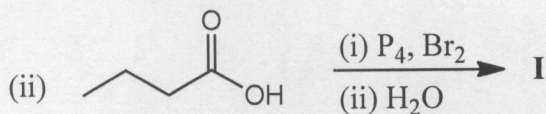
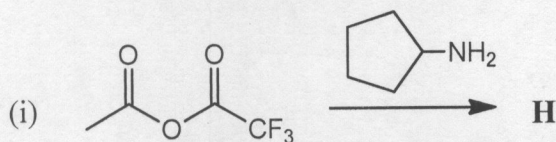
### QUESTION THREE

- (a) Suggest an efficient synthesis for the following target molecules from indicated materials. Show all steps, including the intermediates, clearly. Assume that all needed reagents are available. Please do not write reaction mechanisms.

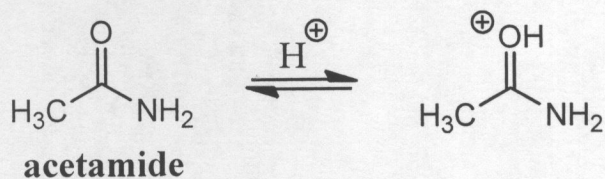


- (b) Predict the product of the following reactions:

(10 marks)



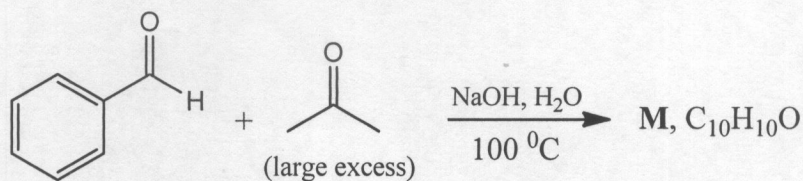
- (c) Protonation of acetamide occurs on oxygen rather than on nitrogen. Briefly explain this observation, illustrating your answer with appropriate resonance structures. (3 marks)



#### QUESTION 4

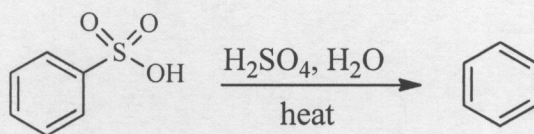
(a) Identify the product and give mechanism of the Claisen-Schmidt reaction shown below:

(9 marks)



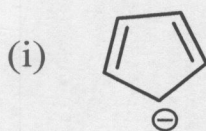
(b) Assuming that you were provided with three (3) amines: ethylamine, diethylamine and triethylamine. Give the name of a laboratory test you would carry out to distinguish the three amines from each other. Write all the reactions involved in the test and clearly show evidence for distinguishing the three amines. Indicate the starting materials, the reagents and the intermediates. (10 marks)

(c) Sulfonation is a reversible reaction. Propose a plausible mechanism for the hydrolysis of benzenesulfonic acid. (6 marks)

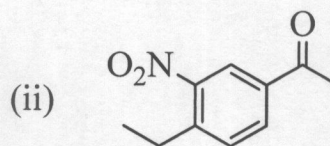
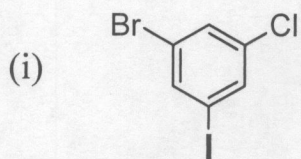


#### QUESTION 5

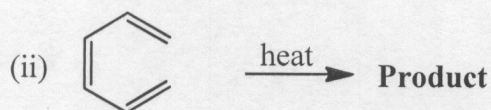
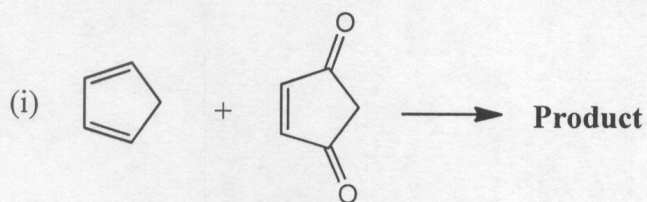
(a) Determine whether each of the following is aromatic, non-aromatic, or anti-aromatic. Show your working. (3 marks)



(b) Starting from benzene or toluene and any reagent that you might need, show clearly how you would synthesise the following compounds: **(12 marks)**

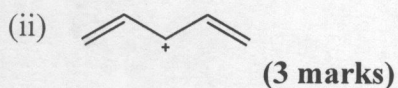
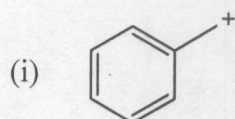


(c) Predict the major products of the following reactions: **(4 marks)**



(d) While amides are much less basic than amines. They are much stronger acids. Amides have  $pK_a$  values in the range 14-16, whereas amines,  $pK_a = 33-35$ . What factor accounts for the much greater acidity of amides. **(3 marks)**

(e) Write the important resonance structures for each of the following: **(3 marks)**



**END OF EXAMINATION  
GOOD LUC**

THE UNIVERSITY OF ZAMBIA  
SCHOOL OF NATURAL SCIENCES

2018/19 ACADEMIC YEAR FINAL-YEAR EXAMINATIONS

CHE3122: ENERGY TRANSDUCTION SYSTEMS

**INSTRUCTIONS:**

**TIME: THREE HOURS**

1. Answer any **FOUR (4)** questions
2. All questions carry **EQUAL MARKS** (25 marks each question)
3. There are **FOUR (4)** printed pages in this examination

P.T.O

### Question 1

- a) **Describe** a detailed **microscopic** structure of a skeletal muscle. [10 marks]
- b) **Explain** in detail the mechanism of **skeletal** muscle contraction. [15 marks]

### Question 2

- a) **What** is meant by the term oxidative phosphorylation? [2.5 marks]
- b) **List** all components of the ATPase protein complex. [10 marks]
- c) **Explain** in detail how ATP is formed by the ATPase in (ii) [10 marks]
- d) **List** two substance that would uncouple oxidative phosphorylation [2.5 marks]

### Question 3

- a) **Explain** how the term 'fluid mosaic model' is used to describe the structure of the plasma membrane. [5 marks]
- b) When transport across the plasma membrane is disrupted, serious medical conditions can develop. For each of the medical conditions below, **indicate** the defect and discuss the consequence as well as the main symptoms associated with the condition.
- i) Cystic fibrosis [3 marks]
  - ii) Multiple sclerosis [4 marks]
  - iii) Familial hypercholesterolemia [3 marks]

P.T.O

UNIVERSITY OF ZAMBIA  
SCHOOL OF NATURAL SCIENCES  
FINAL EXAMINATIONS 2018/2019 ACADEMIC YEAR,  
CHE2615: BASIC PHYSICAL CHEMISTRY

**Duration: Three (3) Hour**

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**Instructions:**

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

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

All questions carry equal marks. **(25 Marks)**

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

**Useful Information and Constants:**

$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$ , Molar volume of gas at STP =  $22.4 \text{ dm}^3 \text{ mol}^{-1}$ , STP = 273 K and 1 atm, 1 atm = 1 bar = 101325 Pa. Avogadro's constant =  $6.02 \times 10^{23} \text{ mol}^{-1}$ , 1 F = 96485 C mol<sup>-1</sup>

---

**Question 1**

- (a) State the assumptions of the kinetic theory of gases? **[4 Marks]**
- (b) (i) Show that the square root of the average of the squares of speeds of all molecules in a sample is given by the equation:

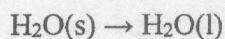
$$u_{rms} = \sqrt{\frac{3RT}{M}} \quad \text{[4 Marks]}$$

- (ii) Draw a sketch diagram showing Maxwell-Boltzmann distribution of molecular speeds **[4 Marks]**
- (c) A gas exerts a pressure of 0.892 atm in a 5.00 L container at 15 °C. The density of the gas is 1.22 g/L. What is the molecular weight of the gas? **[5 Marks]**
- (d) (i) Explain the term *ideal gas behaviour*. **[3 Marks]**
- (ii) Draw a sketch diagram illustrating deviation from ideal gas behaviour. **[5 Marks]**

## Question 2

- (a) The properties of a closed system change following the relation between pressure and volume as  $pV = 3.0$  where  $p$  is in bar and  $V$  is in  $\text{m}^3$ . Calculate the work done when pressure increases from 1.5 bar to 7.5 bar. [7 Marks]

- (b) The entropy change for the process



is  $22.1 \text{ J/K}$  and requires that the surroundings transfer  $6.00 \text{ kJ}$  of heat to the system. Determine whether melting is spontaneous at;

- (i)  $+10.00 \text{ }^\circ\text{C}$  [3 Marks]  
(ii)  $-10.00 \text{ }^\circ\text{C}$ ? [3 Marks]
- (c) The process of heat transfer from hot to cold is an irreversible process is spontaneous. Calculate the total change in entropy if  $4000 \text{ J}$  of heat transfer occurs from a hot reservoir at  $327 \text{ }^\circ\text{C}$  to a cold reservoir at  $-23 \text{ }^\circ\text{C}$  assuming there is no temperature change in either reservoir. [7 Marks]
- (d) Suppose that water is boiling at its boiling point is maintained in a cylinder that has a frictionless piston. For equilibrium to be established, the pressure that must be applied to the piston is  $1 \text{ atm}$  ( $101.325 \text{ kPa}$ ). Suppose that we now reduce the external pressure by an infinitesimal amount in order to have a reversible expansion. If the piston sweeps out a volume of  $2.00 \text{ dm}^3$ , what is the work done by the system? [5 Marks]

## Question 3

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

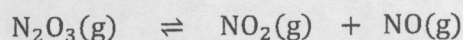
Experiment	Initial concentration of NaOH / $\text{mol dm}^{-3}$	Initial concentration of A / $\text{mol dm}^{-3}$	Initial rate / $\text{mol dm}^{-3} \text{ s}^{-1}$
1	0.040	0.030	$4.0 \times 10^{-1}$
2	0.040	0.045	$6.0 \times 10^{-1}$
3	0.060	0.045	$9.0 \times 10^{-1}$
4	0.120	0.060	to be calculated

Use the data in the table to deduce the order of reaction with respect to A and the order of reaction with respect to NaOH. Hence, calculate the initial rate of reaction in Experiment 4. **[6 Marks]**

- (b) In a further experiment at a different temperature, the initial rate of reaction was found to be  $9.0 \times 10^{-3} \text{ mol dm}^{-3} \text{ s}^{-1}$  when the initial concentration of A was  $0.020 \text{ mol dm}^{-3}$  and the initial concentration of NaOH was  $2.00 \text{ mol dm}^{-3}$ . Under these new conditions with the much higher concentration of sodium hydroxide, the reaction is first order with respect to A and appears to be zero order with respect to sodium hydroxide.
- (i) Calculate a value for the rate constant under these new conditions and state its units. **[4 Marks]**
- (iii) Suggest why the order of reaction with respect to sodium hydroxide appears to be zero under these new conditions. **[4 Marks]**
- (c) The milk at  $37^\circ\text{C}$  *Lactobacillus acidophilus* has a generation time of 75 minutes. Calculate the population relative to initial value at 90 minutes. **[6 Marks]**
- (d) The rate equation for the decomposition of a compound N has a rate constant with the unit  $\text{s}^{-1}$ . The rate constant is  $4.31 \times 10^3 \text{ s}^{-1}$  at 700 K and  $1.78 \times 10^4 \text{ s}^{-1}$  at a temperature  $T$ . Use this information to deduce the overall order of reaction and whether temperature  $T$  is greater or smaller than 700 K. **[5 Marks]**

#### Question 4

- (a) Nitrogen trioxide dissociates according to the reaction



When one mole of  $\text{N}_2\text{O}_3(\text{g})$  is held at  $25^\circ\text{C}$  and 1 bar total pressure until equilibrium is reached, the extent of reaction is 0.30. Calculate  $K_p$ . **[10 Marks]**

- (b) Given that for the same reaction  $K_p$  is equal to 0.15 at  $30^\circ\text{C}$
- (i) What is  $\Delta_r G^\circ$  for this reaction at this temperature? **[3 Marks]**
- (ii) What will be the extent of the reaction that will cause a 10 % conversion of  $\text{N}_2\text{O}_3$  to products. **[4 Marks]**

c) **Discuss** the biochemical mechanisms by which the following substances disrupt neuronal signalling:

- i) Botulinus toxin [3 marks]
- ii) Scorpion venom [3 marks]
- iii) Prozac [4 marks]

#### Question 4

- a) **Explain** cyclic photophosphorylation using a neat diagram. [10 marks]
- b) Assuming a light source has speed of  $2.998 \times 10^8 \text{ ms}^{-1}$ , Planks constant of  $6.626 \times 10^{-34} \text{ J.s}$  and Avogadro's number of  $6.022 \times 10^{23} \text{ mol}^{-1}$ :
  - i) **How** many moles of ATP can be synthesized at 100% efficiency by a photosynthetic organism upon absorption of 1 mol of photons of red light of 700 nm? [8 marks]
  - ii) **How** many molecules of ATP can be produced from 1 photon? [1 mark]
  - iii) **Calculate** the overall efficiency of energy conversion if 1 mole of ATP is formed per 2 equivalents of electrons excited by red light (i.e per 2 mol photons).  $\Delta G^\circ$  for ATP synthesis is  $+30.5 \text{ kJ mol}^{-1}$  [6 marks]

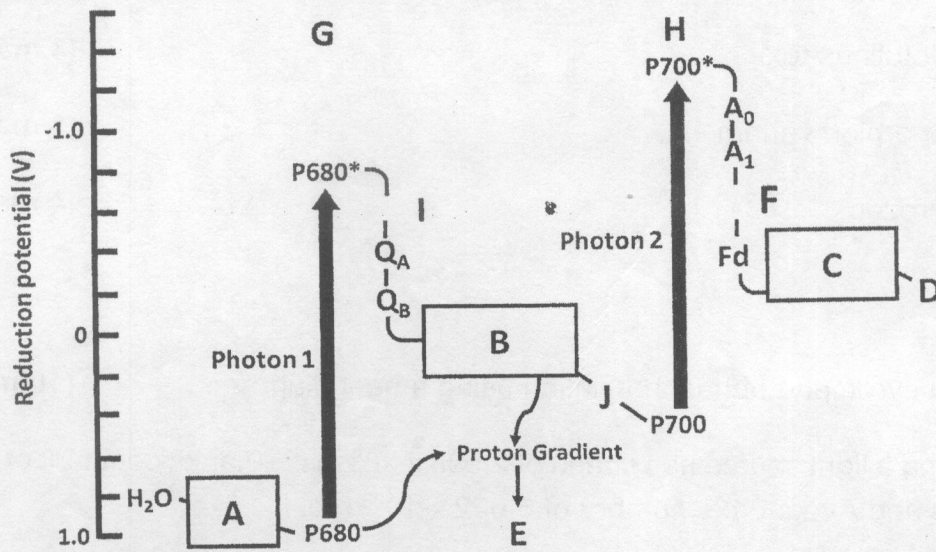
#### Question 5

- a) **Explain** the first three Calvin cycle reactions with clear chemical structures. [10 marks]
- b) **True or False**
  - i) Atrazine inhibits PS II by blocking the transfer of electrons to  $\text{QH}_2$  [1 mark]
  - ii) Dark reactions occur in the stroma [1 mark]
  - iii) The catalytic efficiency of rubisco is low [1 mark]
  - iv) 2-carboxyarabinitol-1-phosphate is a regulator of PSII [2 marks]

P.T.O

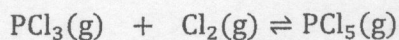
c) Identify the species or process in the diagram labelled A to J [10 marks]

[10 marks]



END OF FINAL EXAMINATION

- (c) Given that  $\Delta_r H^\circ$  has an average value of  $-69.8 \text{ kJ mol}^{-1}$  over the temperature range 500 K to 700 K for the reaction

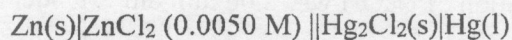


Estimate  $K_p$  at 700 K given that  $K_p = 0.0408$  at 500 K

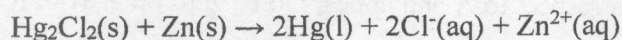
[8 Marks]

### Question 5

Consider the cell at 25°C:



for which the cell reaction is



Given that

$$E^\circ(\text{Zn}^{2+}, \text{Zn}) = -0.7628 \text{ V}$$

$$E^\circ(\text{Hg}_2\text{Cl}_2, \text{Hg}) = +0.2676 \text{ V}$$

- (a) Write the Nernst equation for the cell. [4 Marks]
- (b) Determine the mean ionic activity coefficient of  $\text{ZnCl}_2$  from the Debye-Hückel limiting. [4 Marks]
- (c) Determine  $E_{\text{cell}}^\circ$  and  $E_{\text{cell}}$ . [5 Marks]
- (d) Determine  $\Delta_r G$ ,  $\Delta_r G^\circ$ , and  $K$  for the cell reaction. [7 Marks]
- (e) Given that  $(\partial E_{\text{cell}} / \partial T)_p = -4.52 \times 10^{-4} \text{ V K}^{-1}$ , calculate  $\Delta_r S$  and  $\Delta_r H$ . [5 Marks]

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END OF EXAM

THE UNIVERSITY OF ZAMBIA  
SCHOOL OF NATURAL SCIENCES  
DEPARTMENT OF CHEMISTRY  
2018/2019 ACADEMIC YEAR FINAL EXAMINATION

CHE3222 INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS

**DURATION: THREE HOURS**

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**INSTRUCTIONS**

1. Indicate your student ID number on each of the provided answer booklets.
  2. There are **five** questions in this examination paper; Answer any **four** questions.
  3. All questions carry equal marks.
  4. There are **five printed papers** for the questions; the periodic table is attached also.
  5. Show your reasoning and/ or calculations clearly.
-

### Question 1

- (a) Both fluorescence and phosphorescence are spontaneous emissions of electromagnetic radiation. What is the difference between them?
- (b) X-ray spectroscopy (XRF) spectroscopy is an important analytical technique for elemental analysis.
- (i) Describe in 6 lines or less the fundamental principle of XRF spectroscopy.
  - (ii) One main source of primary x-rays used in XRF spectroscopy is an X-ray tube. With the aid of a well labeled schematic diagram, describe how X-rays are generated in an X-ray tube.
  - (iii) Electrons play a critical role in the production of X-rays in the X-ray tube. State and describe the method used to produce electrons in the X-ray tube.
- (c) Define  $K_{\alpha}$  emission,  $L_{\beta}$  emission, and  $K_{\alpha 2}$  emission.
- (d) Mention the four key components of an XRF machine.

### Question 2

- (a) Describe the principle in chromatographic technique.
- (b) Define the following terms:
- (i) Elution
  - (ii) Eluent
  - (iii) Eluate
  - (iv) Adsorption
- (c) What is the difference between a symmetric peak and a non-symmetric peak in chromatography? Use diagrams to explain your answer.
- (d) There are two related terms used as quantitative measures of chromatographic efficiency in High Performance Liquid Chromatography (HPLC): Number of 'theoretical plates'  $N$  and Plate height  $H$ .
- (i) What do  $N$  and  $H$  mean?
  - (ii) Write the formula for determining  $N$  if you know  $W/2$  which is equal to the width of the peak at half its maximum height.

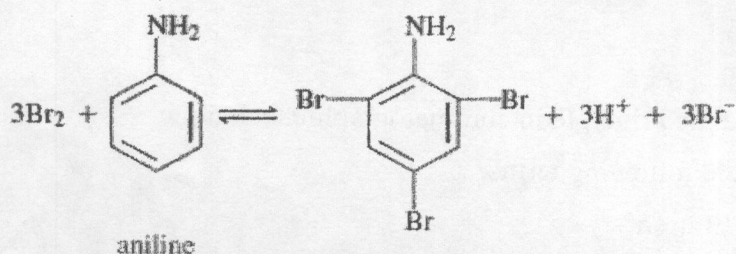
- (iii) Calculate the number of theoretical plates  $N$  and the plate height  $H$ , when the retention time is 20.40 minutes, half of the base width (given in minutes) is 0.65 minutes and the column length is 30 cm.
- (iv) Draw a chromatogram and label it with retention time ( $t_R$ ), width at half height ( $W_{1/2}$ ) and width of the peak ( $W$ ).

Question 3.

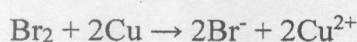
(a) Briefly differentiate between;

- (i) indicator electrode and reference electrode.
- (ii) electrode of the first kind and electrode of the second kind.

(b) Traces of aniline,  $C_6H_5NH_2$ , in drinking water can be determined by reaction with an excess of electrolytically generated  $Br_2$ :



The polarity of the working electrode is then reversed, and the excess  $Br_2$  is determined by a coulometric titration involving the generation of  $Cu(I)$ :



Suitable quantities of  $KBr$  and  $CuSO_4$  were added to a 25.0 mL sample containing aniline.

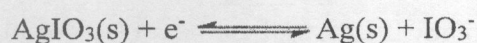
Calculate the number of micrograms of  $C_6H_5NH_2$  in the sample from the data:

Working Electrode Functioning As	Generation Time with Constant Current of 1.51 mA, min
Anode	3.76
Cathode	0.270

- (c) The  $\text{CN}^-$  concentration of 10.0 mL of a plating solution was determined by titration with electrogenerated hydrogen ion to a methyl orange end point. A colour change occurred after 4 min and 11 s with a current of 55.6 mA.
- Calculate the number of grams of NaCN per liter of solution.
  - Calculate the concentration in ppm of NaCN in the solution.
- (d) In four (4) lines or less, describe the principle involved in
- potentiometry.
  - Coulometry

#### Question 4

- Glass/calomel electrode system has several sources of uncertainty when employed in pH measurements. List at least 4 uncertainties.
- Describe the alkaline error in the measurement of pH. Under what circumstances is this error appreciable? How are pH data affected by alkaline error?
- $E^\circ_{Ag}$  for the process is 0.799 V;



- Calculate  $E^0$  for the process.
  - Use the shorthand notation to describe a cell consisting of a saturated calomel reference electrode and a silver indicator electrode that could be used to measure  $\text{pIO}_3$ .
  - Develop an equation that relates the potential of the cell in (b) to  $\text{pIO}_3$ .
  - Calculate  $\text{pIO}_3$  if the cell in (b) has a potential of 0.306 V
- (d) In order to determine  $K_1$  and  $K_2$  for  $\text{H}_3\text{PO}_4$  from titration data, careful pH measurements are made after 0.5 and 1.5 mol of base is added for each mole of acid. It is then assumed



# PERIODIC TABLE OF ELEMENTS

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

hydrogen 1 H																		helium 2 He										
beryllium 4 Be	lithium 3 Li	beryllium 4 Be	boron 5 B	carbon 6 C	nitrogen 7 N	oxygen 8 O	fluorine 9 F	neon 10 Ne	potassium 19 K	calcium 20 Ca	scandium 21 Sc	titanium 22 Ti	vanadium 23 V	chromium 24 Cr	manganese 25 Mn	iron 26 Fe	cobalt 27 Co	nickel 28 Ni	copper 29 Cu	zinc 30 Zn	gallium 31 Ga	germanium 32 Ge	arsenic 33 As	selenium 34 Se	bromine 35 Br	krypton 36 Kr		
1.00794	6.941	9.012182	10.811	12.0107	14.00674	15.9994	18.9984	20.1797	39.0983	40.078	44.95591	47.867	50.9415	51.9961	54.93805	55.845	58.9332	58.6934	63.546	65.409	69.723	72.64	74.9216	78.96	79.904	83.798		
Fr	Ra	Ra	Lr	Rf	Db	Sg	Bh	Hs	Os	Ru	Rh	Pd	Ag	Cd	Hg	Tl	Pb	Bi	Po	At	Rn	Fr	Ra	Ra	Ra	Ra	Ra	Ra
[223]	[226]	[226]	[262]	[261]	[262]	[266]	[264]	[269]	[261]	[269]	[268]	[271]	[272]	[285]	[285]	[283]	[282]	[285]	[284]	[285]	[285]	[289]	[289]	[289]	[289]	[289]	[289]	[289]

**key**  
 element name  
 atomic number  
 symbol  
 atomic mass

lanthanum 57 La	cerium 58 Ce	praseodymium 59 Pr	neodymium 60 Nd	promethium 61 Pm	samarium 62 Sm	europium 63 Eu	gadolinium 64 Gd	terbium 65 Tb	dysprosium 66 Dy	holmium 67 Ho	erbium 68 Er	thulium 69 Tm	ytterbium 70 Yb
138.9055	140.116	140.90765	144.24	[145]	150.36	151.964	157.25	158.9253	162.50	164.930	167.259	168.934	173.04
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
[227]	232.038	231.0359	238.0289	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]



THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Chemistry

2018/19 Academic year Term 1

CHE3411 Final Examination

Main Group Chemistry and Transition metal complexes

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**Instructions:**

Answer any 4 questions, all questions carry equal marks.

Time allowed: Three (3) hours

**QUESTION 1**

1. (a) (i) Give the IUPAC name of the complex:  $[\text{Ph}_4\text{As}][\text{PtCl}_2(\text{H})(\text{CH}_3)]$   
(ii) Draw the structure of:  $\mu$ -amido- $\mu$ -hydroxo bis(tetraminecobalt(IV))  
  
(b) When a four-coordinate square planar complex  $[\text{IrCl}(\text{PPh}_3)_3]$  reacts with  $\text{Cl}_2$ , a six coordinate product  $[\text{IrCl}_3(\text{PPh}_3)_3]$  is formed by a reaction known as oxidative addition. Represent the isomers of the product formed.  
  
(c) The complex  $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3-}$  is of the type  $\text{M}(\text{AA})_3$  where AA is a bidentate ligand. Draw the possible isomers for the complex.

**QUESTION 2**

2. (a) Assign the spectral bands of  $[\text{V}(\text{H}_2\text{O})_6]^{3+}$   
  
(b) The ground state cubic field for a complex is  ${}^5\text{T}_{2g}$ . Determine

- (i) The spin only moment,  $\mu_s$  of the complex
- (ii) The RS term from which the term is arising
- (iii) The d-electron structure of the complex

(c) Complete the table given below:

Complex	Spin allowed/forbidden	Laporte allowed/forbidden	Type of spectra	Intensity of color
K[MnO <sub>4</sub> ]				
[TiCl <sub>6</sub> ] <sup>2-</sup>				
[CoCl <sub>4</sub> ] <sup>2-</sup>				
[Mn(H <sub>2</sub> O) <sub>6</sub> ] <sup>2+</sup>				

### QUESTION 3

- (a) Predict if there is quenching in the given configurations: (i)  $d\epsilon^4\gamma^0$  (ii)  $d\gamma^4\epsilon^2$
- (b) [Fe(H<sub>2</sub>O)<sub>6</sub>]<sup>3+</sup> is labile and exchange its water molecules more rapidly with solvent, (H<sub>2</sub>O\*) whereas the corresponding Cr complex does not. Explain this observation on the basis of CFSE.
- (c) Tetrahedral complexes are automatically high spin. Explain

### QUESTION 4

- (a) Explain why covalent radius increases sharply from C to Si, but only slightly from Si to Pb.
- (b) Ionisation energy decreases from Si to Ge to Sn but slightly increases from Sn to Pb. What is ionisation energy and why does it decrease and increase as said?
- (c) Explain why Sn (II) salts are used as reducing agents while Pb (IV) salts are used as strong oxidising agents.
- (d) N<sub>2(g)</sub> exists as a diatomic molecule, N<sub>2</sub>. P, As & Sb however, exist as tetratomic molecules, P<sub>4</sub>, As<sub>4</sub> and Sb<sub>4</sub>. Explain why N can exist as N<sub>2</sub> while P, As & Sb can't.
- (e) In group 15, N has strongest tendency to form N<sup>3-</sup> ions, P forms P<sup>3-</sup> ions less readily and Bi hardly forms negative oxidation state. Explain.

## QUESTION 5

- (a) With the help of chemical reactions, state how sulphur at oxidation state +4 in  $\text{SO}_2$ , achieves maximum covalency of six. Name the type of reaction involved in this process.
- (b) How is sulphuric acid made in the contact process?
- (c) Explain why molecular halogens exist as gases, i.e.  $\text{F}_2$ ,  $\text{Cl}_2$ , liquids, i.e.  $\text{Br}_2$  and solids, i.e.  $\text{I}_2$  at room temperature.
- (d) F exhibits only  $-1$  oxidation state in its compounds while Cl, Br, I exhibit  $-1$ ,  $+1$ ,  $+3$ ,  $+5$ ,  $+7$ . Explain why.
- (e) Hypochlorous acid is one of the oxoacids of chlorine.
  - (i) State two conditions of how it disproportionate and the disproportionation reactions.
  - (ii) Draw and state the structure of  $\text{HClO}$  and the hybridisation of the oxygen atom in this molecule.

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**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																
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 Cesium	56 Ba 137.33 Barium	57-71 89-103	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantalum	74 W 183.84 Tungsten	75 Re 186.21 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.97 Gold	80 Hg 200.59 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po 208.98 Polonium	85 At 209.99 Astatine	86 Rn 222.02 Radon
87 Fr (223.02) Francium	88 Ra 226.03 Radium	89-103	104 Rf 261.11	105 Db 262.11	106 Sg 266	107 Bh 264	108 Hs 277	109 Mt 266	110 Ds 271	111 Rg 272	112 Cn 277	113	114 Fl 296	115	116 Lv 292	117	118

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

2018 Academic year Term 2 Final Exam

CHE3422

Organometallics and Reaction Mechanism

Instructions: Answer any four questions

All questions carry equal marks

Duration: 3 hours

Answer EACH question on a fresh page.

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QUESTION 1

- (a) A sample of Uranium mineral was found to contain 0.214 gm of lead-206 for every gram of Uranium. Calculate the time when the mineral was formed in the earth's crust? The  $t^{1/2}$  of U-238 is  $4.5 \times 10^9$  years.
- (b) (i) Give the product of the nuclear reaction
- $${}_{98}\text{Cf}^{250} + {}_5\text{B}^{11} \rightarrow ? + 4 {}_0\text{n}^1$$
- (ii)  ${}_{12}\text{Mg}^{24}$  (d,  $\alpha$ )
- (c) When a positron and an electron collide, they are annihilated and two gamma photons of equal energy are emitted. Calculate the wavelength corresponding to their gamma emission. [ Mass of electron =  $9.11 \times 10^{-31}$  kg, Speed of light =  $2.9979 \times 10^8$  m/s and Plancks constant =  $6.62 \times 10^{-34}$  J.s

QUESTION 2

- (a) Comment on the behaviour of  $\text{HNO}_3$  in solvents (i) liquid  $\text{NH}_3$  (ii)  $\text{H}_2\text{SO}_4$
- (b) Give balanced equations for a reaction between (i)  $\text{SOCl}_2$  and  $\text{Cs}_2\text{SO}_3$  (ii)  $\text{SOCl}_2$  and  $\text{KBr}$
- (c) What is a polar aprotic solvent? Give two examples.

### QUESTION 3

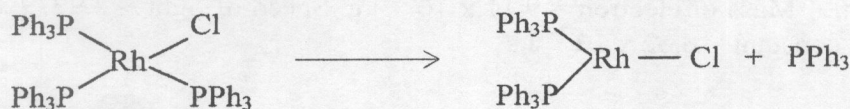
- (a) Describe how do you separate lanthanide ions from a solution containing a mixture of  $\text{Ln}(\text{NO}_3)_3$ , if you are provided with hydroxyl ion solution? Explain the principle involved.
- (b) Explain that (i)  $\text{Ce}^{3+}$  is more basic than  $\text{Ce}^{4+}$  (ii)  $\text{La}^{3+}$  is colorless but  $\text{Lu}^{4+}$  is orange red.
- (c) Actinides form oxocations but lanthanides don't. Elaborate the statement.

### QUESTION 4

- (a) What properties or characteristics or features of an atom or ligand enhance Electron-richness and Electron-deficiency as used in organometallic chemistry?
- (b) Which compound in each group is more electron-rich and why?  
(i)  $\text{Ti}(+2) d^2$  or  $\text{Pt}(+2) d^8$   
(ii)  $\text{Al}(\text{CH}_3)_3$  or  $\text{N}(\text{CH}_3)_3$   
(iii) Which of these two compounds  $\text{PMe}_3$  and  $\text{P}(\text{OMe})_3$  will be electron-rich and which will be electron deficient? Explain your answer.
- (c) (i) Comment on the observation that the  $\nu(\text{CO})$  band in  $[\text{Fe}(\text{CO})_6]^{2+}$  appears at  $2203 \text{ cm}^{-1}$  whilst in free CO it's at  $2143 \text{ cm}^{-1}$ .  
(ii) Given  $\text{V}(\text{CO})_6$  and  $[\text{V}(\text{CO})_6]^-$ , which one will have a shorter C-O bond length and which one will have a shorter V-C bond length? Justify your answer.

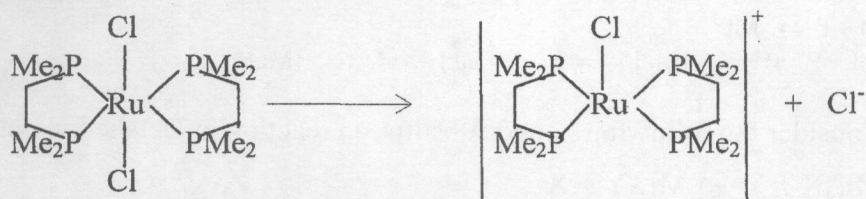
### QUESTION 5

(a) Reaction I

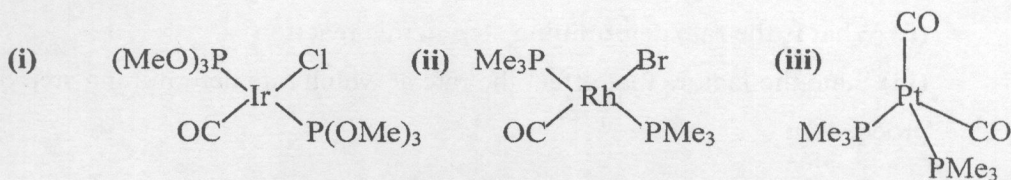


- (i) Name the reactant organometallic reagent in Reaction I above and state its most important usage.
- (ii) What type of organometallic reaction does reaction I above represent?
- (iii) Briefly define the reaction type you suggested in (b) above.
- (iv) In reaction I above, why does the  $\text{PPh}_3$  ligand fall off instead of the  $\text{Cl}^-$  ligand?

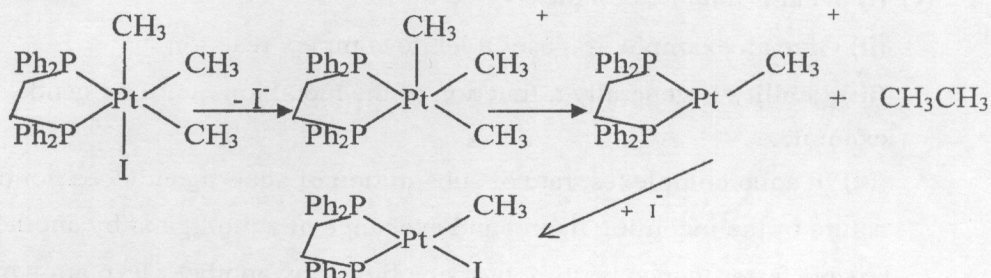
**(b) Reaction II**



- (i) What type of organometallic reaction does reaction II above represent?  
 (ii) Explain why in reaction II the  $\text{Cl}^-$  ion ligand falls off whereas in reaction I it is the triphenylphosphine ligand that falls off.  
 (iii) to which of the following complexes will  $\text{H}_2$  undergo oxidative addition most readily and why?



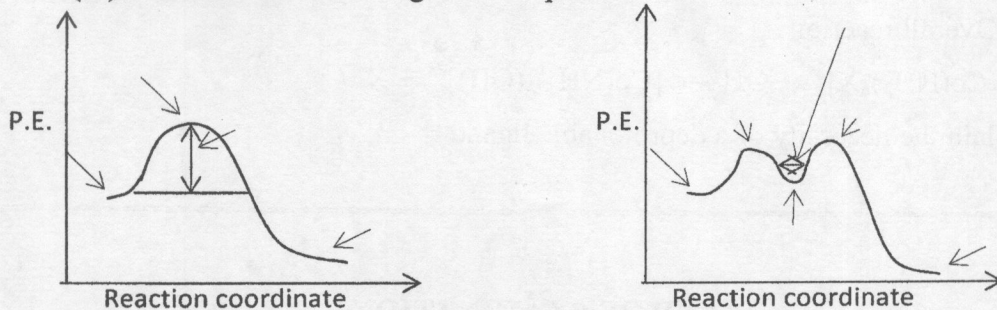
**(c) Reaction III**



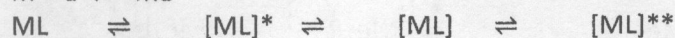
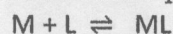
- (i) Explain reaction (III) above.  
 (ii) We see in reaction (III) above that  $\text{CH}_3\text{CH}_3$  falls off instead of  $\text{CH}_3\text{I}$ . Propose the reasons why.

**QUESTION 6**

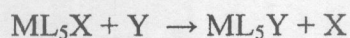
- (a) (i) What is meant by the term 'reaction mechanism'?  
 (ii) What is meant by the term 'Rate Law'?  
 (iii) Consider the following reaction profiles:



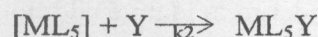
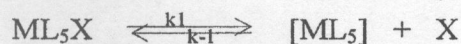
Label these profiles for the reaction represented by the following equation:



(b) Consider the following ligand substitution reaction in Octahedral complexes



where X is the leaving group and Y is the entering group, proceeding by the following mechanism



- (i) What mechanism pathway does this reaction present?
- (ii) What is the rate determining step in this reaction?
- (iii) State the factors that affect the rate at which rate determining step of this reaction proceeds.

(c) (i) What is a labile complex?

(ii) Give an example of a useful labile complex reaction.

(iii) Lability is generally a function of the metal ion, not the ligands. Illustrate with an example.

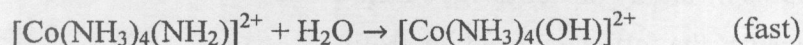
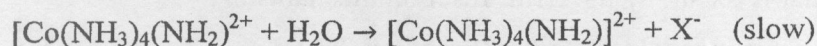
(iv) In aquo complexes, rate of substitution of aquo ligand does not depend on the nature of the incoming ligand and exchange of aquo ligand by another ligand is always faster than substitution of one ligand by another. Explain why.

(v) The Conjugate Base Mechanism ( $S_N1CB$ ) of Substitution mechanism requires a

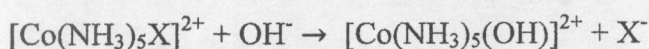
a. deprotonatable ligand on the complex e.g.  $NH_3$ ,  $H_2O$  and

b. presence of hydroxide  $OH^-$  in aqueous solutions.

The mechanism using the  $[Co(NH_3)_5X]^{2+}$  complex proceeds as follows:



Overall reaction



Explain the necessity of a deprotonable ligand

---

**END OF EXAMINATION**

# PERIODIC TABLE OF ELEMENTS

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

		<b>key</b>																		
		element name atomic number symbol atomic mass																		
hydrogen 1 H 1.00794	beryllium 4 Be 9.012182																	helium 2 He 4.002602		
lithium 3 Li 6.941	sodium 11 Na 22.98977	potassium 19 K 39.0983	calcium 20 Ca 40.078	scandium 21 Sc 44.95591	titanium 22 Ti 47.867	vanadium 23 V 50.9415	chromium 24 Cr 51.9961	manganese 25 Mn 54.93805	iron 26 Fe 55.845	cobalt 27 Co 58.9332	nickel 28 Ni 58.6934	copper 29 Cu 63.546	zinc 30 Zn 65.409	gallium 31 Ga 69.723	germanium 32 Ge 72.64	arsenic 33 As 74.9216	selenium 34 Se 78.96	bromine 35 Br 79.904	krpton 36 Kr 83.798	
francium 87 Fr [223]	radium 88 Ra [226]	cesium 55 Cs 132.90545	barium 56 Ba 137.327	thallium 81 Tl [204.3863]	lead 82 Pb 207.2	thorium 90 Th [232]	protactinium 91 Pa [231.0369]	uranium 92 U 238.0289	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendeleevium 101 Md [258]	nobelium 102 No [259]	lawrencium 103 Lr [261]	actinium 89 Ac [227]

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

**2018 ACADEMIC YEAR  
FINAL EXAMINATIONS**

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

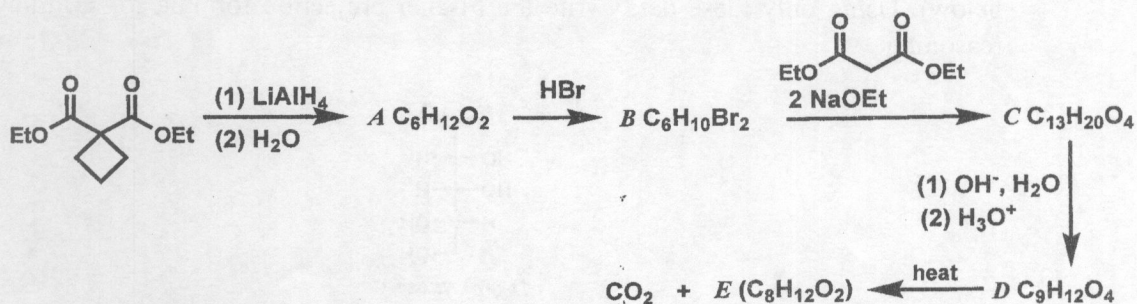
**TIME: THREE (3) HOURS**

**INSTRUCTIONS:**

1. ANSWER ANY FOUR (4) QUESTIONS.
2. EACH QUESTION CARRIES 25 MARKS.
3. PRESENT YOUR ANSWERS IN A LOGICAL MANNER.
4. ENSURE THAT YOU HAVE 5 PRINTED PAGES AND FIVE (5) QUESTIONS.

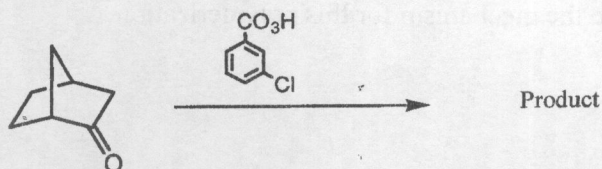
### QUESTION 1

- (a) Compound *E*, a compound with two four-membered rings, has been synthesized by the following route. Deduce the structures of this compound and those of the intermediates *A-D*. (10 marks)



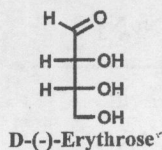
- (b) Show how periodic acid could be used to distinguish between an aldohexose and a ketohexose. What products would you obtain from each, and how many molar equivalents of  $\text{HIO}_4$  would be consumed? (8 marks)

- (b) Identify the product and propose a plausible mechanism for the following reaction: (7 marks)



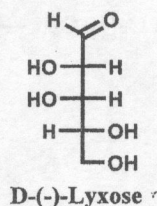
### QUESTION 2

- (a) Outline a Kiliani–Fischer synthesis of epimeric aldopentoses starting with D-(-)-erythrose (structure shown below) (use Fischer projections). (10 marks)

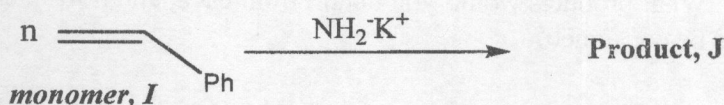


(b) The two epimeric aldopentoses that one obtains are **F** and **G**. Nitric acid oxidation of **G** yields an optically inactive aldaric acid, whereas similar oxidation of **F** yields an optically active product. On the basis of this information alone, which Fischer projection represents **F** and which one represents **G**? (2 marks)

(c) When the aldohexose **H** is treated with nitric acid, it yields an optically inactive aldaric acid. When **H** is subjected to Ruff degradation, it yields D-(-)-lyxose (see structure below). Using only these data, write the Fischer projection formula for **H**. Show your reasoning. (5 marks)



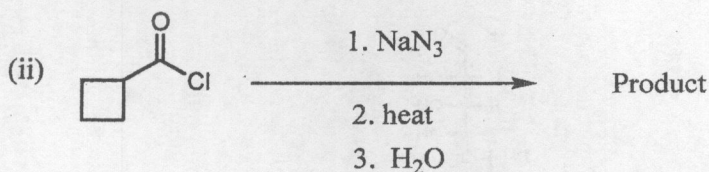
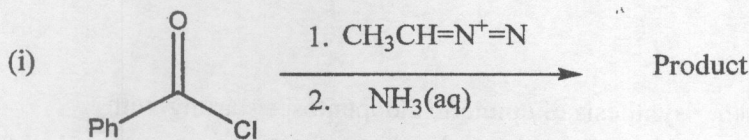
(d) Product, **J** shown below produced by polymerisation of monomer, **I**:



- (i) Name this type of polymerisation (1 mark)  
(ii) Draw the structure of the product, **D** (2 marks)  
(iii) Write the mechanism for this polymerization (5 marks)

### QUESTION 3

(a) Identify the product and propose a plausible mechanism for the following reactions: (17 marks)



(b) Give appropriate structural formulas to illustrate each of the following:

(8 marks)

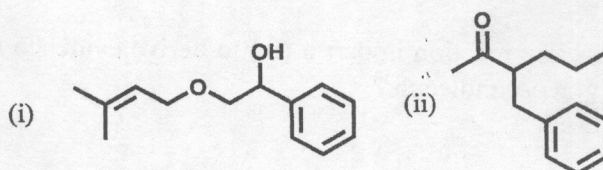
- (i) An aldopentose (straight chain Fischer projection formula)
- (ii) A non-reducing sugar (cyclic form)
- (iii) Anomers (cyclic form)
- (iv) Epimers (straight chain Fischer projection formula)

#### QUESTION 4

(a) Draw the structure of the product expected from the killing of living polystyrene (resulting from anionic polymerization of styrene) by each of the following reagents: (7 marks)

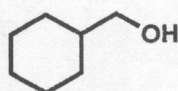
- (i) water
- (ii) carbon dioxide then water
- (iii) a small amount of ethylene oxide then water

(b) Outline a retrosynthetic analysis for the following molecules. In each case, outline the corresponding synthesis clearly showing reagents and reaction conditions for each step. Assume starting materials containing  $\leq 6$  carbon atoms are readily available. (18 marks)

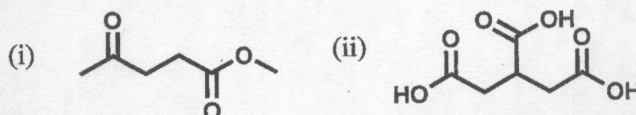


#### QUESTION 5

(a) Propose a synthetic approach for the following compound from diethyl malonate and any other organic and inorganic reagents. Assume starting materials containing  $\leq 6$  carbon atoms are readily available. (11 marks)

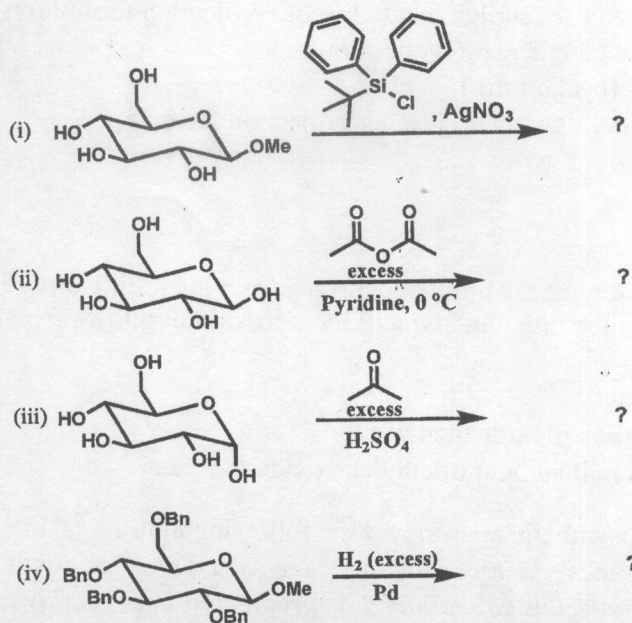


(b) Provide the systematic names for the following polyfunctional compounds. (3 marks)



(c) Predict the products of the following reactions:

(8 marks)



(d) How would you use the reaction in part a (iv) to derive evidence for the existence of the pyranose form of the glucose molecule? (3 marks)

**END OF EXAMINATION QUESTIONS**

THE UNIVERSITY OF ZAMBIA  
SCHOOL OF NATURAL SCIENCES

2018 ACADEMIC YEAR FINAL EXAMINATIONS  
CHE 4102: BIOCHEMICAL RESEARCH TECHNIQUES

**INSTRUCTIONS:**

Time: Three (3) hours

All questions carry **equal marks** (25 marks each)

Answer any **four (4)** questions

Write your computer number on all answer booklets

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

---

**Question 1**

- a) With reference to lipid and protein hormones, **discuss** how the characteristics of hormones will influence the way in which they initiate signal transduction in a target cell.

[5 marks]

- b) **Write** short notes on the following:

- I. Viral oncogenes and their role in the development of cancer.  
[4 marks]
- II. The role of G-proteins in signal transduction.  
[4 marks]
- III. The role of liver enzymes in the inactivation of steroid hormones.  
[4 marks]

- c) **What** is meant by the term 'receptor desensitization'? Using the example of the  $\beta$ -adrenergic receptor, **outline** the steps involved in the desensitization of a hormone receptor.

[8 marks]

✓ **Question 2**

Glycogen break down and synthesis may be regulated hormonally.

- a) **Name** two main hormones that regulate these metabolic pathways.  
[5 marks]
- b) Using the any hormone named in a), **explain** in detail the hormonal regulation of glycogen breakdown. (Include positive and negative regulation)  
[20 marks]

epinephrine  
Insulin  
glucagon

**Question 3**

- a) **Explain** the following terms/expressions:
- i) epitope
  - ii) complement system
  - iii) phagocytosis

[9 marks]

- b) **Other than lupus, name** any four (4) autoimmune diseases.  
[6 marks]

- c) **How** do autoimmune diseases arise considering the fact that mechanisms that govern self/non-self discrimination are in place? In other words; **what** causes autoimmune diseases?

[10 marks]

**Question 4**

- a) A sample of radioisotope has an activity of 450  $\mu\text{Ci}$  after 2 days. If the rate constant for the isotope is  $0.056 \text{ day}^{-1}$ , **what** was the activity of the sample 2 days ago? [10 marks]

- a) A container having 10  $\mu\text{Ci}$  of L-phenylalanine -  $^{14}\text{C}$  (uniformly labeled) in 1 mL of solution was found to have a specific activity of 15  $\mu\text{Ci}/\text{mmol}$ . **Calculate** the concentration of L-phenylalanine in g/ml.

(H = 1.0, N = 14.0, O = 16.0)

[15 marks]

Rm C = H

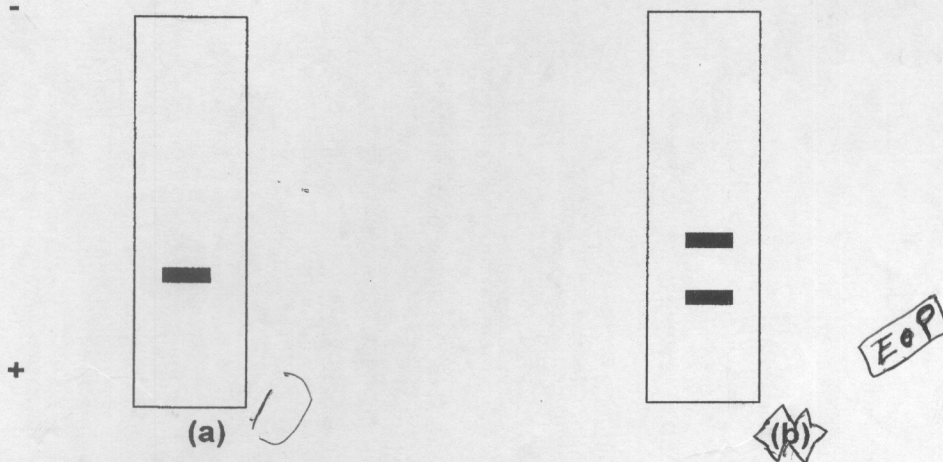
X  
= 15  
20

**Question 5**

- a) Four pure proteins were used as standards to construct a standard curve for a molecular weight analysis via SDS-gel electrophoresis. Protein 1, with molecular weight of 15,000, was the smallest. Protein 2 (MW = 35,000) moved only 39 % as far as protein 1. Protein 3 (MW = 25,000) moved only 63 % as far as protein 1. Protein 4 (MW = 20,000) moved only 81 % as far as protein 1.

**Construct** a standard curve (Rel. mobility Vs Log<sub>mw</sub>) for this data, and then **determine** the molecular weight of the unknown protein that had a mobility value (under the same conditions) midway between that of proteins 2 and 3.  
**[15 marks]**

- b) A different protein Z was divided into 2 aliquots. One aliquot was subjected to regular PAGE and the other to SDS-PAGE giving the results shown in figure 1 below. **What** conclusion can you make regarding the structure of the protein Z?  
**[10 marks]**



**Figure 1** Regular (a) and SDS-PAGE (b) of protein Z

**END OF EXAMINATION**

THE UNIVERSITY OF ZAMBIA  
SCHOOL OF NATURAL SCIENCES

2018/2019 ACADEMIC YEAR FIRST TERM FINAL EXAMINATIONS

CHE4211 ANALYSIS OF INORGANIC COMPOUNDS

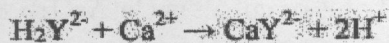
TIME: THREE HOURS

INSTRUCTIONS

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

**Question 1**

- (a) To collect a surface water sample from a water body or other surface water conveyance, a variety of tools can be used. Mention any four of these
- (b) Other than pH, mention five parameters measure for physical examination of water samples.
- (c) The hardness of water is due in part to the presence of  $\text{Ca}^{2+}$  ions in water. The concentration of  $\text{Ca}^{2+}$  ions is usually expressed as ppm  $\text{CaCO}_3$  in the water sample.  $\text{Ca}^{2+}$  can be analyzed by titration with EDTA using an appropriate indicator. EDTA itself is not very water soluble so the disodium salt is used,  $\text{Na}_2\text{H}_2\text{C}_{10}\text{H}_{12}\text{N}_2\text{O}_4$ . For the purpose of simplicity, Y will stand for  $\text{C}_{10}\text{H}_{12}\text{N}_2\text{O}_4$ . The EDTA we use is thus  $\text{Na}_2\text{H}_2\text{Y}$ . The part that reacts with  $\text{Ca}^{2+}$  is  $\text{H}_2\text{Y}^{2-}$  according to the following equation.



The procedure is done in 3 steps 1) Preparation of a standard  $\text{Ca}^{2+}$  solution, 2) Standardization of EDTA with the standard calcium solution and, 3) Analysis of an unknown  $\text{Ca}^{2+}$  sample with the standardized EDTA solution.

- (i) What indicator is usually used in these titrations?
- (ii) What type of a titration is this one?
- (iii) 0.405 g of  $\text{CaCO}_3$  is dissolved in HCl and diluted to a volume of 250.00 mL. What is the molarity of calcium ions in the solution?
- (iv) A 25.00 mL aliquot (a portion or part) of the standard calcium solution reacts with 27.25 mL of the EDTA solution. What is the molarity of the EDTA?

- (v) A 50.00 mL unknown solution requires 25.55 ml of the standardized EDTA solution for complete reaction. What is the  $\text{Ca}^{2+}$  concentration in the unknown reported as ppm  $\text{CaCO}_3$ ?
- (d) How does turbidity differ from Total Suspended Solids? How do the two relate with each other?

### Question 2

- (a) A sample of potassium is analyzed by FES using the standard addition method. Two 0.5ml aliquots are added to 5.0ml portions of water. To one portion is added 10 $\mu\text{L}$  0.05M KCl solution. The net emission signals in arbitrary units are 32.1 and 58.6. What is the concentration of potassium?
- (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) Explain what limit of detection and limit of quantitation of an instrumental method of analysis mean. A blank sample gave the following readings: 0.01, 0.02, 0.05, 0.013, 0.012, 0.06. Calculate the  
 (i) Limit of detection  
 (ii) Limit of quantitation.
- (d) What is the minimum value of D that will allow the extraction of 99.0% of a solute from 75.0  $\text{cm}^3$  of water with four successive extractions by 75.0  $\text{cm}^3$  quantities of ether?

### Question 3

- (a) One of the important ores of cobalt is  $\text{Co}(\text{AsO}_4)_2 \cdot \text{H}_2\text{O}$ . How much of the ore is needed to make 1.0kg of cobalt?
- (b) In the determination of manganese at 403.3nm, solution X, containing an aliquot of the unknown solution gave a meter reading of 45. Solution Y, containing the same quantity of unknown solution plus 100ppm of added manganese; gave a meter reading of 83.5. Calculate the amount of manganese in solution X.
- (c) An ore is analyzed for the Mn content by converting Mn to  $\text{Mn}_3\text{O}_4$  and weighing it. If a 2.1 g sample yields  $\text{Mn}_3\text{O}_4$  weighing 1.5 g, what would be the %  $\text{MnO}_3$  in the sample, and %Mn?
- (d) A sample of copper ore (0.20g) was analysed by iodometry. Cu (II) was reduced to Cu (I) by iodide [ $2\text{Cu}^{2+} + 4\text{I}^- \longrightarrow 2\text{CuI} + \text{I}_2$ ]. What is the copper content (%) of the ore if 20.0  $\text{cm}^3$  of 0.2 M  $\text{Na}_2\text{S}_2\text{O}_3$  is used up for titrating the liberated iodine [ $\text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \longrightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-}$ ]

**Question 4**

- (i) Name all the major nutrients in a fertiliser, and, state the specific one that promotes a good roots system in plants?
  - (ii) Given that the analysis of certain fertilizer yielded the following elemental analysis results: 22.67% P, 22.00% N and ballast 8.00%. How would you report this result officially according to the N-P-K Convention?
- (a) Explain what limit of detection and limit of quantitation of an instrumental method of analysis mean. A blank sample gave the following readings: 0.01, 0.02, 0.05, 0.013, 0.012, 0.06. Calculate the
- (i) Limit of detection
  - (ii) Limit of quantitation.
- (b) (i) Discuss 2 schemes used to determine silica in rocks
- (i) Account for characteristics of a 16-55-15 fertilizer. What is the content of ballast in this fertilizer
- (c) (i) State the four factors that affect the setting time of Portland cement
- (ii) Two methods are available for the determination of calcium carbonate in soils. Compare and contrast the two methods with respect to field use.

**Question 5**

- (a) (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.
- (b) You are the chief analyst for a mining company that is yet to open a mine in Kalumbila, Solwezi. This place is known for ores rich in copper amongst other elements. An ore sample of mass 4.10 kg is collected for analysis.
- (i) Briefly describe how this ore sample can be **prepared** before the actual analysis. **Give the individual steps involved in point form.** Remember that it must be in solution form before introduction into a suitable analytical machine.
- (ii) Propose two analytical techniques that can be used to analyse the ore sample in your lab.
- (iii) For prompt acquisition of results with regards to Cu content, what technique can be employed **on-site** to obtain the results in real time?
- (c) There are four most important things to know before beginning any type of chemical analysis. Mention any three of these important points to be considered.
- (d) Define biochemical oxygen demand and briefly describe how it can be determined in a sample of waste water.

END OF EXAMINATION

The Periodic Table of Elements

1 2 3 4 5 6 7 0 (9)

Key

relative atomic mass  
atomic symbol  
name  
atomic (proton) number

1.0  
H  
hydrogen  
1

6.9 Li lithium 3	9.0 Be beryllium 4	10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	27.0 Al aluminum 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs cesium 55	137.3 Ba barium 56	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	208.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85
[223] Fr francium 87	[226] Ra radium 88	[208] Pb lead 82	[209] Bi bismuth 83	[210] Po polonium 84	[211] At astatine 85	[212] Rn radon 86	[222] Rn radon 86
[223] Ac actinium 89	[226] Th thorium 90	[208] Pb lead 82	[209] Bi bismuth 83	[210] Po polonium 84	[211] At astatine 85	[212] Rn radon 86	[222] Rn radon 86
[223] Pa protactinium 91	[226] U uranium 92	[208] Pb lead 82	[209] Bi bismuth 83	[210] Po polonium 84	[211] At astatine 85	[212] Rn radon 86	[222] Rn radon 86
[223] Th thorium 90	[226] Pa protactinium 91	[208] Pb lead 82	[209] Bi bismuth 83	[210] Po polonium 84	[211] At astatine 85	[212] Rn radon 86	[222] Rn radon 86
[223] Th thorium 90	[226] Pa protactinium 91	[208] Pb lead 82	[209] Bi bismuth 83	[210] Po polonium 84	[211] At astatine 85	[212] Rn radon 86	[222] Rn radon 86

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 thulium 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
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THE UNIVERSITY OF ZAMBIA  
SCHOOL OF NATURAL SCIENCES  
DEPARTMENT OF CHEMISTRY  
2018/2019 ACADEMIC YEAR FINAL EXAMINATION

**CHE4222 FOOD, DRUG, PESTICIDE AND DETERGENT ANALYSIS**

**DURATION: THREE HOURS**

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**INSTRUCTIONS**

1. Indicate your student ID number on each of the provided answer booklets.
  2. There are **five** questions in this examination paper; Answer any **four** questions.
  3. All questions carry equal marks.
  4. There are **three printed papers** for the questions; the periodic table is attached also.
  5. Show your reasoning and/ or calculations clearly.
-

### Question 1

- (a) A 5.00 g sample of food grade oil was reacted with excess KI to determine peroxide value. The free iodine was titrated with a standardized solution of 0.10 N  $\text{Na}_2\text{S}_2\text{O}_3$ . The amount of titrant required was 0.60 ml blank corrected. Calculate the peroxide value of the oil.
- (b) Describe the procedure you would use to determine whether pasteurization or sterilization of your milk has been thoroughly carried out.
- (c) Define the following;
  - (i) acid value
  - (ii) peroxide value
  - (iii) iodine value
- (d) An unlabeled product smells like butter. How would you confirm whether it is butter or margarine and what compound(s) may give such an odour?

### Question 2

- (a) Briefly explain what you understand by the following terms
  - (i) Drug of abuse
  - (ii) Narcotic drugs
  - (iii) Psychotropic substance
- (b) A drug derived directly from opium and used in its natural state without chemical modification is known as an opiate. Opiates include morphine, codeine, thebaine, narcotine and papaverine. Describe the extraction of morphine from opium and extraction of heroin from morphine.
- (c) Cannabis is an example of a psychotropic substance.
  - (i) Briefly describe the extraction and analysis of cannabis from plant material.
  - (ii) State what marijuana does to human beings when smoked.
  - (iii) Mr. Banda has been smoking marijuana for the past ten years. When recently learned about the effects of marijuana, he decided to suddenly stop. List the challenges that he is facing during the withdraw period.

### Question 3

- (a) Briefly describe the preparation of the 'fusion' filtrate. How is it used for the specific tests including nitrogen, sulphur, halides (chlorine, bromine and iodine)?
- (b) Describe a test that would be used to distinguish aldehydes from ketones.
- (c) Describe how you would distinguish Primary, Secondary and Tertiary Amines.
- (d) Briefly describe how you would determine nitrates and N-nitrosamines in cheese.

### Question 4





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

**2018 ACADEMIC YEAR  
FINAL EXAMINATIONS**

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

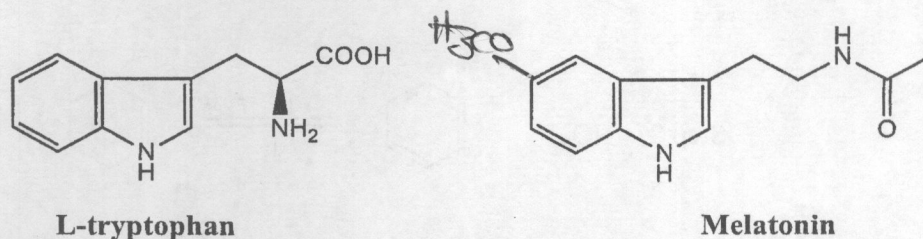
**TIME ALLOWED: THREE (3) HOURS**

**INSTRUCTIONS:**

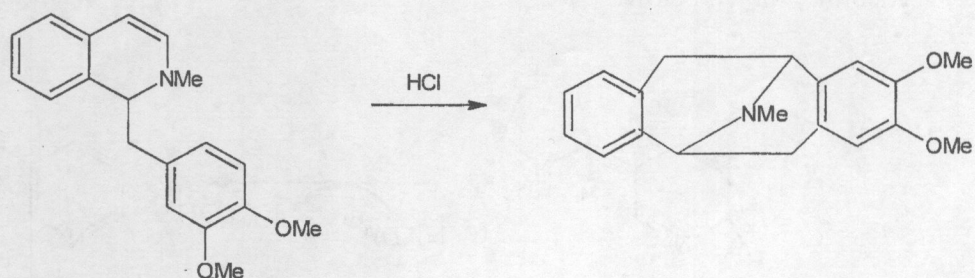
1. ANSWER ANY FOUR (4) QUESTIONS.
2. EACH QUESTION CARRIES 25 MARKS.
3. PRESENT YOUR ANSWERS IN A LOGICAL MANNER.
4. PLEASE ENSURE THAT YOU HAVE SEVEN (7) PRINTED PAGES AND FIVE (5) QUESTIONS.

## QUESTION ONE

- (a) Melatonin, an indole alkaloid found in animals, plants and microbes, is a hormone which regulates circadian rhythm in humans. Outline a plausible biogenetic pathway for melatonin from its amino acid precursor *L*-tryptophan, showing all steps clearly. (10 marks)



- (b) Alkaloids undergo wide ranging acid and base catalyzed rearrangements. Propose a plausible mechanism for the transformation shown below: (7 marks)



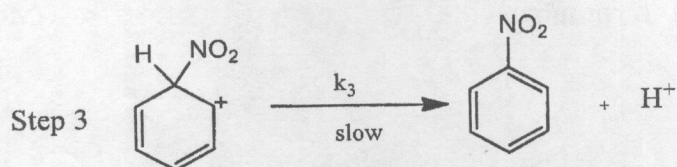
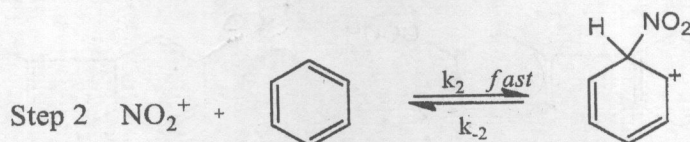
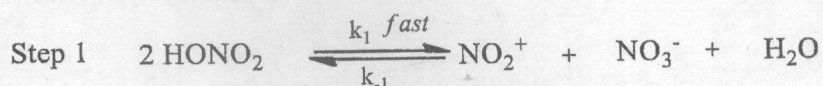
- (c) Match the  $\rho$  values with the appropriate reactions. Explain your reasoning.  
Reaction constants ( $\rho$ ): +2.45, +0.75, -2.39, -7.29

Reactions are:

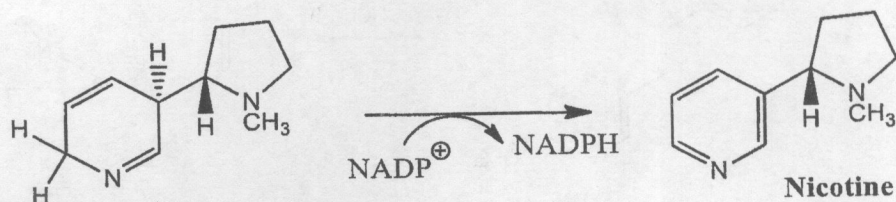
- |   |           |
|---|-----------|
| (i) Nitration of substituted benzenes                                       | (2 marks) |
| (ii) Ionization of substituted benzenethiols                                | (2 marks) |
| (iii) Ionization of substituted benzenephosphonic acids                     | (2 marks) |
| (iv) Reaction of substituted <i>N,N</i> -dimethylaniline with methyl iodide | (2 marks) |

## QUESTION TWO

- (a) For the following proposed reaction mechanism of the nitration of benzene, derive an overall kinetic rate equation by applying the steady state approximation method. (10 marks)



- (b) Suggest a plausible mechanism for the last step in the biosynthesis of the tobacco alkaloid Nicotine, shown below: (3 marks)



- (c) Show how the following experimental evidence can be used to deduce the structure of a disaccharide A,  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ . Use the ring (conformational) structures to answer this question.
- The disaccharide A gives positive Tollens test and undergoes mutarotation.
  - Treatment of A with a large excess of methyl iodide in presence of silver oxide followed by acidic hydrolysis gives equimolar quantities of 2,3,6-tri-O-methyl D-glucose and 2,3,4,6-tetra-O-methyl D-galactose.
  - Oxidation of A with bromine water gives a compound B, which upon hydrolysis with dilute hydrochloric acid gives D-galactose and D-gluconic acid.
  - Exhaustive methylation of B followed by acidic hydrolysis gives 2,3,6-tri-O-methyl-D-gluconolactone and 2,3,4,6-tetra-O-methyl D-galactose.
  - The coupling constant,  $^3J_{\text{H}_1, \text{H}_2}$  for the hydrogen at anomeric carbon of glycosidic linkage in A was found to be 3.5 Hz.

(12 marks)

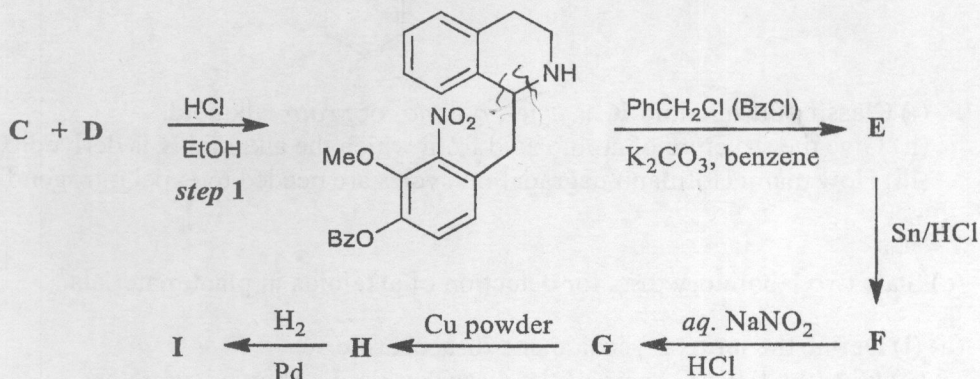
### QUESTION THREE

(a) Substituted methyl benzoates hydrolyze rapidly in 95 % sulphuric acid. A study of the effect of substituents on phenyl ring on the rate of reaction gave the following results:

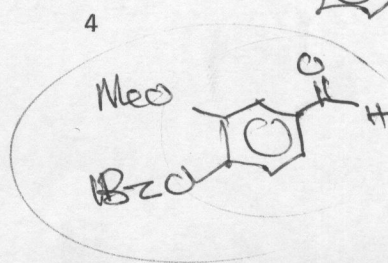
Substituent	<i>p</i> -Me	<i>m</i> -Me	H	<i>m</i> -Cl	<i>m</i> -Br
$k \text{ (sec}^{-1}\text{)}$	$2.41 \times 10^{-4}$	$1.51 \times 10^{-4}$	$6.5 \times 10^{-5}$	$3.5 \times 10^{-6}$	$3.2 \times 10^{-6}$

- (i) Determine the value of  $\rho$  (rho) for this reaction and predict the rate constant for the hydrolysis of methyl *p*-fluorobenzoate (5 marks)
- (ii) For the hydrolysis of methyl *o*-methylbenzoate and methyl *p*-methoxybenzoate the rate constants are:  $182 \times 10^{-4}$ ; and  $10.2 \times 10^{-4}$ , respectively. Comment on these results. (2 marks)
- (iii) Substituents have very little effect upon the rate of hydrolysis of methyl benzoates in dilute sulphuric acid. Compare this observation with the results given above and suggest an explanation. (4 marks)

(b) A synthesis of a bronchodilator and anti-inflammatory alkaloid **I**, isolated from root bark of a plant is outlined below:

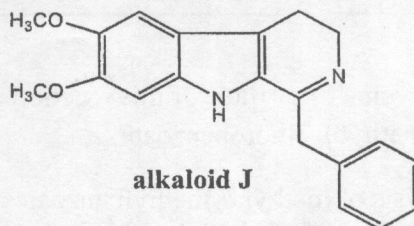


- (i) Give the structures of starting materials **C** and **D** for step 1 (4 marks)
- (ii) Identify the intermediates **E** - **H**. (8 marks)
- (iii) What is the structure of the alkaloid **I**? (2 marks)

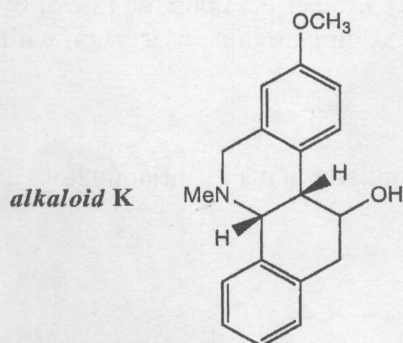


## QUESTION FOUR

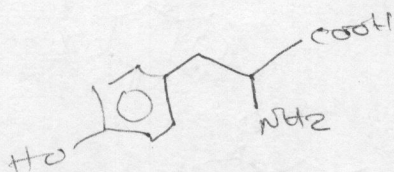
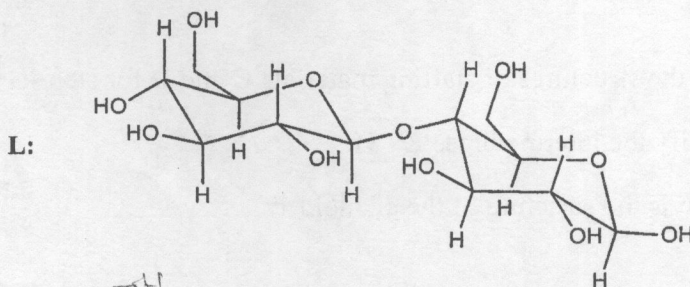
- (a) Using the disconnection approach, propose an efficient synthesis for the alkaloid **J** shown below. Show all steps clearly, including the reagents, conditions and the intermediates for each step. Please do not write any reaction mechanism. Assume that 5,6-dihydroxyindole, and phenyl acetic acid ( $C_6H_5CH_2COOH$ ) are available. (11 marks)



- (b) Consider the alkaloid **K**, shown below:



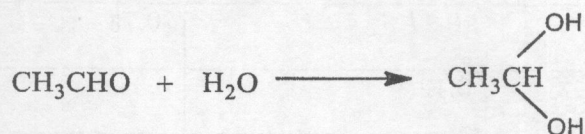
- (i) Classify the alkaloid **K** as *true*-, *pseudo*- or *proto*- alkaloid. (1 mark)  
 (ii) Give the structure of amino acid from which the alkaloid **K** is derived. (1 mark)  
 (iii) How many Hofmann degradation cycles are needed to expel nitrogen from the alkaloid **K**? (1 mark)
- (c) State two laboratory tests for detection of alkaloids in plant materials. (2 marks)
- (d) (i) Define the terms glycoside and disaccharide. (4 marks)  
 (ii) Give the IUPAC name of the disaccharide, **L**, shown below: (2 marks)



- (e) The sulphonation of tritium-labelled bromobenzene is much slower than that of normal benzene, while nitration of nitrobenzene is unaffected by isotopic substitution on the aromatic ring. Explain these observations. (4 marks)

### QUESTION FIVE

- (a) In aqueous solution acetaldehyde is slowly hydrated.



In acetate buffer the reaction is subject to acid and base catalysis. The first order rate constants ( $k_{\text{obs}}$ ) in two different acetate buffers, of known hydrogen ion concentration, were measured with the following results ( $r = \text{buffer ratio}$ ) [ $\text{CH}_3\text{CO}_2\text{H}/\text{CH}_3\text{CO}_2^-$ ].

(i) $[\text{H}^+] = 3.36 \times 10^{-3} \text{ M}$		$r = 0.118$				
$[\text{CH}_3\text{CO}_2\text{H}] (\text{M}) \times 10^{-3}$	2.7	4.9	6.9	9.0	10.9	
$k_{\text{obs}} (\text{min}^{-1}) \times 10^{-2}$	6.6	8.7	9.9	11.6	12.7	
(ii) $[\text{H}^+] = 8.78 \times 10^{-3} \text{ M}$		$r = 0.308$				
$[\text{CH}_3\text{CO}_2\text{H}] (\text{M}) \times 10^{-3}$	3.0	4.7	7.4	8.7	11.3	15.2
$k_{\text{obs}} (\text{min}^{-1}) \times 10^{-2}$	8.2	9.3	10.2	10.6	12.3	13.4

The overall rate equation for this general acid catalyzed reaction was found to be as follows:

$$k_{\text{obs}} = k_0 + k_1[\text{H}^+] + k_2[\text{CH}_3\text{CO}_2\text{H}] + k_3[\text{CH}_3\text{CO}_2^-]$$

- (i) Derive an equation relating  $k_{\text{obs}}$  to the concentration of acetic acid. (5 marks)
- (ii) From the derived equation plot a graph of  $k_{\text{obs}}$  versus  $[\text{CH}_3\text{CO}_2\text{H}]$  for each set of values at  $r = 0.118$  and  $0.308$ . (8 marks)
- (iii) Use the information obtained from the plotted graphs to calculate the values of the rate constants,  $k_0$ ,  $k_1$ ,  $k_2$ , and  $k_3$ . (12 marks)

45  
7.5

END OF EXAMINATION  
GOOD LUCK!

## APPENDIX

### USEFUL DATA

Substituent	HAMMETT CONSTANTS		
	$\sigma$	$\sigma^+$	$\sigma^-$
H	0.00	0.00	0.00
<i>p</i> -MeO	-0.27	-0.78	-0.27
<i>m</i> -MeO	0.12	0.05	
<i>p</i> -Me	-0.17	-0.31	-0.17
<i>m</i> -Me	-0.07	-0.07	-0.07
<i>p</i> -Bu <sup>t</sup>	-0.20	-0.26	
<i>m</i> -Bu <sup>t</sup>	-0.10	-0.06	
<i>p</i> -F	0.06	-0.07	
<i>m</i> -F	0.34	0.35	
<i>p</i> -Br	0.23	0.15	0.22
<i>m</i> -Br	0.39	0.41	
<i>p</i> -Cl	0.23	0.11	
<i>m</i> -Cl	0.37	0.40	0.38
<i>p</i> -CO <sub>2</sub> Et	0.45	0.48	0.68
<i>p</i> -NO <sub>2</sub>	0.78	0.79	1.27
<i>m</i> -NO <sub>2</sub>	0.71	0.67	0.70

**UNIVERSITY OF ZAMBIA**  
**SCHOOL OF NATURAL SCIENCES**  
**CHEMISTRY DEPARTMENT**

**2018 Academic End of Year Exams**

**CHE 4822 Inorganic Industrial Chemistry II**

**Answer any FOUR Questions**

**Duration: 3Hours**

---

**Question 1**

(a) In the Contact process, conversion of sulphur dioxide to sulphur trioxide is reversible, with the forward reaction forming sulphur trioxide being exothermic. There are a number of ways that the choice of conditions affects the process:

- they affect the position of equilibrium;
- they affect the rate of the reaction;
- they affect the economics of the process.

Where relevant, explain how each of these choices: (i)  $\text{SO}_2$ :  $\text{O}_2$  ratio, (ii) temperature, (iii) pressure and (iv) catalyst affect each of the following: (1) position of equilibrium (2) rate of the reaction and (3) economics of the process, i.e. what is the effect of each of  $\text{SO}_2$ :  $\text{O}_2$  ratio, temperature, pressure and catalyst on each of position of equilibrium, rate of reaction and economics of the process.

(b) State the challenges encountered during the solution synthesis operation in the manufacture of urea and how they are mitigated.

**Question 2**

(a) With the help of a process diagram, describe the production of weak nitric acid.

(b) (i) What emissions discharge from nitric acid production?

(ii) Where are they generated in the processing of nitric acid?

(iii) Suggest the factors that would lead to increased emissions discharge in this process.

(c) How would you bring these emissions under control?

**Question 3**

(a) (i) Draw a diagram to show how elemental sulphur is mined using Frasch Process.

(ii) Briefly describe the proceedings in the Frasch process of mining elemental sulphur.

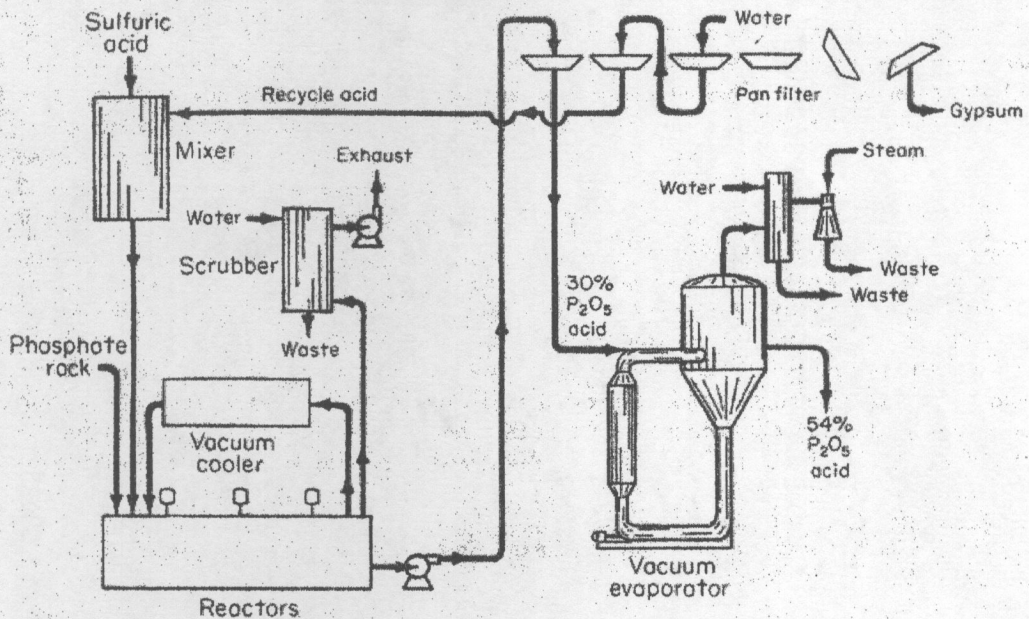
(iii) What two properties of sulphur does this process take advantage of?

(b) (i) Draw and label the process diagram for the manufacture of urea.

(ii) Describe solution synthesis operation in the manufacture of urea.

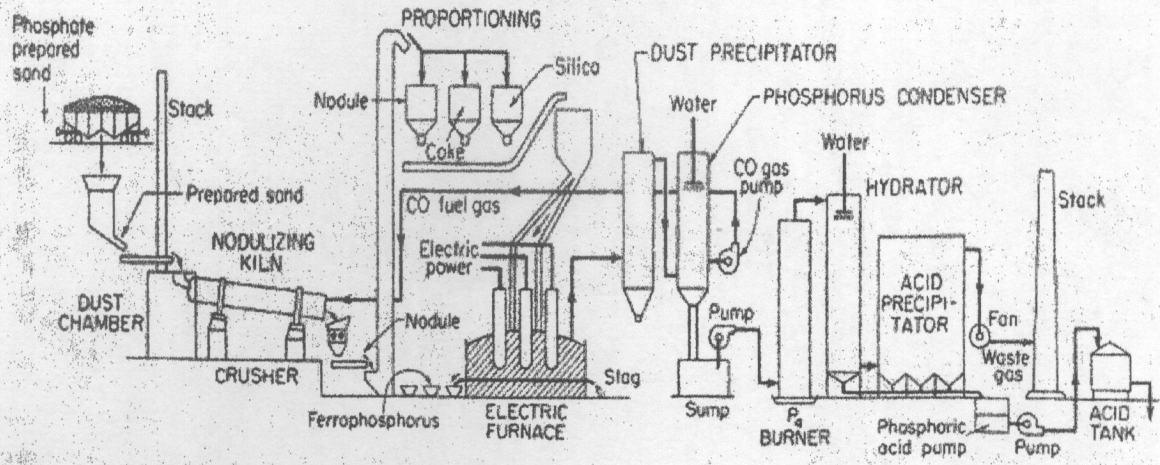
#### Question 4

- Discuss the characteristics, advantages and disadvantages of complex fertilizers such as NPK fertilizers. Critically compare NPK with Single Superphosphate fertilizer.
- List three types of Inorganic fertilizers and briefly discuss the functions and the major sources of macronutrients in crop production.
- With the aid of the process diagram provided, briefly discuss the manufacture of phosphoric acid using the Bird Prayon tilting pan filters.



#### Question 5

- Discuss briefly the Raw Materials and Principles of manufacturing for NPK fertilizers.
- Discuss briefly the manufacture of Triple Superphosphate with the help of a flow Diagram. Explain briefly the major Steps involved in the production of TSP and write the chemical reactions for this process.
- With the aid of the process diagram provided, briefly discuss the three major steps: combustion, hydration, and demisting involved in the Thermal process of phosphoric acid manufacture.



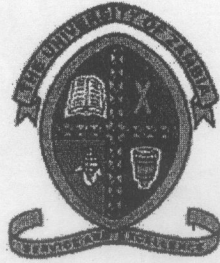
END OF EXAMINATION

# PERIODIC TABLE OF ELEMENTS

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

		key																																																																																																																																																																																																					
		element name		atomic number		symbol		atomic mass																																																																																																																																																																																															
hydrogen	1	1.00794	beryllium	4	Be	9.012182	lithium	3	Li	6.941	sodium	11	magnesium	12	Mg	24.3050	calcium	20	Ca	40.078	potassium	19	scandium	21	titanium	22	vanadium	23	chromium	24	manganese	25	iron	26	cobalt	27	nickel	28	copper	29	zinc	30	gallium	31	germanium	32	arsenic	33	selenium	34	bromine	35	krypton	36	rubidium	37	strontium	38	yttrium	39	zirconium	40	niobium	41	molybdenum	42	technetium	43	ruthenium	44	rhodium	45	palladium	46	silver	47	cadmium	48	indium	49	tin	50	antimony	51	tellurium	52	iodine	53	xenon	54	cesium	55	barium	56	lanthanum	57	cerium	58	praseodymium	59	neodymium	60	promethium	61	samarium	62	europium	63	gadolinium	64	terbium	65	dyprosium	66	holmium	67	erbium	68	thulium	69	ytterbium	70	thallium	81	lead	82	bismuth	83	polonium	84	astatine	85	radon	86	francium	87	radium	88	actinium	89	thorium	90	protactinium	91	uranium	92	neptunium	93	plutonium	94	americium	95	curium	96	berkelium	97	californium	98	escherichium	99	fermium	100	mendelevium	101	nobelium	102	lawrencium	103	bohrium	104	hassium	105	meitnerium	106	darmstadtium	107	roentgenium	108	copernicium	109	nihonium	110	flerovium	111	tennessine	112	oganesson	113	bohrium	114	hassium	115	meitnerium	116	darmstadtium	117	tennessine	118	oganesson

lanthanum	57	138.905	cerium	58	140.116	praseodymium	59	140.90765	neodymium	60	144.24	promethium	61	145	samarium	62	150.36	europium	63	151.964	gadolinium	64	157.25	terbium	65	158.9253	dyprosium	66	162.50	holmium	67	164.930	erbium	68	167.259	thulium	69	188.934	ytterbium	70	173.04
actinium	89	227	thorium	90	232	protactinium	91	231	uranium	92	238	neptunium	93	237	plutonium	94	244	americium	95	243	curium	96	247	berkelium	97	247	californium	98	251	escherichium	99	252	fermium	100	257	mendelevium	101	258	nobelium	102	259



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

**FINAL EXAMINATION**

**CSC 2000**  
**Computer Programming**

Date: 23<sup>rd</sup> November 2018  
Time: 14:00hrs – 17:00hrs  
Duration: 3 Hours  
Venue: P207

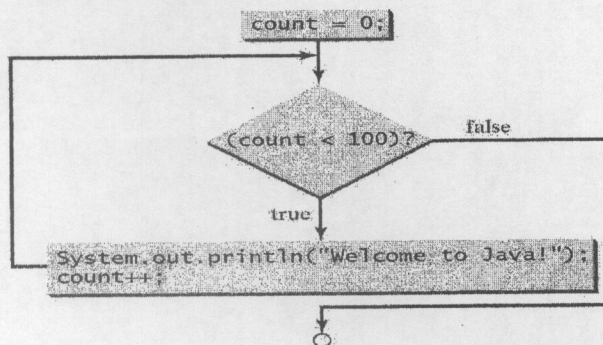
**Instructions**

1. There are **two (2)** sections in this exam paper.
2. *Answer all the questions in **Section A** and choose any three (3) questions from **Section B***

## SECTION A. Short answers (40 marks)

You are required to answer all questions in this section.

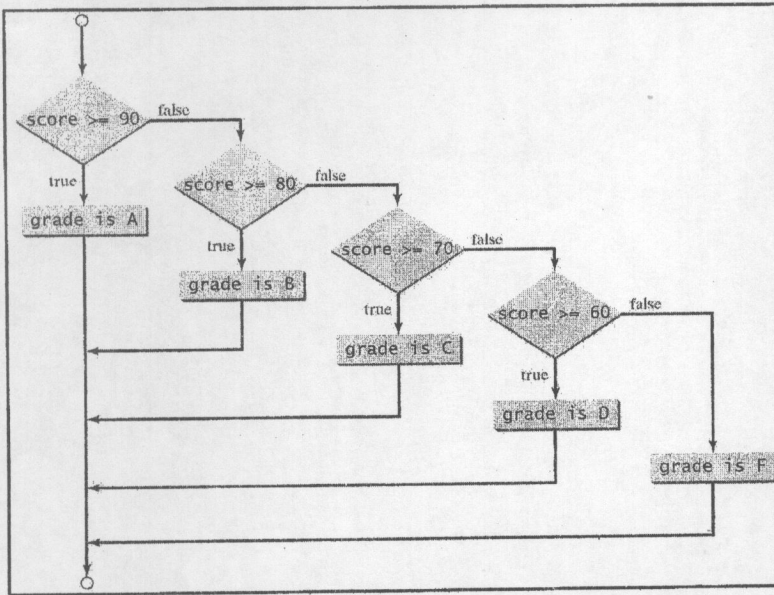
1. Illustrate and explain state transitioning of a java thread. [6 marks]
2. In Java programming an object is said to have both state and behavior. What does Java use to define state and behavior? [2 marks] ✓
3. While designing a program, a programmer notes that variable **a** needs to be accessible to all classes in the same package only, variable **b** can be accessed from anywhere, variable **c** should only be accessed from inside the same class and variable **d** is accessible only to classes in the same package and to its subclasses. All variables are of type integer. Write code to declare the variables clearly showing the access modifiers. [4 marks] ✓
4. Briefly explain the types of programming errors a programmer may encounter in java. [3 marks] ✓
5. What is the major difference between checked and unchecked exceptions? [2 marks]
6. List all the java primitives together with their size in bits. [4 marks] ✓
7. Write java code that implements the following flow chart. [3 marks] ✓



*write with class*  
*local variable*  
*instance variable*  
*public variable*

8. Briefly explain three methods for executing SQL queries using java? [3 marks]
9. What is the difference between method overriding and method overloading? [4 marks] ✓
10. While trying to write code Chibwe faces some challenges related to the scope of variables. Briefly explain the three variable types found in java to help Chibwe overcome his challenges. [3 marks] ✓
11. What are the three conditions that must be met when choosing an identifier [3 marks]

12. To assign grades to students, a programmer comes up with the following flow chart. Write java code that implements the flow chart. [3 marks] ✓



~~for (score >= 90)~~

not  
 do  
   system  
 while  
   else

~~for~~ score >= 90

System  
 else  
 for

## SECTION B (60 marks)

Answer any three (3) of the five (5) questions. Each question carries 20 marks

1. Loops are a fundamental concept in all programming languages. For this reason, java also has loop implementations.

- What is a sentinel and when does it come in useful? [3 marks]
- How do you write an infinite loop using the “while”, “for” statement? [2 marks] ✓
- Consider the following code snippet. What is wrong with the code and what would you propose as a remedy. [3 marks] ✓
- Hexadecimals are often used in computer systems programming. To convert a decimal number  $d$  to a hexadecimal number you need to find the hexadecimal digits  $h_n, h_{n-1}, h_{n-2}, \dots, h_2, h_1,$  and  $h_0$  such that

$$d = h_n \times 16^n + h_{n-1} \times 16^{n-1} + h_{n-2} \times 16^{n-2} + \dots + h_2 \times 16^2 + h_1 \times 16^1 + h_0 \times 16^0$$

These hexadecimal digits can be found by successively dividing  $d$  by 16 until the quotient is 0. The remainders are  $h_0, h_1, h_2, \dots, h_{n-2}, h_{n-1},$  and  $h_n$ .

I. Write java code for a class called MyInteger. MyInteger should have one constructor that accepts an integer as an argument. It should also have a method that returns the hexadecimal equivalent of the integer. [8 marks]

II. Write a test class for MyInteger. [4 marks]

```
double item = 1; double sum = 0;
while (item != 0) {
    sum += item;
    item -= 0.1;
}
System.out.println(sum);
```

2. Two programming students decide to meet at a restaurant between 12:00hrs and 13:00hrs. They agree that whoever arrives first should wait for the other for no more than 15 minutes. One of the students develops a concern for the possibility of them successfully meeting. Being a programming savvy he decides to write a program to estimate the probability of them meeting. For this he uses a Monte Carlo simulation.

- Monte Carlo simulations require random number generation. Which java class can be used to generate random numbers? [2 marks]
- How can a java programmer write code to make use of code written by other programmers? Write code for making sure that the class in Q2(a) is made available. [4 marks]
- Either student can arrive from the 1st to 59th minute in the 12:00-13:00 period. The students arrive at times  $x_1$  and  $x_2$ . If  $|x_1 - x_2| \leq 15$  it implies that the students meet and thus we consider this as a hit. The probability of the students meeting is

approximately  $\text{numberOfHits}/\text{numberOfTrials}$ . Assuming the students arrive between

```
public class Test {
    public static void main(String[] args) {
        int x = 1;
        int[] y = new int[10];
        m(x, y);
        System.out.println("x is " + x);
        System.out.println("y[0] is " + y[0]);
    }
    public static void m(int number, int[] numbers) {
        number = 1001;
        numbers[0] = 5555;
    }
}
```

12:00 and 13:00, write code for a class that can be used to generate MonteCarlo objects. The class should have two constructors. One for specifying the number of trials and another that sets the number of trials to 1000000. The class should also have a method for generating a random number using the same seed and also a method for invoking the experiment that returns the probability of meeting. [8 marks]

d) Write code for a class for running 10 experiments using the MonteCarlo class. The class then reports the probability as an average of running the 10 experiments. [6 marks]

3. Complete programming languages need a kind of container object that holds a fixed number of values of a single type. For this java uses arrays.

a) Write code showing how one can declare, create and initialize an array of integers in one step. [3 marks] ✓

b) Even though arrays are single typed it is sometimes necessary to work with different subtypes derived from the same supertype in the same array. Clearly explain giving an appropriate example how this can be achieved. [6 marks]

c) Java is said to pass objects by value and not by reference

I. There are important differences between passing a value of variables of primitive data types and passing arrays. What are these differences? [4 marks]

II. What is the output of the following code? [4 marks] ✓

d) A linear search algorithm compares a key element, *key*, sequentially with each element in an array. The method continues to do so until the *key* matches an element in the array or the array is exhausted without a match being found. If a match is made, the linear search returns the index of the element in the array that matches the *key*. If no match is found, the search returns -1. Write code for a method that implements a linear search algorithm. [3 marks]

Systems

4. Selections are a very useful concept in java.

- a) Using generic code, explain how a switch statement works. [6 marks]
- b) Write a program that prompts a user to enter a numerator and denominator of a fraction. The program then uses the numerator and denominator to determine whether the number is a proper fraction or an improper fraction. If it is a proper fraction, it displays the number. If not, it reduces it to a mixed fraction or to an integer. [7 marks]

- c) Write a program that prompts the user to enter the coordinates of two points  $(x_1, y_1)$  and  $(x_2, y_2)$ , and displays the line equation in the slope-intercept form, i.e.,  $y = mx + b$ .  $m$  and  $b$  can be computed using the following formula:

$$m = (y_2 - y_1)/(x_2 - x_1) \quad b = y_1 - mx_1$$

Don't display  $m$  if it is 1 and don't display  $b$  if it is 0. [7 marks]

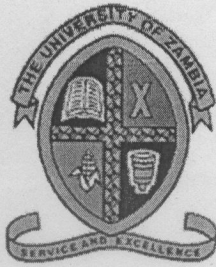
5. A programmer is planning to write a program for handling different types of cars; type A, B and C. All cars need to be able to accelerate and shift gears up. The shift gears up function gets an integer as input and returns the next gear. The acceleration function gets the time period in seconds as an integer and current speed in km/h as an integer and then returns a new speed in km/h. These basic functions should be inherited and implemented by all car types.

- a) What java construct can be used to force programmers to implement the said functions? [2 marks]
- b) Write code for establishing such a contract. [6 marks]
- c) The following table shows how the different car types implement the acceleration and shift gears up functions. It also shows some extra functionality which each car type has. The extra functionalities are safety features which stop the car (return speed 0) if the input is true (condition detected). Write code for the implementation of the three car types. [12 marks]

Car type	Type A	Type B	Type C
Acceleration function	20m/s. Maximum speed 140km/h	23m/s. Maximum speed 160km/h	27m/s. Maximum speed 240km/h
Shift gears up function	Maximum gear 4	Maximum gear 5	Maximum gear 6
Extra functionality	Can automatically break when it detects an object	Can detect stress of the driver	Can detect soberness of the driver.

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The end of the examination paper



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

**FINAL EXAMINATION**

**CSC 2000**  
**Computer Programming**

Date: 8<sup>th</sup> November 2019  
Time: 09:00hrs – 12:00hrs  
Duration: 3 Hours  
Venue: P207

**Instructions**

1. There are **two (2) sections** in this exam paper.
2. Only the java programming language should be used in this exam
3. *Answer all* the questions in **Section A** and choose *any three (3)* questions from **Section B**

## SECTION A. Short answers (40 marks)

You are required to answer all questions in this section.

1. Given the following code

```
public class Example2 {  
    public static void main(String argv[]) {  
        int a = 4;  
        int b = a-++a;  
        System.out.println(b);  
    }  
}
```

- What is the output? [2 marks]
  - Give a walk-through of how the interpreter interprets the given code taking into consideration operator precedence. [4 marks]
2. Illustrate and explain state transitioning of a java thread. [6 marks]
3. By making use of the printf method write code that outputs the following table. Do not make use of any mathematical calculations. Output the values as they literally are. [6 marks]

Degrees	Radians	Sine	Cosine	Tangent
30	0.5236	0.5000	0.8660	0.5774
60	1.0472	0.8660	0.5000	1.7321

4. A palindrome is a word that reads the same whether read from front to end or end to front. For example, the word *ANNA*. Write code for a method that gets a String as input and checks whether it is a palindrome or not. The method returns a boolean indicating whether the word is a palindrome or not. [6 marks]
5. Write Java code that implements the following UML. [10 marks]

Course	
-courseName: String	The name of the course.
-students: String[]	An array to store the students for the course.
-numberOfStudents: int	The number of students (default: 0).
+Course(courseName: String)	Creates a course with the specified name.
+getCourseName(): String	Returns the course name.
+addStudent(student: String): void	Adds a new student to the course.
+dropStudent(student: String): void	Drops a student from the course.
+getStudents(): String[]	Returns the students in the course.
+getNumberOfStudents(): int	Returns the number of students in the course.

## **SECTION B**

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This section has **THREE** Questions. Choose any two questions

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### **Question I**

- a) After completing your bachelor of computer science degree, one of the startup companies has decided to employ you. They would like you to advise management on the issues surrounding cloud computing. Management has requested that you give them a report on cloud services sourcing and concerns that come with cloud service sourcing [8 Marks].
- i. In your report to management, Give any four major reasons why **cloud sourcing** is becoming a Big Deal today why you would like the company to use this service
  - ii. In your report, highlight the major concerns that come with cloud computing sourcing
- b) Briefly discuss each of the following Prominent Components of Cluster Computers [5 Marks]
- i. State of the art Operating Systems
  - ii. High Performance Networks/Switches
  - iii. Fast Communication Protocols and Services
  - iv. Cluster Middleware
  - v. Applications and Subsystems
- c) A single system image is the illusion, created by software or hardware, that presents a collection of resources as one, more powerful resource. It makes the cluster appear like a single machine to the user, to applications, and to the network [7 Marks].
- i. Discuss the major and key benefits of a Single System Image
  - ii. What are the desired single system image services

## SECTION B [60 Marks]

**INSTRUCTIONS:** There are four questions in this section. Answer **ONLY** three. Each question carries a weight of 20 Marks.

### **Question 2 [20 Marks]**

- i. When you embark on any data mining task, the data pre-processing stage is a very important stage. It ensures data quality for data mining tasks. State and briefly describe seven (7) activities involved in the data pre-processing stage of the knowledge discovery in databases process. [7 Marks]
- ii. Discuss what is involved in the post-processing stage of the knowledge discovery in databases. State at least three activities involved. [3 marks]
- iii. Draw a well labelled diagram depicting the process of knowledge discovery in databases (KDD). [5 Marks]
- iv. State and briefly describe five (5) motivating challenges that has brought about development of data mining. [5 Marks]

### **Question 3 [20 Marks]**

- i. How is it that traditional “databases” techniques are unsuitable for data mining tasks? Give five (5) possible reasons. [5 Marks]
- ii. State five (5) challenges that most data mining engineers get to face with data for their data mining tasks? [5 Marks]
- iii. State and briefly describe three (3) characteristics of data sets that have a significant impact on the data mining techniques used. [6 marks]
- iv. State and briefly describe four (4) characteristics that describe attributes of data objects in a given data set. [4 Marks]

#### Question 4 [20 Marks]

Consider the following algorithm for finding k-nearest neighbors:

---

**for**  $i = 1$  to the *number of data objects* **do**:

-find the distances of the  $i^{\text{th}}$  object to all other objects

-sort these distances in decreasing order

(Keep track of which object is associated with each distance)

**return** the objects associated with the first K distances of the sorted list

**end for**

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- i. Describe four (4) potential problems with this algorithm if there are duplicate objects in the dataset. Assume the distance function will return a distance of 0 only for objects that are the same. [5 Marks]
- ii. What are your proposed solutions to the problems you have described in question (i) above. [5 Marks]
- iii. As you can observe, the kNN algorithm given above is for classification tasks. However, we also use kNN algorithm, with minimal modification of the algorithm in order to predict continuous variables. Your task is to modify the kNN above to make it suitable for regression tasks. [10 Marks]

#### Question 5 [20 Marks]

- i. Suppose after graduation you are employed as a data mining consultant for a financial institution like a bank. Describe how data mining can help the company by giving specific examples of how techniques, such as clustering, classification, regression, association rule mining, and anomaly detection can be applied. [20 Marks]

-- End of exam--