

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

EXAMINATION PAST PAPERS FOR 2022/2023

1. BIO1400: CELL MOLECULAR BIOLOGY AND GENETICS
2. CHE1000: INTRODUCTORY CHEMISTRY
3. CHE1010: INTRODUCTORY CHEMISTRY FOR MEDICAL AND HEALTHY SCIENCES
4. CHE2112: INTRODUCTORY BIOCHEMISTRY
5. ICT1010: COMPUTER SYSTEMS AND ARCHITECTURE
6. ICT3010: WEB AND DATABASE TECHNOLOGIES
7. ICT3020: FUNDAMENTALS OF SOFTWARE ENGINEERING AND PROJECT MANAGEMENT
8. ICT9025: MOBILE APPLICATION AND TECHNOLOGIES
9. ICT9065: FUNDAMENTALS OF MULTIMEDIA
10. MATH1110: MATHEMATICS FOR SOCIAL SCIENCES
11. MATH1100: FOUNDATION MATHEMATICS
12. MATH1120: INTRODUCTORY MATHEMATICS STATISTICS AND PROBABILITY
13. MATH2100: ANALYTICAL GEOMETRY AND CALCULUS
14. MATH2110: ENGINEERING MATHEMATICS 1
15. MATH3110: ENGINEERING MATHEMATICS 2
16. MATH4119: ENGINEERING MATHEMATICS 3
17. PHY1110: INTRODUCTORY PHYSICS
18. PHY1015: INTRODUCTORY PHYSICS FOR MEDICAL SCIENCES

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

2022 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 1400: CELL MOLECULAR BIOLOGY AND GENETICS
THEORY PAPER

DURATION: THREE HOURS

INSTRUCTIONS

1. Use the answer sheet provided to answer the questions.
 2. Answer all questions.
 3. Choose the best answer.
 4. Each correct answer carries 4 marks.
 5. Each wrong answer carries (-1) mark.
 6. A blank space carries (-1) mark.
 7. I don't know carries 0 mark.
 8. You are not allowed to communicate with other candidates during the examination.
 9. Hand over the question paper and answer sheet at the end of the examination.
-

1. Which of the following is not a property of water?
 1. It has a high surface tension.
 2. It has a high heat capacity.
 3. It requires a lot of heat energy for it to be converted from a liquid to a gas.
 4. It is a nonpolar solvent.
 5. It is dipolar.
 6. I do not know.

2. Nucleotides are composed of ...
 1. Ribose and proteins
 2. Deoxyribose and phosphate
 3. Sugar, Nitrogenous base and protein
 4. Nucleoside and phosphate
 5. Nucleoside and sugar
 6. I do not know.

3. Which of the following structures is found in both prokaryotes and eukaryotes?
 1. Golgi apparatus.
 2. Endoplasmic reticulum.
 3. Mitochondrion.
 4. Nucleus.
 5. Ribosome.
 6. I do not know.

4. Proteins are modified in the ... of the eukaryotic cell.
 1. smooth endoplasmic reticulum
 2. Golgi apparatus
 3. ribosome
 4. nucleus
 5. nucleolus
 6. I do not know.

5. Why is the amino group in proteins polar?
 1. Electrons are shared equally between nitrogen and hydrogen atoms.
 2. Nitrogen is more electronegative than hydrogen.
 3. Nitrogen forms ionic bonds with hydrogen.
 4. Nitrogen has acidic properties.
 5. Nitrogen is more electropositive than hydrogen..
 6. I do not know.

6. Identify the incorrect statement about enzymes.
 1. They are much larger than their substrates.
 2. Only a small portion of their structure is directly involved in catalysis.
 3. The lock and key model explains enzyme specificity.
 4. Enzymes work by raising activation energy needed for the reaction.
 5. Different enzymes have different amino acids arrangements in their active sites.
 6. I do not know.

PROCEED TO THE NEXT PAGE

7. Identify the structure that is not found in prokaryotic cells.
1. Plasmid
 2. Cell membrane.
 3. Mitochondrion.
 4. Ribosome
 5. Cell wall.
 6. I do not know.
8. Which of the following is not true about a transfer RNA structure?
1. D arm.
 2. T arm.
 3. Anticodon arm.
 4. Amino acid acceptor arm.
 5. The CCA sequence is found at its 5'-end.
 6. I do not know.
9. Select a statement that is true about plasma membranes.
1. All living cells are surrounded by a plasma membrane.
 2. Cells receive chemical messages from the environment through the plasma membrane.
 3. Plasma membranes have protein channels through which nutrients for the cell can pass.
 4. Cholesterol is part of plasma membranes.
 5. All the above statements are true.
 6. I do not know.
10. A prokaryotic cell lacks....
1. plasma membrane.
 2. nuclear envelope.
 3. cilia.
 4. ribosome.
 5. flagellum.
 6. I do not know.
11. Which of the following is true about enzyme cofactors?
1. Cofactors are always proteins.
 2. Enzymes can function without the presence of cofactors.
 3. Cofactors are primarily involved in stabilizing the enzyme's tertiary structure.
 4. Cofactors are essential for enzyme catalytic activity.
 5. Cofactors are carbohydrate in nature.
 6. I do not know.

TURN OVER

12. Bacterial cell wall is made up of...
1. cellulose
 2. polysaccharide *
 3. peptidoglycan ✓
 4. hem:cellulose*
 5. wax*
 6. I do not know.
13. The number of ... is equivalent to the atomic number.
1. electrons
 2. neutrons ✓
 3. shell
 4. orbitals
 5. protons
 6. I do not know.
14. Which of the following is a normal pair of nitrogenous bases of DNA?
1. Guanine and cytosine
 2. Uracil and adenine
 3. Cytosine and adenine
 4. Thymine and uracil
 5. Thymine and cytosine
 6. I do not know.
15. In the electron configuration for the oxygen atom, how many electrons occupy the second energy level?
1. 2
 2. 4
 3. 6
 4. 8
 5. 10
 6. I do not know.
16. Which of the following is not a function of the bacterial cell? *wall*
1. Gives shape and rigidity to the cell.
 2. Protects the cell from rupturing ✓
 3. Surrounds the plasma membrane
 4. Is the site of action for some antibiotics
 5. Contains genetic material.
 6. I do not know.

PROCEED TO THE NEXT PAGE

17. Choose the statement that best describes the formation of a pyranose ring in hexose sugars.

1. Carbon 1 is linked to carbon 2 through an oxygen atom..
2. Carbon 1 is linked to carbon 3 through an oxygen atom.
3. Carbon 1 is linked to carbon 4 through an oxygen atom.
4. Carbon 1 is linked to carbon 5 through an oxygen atom.
5. Carbon 1 is linked to carbon 6 through an oxygen atom..
6. I do not know.

18. Choose the statement that is false about phospholipids.

1. There is a phosphate group in the place of a fatty acid chain.
2. They have hydrophilic properties.
3. They have hydrophobic properties.
4. They cannot transport hydrophobic substances.
5. The fatty acid chains of phospholipids do not interact with water.
6. I do not know.

19. A random change in the electric charges between neutral molecules is due to ...

1. a hydrogen bond.
2. van der Waals interactions.
3. an ionic bond ✓
4. hydrophobic interactions.
5. covalent bonds.
6. I do not know.

20. When oxygen combines with hydrogen to form water it...

1. has two nonbonding pairs of electrons.
2. has one pair of electrons that do not participate in bonding.
3. forms two ionic bonds.
4. develops a net positive charge.
5. forms intramolecular hydrogen bonds with other water molecules. ✓
6. I do not know.

21. Which of the following items explains the physical and chemical properties of water?

1. Hydrogen bonding.
2. Ionic bonds.
3. The electropositive oxygen atom.
4. Non-polar covalent bonds ✓
5. van der Waals interactions.
6. I do not know.

TURN OVER

22. In an atom nucleus, the attraction of electrons to protons is by the...

1. effect of the outermost shells.
2. effect of P-orbitals only.
3. electromagnetic force. ✓
4. nuclear force.
5. neutrons.
6. I do not know.

23. Sucrose is a non-reducing sugar because of the presence of the ... glycosidic bond.

1. β 1 - 2
2. α 1 - 2
3. β 1 - 4 ~~←-4~~
4. β 1 - 4 ~~←-4~~
5. β 1 - 6
6. I do not know. ✓

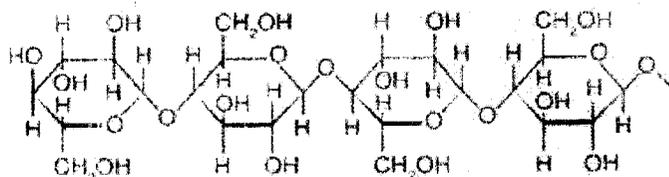
24. Which of the following is not a function of carbohydrates in living organisms?

1. Energy storage
2. Instant energy
3. Production of roughage in the human digestive system.
4. Structural support.
5. Genetic information storage. ✓
6. I do not know.

25. Water is able to expand when it freezes because of the ...

1. formation of covalent bonds
2. disruption of hydrogen bonds
3. breaking of ionic bonds
4. increase in density.
5. formation of rigid hydrogen bonds. ✓
6. I do not know.

26. The molecule below is ...



1. starch with α -1,4-linkage of galactose units. ✓
2. amylose with α -glucose units.
3. glycogen with; β -1,4-linkages of galactose
4. amylopectin with α -1,4-linkages of glucose.
5. cellulose with β 1,4 linkages of glucose molecules.
6. I do not know.

PROCEED TO THE NEXT PAGE

27. Identify the correct statement about fats.
1. Saturated fats have straight chains and are solid at room temperature.
 2. Saturated fats have straight chains and are liquid at room temperature.
 3. Unsaturated fats have bends in their chains and are solid at room temperature.
 4. Unsaturated fats have straight chains and are liquid at room temperature.
 5. Both saturated and unsaturated fats have straight chains and are liquid at room temperature.
 6. I do not know.
28. Which of the following statements is false about hydrogen bonds?
1. They are responsible for the high boiling point of water. ✓
 2. They are weaker than van der Waals forces.
 3. They are weaker than covalent bonds.
 4. They are weaker than ionic bonds.
 5. They are responsible for holding the two DNA strands together.
 6. I do not know.
29. The most common lipids in cells are...
1. phospholipids
 2. glycolipids ✓
 3. triglycerides
 4. cholesterol
 5. steroids
 6. I do not know.
30. With which of the following substances can lipids form a micelle?
1. Water. ✓
 2. Phospholipid.
 3. Glycerol.
 4. Sodium chloride solution.
 5. Sugar solution.
 6. I do not know.
31. Which of the following fatty acids is monounsaturated?
1. $C_{17}H_{32}O_2$.
 2. $C_{17}H_{35}O_2$.
 3. $C_{17}H_{34}O_2$.
 4. $C_{17}H_{36}O_2$.
 5. $C_{17}H_{37}O_2$.
 6. I do not know. ✓

TURN OVER

32. Some insects can walk on water because...
1. of the hydrophobic forces between water molecules.
 2. of adhesive forces between water molecules and the insect.
 3. of cohesive forces between water molecules.
 4. water is electrically neutral. ✗
 5. of cohesive forces between water molecules and the insect.
 6. I do not know. ✓
33. Identify the correct chemical formula for glycerol.
1. $C_3H_8O_3$
 2. C_3H-O_3
 3. $C_3H_7O_3$
 4. $C_3H_4O_3$
 5. $C_3H_1O_3$
 6. I do not know. ✓
34. Identify the incorrect statement about amino acids.
1. They have the same basic structure. ✓
 2. Each amino acid has a unique R group.
 3. They are amphoteric molecules.
 4. The R-groups are involved in peptide bond formation.
 5. The most common amino acids in proteins are α -amino acids. ✓
 6. I do not know.
35. Which of the following options represents the correct ground state electronic configuration of an atom?
1. $1s^2 2s^2 2p^7 3s^3$
 2. $1s^2 2s^2 2p^5 3s^3$
 3. $1s^2 2s^2 2p^6 3s^2$
 4. $1s^2 2s^2 2p^4 3s^2$ ✓
 5. $1s^2 2s^2 2p^6 3s^3$
 6. I do not know.
36. Which part determines the basic character of an amino acid?
1. The central carbon.
 2. Hydrogen atom.
 3. The carboxylic group.
 4. The amino group.
 5. The alkyl group. ✓
 6. I do not know.

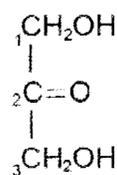
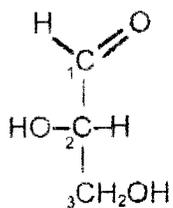
PROCEED TO THE NEXT PAGE

37. Which of the following bonds are not present in the tertiary structure of proteins?
1. Hydrogen bonds. ✓
 2. Disulfide bonds.
 3. Ionic bonds. ✓
 4. Phosphoester bonds.
 5. Peptide bonds.
 6. I do not know.
38. A protein with four peptide bonds is called ...
1. tetrapeptide ✓
 2. tripeptide
 3. dipeptide
 4. pentapeptide
 5. hexapeptide.
 6. I do not know.
39. Substances that inactivate the action of enzymes by binding to enzyme allosteric site - are referred to as ...
1. coenzymes.
 2. cofactors. ✓
 3. non-competitive inhibitors.
 4. competitive inhibitors.
 5. prosthetic groups.
 6. I do not know.
40. Which one of the following statements is correct?
1. Electrons closer to the nucleus have no energy.
 2. Electrons closer to the nucleus have higher energy. ✓
 3. Electrons further away from the nucleus have lower energy.
 4. Electrons further away from the nucleus have higher energy.
 5. Electrons further away from the nucleus have no energy.
 6. I do not know.
41. The folding of polypeptide chains into beta pleated sheets results into a ... structure.
1. tertiary
 2. secondary
 3. primary
 4. quaternary
 5. globular
 6. I do not know.

TURN OVER

42. Which of the following statements about enzymes is false?
1. Enzymes are protein in nature.
 2. Each enzyme catalyzes one specific substrate .
 3. A temperature above 40 degrees celsius can denature human enzymes.
 4. Denatured enzymes can catalyse a chemical reaction at a lower rate.
 5. Enzymes work at maximum rate under optimum conditions
 6. I do not know.
43. Which of the following pyrimidines is found in both RNA and DNA?
1. Thymine.
 2. Uracil.
 3. Cytosine.
 4. Adenine.
 5. Guanine
 6. I do not know.
44. Which of the following biological molecules is represented by the general formula $(CH_2O)_n$.
1. glucose.
 2. sucrose.
 3. starch .
 4. maltose.
 5. ribose. *de-oxyrubose*
 6. I do not know.
45. Genes which are present in the homologous region of X and Y chromosomes are ...
1. known as autosomal genes.
 2. sex linked.
 3. responsible for sex determination.
 4. unlinked.
 5. responsible for high rate of disease in males.
 6. I do not know

Use molecules A and B below and answer questions 46 and 47.



PROCEED TO THE NEXT PAGE

46. Which of the following carbons are nonreactive?
1. Carbon 2 in A and carbon 2 in B.
 2. Carbon 1 of A only.
 3. Carbon 1 of A and carbon 3 of B.
 4. Carbon 2 of B only
 5. Carbon 2 of A and carbon 3 in B.
 6. I do not know.
47. Which of the following statements is false about molecules A and B?
1. They are structural isomers of each other.
 2. Both molecules have polar bonds.
 3. Molecule A is a ketose while B is an aldose. ✓
 4. Both molecules are insoluble in a hydrophobic solvent.
 5. Both molecules are carbohydrates.
 6. I do not know.
48. Which of the following structures is not found in plants cells?
1. DNA
 2. cytoplasm.
 3. plasma membrane.
 4. Centrioles
 5. ribosomes.
 6. I do not know.
49. Out of the 20 common amino acids, only ... is optically inactive because its side chain ...
1. alanine; is a simple methyl group.
 2. glycine; is a hydrogen atom.
 3. cysteine; contains Sulphur
 4. glutamic acid; has a hydrogen atom.
 5. proline; is a methyl group.
 6. I do not know.
50. Choose the false statement about the structure of RNA.
1. It is a single polynucleotide chain.
 2. Ribose is part of RNA structure.
 3. In some cases RNA chains can fold into complex structures.
 4. Folded portion of RNA are held by hydrogen bonds.
 5. Thymine is part of RNA structure.
 6. I do not know.

TURN OVER

Using the provided Genetic code table on page 21, answer questions 51 and 52.

51. Which of the following represents the Wobble hypothesis?
1. The codon UUU may pair with the anticodon UUA.
 2. The codon UUU may pair with the anticodon AAA.
 3. The codon UUU may pair with the anticodon TTT.
 4. The codon UUU may pair with the anticodon AAT.
 5. The codon UUU may pair with the anticodon AAG.
 6. I do not know.
52. Which of the following represents the codon, anticodon and DNA bases for tryptophan?
1. UGG, ACC, TGG.
 2. UGG, ACC, ACC.
 3. UGA, ACC, ACT.
 4. AUG, AUC, ATC.
 5. AUG, UAC, TAC.
 6. I do not know.
53. In a dihybrid cross involving the genotypes AaBb and aabb (A: dominant for purple stem, a: recessive for green stem, B: short petals, b: long petals), the phenotypes produced are 220 (purple stem with short purple), 231 (purple stem with long petals), 210 (green stem with short petals) and 239 (green stem with long petals) plants. Using the phenotypic ratio of 1:1:1:1 and the chi-squared distribution table provided on page 21, what is the conclusion about the genes involved in stem colour and length of the petals?
1. ~~The genes are linked and~~ assort independently.
 2. The genes are unlinked and do not assort independently.
 3. The genes are linked and do not assort independently.
 4. The genes are unlinked and assort independently.
 5. The genes are linked and assort independently.
 6. I do not know.
54. Choose the correct statement about the role of helicase during DNA replication.
1. It breaks hydrogen bonds between base pairs to separate the two strands of DNA.
 2. It catalyzes formation of phosphodiester bonds.
 3. It generates primers.
 4. It proofreads newly formed DNA.
 5. It joins Okazaki fragments
 6. I do not know.

PROCEED TO THE NEXT PAGE

55. Hemophilia is caused by.... allele carried by the X chromosome.
1. incomplete dominant
 2. codominant
 3. lethal allele
 4. dominant
 5. recessive
 6. I do not know.
56. Which of the following is not a chemical mutagen?
1. Intercalating agent.
 2. Base analogue.
 3. Alkylating agent. *
 4. Ultraviolet radiation. *
 5. Deaminating agent. *
 6. I do not know.
57. DNA ligase
1. Removes supercoils from the DNA molecule.
 2. Covalently joins two adjacent nucleotides.
 3. Initiates DNA replication.
 4. Identifies the origin of replication.
 5. Is involved in proofreading.
 6. I do not know.
58. Identify the incorrect statement about meiosis.
1. Enables maintenance of chromosome number of a species.
 2. Introduces genetic variation in species.
 3. Produces gametes which are genetically different.
 4. Gives rise to four haploid daughter cells.
 5. Enables organisms to grow and replace old cells.
 6. I do not know.
59. The... sequence indicates the starting point of transcription.
1. terminator
 2. promoter
 3. operator
 4. regulator
 5. structural gene
 6. I do not know.
60. Which of the following is an example of a qualitative trait in humans?
1. Blood group. ✓
 2. Height.
 3. Intelligence.
 4. Skin colour.
 5. Body weight.
 6. I do not know.

TURN OVER

61. The yellow fur allele in mice is dominant over the grey allele. It was observed that when two yellow mice were crossed, offspring had a phenotypic ratio of 2 yellow: 1 grey instead of the Mendelian 3:1 ratio. The results suggest that the trait for fur colour is controlled by
1. quantitative trait inheritance
 2. multiple alleles.
 3. lethal alleles
 4. co dominant alleles
 5. incompletely dominant alleles.
 6. I do not know.
62. Identify the enzyme associated with the initiation of transcription.
1. DNA polymerase I. ✓
 2. DNA polymerase II.
 3. Amino acid synthetase.
 4. RNA ligase.
 5. RNA polymerase.
 6. I do not know.
63. The presence of a methylated guanine head on an RNA molecule indicates
1. exons which must be removed. ✓
 2. a newly synthesized tRNA molecule.
 3. the initiation of transcription.
 4. a mature tRNA molecule.
 5. a mature mRNA molecule.
 6. I do not know.
64. When performing a dihybrid cross between two heterozygous individuals (AaBb x AaBb), what is the probability of obtaining an offspring with the genotype AaBb?
1. $\frac{1}{4}$
 2. $\frac{1}{8}$
 3. $\frac{1}{16}$
 4. $\frac{3}{16}$
 5. $\frac{9}{16}$
 6. I do not know.
65. In eukaryotic cells, transcription cannot begin until,....
1. The two DNA strands have completely separated and exposed the promoter.
 2. The sigma factor has bound to the promoter.
 3. The 5' caps are removed from the template DNA.
 4. DNA polymerase attaches to the promotor.
 5. The introns are removed from the DNA template
 6. I do not know.

PROCEED TO THE NEXT PAGE

66. Determine the number of amino acids that would be specified from the mRNA sequence:
5'-AUGAAACGGUU-3'
1. 2
 2. 3
 3. 4
 4. 5
 5. 6
 6. I do not know.
67. A cross between an individual with a dominant phenotype with another one with a recessive phenotype is called a ... cross.
1. monohybrid.
 2. test
 3. reciprocal
 4. dihybrid cross
 5. heterozygous
 6. I do not know.
68. During translation, each target amino acid is activated by ATP using ...
1. aminoacyl-tRNA synthetase.
 2. peptidyl transferase.
 3. initiation factors.
 4. elongation factors.
 5. release factors.
 6. I do not know.
69. During the process of translation ...
1. the growing poly peptide is passed from the P-site to A-site.
 2. all incoming tRNA must first bind to the P-site.
 3. initiation begins with the binding of the ribosome to the start anticodon.
 4. the message on tRNA is translated into a polypeptide.
 5. termination is achieved by the binding of tRNA to the stop codon.
 6. I do not know.
70. Choose a statement, which is incorrect about prokaryotic DNA replication.
1. It starts at the origin of replication.
 2. DNA helicase creates the replication fork.
 3. It starts at any random location.
 4. Proteins called dnaA bind to the origin of replication.
 5. DNA polymerase synthesizes the DNA molecule in the 5' to 3' direction.
 6. I do not know.

TURN OVER

71. Initiation of DNA replication takes place at the ...
1. promotor sequence after the binding of the enzyme topoisomerase.
 2. origin of replication after the binding of dnaA protein.
 3. promotor sequence after the binding of DNA protein.
 4. origin of replication after the binding of single strand binding protein.
 5. origin of replication after the binding of the enzyme helicase.
 6. I do not know.
72. The enzyme amino acyl- tRNA synthetase
1. synthesizes tRNA.
 2. activates the target amino acid.
 3. attaches an amino acid to mRNA.
 4. synthesizes mRNA.
 5. activates the target tRNA.
 6. I do not know.
73. Expression of a gene involves...
1. the process of replication only.
 2. the process of translation only.
 3. the processes of DNA replication and trascription.
 4. the processes of transcription and translation.
 5. the processes of replication and translation.
 6. I do not know.
74. Which of the following can result in a stop codon?
1. Neutral mutation.
 2. Missense mutation.
 3. Silent mutation.
 4. Frameshift mutation.
 5. Nonsense mutation.
 6. I do not know.
75. Association of DNA and histone is mediated by....
1. covalent bonding.
 2. ionic bonding.
 3. hydrogen bonding
 4. hydrophobic interaction.
 5. van der Waals interaction
 6. I do not know.
76. Which one of the following is the longest phase of meiosis?
1. Prophase II.
 2. Metaphase I.
 3. Telophase I.
 4. Prophase I.
 5. Metaphase II.
 6. I do not know.

PROCEED TO THE NEXT PAGE

77. Choose the correct statement for multiple alleles (blood group) in humans.

1. I^A is dominant to I^B .
2. I^B is dominant to I^A .
3. I^O is codominant to I^A .
4. I^A is codominant to I^B .
5. I^O is codominant to I^B .
6. I do not know.

78. The ... is not part of the post-translational modification.

1. removal of some amino acids
2. addition of alkyl groups to amino acids
3. attachment of activated amino acids to tRNA
4. addition of oligosaccharides
5. enzymatic processing of primary RNA
6. I do not know.

79. Sickle cell anaemia is a result of a mutation involving the substitution of ... for valine in the haemoglobin β -chain.

1. methionine
2. alanine
3. glutamic acid
4. glutamine
5. glycine
6. I do not know.

80. The growth of a cell starts with the ... of the cell cycle.

1. G_0 phase.
2. M phase.
3. S phase.
4. G_1 phase
5. G_2 phase
6. I do not know.

81. Which of the following laws of inheritance apply universally?

1. The Law of Dominance
2. The Law of Segregation
3. The Law of Independent Assortment.
4. The Laws of segregation and independent assortment
5. The Laws of dominance and segregation
6. I do not know.

TURN OVER

82. A woman of blood group A has a child whose blood group is O. Which one of the following is the possible blood group of the child's father?
1. A or AB
 2. B or AB
 3. O or AB
 4. O only
 5. A or B or O
 6. I do not know.
83. Which of the following is a characteristic of the G_0 phase of the cell cycle?
1. Active cell division
 2. Rapid DNA synthesis
 3. Resting and non-dividing state
 4. Formation of two daughter cells
 5. High mitotic index.
 6. I do not know.
84. The role of mRNA is to ..
1. speed up the process of protein synthesis.
 2. translate the genetic code into a specific amino acid.
 3. transmit genetic information for protein synthesis.
 4. modify newly synthesized proteins.
 5. provide information needed for DNA synthesis.
 6. I do not know.
85. Identify the number of homologous pairs of chromosomes in humans.
1. 46.
 2. 23.
 3. 92.
 4. 44.
 5. 22.
 6. I do not know.
86. Choose the statement that is correct about RNA splicing during post-transcriptional modifications in eukaryotes.
1. The 3' end of the RNA transcript is replaced with 7-methylguanosine.
 2. There is addition of poly adenine to the 3' end of the RNA transcript.
 3. The RNA transcript is elongated.
 4. There is removal of introns.
 5. There is removal of exons.
 6. I do not know.

PROCEED TO THE NEXT PAGE

87. Which of the following statements is not correct about the transcription process?
1. DNA is transcribed into RNA. ✓
 2. In eukaryotes one mRNA transcribes several genes.
 3. In prokaryotes one mRNA transcribes several genes.
 4. The immediate product of transcription is a primary transcript.
 5. Capping and polyadenylation process are necessary to protect the primary transcript.
 6. I do not know.
88. In a family of four including a normal mother, a normal father, a colour blind son and a normal son, which other member of the family carries the colour blindness allele?
1. The father
 2. The mother
 3. The normal son
 4. The mother and the normal son.
 5. The father and the mother.
 6. I do not know.
89. Which of the following is not true about the role of mRNA during the process of translation?
1. It carries the genetic code derived from template DNA.
 2. Three bases in mRNA constitute a codon, which specifies a particular amino acid.
 3. The mRNA sequence is used to assemble a chain of amino acids that form a protein.
 4. The mRNA is a nonlinear molecule and varies in length according to length of polypeptide that it codes for.
 5. The message on mRNA is translated in the 5' to 3' direction. in .
 6. I do not know.
90. Crossing over, an important genetic event in meiosis, takes place during ..., where chromatids of homologous chromosomes exchange genetic material, increasing genetic....
1. prophase I, diversity
 2. metaphase I, stability
 3. anaphase I, mutation
 4. telophase I, uniformity
 5. interphase I, replication
 6. I do not know.
91. If H is for tall trait which is dominant and h is the recessive trait for short, which of the following cross will result in 1 tall: 1 short progeny?
1. HH X hh
 2. Hh X Hh
 3. Hh X hh
 4. HH X Hh
 5. hh X hh
 6. I do not know.

TURN OVER

92. X-linked genetic disorders are much more common in males because...
1. males have only a single copy of X chromosome.
 2. males are not hemizygous for X-linked genes.
 3. of high levels of testosterone in males.
 4. of their non X-linked inheritance pattern.
 5. X-linked genes have the same inheritance patterns with autosomal genes.
 6. I do not know.

Use the information below to answer questions 93 to 95 that follow. The Chi squared table is provided on page 21.

A male fruit fly (*Drosophila melanogaster*) with red eyes and long wings (RRLl) was mated with a female with purple eyes and vestigial wings (rrll). All of the offspring in the F1 generation has red eyes and long wings. These F1 flies were crossed with purple-eyed, vestigial winged flies. Their offspring, the F₂ generation appeared as indicated below:

- 41 red eyes, long wings
- 38 purple eyes, vestigial wings
- 39 purple eyes, long wings
- 42 red eyes, vestigial wings

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

93. The calculated chi-squared value is ...

1. 0
2. 10
3. 6
4. 0.25
5. 0.5
6. I do not know.

94. The tabulated chi squared valued at 5% (0.05) is ...

1. 3.841
2. 5.991
3. 7.815
4. 9.488
5. 11.070
6. I do not know.

95. The results of this cross ...

1. agree with the Mendelian's F₂ dihybrid ratio
2. suggest that two genes with alleles R, r, and L, l are on different chromosomes
3. suggest that the two genes are on the same chromosome.
4. suggested that the differences between the observed and expected numbers of offspring are significant.
5. The deviation in the observed and expected numbers of offspring is not attributed to chance.
6. I do not know.

PROCEED TO THE NEXT PAGE

96. In the human ABO blood group with three alleles, I^A , I^B and I^O , what is the number of possible genotypes and phenotypes?
1. 3 genotypes and 2 phenotypes.
 2. 4 genotypes and 6 phenotypes.
 3. 6 genotypes and 4 phenotypes.
 4. 3 genotypes and 6 phenotypes.
 5. 12 genotypes and 4 phenotypes.
 6. I do not know.
97. Which of the following does not bring about variation in organisms?
1. Recombination.
 2. Meiosis.
 3. Sexual reproduction.
 4. Crossing over.
 5. Independent assortment.
 6. I do not know.
98. Why do X-linked recessive traits appear more often in males than in females?
1. All alleles of the traits on the X-chromosome are dominant in males.
 2. Males can only inherit the traits from the mother and not from the father.
 3. A single recessive allele on the X chromosome will always produce the trait in a male.
 4. Males have two alleles of the trait on their X chromosome.
 5. Females can only inherit the trait from the father and not the mother.
 6. I do not know.
99. What is the difference between DNA in bacteria and the one in eukaryotic cells?
1. Prokaryotic DNA is single stranded; Eukaryotic DNA is a double helix
 2. Prokaryotic DNA contains uracil; Eukaryotic DNA has thymine instead
 3. Prokaryotic DNA is a plasmid; Eukaryotic DNA is circular
 4. Prokaryotic DNA is circular; Eukaryotic DNA is a straight chain
 5. Prokaryotic DNA and eukaryotic DNA are the same
 6. I do not know.
100. During mitosis, the chromatids of a chromosome are held together by a structure called the...
1. centrosome
 2. centromere
 3. spindle fibres
 4. cytoplasm
 5. chiasma
 6. I do not know.

TURN OVER

Table 1. Genetic code

		Second Position					
		U	C	A	G		
First Position	U	UUU } Phe UUC } UUA } Leu UUG }	UCU } UCC } Ser UCA } UCG }	UAU } Tyr UAC } UAA } Stop UAG } Stop	UGU } Cys UGC } UGA } Stop UGG } Trp	U C A G	Third Position
	C	CUU } CUC } Leu CUA } CUG }	CCU } CCC } Pro CCA } CCG }	CAU } His CAC } CAA } Gln CAG }	CGU } CGC } Arg CGA } CGG }	U C A G	
	A	AUU } AUC } Ile AUA } AUG } Met	ACU } ACC } Thr ACA } ACG }	AAU } Asn AAC } AAA } Lys AAG }	AGU } Ser AGC } AGA } Arg AGG }	U C A G	
	G	GUU } GUC } Val GUA } GUG }	GCU } GCC } Ala GCA } GCC }	GAU } Asp GAC } GAA } Glu GAG }	GGU } GGC } Gly GGA } GGG }	U C A G	

Table 2. Chi-square table

The probabilities associated with values of χ^2

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

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2022/2023 ACADEMIC YEAR
FINAL EXAMINATION

CHE1000: Introductory Chemistry
TIME: Three (03) hours

INSTRUCTIONS TO THE CANDIDATES

1. Indicate your **student ID number** and **TG number** on each of your answer booklets.
2. The Exam consists of three (3) sections: **A, B** and **C**
3. Section **A** has twenty (20) multiple choice questions. Each question carries two (2) marks. (Total marks = 40).
4. Section **B** has ten (10) final answer only questions. Each question carries two (2) marks. (Total marks = 20).
5. Section **C** has one (1) Lab question carrying 10 marks and six (6) show your questions carrying five (5) marks each. (Total marks = 40).
6. **ATTEMPT ALL QUESTIONS IN ALL SECTIONS.**
7. **FOR SECTION A, ANSWERS MUST BE GIVEN IN THE ANSWER GRID PROVIDED**
8. **FOR SECTION B AND C, ANSWERS MUST BE GIVEN IN THE ANSWER BOOKLETS PROVIDED.**
9. **ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY WHERE NECESSARY.**

INFORMATION TO THE CANDIDATES:

1. Periodic table is printed on the last page.

<u>USEFUL DATA</u>	<u>Universal Gas Constant R</u>
Avogadro's constant, N_A	$8.3145 \text{ J mol}^{-1} \text{ K}^{-1}$
Molar volume of gas at S.T.P	$8.3145 \text{ k Pa L K}^{-1} \text{ mol}^{-1}$
Planks constant, h	$0.083145 \text{ L bar mol}^{-1} \text{ K}^{-1}$
Rydberg constant, R_H	$0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$
Speed of light in a vacuum, c	$62.364 \text{ L torr mol}^{-1} \text{ K}^{-1}$
Mass of an electron	$62.364 \text{ L mmHg mol}^{-1} \text{ K}^{-1}$
1 electron volt	
1 Joule, J	
1 Faraday, F.	
1 Volt, V	
$6.022 \times 10^{23} \text{ mol}^{-1}$	
$22.4 \text{ dm}^3 \text{ mol}^{-1}$	
$6.626 \times 10^{-34} \text{ Js}$	
$1.097 \times 10^7 \text{ m}^{-1} / 2.178 \times 10^{-18} \text{ J}$	
$3.00 \times 10^8 \text{ ms}^{-1}$	
$9.11 \times 10^{-31} \text{ Kg}$	
$1.602 \times 10^{-19} \text{ J}$	
$1 \text{ J} = 1 \text{ kg. m}^2. \text{ s}^{-2}$	
96485 C mol^{-1}	
1 J C^{-1}	
<u>Pressure</u>	<u>STP:</u>
$1 \text{ atm} = 1.01325 \times 10^5 \text{ Pa} = 1.01325 \times 10^5 \text{ N m}^{-2}$	Temperature
= 760 torr	273.15 K
= 760 mmHg	Pressure
= 1.01325 bar	1.00 atm
$1 \text{ bar} = 1.00000 \times 10^5 \text{ Pa} = 1.00000 \times 10^5 \text{ N m}^{-2}$	

SECTION A (MULTIPLE CHOICE QUESTIONS)

Answer ALL questions on the answer grid provided. Each question carries 2 marks.

A 1. In the balanced molecular equation for the neutralization of sodium hydroxide with sulfuric acid, the products are:



A 2. The mass in grams of 2.6×10^{22} chlorine atoms is:

[A] 4.4 [B] 11 [C] 0.76 [D] 1.5

A 3. A real gas most closely approaches the behaviour of an ideal gas under conditions of:

[A] high P and low T [B] low P and high T [C] low P and low T [D] high P and high T

A 4. Which of the following electromagnetic waves has the highest frequency?

[A] Radio waves [B] X-rays [C] Gamma rays [D] Infra-red

A 5. The table below shows the colours of light emitted when an electron in hydrogen atom makes transitions at a certain wavelength.

Colour of light	Wavelength (nm)
Blue	435
green	486
Orange	657
Yellow	570

What colour of light is emitted when an excited electron in the hydrogen atom falls from $n = 5$ to $n = 2$.

[A] Blue [B] Green [C] Orange [D] Yellow

A 6. Generally, across a period of the periodic table from left to right, the first ionization energy increases. This is due to the:

[A] Increase in effective nuclear charge. [B] Increase in atomic radius.
[C] Increase in shielding effect. [D] Decrease in number of electrons.

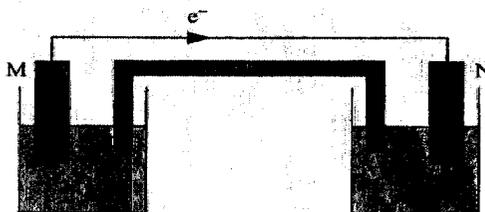
A 7. Which one of the following violates the octet rule?

[A] PCl_3 [B] CBr_4 [C] OF_2 [D] AsF_5

A 8. The half-life for a first-order reaction is 32 s. What was the original concentration if, after 2.0 minutes, the reactant concentration is 0.062 M?

[A] 0.84 M [B] 0.069 M [C] 0.091 M [D] 0.075 M

A 9. Which of the following is true of the electrochemical cell represented below?

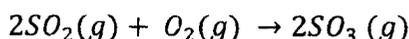


- [A] Metal M is being oxidised
 [B] Metal N is the reducing agent
 [C] N^{2+} ions are being oxidised
 [D] M^{2+} ions are being reduced

A 10. A chemical reaction that absorbs heat from the surroundings is said to be _____ and has a _____ ΔH at constant pressure.

- [A] endothermic, positive
 [B] endothermic, negative
 [C] exothermic, negative
 [D] exothermic, positive

A 11. Calculate the change in enthalpy (ΔH_{rxn}^\ominus) for the reaction of sulphur dioxide and oxygen



given the following data

Molecule	ΔH_f^\ominus (KJ/mol)
SO_2	-296.8
O_2	0.00
SO_3	-395.7

- [A] -98.9 KJ [B] -197.8 KJ [C] 197.8 KJ [D] Not enough information given.

A 12. Which of the following has highest boiling point?

- [A] Helium [B] Neon [C] Krypton [D] Argon

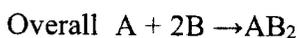
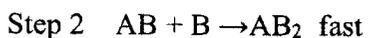
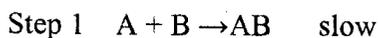
A 13. What is the triple point in a phase diagram?

- [A] The point where the temperature and pressure conditions are fixed for all three physical states
 [B] The point on the graph where supercritical fluid is found
 [C] The point on the graph where solid and gas are in equilibrium
 [D] The point where sublimation takes place

A 14. Sea water is dangerous to drink because seawater is _____ to your body tissues and can cause you to lose water.

- [A] isotonic [B] hypertonic [C] hygroscopic [D] hypotonic

A 15. Suppose the reaction: $A + 2B \rightarrow AB_2$ occurs by the following mechanism:



The rate law expression must be Rate = _____.

- [A] $k[A]$ [B] $k[A][B]^2$ [C] $k[A][B]$ [D] $k[AB][B]$

A 16. Calculate the equilibrium constant for the reaction of O_2 with N_2 to give NO at 423K given that $\Delta G^\circ = +22.7\text{KJ/mol}$.

- [A] 6.45×10^{-3} [B] 2.58×10^{-3} [C] 1.58×10^{-3} [D] 5.8×10^{-3}

A 17. What is the pH of an aqueous solution at 25°C that contains $3.98 \times 10^{-9}\text{ M}$ hydroxide ion?

- [A] 7.0 [B] 9.0 [C] 5.6 [D] 8.4

A 18. Which of the following combinations **cannot** produce a buffer solution?

- [A] HNO_2 and NaNO_2 [B] HCN and NaCN [C] HClO_4 and NaClO_4 [D] NH_3 and $(\text{NH}_4)_2\text{SO}_4$

A 19. Hybridization of carbon in a carbanion is:

- [A] sp hybridized [B] sp^2 hybridized [C] sp^3 hybridized [D] None of these

A 20. Select the correct structure of 2-methyl propanal:

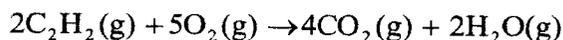
- [A] CH_3CHO [B] $\text{CH}_3\text{CH}_2\text{CHO}$ [C] $\text{CH}_3\text{CH}(\text{CH}_3)\text{CHO}$ [D] $(\text{CH}_3)_2\text{CHCH}_2\text{CHO}$

[TOTAL: 40 MARKS]

SECTION B (FINAL ANSWER ONLY QUESTIONS)

Answer ALL questions. Each question carries 2 marks.

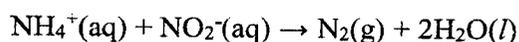
- B 1. A sample of 1.00L of C_2H_2 at a temperature of 373.15 K and pressure of 1.00 atmospheres reacted completely with oxygen according to the reaction:



Use the ideal gas equation to calculate the initial moles of C_2H_2

- B 2. Using shorthand notation, write down the electron configuration of copper (II) ion.
- B 3. Consider an electrochemical cell with the following half-reactions:
- $$Ag^+(aq) + e^- \rightarrow Ag(s) \text{ (reduction)} \quad E^\circ_{(Ag^+/Ag)} = +0.80 \text{ V}$$
- $$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^- \text{ (oxidation)} \quad E^\circ_{(Zn^{2+}/Zn)} = -0.76 \text{ V.}$$
- Given that $[Ag^+] = 0.01 \text{ M}$, $[Zn^{2+}] = 1.0 \text{ M}$, Calculate the potential of this electrochemical cell.
- B 4. A system releases 125 kJ of heat while 104 kJ of work is done on it. Calculate ΔE .
- B 5. Name the intermolecular force of attraction resulting from the shift of electron cloud setting up instantaneous dipoles.
- B 6. What is the vapor pressure of an aqueous solution that has a solute mole fraction of 0.1000? The vapor pressure of water is 25.756 mmHg at 25 °C.
- B 7. Substances in a pure state have a higher freezing point than the solutions containing dissolved solute particles. Which colligative property is demonstrated by the given statement?

- B 8. Given the following data for this reaction:



EXPT	$[NH_4^+]$	$[NO_2^-]$	RATE
1	0.010 M	0.020 M	0.020 M/s
2	0.015 M	0.020 M	0.030 M/s
3	0.010 M	0.010 M	0.005 M/s

Determine the rate law for the reaction.

- B 9. Given that the K_{sp} of AgCl at 25° C is 2.8×10^{-10} . Calculate the solubility in mol/L.

B 10. Write the equilibrium constant, K_c expression for the reaction below:



SECTION B TOTAL MARKS = 20 MARKS

SECTION C (SHOW YOUR WORKING)

Answer **ALL** questions.

Question C1 carries 10 marks and **ALL** other questions carry 5 marks each.

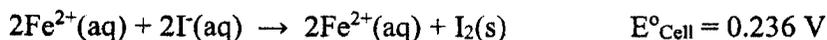
C 1. Laboratory question

- (a) In a titration experiment 25.00 cm^3 of Hydrochloric acid was pipetted out and transferred to a 250 cm^3 volumetric flask and made up to mark. Write in two brief sentences how you make up this solution. [2 marks]
- (b) A 25 cm^3 of the made-up solution was taken in a conical flask and titrated against 0.1 mol/dm^3 Sodium hydroxide solution taken in burette.
- (i) Suggest an indicator that can be used for this titration experiment. [1 mark]
- (ii) If Hydrochloric acid reacts with Sodium hydroxide react in 1:1 ratio and a mean titre of 30.00 cm^3 was obtained, calculate the number of moles in the mean titre. [2 marks]
- (iii) Calculate the concentration of dilute acid used in the titration experiment. [2 marks]
- (iv) Calculate the concentration of undiluted acid. [3 marks]

C 2. The brilliant red color seen in fireworks displays is due to $4.62 \times 10^{14} \text{ Hz}$ strontium emission. Calculate:

- a) The wavelength of light emitted in nanometers.
b) The photon energy emitted in joules.

C 3. Given an electrochemical cell in which the following reaction is occurring at 25°C :

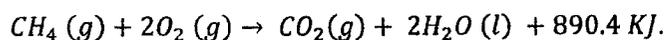


Deduce whether this reaction proceeds spontaneously or not and calculate the equilibrium constant of the electrochemical reaction. [5 marks]

C 4.

- a) A 6.22 kg piece of copper metal is heated from 20.5°C to 324.3°C . Calculate the heat absorbed (in kJ) by the metal, given that the specific heat capacity of copper is $0.385 \text{ J/g}\cdot^\circ\text{C}$. [2 marks]

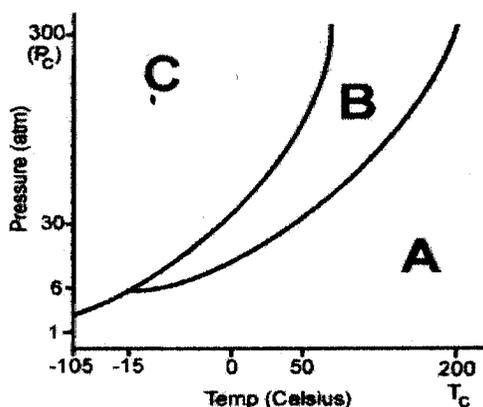
- b) The complete combustion of methane produces carbon dioxide and water is given below:



Draw a labeled energy profile diagram for the reaction.

[3 mark]

- C 5. Phase diagram of a hypothetical substance is given below:



- (i) The area of the graph that represents the solid phase is..... [1 mark]
 (ii) A phase change from Phase B to Phase A is known as..... [1 mark]
 (iii) At 30 atmospheres pressure, the boiling point of this substance is..... [1 mark]
 (iv) At what temperature and pressure does the triple point of this substance occur? [1 mark]
 (v) If the temperature of the substance is held constant at -15°C , the phase change that would occur with an increase of pressure from 1 atmosphere to 30 atmospheres is... [1 mark]

- C 6. Magnesium fluoride dissolves in water to the extent of 0.00170 g per 100 mL. Calculate the K_{sp} for this compound (MgF_2). [5 mark]

- C 7. Consider the following reaction given below:



- a) Write the structure of the organic product. [1 mark]
 b) Name the product. [1 mark]
 c) Name this type of reaction. [1 mark]
 d) Is this a unimolecular ($\text{SN}1$) or bimolecular ($\text{SN}2$) mechanism type of reaction? [1 mark]
 e) Identify the nucleophile and electrophile, by writing their structures respectively. [1 mark]

[TOTAL: 40 MARKS]

END OF EXAMINATION

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

hydrogen 1 H	beryllium 4 Be	lithium 3 Li	sodium 11 Na	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	boron 5 B	carbon 6 C	nitrogen 7 N	oxygen 8 O	fluorine 9 F	helium 2 He
1.00794	9.012182	6.941	22.98977	39.0983	40.078	44.95591	47.887	50.9415	51.9961	54.93805	55.845	58.9332	58.6934	63.546	65.409	10.811	12.0107	14.00674	15.9994	18.9984	4.002602
																aluminium 13	silicon 14	phosphorus 15	sulphur 16	chlorine 17	argon 18
																gallium 31	germanium 32	arsenic 33	selenium 34	bromine 35	krypton 36
																indium 49	tin 50	antimony 51	tellurium 52	iodine 53	xenon 54
																thallium 81	lead 82	bismuth 83	polonium 84	astatine 85	radon 86
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																cadmium 48	silver 47	palladium 46	rhodium 45	ruhenium 44	technetium 43
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
																mercury 80	gold 79	platinum 78	iridium 77	osmium 76	rhodium 45
				</																	

TEST 1 SECTION A
ANSWER GRID

In this section, put a cross (x) or a tick (√) in the appropriate box to indicate your answer. If the cross or tick is on the dividing line, it will not be counted.

Q. No.	[A]	[B]	[C]	[D]
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2022/2023 ACADEMIC YEAR

FINAL EXAMINATION

CHE1010: Introductory Chemistry for Medical and Health Sciences

TIME: Three (3) Hours

INSTRUCTIONS TO THE CANDIDATES

1. Indicate your **student ID number** and **TG number** on all the Answer Booklets provided.
2. The examination consists of three (3) sections: **A, B** and **C**
3. Section **A** has twenty (20) multiple choice questions. Each question carries two (2) marks. (Total marks = 40). Answer Grid is provided for multiple choice questions.
4. Section **B** has ten (10) **final answer only** questions. Each question carries two (2) marks. (Total marks = 20).
5. Section **C** has one (1) Lab question carrying **10 marks** and six (6) show your work questions carrying five (5) marks each. (Total marks = 40).
6. **ATTEMPT ALL QUESTIONS IN ALL SECTIONS.**
7. **ANSWERS MUST BE MADE IN THE PROVIDED ANSWER BOOKLET.**
8. **ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.**

INFORMATION TO THE CANDIDATES:

1. **Periodic table and Analytical Data sheet are given.**

2. **USEFUL DATA**

Avogadro's constant, N_A	$6.022 \times 10^{23} \text{ mol}^{-1}$
Molar volume of gas at S.T.P	$22.4 \text{ dm}^3 \text{ mol}^{-1}$
Planks constant, h	$6.626 \times 10^{-34} \text{ Js}$
Rydberg constant, R_H	$1.097 \times 10^7 \text{ m}^{-1} / 2.178 \times 10^{-18} \text{ J}$
Speed of light in a vacuum, c	$3.00 \times 10^8 \text{ ms}^{-1}$
Mass of an electron	$9.11 \times 10^{-31} \text{ Kg}$
1 electron volt	$1.602 \times 10^{-19} \text{ J}$
1 Joule = 1 J = 1 kg. m ² . s ⁻²	
1 Faraday (F) = 96485 C mol ⁻¹	

Universal Gas Constant R

Pressure

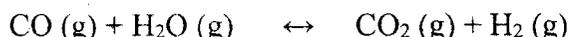
8.3145 J mol ⁻¹ K ⁻¹	1 atm = $1.01325 \times 10^5 \text{ Pa}$
8.3145 k Pa L K ⁻¹ mol ⁻¹	= $1.01325 \times 10^5 \text{ N m}^{-2}$
0.083145 L bar mol ⁻¹ K ⁻¹	= 760 torr
0.08206 L atm mol ⁻¹ K ⁻¹	= 760 mmHg
62.364 L torr mol ⁻¹ K ⁻¹	= 1.01325 bar
62.364 L mmHg mol ⁻¹ K ⁻¹	1 bar = $1.00000 \times 10^5 \text{ Pa}$
	1 bar = $1.00000 \times 10^5 \text{ N m}^{-2}$

Section A

Answer ALL Section A questions on the Answer Grid

- A1. The limiting reagent in a chemical reaction is one that:
(a) has the largest molar mass (b) is consumed completely
(c) has the smallest molar mass (d) is a primary standard
- A2. Which of the following is NOT an empirical formula?
(a) $C_6H_{14}O$ (b) $C_6Na_2O_6$ (c) $C_{14}H_8O_5$ (d) $C_4H_8N_3$
- A3. Of the following atoms, which has the lowest electron affinity?
(a) F (b) Si (c) O (d) Ca
- A4. Of the following ions, which one has the smallest radius?
(a) K^+ (b) Ca^{2+} (c) Sc^{3+} (d) Rb^+
- A5. The molecular geometry of thionyl chloride, $SOCl_2$, by application of VSEPR is:
(a) Trigonal planar (b) T-shaped (c) Tetrahedral (d) Trigonal pyramid
- A6. A biomedical scientist used a syringe to collect only one sample of blood from an HIV patient for the determination of viral load. In relation to sampling, what type of sample did the biomedical scientist collect?
(a) Grab sample (b) Composite sample (c) Blood sample (d) Specific sample
- A7. is the series of procedures applied to a sample prior to analysis.
(a) Pre-analysis clean up (b) Sample preparation (c) Filler elimination (d) Matrix removal
- A8. Consider the following data set; 3.080, 3.094, 3.107, 3.056, 3.112, 3.174, 3.198.
Calculate the mean and median.
(a) 3.117 and 3.107 (b) 3.107 and 3.117 (c) 3.198 and 3.056 (d) 3.107 and 4.001
- A9. For a redox reaction to be spontaneous, what should be the sign of ΔG and E_{cell}
- | | ΔG | E_{cell} |
|-----|------------|------------|
| (a) | + | - |
| (b) | + | + |
| (c) | - | + |
| (d) | - | - |
- A10. What is the oxidation state of O in NaO
(a) $-1/2$ (b) $+1/2$ (c) -1 (d) $+1$
- A11. How is the reaction quotient used to determine whether a system is at equilibrium or not?
(a) The reaction is at equilibrium when $Q < K_{eq}$.
(b) The reaction is at equilibrium when $Q > K_{eq}$.
(c) At equilibrium, the reaction quotient is undefined.
(d) The reaction is at equilibrium when $Q = K_{eq}$.
-

A12. In the coal-gasification process, carbon monoxide is converted to carbon dioxide via the following reaction:



In an experiment, 0.35 mol of CO and 0.40 mol of H₂O were placed in a 1.00 L reaction vessel. At equilibrium, there were 0.19 mol of CO remaining. K_{eq} at the temperature of the experiment is _____.

- (a) 0.75 (b) 1.0 (c) 5.47 (d) 0.56

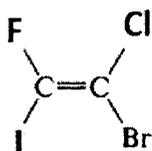
A13. A buffer solution can be prepared by mixing _____.

- (a) a strong acid and weak base (b) a weak acid and weak base
(c) a strong acid and its salt (d) a weak base and its salt of strong acid

A14. The conjugate base of HSO_4^- is _____.

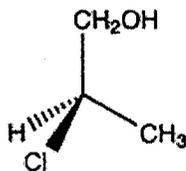
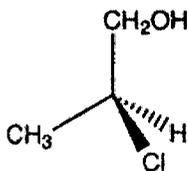
- (a) H_2SO_4 (b) SO_4^{2-} (c) H_3SO_4^+ (d) HSO_4^+

A15. Deduce whether the structure shown below is an E- or Z- isomer.



- (a) E-isomer (b) Z-isomer (c) Both E/Z isomer (d) Neither E nor Z isomer

A16. The following organic compounds are mirror images of each other. Which term best describes these isomers?



- (a) Achiral isomers (b) Superimposable carbons
(c) Enantiomers (d) Non superimposable carbons

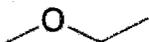
A17. Which three factors affect the rate of a chemical reaction?

- (a) temperature, pressure, and humidity
(b) temperature, reactant concentration and catalyst
(c) temperature, reactant concentration and pressure
(d) temperature, product concentration and container volume

A18. The rate constant (k) in a rate law expression is

- (a) is independent of concentration (b) is called the Arrhenius constant
(c) is dimensionless (d) is independent of the temperature

A19. What is the IUPAC name for the organic molecule given below?



- (a) Ethyl methyl ether
(b) Methoxypropane
(c) Methyl ether ethane
(d) Methyl ethyl ether

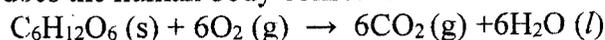
A20. The reaction of 1-bromohexane with sodium hydroxide will yield _____.

- (a) A 2° alcohol (b) A 3° alcohol (c) A 1° alcohol (d) Pentanol

Section B Answer ALL section B questions on one page in your answer Booklet.

B1. Balance the following chemical reaction: $\text{Cr}(\text{OH})_3 + \text{HClO}_4 \rightarrow \text{Cr}(\text{ClO}_4)_3 + \text{H}_2\text{O}$

B2. The human body needs at least 1.03×10^{-2} mol O_2 every minute. If all of this oxygen is used for the cellular respiration reaction that breaks down glucose, how many moles of glucose does the human body consume each minute? The reaction can be represented as:



B3. At its closest approach, Mars is 56 million km from Earth. How long would a radio message from a space probe on Mars take to reach Earth when the planets are at this distance?

B4. Draw the structure for NH_3 and indicate the charge distribution for each polar bond using δ^+ and δ^- . Determine whether the molecule is overall polar.

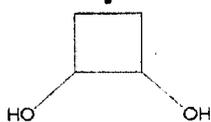
B5. The result of an analysis is 36.97 g and the accepted value is 37.06 g. What is the relative error in parts per thousand?

B6. A steady current of 1.6 A was passed for 10 minutes through an electrolytic cell. How many coulombs of electricity were passed?

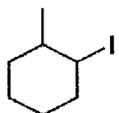
B7. Consider the reaction: $\text{N}_2(\text{g}) + \text{H}_2(\text{g}) \leftrightarrow \text{NH}_3(\text{g})$
Write the expression for the equilibrium constant, K_p , for the reaction.

B8. The first order rate constant for the decomposition of N_2O_2 at 0°C is $5.2 \times 10^{-6} \text{ min}^{-1}$. If the energy of activation is 6200 joules per mole, calculate the rate constant at 25°C .

B9. The organic compound below is cyclobutan-1, 2-diol. Is the molecule chiral or achiral?



B10 Give the IUPAC name for organic compound given below



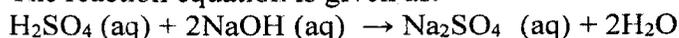
Section C

Answer ALL questions. Logically show ALL your workings. Marks allocated for each part of the question are indicated in brackets. Each question carries a total of 5 marks.

C1. In a titration experiment, a 25.00 cm³ of Sulphuric acid was pipetted out and transferred to 500 cm³ standard flask and made up to the mark. A rinsed pipette was used to transfer 25.00 cm³ of the diluted acid to a conical flask. An average volume of 25.00 cm³ of sodium hydroxide solution was required to neutralise the above acid.

(a) State the effect on the titre if the pipette used to transfer the acid was filled above the mark? (1)

The reaction equation is given as:



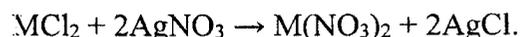
(b) If the concentration of Sodium Hydroxide used is 0.1 mol/dm³, calculate the number of moles in mean titre. (2)

(c) Calculate the number of moles of acid transferred into conical flask. (2)

(d) Calculate the concentration of undiluted acid in mol/dm³. (3)

(e) Calculate the percentage uncertainty of 500 cm³ volumetric flask with an uncertainty of 0.5 cm³. (2)

C2. A metal chloride reacts with silver nitrate solution to give a precipitate of silver chloride according to following equation:



When a solution containing 0.4750 g of metal chloride is made to react with silver nitrate, 1.435 g of silver chloride are formed. Identify the metal.

C3. You are developing a new colorimetric procedure for determining glucose content in blood serum.

You have chosen the standard Folin-Wu procedure with which to compare your results.

From the following two sets of replicate analyses on the same sample, determine whether the variance of your method differs significantly from that of the standard method.

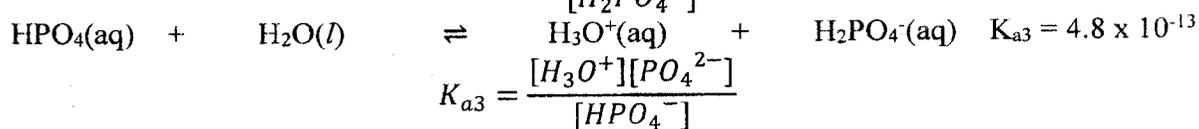
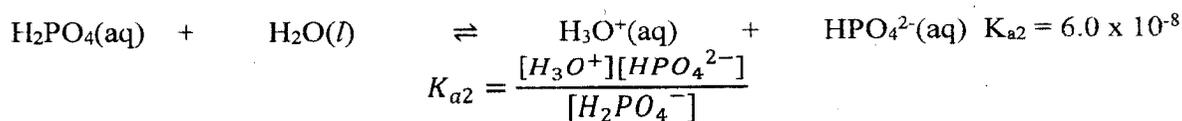
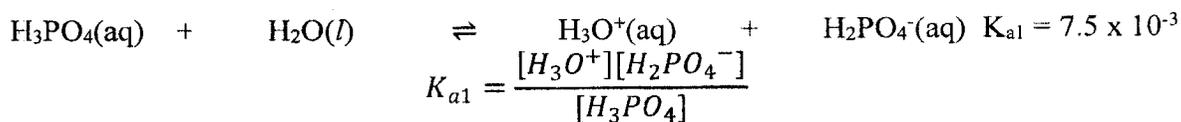
Experiment no	1	2	3	4	5	6	7	Mean
Your method (mg/L)	127	125	123	130	131	126	129	127
Folin-Wu method (mg/L)	130	128	131	129	127	125	-	128

C4. (a) Describe the steps in a sampling operation. (3)

(b) A food sample was analysed for potassium ion content. The following results were obtained: % K: 3.09, 4, 2.775, 2.5, 3.80. Given that the standard deviation of this data is 0.647, calculate the coefficient of variation. (2)

C5. Phosphoric acid is a common ingredient in traditional cola drinks. It is added to enhance taste.

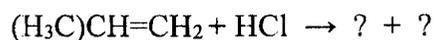
Assuming that in cola drinks the initial concentration of phosphoric acid is 0.007M, calculate the pH in this solution.



C6. (a) Derive the expression for half-life of a second order reaction. (2)

(a) The reaction $\text{A} \rightarrow \text{B}$ is a second-order process. When the initial concentration of A is 0.50 M, the half-life is 8.0 minutes. What is the half-life if the initial concentration of A is 0.10 M? (3)

C7. Predict the major product and write the reaction mechanism according to the reaction given below:



END OF EXAMINATION

Values of F at the 95% Confidence Level

	$v_1 = 2$	3	4	5	6	7	8	9	10	15	20	30
$v_2 = 2$	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.5
3	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.70	8.66	8.62
4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.86	5.80	5.75
5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.62	4.56	4.50
6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	3.94	3.87	3.81
7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.51	3.44	3.38
8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.22	3.15	3.08
9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.01	2.94	2.86
10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.85	2.77	2.70
15	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.40	2.33	2.25
20	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.20	2.12	2.04
30	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.01	1.93	1.84

Values of t for ν Degrees of Freedom for Various Confidence Levels*

ν	Confidence Level			
	90%	95%	99%	99.5%
1	6.314	12.706	63.657	127.32
2	2.920	4.303	9.925	14.089
3	2.353	3.182	5.841	7.453
4	2.132	2.776	4.604	5.598
5	2.015	2.571	4.032	4.773
6	1.943	2.447	3.707	4.317
7	1.895	2.365	3.500	4.029
8	1.860	2.306	3.355	3.832
9	1.833	2.262	3.250	3.690
10	1.812	2.228	3.169	3.581
15	1.753	2.131	2.947	3.252
20	1.725	2.086	2.845	3.153
25	1.708	2.060	2.787	3.078
∞	1.645	1.960	2.576	2.807

* $\nu = N - 1 =$ degrees of freedom.

Rejection Quotient, Q , at Different Confidence Limits*

No. of Observations	Confidence Level		
	Q_{90}	Q_{95}	Q_{99}
3	0.941	0.970	0.994
4	0.765	0.829	0.926
5	0.642	0.710	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568
15	0.338	0.384	0.475
20	0.300	0.342	0.425
25	0.277	0.317	0.393
30	0.260	0.298	0.372

*Adapted from D. B. Rorabecher, *Anal. Chem.*, 63 (1991) 139.

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

hydrogen 1 H 1.00794	beryllium 4 Be 9.012182	lithium 3 Li 6.941	magnesium 12 Mg 24.3050	calcium 20 Ca 40.078	strontium 38 Sr 87.62	barium 56 Ba 137.327	radium 88 Ra [226]	francium 87 Fr [223]	caesium 55 Cs 132.90545	lawrencium 103 Lr [262]	lutetium 71 Lu 174.967	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	hafnium 72 Hf 178.49	rutherfordium 104 Rf [261]	seaborgium 106 Sg [266]	dubnium 105 Db [262]	tennessine 117 Ts [289]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	roentgenium 111 Rg [272]	copernicium 112 Cn [285]	unbinilium 114 Uu [289]	ununquadium 114 Uuq [289]	thallium 81 Tl 204.3833	lead 82 Pb 207.2	bismuth 83 Bi 208.980	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]	francium 87 Fr [223]	radium 88 Ra [226]	actinium 89 Ac [227]	thorium 90 Th 232.038	protactinium 91 Pa 231.0359	uranium 92 U 238.0289	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.964	gadolinium 64 Gd 157.25	terbium 65 Tb 158.9253	dysprosium 66 Dy 162.50	holmium 67 Ho 164.930	erbium 68 Er 167.259	thulium 69 Tm 168.934	ytterbium 70 Yb 173.04	lutetium 71 Lu 174.967	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	roentgenium 111 Rg [272]	copernicium 112 Cn [285]	unbinilium 114 Uu [289]	ununquadium 114 Uuq [289]	tennessine 117 Ts [289]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	roentgenium 111 Rg [272]	copernicium 112 Cn [285]	unbinilium 114 Uu [289]	ununquadium 114 Uuq [289]	thallium 81 Tl 204.3833	lead 82 Pb 207.2	bismuth 83 Bi 208.980	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]	francium 87 Fr [223]	radium 88 Ra [226]	actinium 89 Ac [227]	thorium 90 Th 232.038	protactinium 91 Pa 231.0359	uranium 92 U 238.0289	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.964	gadolinium 64 Gd 157.25	terbium 65 Tb 158.9253	dysprosium 66 Dy 162.50	holmium 67 Ho 164.930	erbium 68 Er 167.259	thulium 69 Tm 168.934	ytterbium 70 Yb 173.04	lutetium 71 Lu 174.967
--------------------------------------	-----------------------------------------	------------------------------------	-----------------------------------------	--------------------------------------	---------------------------------------	--------------------------------------	------------------------------------	--------------------------------------	-----------------------------------------	-----------------------------------------	----------------------------------------	-----------------------------------------	--------------------------------------------	--------------------------------------	--------------------------------------------	-----------------------------------------	--------------------------------------	-----------------------------------------	--------------------------------------	--------------------------------------	-----------------------------------------	------------------------------------------	------------------------------------------	-----------------------------------------	-------------------------------------------	-----------------------------------------	----------------------------------	---------------------------------------	--------------------------------------	--------------------------------------	-----------------------------------	--------------------------------------	------------------------------------	--------------------------------------	---------------------------------------	---------------------------------------------	---------------------------------------	----------------------------------------	----------------------------------------	---------------------------------------	----------------------------------------	-----------------------------------------	----------------------------------------	-----------------------------------------	---------------------------------------	--------------------------------------	---------------------------------------	----------------------------------------	----------------------------------------	---------------------------------------	-----------------------------------------	-----------------------------------------	--------------------------------------	------------------------------------------	---------------------------------------	--------------------------------------	--------------------------------------	-----------------------------------------	------------------------------------------	------------------------------------------	-----------------------------------------	-------------------------------------------	-----------------------------------------	--------------------------------------	--------------------------------------	-----------------------------------------	------------------------------------------	------------------------------------------	-----------------------------------------	-------------------------------------------	-----------------------------------------	----------------------------------	---------------------------------------	--------------------------------------	--------------------------------------	-----------------------------------	--------------------------------------	------------------------------------	--------------------------------------	---------------------------------------	---------------------------------------------	---------------------------------------	----------------------------------------	----------------------------------------	---------------------------------------	----------------------------------------	-----------------------------------------	----------------------------------------	-----------------------------------------	---------------------------------------	--------------------------------------	---------------------------------------	----------------------------------------	----------------------------------------

key
element name
atomic number
symbol
atomic mass

lanthanum 57 La 138.9055	cerium 58 Ce 140.116	praseodymium 59 Pr 140.90765	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.964	gadolinium 64 Gd 157.25	terbium 65 Tb 158.9253	dysprosium 66 Dy 162.50	holmium 67 Ho 164.930	erbium 68 Er 167.259	thulium 69 Tm 168.934	ytterbium 70 Yb 173.04	lanthanum 57 La 138.9055	cerium 58 Ce 140.116	praseodymium 59 Pr 140.90765	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.964	gadolinium 64 Gd 157.25	terbium 65 Tb 158.9253	dysprosium 66 Dy 162.50	holmium 67 Ho 164.930	erbium 68 Er 167.259	thulium 69 Tm 168.934	ytterbium 70 Yb 173.04	actinium 89 Ac [227]	thorium 90 Th 232.038	protactinium 91 Pa 231.0359	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]	mendelevium 101 Md [258]	nobelium 102 No [259]
------------------------------------------	--------------------------------------	----------------------------------------------	----------------------------------------	----------------------------------------	---------------------------------------	----------------------------------------	-----------------------------------------	----------------------------------------	-----------------------------------------	---------------------------------------	--------------------------------------	---------------------------------------	----------------------------------------	------------------------------------------	--------------------------------------	----------------------------------------------	----------------------------------------	----------------------------------------	---------------------------------------	----------------------------------------	-----------------------------------------	----------------------------------------	-----------------------------------------	---------------------------------------	--------------------------------------	---------------------------------------	----------------------------------------	--------------------------------------	---------------------------------------	---------------------------------------------	---------------------------------------	---------------------------------------	---------------------------------------	---------------------------------------	------------------------------------	---------------------------------------	-----------------------------------------	-----------------------------------------	--------------------------------------	------------------------------------------	---------------------------------------

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2022/23 ACADEMIC YEAR FINAL EXAMINATIONS
NOVEMBER 2023

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 **FIVE (5)** printed pages

QUESTION 1

- a) **Describe** briefly **any two** properties of water that makes it suitable for the sustenance of life. [2 marks]
- b) Using a suitable **formula**, **describe** instantaneous buffer capacity [4 marks]
- c) An enzyme-catalyzed reaction was carried out in a solution buffered with 0.03 M phosphate, pH 7.2. As a result of the reaction, 0.004 mole/Liter of acid was formed. ($pK_{a2}=6.76$)
- i. **What** was the pH at the end of the reaction? [6 marks]
- ii. **What** would be the pH if no buffer were present? [4 marks]
- iii. **Write** the chemical equation showing how the phosphate buffer resisted a large change in pH. (Hint: NaH_2PO_4) [4 marks]

QUESTION 2

- a) **Name** three amino acids that are positively charged at neutral pH. [3 marks]
- b) **Name** three amino acids that contain hydroxyl groups. [3 marks]
- c) **Translate** the following amino acid sequence into one letter code: [3 marks]
Ser-Cys-Ile-Glu-Asn-Cys-Glu-Ile-Ser-Gly-Arg-Glu-Ala-Thr-Ser-Glu-Glu
- d) **What** is the approximate molecular weight of a protein composed of 3700 amino acids? [2 marks]
- e) Approximately **how** many amino acids are required to form a polypeptide chain with molecular weight of 410, 000? **What** is its approximate length assuming its an alpha helix? [5 mark]
- f) **What** is the net charge on the amino acid Leucine at pH 6 and at pH 12? [4 marks]

QUESTION 3

Sucralose, (Figure 1) an artificial “sweetener” widely used the world over is synthesised from sucrose. It is believed not to be digestible by humans however, it is well over 385 times sweeter than sucrose.

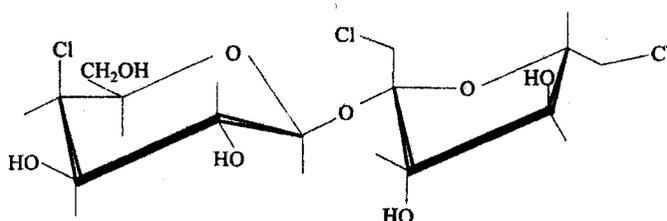


Figure 1. Sucralose

- What** is an artificial sweetener? [1 marks]
- What** is the current known advantage of consuming sucralose over sucrose which is far less sweet than sucralose? [1 mark]
- Draw** the structure of sucrose (*pay attention to orientation of atoms*) and **state** the type of bond connecting the monosaccharides in sucrose? [6 marks]
- State** the two products of sucrase’s action on sucrose and **explain** whether both products are able to react with Tollens reagent? [3 marks]
- Why** is Sucrase also called an “invertase”? [3 marks]
- Define** mutarotation hence is sucrose able to show mutarotation, explain? [3 marks]
- Disaccharides’ reaction with phenyl hydrazine to form asazones is an easy way of differentiating disaccharides during their chemical identification.
 - State** whether sucrose is able to form osazones and if not, explain? [2 marks]
 - Why** are disaccharide asazones an easy way of chemically identifying/differentiating disaccharides. [1 mark]

QUESTION 4

James Watson, in 1968, observed that “a structure this pretty just had to exist” referring to one of the nucleic acids. Subsequently understanding the structure of nucleic acids and how they work has led to a deeper understanding of life at a molecular level.

- State** the structural definition of nucleic acids. [1 mark]
- State** the three structural differences between the two nucleic acids. [4 marks]

- c) The intricacies of the nucleic acid structures lie in understanding the properties of their monomers and the rules that govern their connectivity.
- Why** is deoxyribonucleic acid always applied on the anode during electrophoresis separation no matter what the source of the deoxyribonucleic acid? [1 mark]
 - Generally, **how** would you quickly differentiate genomic deoxyribonucleic acid from two different species? [1 mark]
- d) A sample of double stranded DNA was found to contain 30 % adenylate of the nucleotide residues.
- What** is the percentage composition of guanylate of this DNA? (Show all your calculations). [4 marks]
 - State** Chargaff's rule you used to answer question (d,i) above. [2 marks]
 - Calculate** the asymmetrical ratio of (A+T)/G+C? [1 mark]
- e) Several attempts have been made to design nucleoside based drugs for treatment of HIV/AIDS with measurable success. Thus, 3'-Azido-2',3'-dideoxythymidine (AZT) (a nucleoside) structural analogue of Thymine deoxyribose has been used in treatment of HIV/AIDS.
- Why** is AZT not administered or given to patients as a nucleotide (AZT triphosphate) but as a nucleoside? [1 marks]
 - How** does AZT work as a drug for HIV/AIDS from the time it is absorbed into the blood. [5 marks]

QUESTION 5

CHE 2112 students were analysing the ratio of 18:0 and 18:2^{Δ9,12} fatty acids in a food sample.

- Write** the systematic name for each fatty acid. [4 marks]
- Which** of the two fatty acids has a higher melting point? **Explain** your answer. [4 marks]
- What** simple test can be used to differentiate the two fatty acids? [2 marks]
- Draw** the full chemical structure of an optically INACTIVE triacylglycerol that yields 2 moles of 18:0 fatty acid and 1 mole of 18:2^{Δ9,12} fatty acid. [6 marks]
- Mention** any 2 (two) biological roles of fatty acids. [4 marks]

QUESTION 6

- a) In your answer book, **draw** well labelled diagrams to illustrate the ways in which the rate of an enzyme controlled reaction depends on the following:
- i. pH [2 marks]
 - ii. Enzyme concentration [2 marks]
 - iii. Substrate concentration [2 marks]
- b) The reaction below shows the breakdown of lactose into glucose and galactose.



- i. **Calculate** the standard free-energy change for this enzyme-catalyzed reaction at 25 °C and pH 7.0 given $K_{\text{eq}} = 0.3$. [4 marks]
[R = 8.3143 J. K⁻¹ mol⁻¹; use 273.15 to convert °C to K]
- ii. Below is data obtained for lactase enzyme in presence and absence of maltose. **Determine** V_{max} and K_m of both reactions using an appropriate plot and establish the effect of maltose on the lactase reaction? [10 marks]

[Lactose] moles/litre	Velocity (moles/min)	
	Without maltose	With maltose
0.3×10^{-5}	10.4	4.1
0.5×10^{-5}	14.5	6.4
1.0×10^{-5}	22.5	11.3
3.0×10^{-5}	33.8	22.6
9.0×10^{-5}	40.5	33

END OF EXAMINATION

The University of Zambia

End of Year Examinations: October/November 2023

ICT 1110: Computer Systems and Architecture

Marks: 100

Time: Three (3) hours

Instructions:

- This examination paper consists of a total of six (6) questions and six (6) pages.
 - Answer all questions from **Section A** and any four (4) questions from **Section B**.
 - Show all calculations where applicable.
 - You are allowed to use a certified scientific calculator if you wish to do so.
 - Page six (6) has reference tables for MIPS instructions and system calls.
-

Section A [Answer all questions]

Question 1 [20]

- a) For each of the following logic gates, draw the gate and provide a complete truth table aligned with all possible inputs
- i) XOR [2]
 - ii) NAND [2]
- b) For each of the following MIPS assembler instructions, decode the equivalent MIPS binary instruction and outline the MIPS Datapath and Control components that are utilised during execution of the instruction
- i) `addi $9, $0, -50` [4]
 - ii) `sub $10, $11, $13` [4]
- c) Write MIPS assembler instructions for accomplishing the following tasks
- i) Printing an integer onto the console [2]
 - ii) Reading an integer input [2]
 - iii) Exiting a program gracefully [1]
- d) Distinguish between full backups, incremental backups and differential backups by referring to their relative cost, backup efficiency, restoration efficiency and size required for backups [3]

Section B [Answer any four (4) questions ONLY]

Question 2 [20]

Consider the circuit shown in Figure 1, and answer the questions that follow.

- e) For each of the three (3) unique logic gates in the circuit, redraw the gate, state the boolean algebraic operation associated with the gate and briefly describe the boolean algebraic rules associated with the gate [6]
- f) For each of the two (2) expression outputs S and C, derive the boolean algebraic expressions [4]
- g) Draw a truth table for the expression outputs S and C [10]

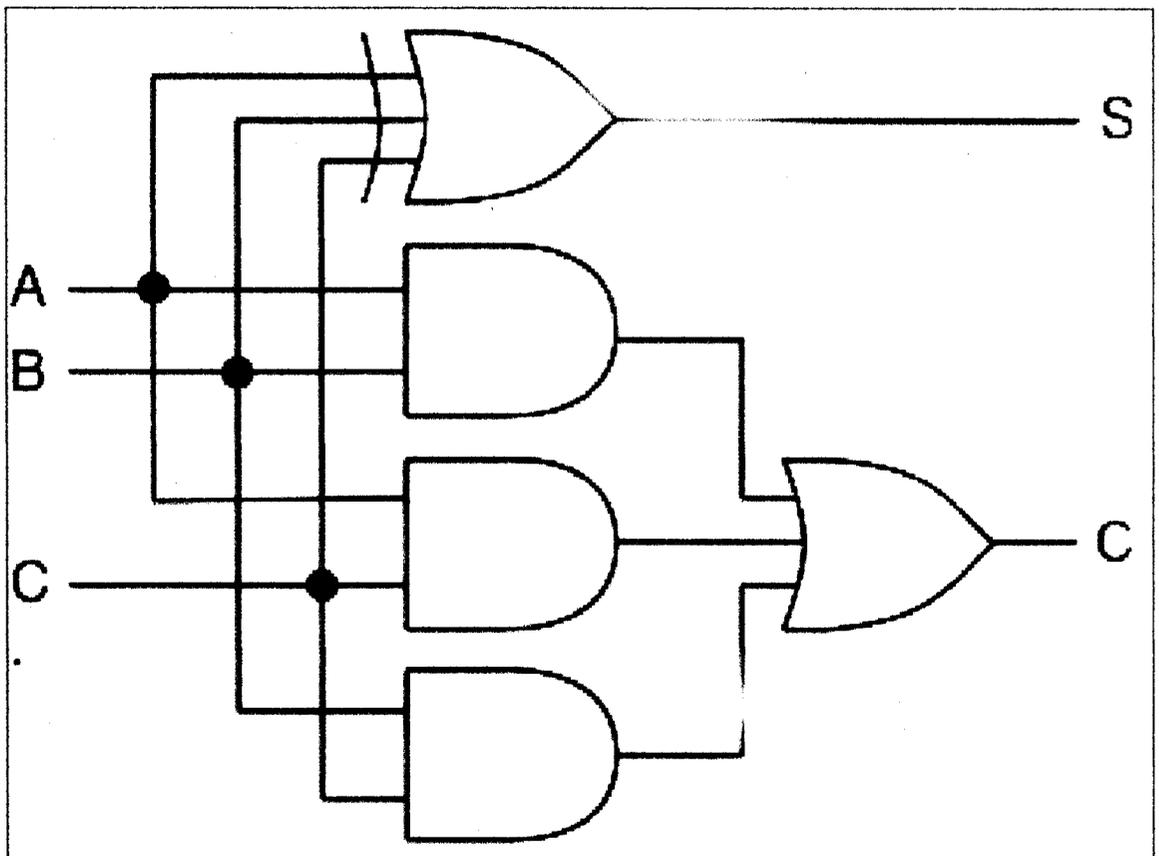


Figure 1: Logic Structure

Question 3 [20]

Consider the MIPS Datapath and Control illustration shown in Figure 2, and answer the questions that follow.

- a) Briefly describe the role of each of the following MIPS Datapath and Control components
- i) Register File [1]
 - ii) Arithmetic Logic Unit [1]
 - iii) Adder linked to the Program Counter [1]
 - iv) Sign Extend [1]
 - v) Multiplexer (MUX) linked to the Arithmetic Logic Unit [1]
 - vi) Program Counter [1]
- b) Assuming a MIPS program, comprising of the single instruction **addi \$12, \$11, -2023**, is run
- i) Briefly outline how the MIPS program would be run, relative to the machine cycle [4]
 - ii) Decode the instruction **addi \$12, \$11, -2023** into its equivalent MIPS binary representation [6]
- c) Assuming the status of the CPU is such that register \$11 has the value -4, state the values of the following components
- i) Read Register 1 [1]
 - ii) Write Register [1]
 - iii) Input value into Sign Extend component [1]
 - iv) Output value from the Sign Extend component [1]

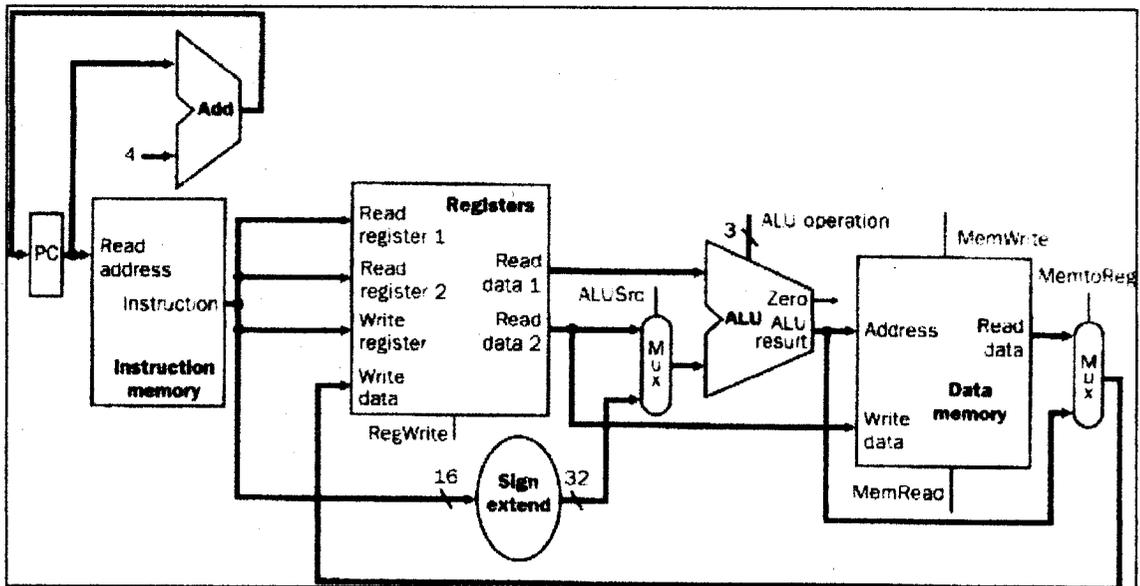


Figure 2: MIPS Datapath and Control

Question 4 [20]

Consider an extensible Web-based application software being developed such that it will eventually be made freely available and open source. In addition, the Web-based application is meant to be developed such that it is incorporated with Web services, with the primary programming language being interpreted.

- a) State any two (2) types/categories of computer systems that would be used to install and host the Web-based application, providing a justification for your answer [2]
- b) State and describe the role of ANY five (5) application software that will be required once the Web-based application is deployed for use [6]
- c) Briefly describe ANY two (2) advantages of having the application free and open source [2]
- d) Briefly describe ANY two (2) disadvantages of having the application free and open source [2]
- e) Describe how the Web-based application would be designed and implemented, relative to the so-called Software Development Life Cycle [5]
- f) Briefly describe the significance of the following characteristics for the Web-application
 - i) Web-based [1]
 - ii) Extensibility [1]
 - iii) Web service integration [1]

Question 5 [20]

The Von Neumann model is a generic abstracted representation of high-level functional units associated with digital computer systems.

- a) Peripherals are an integral part of the Input/Output unit
 - i) Briefly describe the four (4) classic categories of peripherals and for each peripheral, provide a specific example [8]
 - ii) Briefly describe any four (4) aspects for classifying peripherals [4]
- b) The so-called Input/Output Subsystem/Module is a crucial component of the Input/Output unit
 - i) Describe any three (3) design considerations for the Input/Output Module [3]
 - ii) Explain the role of I/O controllers [1]
- c) Consider a 205MB file to be downloaded via an MTN network. Compute the download speed (in mbps) if the file is to be downloaded within 5 minutes [4]

Question 6 [20]

Computers are primarily used to process data, with the data manifesting itself in various primitive forms such as textual context, images, sound and video.

- a) Data manipulated by computer is eventually persistently stored on secondary storage
 - i) Briefly explain why secondary storage is sometimes referred to as “mass storage” [1]
 - ii) Distinguish between storage medium and storage devices [2]
 - iii) Explain how you would evaluate the appropriateness of a storage medium using any five (5) factors [5]
- b) Distinguish between lossy compression and lossless compression and provide an example scenario for each type of compression [4]
- c) Data is logically stored on filesystem in structures that are referred to as files
 - i) Explain the difference between files and directories [2]
 - ii) Describe any six (6) operations that can be performed on files [6]

Table 1: MIPS System Calls

Code	Service	Argument	Result
1	Print Integer	\$a0=Integer Value	-
4	Print String	\$a0=String Address	-
5	Read Integer	-	\$v0=Integer Value
8	Read String	\$a0=String Address \$a1=length	-

Table 2: MIPS Instructions

Instruction	Description	Opcode/FUNCT
add <Rdes>, <Rsrc1>, <Rsrc2>	Addition	0/20hex
addi <Rdes>, <Rsrc1>, <Rsrc2>	Addition	8hex
sub <Rdes>, <Rsrc1>, <Rsrc2>	Subtraction	0/22hex
b <label>	Unconditional branching	-
beq <Rsrc1>, <Rsrc2>, <label>	Branch if equal	4hex
bne <Rsrc1>, <Rsrc2>, <label>	Branch if not equal	5hex
blt <Rsrc1>, <Rsrc2>, <label>	Branch if less than	-
bgt <Rsrc1>, <Rsrc2>, <label>	Branch if greater than	-

—End of Examination—

THE UNIVERSITY OF ZAMBIA
END OF YEAR EXAMINATIONS: NOVEMBER 2023
ICT
3010: WEB AND DATABASE TECHNOLOGIES

Instructions: Answer three (3) questions
Time: Three (3) hours
Total Marks: 100 marks

SECTION A: COMPULSORY (40 MARKS)

1. (a) Company X has asked you to design and create a web database application to allow its members to register online. The company requests you to use a free and open source database management system for creating the database.
 - i. Explain the first steps you will take to develop the said web database application. [8 marks]
 - ii. How many entities will the database for the application have? [2 marks]
 - iii. Explain the concept of free open access and state four examples of free open access database management systems. [8 marks]
 - iv. How many tables is the school database likely to have? [2 marks]

- (b)
 - i. Explain the major differences between HTML and PHP. [10 marks]
 - ii. Write a PHP script that prompts the user to enter a name and a password in a form. The correct name is "Rajesh," and the password is "Khan." If the user enters the correct name and password, the script should display "Welcome." If incorrect details are entered, it should display "Try again." [10 marks]

SECTION B: CHOOSE TWO QUESTIONS FROM THIS SECTION (60 MARKS)

2. (a) Write and explain five (5) post-table creation SQL statements. [15 marks]
(b) Compare and contrast XHTML and HTML 5. [15 marks]
3. (a) Write the HTML tags and CSS codes that can be used to create the following:
- i) a link to the *Zambian Librarian* at <https://www.zambianlibrarian.com> [5 marks]
 - ii) a space of 10 pixels between the borders and contents of the web page. [3 marks]
 - iii) a text shadow to a selector h1. [3 marks]
 - iv) a background color for the body of the web page using hexadecimal colors. [4 marks]
- (b) Explain the five modern features of CSS3. [15 marks]
1. (a) Write short notes on **five** (5) of the following concepts/terms: [15 marks]
- i. Apache
 - ii. Padding
 - iii. Entity
 - iv. Get
 - v. Data
 - vi. Syntax
- (b) Explain how a database could be normalized up to level three. [15 marks]

END OF EXAMINATION

The University of Zambia

End of Year Supplementary Examinations: February 2023

ICT 3020: Fundamentals of Software Engineering and Project Management

Marks: 100

Time: Three (3) hours

Instructions:

- This examination paper consists of a total of five (5) questions and four (4) pages.
 - Answer all questions from **Section A** and any three (3) questions from **Section B**.
 - Show all calculations where applicable.
 - You are allowed to use a certified scientific calculator if you wish to do so.
-

Section A [Questions 1 is compulsory]

Question 1 [25]

Consider a Git repository for a Python Web application, publicly hosted on Github via the URL <https://github.com/lightonphiri/code-unza22-ict3020.git>

- a) Git is an example of a so-called distributed version control system.
- i) Distinguish between Git and Github. [3]
 - ii) Besides Git provide an example of any popular version control system [1]
 - iii) Besides Github, provide an alternative platform/service that would be used to perform similar functionalities as Github [1]
- b) Assuming you are part of a team of five (5) individuals collaboratively working on the repository “code-unza22-ict3020”
- i) Clearly illustrate how your team would take advantage of Git's distributed versioning feature to effectively collaborate and version the source code [5]
 - ii) Briefly outline how merge conflicts would be handled by your team [4]
- c) While different, Git branches and tags are generally used to keep track of development lines

- i) Distinguish between Git branches and tags [2]
- ii) Provide a practical scenario when branches are more likely to be used in preference to tags [2]
- iii) Provide a practical scenario when tags are more likely to be used in preference to branches [2]
- d) Provide a syntactically correct Git command required to accomplish each of the following tasks
 - i) Creating a new branch with the commit "c81a92dd3c568e64a6eb28e710543ba03890d3cd" [2]
 - ii) View all commit messages associated with the repository [1]
 - iii) Change the local repository user name to "ICT 3020 Student" [1]
 - iv) Changing/correcting the last commit message by replacing the message with the text "ICT 3020 Supplementary Examination" [1]

Section B [Answer any three (3) questions ONLY]

Question 2 [25]

Software process models are defined as abstract representations of processes used to model the structured set of process activities required to develop a software system.

- a) Briefly describe the five (5) software process activities that are associated with the Software Development Life Cycle, specify the key activities performed in the process activities [10]
- b) The DataLab Research Group at The University of Zambia is planning to implement a departmental Website—using the generic content management system WordPress—in order to make publicly available information specific to the department.
 - i) Briefly outline four (4) factors that influence the choice of process model to use in a Software Engineering project [4]
 - ii) State the software process model that would be appropriate to implement the Website, justifying your answer [5]
 - iii) Briefly outline two (2) advantages and two (2) disadvantages of the process model stated in (ii), above [4]
 - iv) Besides the process model stated in (ii), above, state and describe two (2) other process models commonly used in Software Engineering projects [2]

Question 3 [25]

Consider the activities shown in the Work Breakdown Structure in Figure 1, associated with a software development project and answer the questions that follow.

- a) Draw a Work Breakdown Structure, using the graphical notation [3]

- b) Activity Network diagrams are one of the most commonly used project management artifacts
 - i) Using Figure 1, draw an Activity Network diagram using the Activity on Node approach [10]
 - ii) Use the Activity Network diagram, illustrated in (i) to determine the estimated project duration [2]
- c) Using Figure 1, draw a Gantt chart, with all essential elements [10]

Question 4 [25]

Effective project management is a necessary and essential component of Software Engineering.

- a) Risk management is concerned with identifying risks and drawing up plans to minimise their effect on a project.
 - i) Briefly outline the significance of risk management, by making references to the three (3) key metrics used to measure software project success [6]
 - ii) Describe the risk management process by making reference to the four (4) stages of risk management [8]
 - iii) Describe five (5) generic risks generally associated with software projects [5]
- b) Project scheduling, in part, involves deciding how the work in a project will be organized as separate tasks, and when and how these tasks will be executed.
 - i) Briefly describe the software project scheduling process [2]
 - ii) The Gantt chart is one of the most widely used graphical notations for representing project schedules. Briefly describe four (4) aspects/elements of a Gantt chart [4]

Question 5 [25]

Software pricing and estimation are key aspects of software project planning.

- a) Briefly outline five (5) factors that significantly affect software project pricing [5]
- b) Under pricing and increased pricing are two (2) of the most commonly exploited pricing strategies. Compare and contrast between under pricing and increased pricing [2]
- c) Briefly explain how estimation uncertainty is affected during the various software process activities [2]
- d) Briefly outline four (4) reasons why project estimation is significant [4]
- e) In order to determine the relative cost and effort associated with a software project, organisations generally take advantage of pre-existing estimation techniques.
 - i) Briefly describe three (3) popular software estimation techniques [6]
 - ii) For each of the estimation techniques in (i), provide one advantage of the technique [6]

Task	Duration (days)	Dependencies
Requirements Elicitation (T1)	30	
Requirements Specification (T2)	20	
Implementation—Iteration #1 (T3)	20	T1
System Design (T4)	30	
Implementation—Iteration #2 (T5)	30	T2, T4
Implementation—Iteration #3 (T6)	10	T1, T2
Project Management (T7)	40	T1
Unit Testing (T8)	30	T4
Component Testing (T9)	20	T3, T6
Integration Testing (T10)	20	T7, T8
System Testing (T11)	20	T9
User Acceptance Testing (T12)	20	T10, T11

Figure 1: Work Breakdown Structure

—End of Examination—

THE UNIVERSITY OF ZAMBIA
MID-YEAR EXAMINATIONS: JUNE, 2023
ICT 9025: MOBILE APPLICATIONS AND TECHNOLOGIES

INSTRUCTIONS:

- This examination paper consists of a total of four (4) questions and two (2) pages.
- Answer all questions from **Section A** and any two (2) questions from **Section B**.

MARKS: 90

TIME: Three (3) hours

SECTION A (COMPULSORY) 30 MARKS

Question 1 [30 Marks]

- a) Regarding GSM:
- i. Explain two functions of the BSC [2]
 - ii. Explain three functions of the MSC [3]
 - iii. Describe two types of antennae that a BTS can use, additionally for each type:
give an example of a location that would be ideal for the antennae [4]
 - iv. Give the function of the SMS-GMSC [2]
 - v. Draw an illustration which indicates the function of the SMS-GMSC [4]
- b) Explain three differences between i-Mode and WAP 2.0 [3]
- c) Regarding the Open Handset Alliance (OHA), explain what the OHA is and give one purpose of the OHA [2]
- d) Explain four advantages of GSM compared to first generation mobile networks [4]
- e) Describe each of the following Android application components:
- i. Activity [2]
 - ii. View [2]
 - iii. Content Provider [2]

SECTION B (ANSWER ANY TWO QUESTIONS) 30 MARKS EACH

Question 2

- a) Describe two disadvantages of 5G networks [2]
- b) Regarding GPRS:
- i. Explain two functions of the VLR [2]
 - ii. Explain the difference between the GMSC and the GGSN [2]
 - iii. Besides data transmission speed, give two differences between GSM and GPRS [2]
- c) Besides Tele-services, explain two categories of service which GSM uses [4]
- d) Regarding the WCDMA 3G network:
- i. Explain the difference between 'WCDMA with FDD' and 'WCDMA with TDD' [2]
 - ii. Give an illustration of FDD and an illustration of TDD [4]
-

- e) Regarding 4G networks:
 - i. Describe what SC-FDMA is [2]
 - ii. Explain why LTE does not use OFDMA for the downlink [2]
 - iii. Give two differences between LTE and WiMax [2]
 - iv. Explain why UMB was discontinued [2]
 - v. In LTE: explain two functions of the PCRF and two functions of the HSS [4]

Question 3

- a) Suppose a CDMA Base Station has the chip sequence 1011
 - i. Explain the purpose of a chip sequence [2]
 - ii. Give the code that would be transmitted to represent the data 100110. [3]
- b) Regarding Ad-hoc mobile networks:
 - i. Explain what SWAN is and give one difference between SWAN and INSIGNIA [3]
 - ii. Describe the RTS-CTS protocol and indicate when it is used [3]
 - iii. Give an illustration showcasing the function of the RTS-CTS protocol [3]
 - iv. Explain the difference between proactive routing and reactive routing [2]
- c) Explain two difference between CDMA2000 and WCDMA [4]
- d) Regarding mobile computing, explain any three security issues of confidentiality [6]
- e) Describe two differences between Pervasive computing and Traditional business computing [4]

Question 4

- a) Regarding DSSS and FHSS:
 - i. Explain the difference between DSSS and FHSS [2]
 - ii. Which of the two (DSSS and FHSS) has better security, justify your answer [2]
- b) Concerning the Android operating system and application development:
 - i. Give three advantages of using Kotlin for Android application development compared to using Java [3]
 - ii. Explain two functions of the operating system which are not carried out by the Linux kernel [2]
 - iii. Explain two functions of the Linux kernel [2]
 - iv. List and describe the functions of any three Android software libraries [3]
- c) Explain four differences between cdmaOne and UMTS [4]
- d) Describe three types of 5G networks. Additionally, besides data transmission speed, explain one advantage of 5G networks compared to 4G networks [4]
- e) In a UMTS network, explain the function of each of the following: the RNC, the IMS the AUC and the Node B [4]
- f) Give the difference between OMC and NMC in a GSM network. Additionally, give an illustration that indicates the difference between OMC and NMC [4]

— END OF EXAMINATION —

THE UNIVERSITY OF ZAMBIA

END OF YEAR EXAMINATIONS: OCTOBER /NOVEMBER 2023

ICT 9065: FUNDAMENTALS OF MULTIMEDIA

INSTRUCTIONS: ANSWER THREE (3) QUESTIONS.

TIME: THREE (3) HOURS

SECTION A: COMPULSORY (40 MARKS)

1. Discuss the hardware and software components that are required in multimedia Systems.

SECTION B: ANSWER ANY TWO (30 MARKS EACH)

2. a) Compare and contrast static media and dynamic media.
b) Discuss the advantages and disadvantages of each.
3. Write short notes on any **five** of the following concepts: - (*NOTE on average short notes cover about half a page and they are more than just definitions.*)
 - a) Data compression
 - b) Multimedia System
 - c) Distributed Networks
 - d) Image Compression Manager
 - e) Component Manager
 - f) Virtual reality
4. Discuss the components of a multimedia system.

END OF EXAMINATION

The University of Zambia
Department of Mathematics and Statistics
2022/23 Academic Year
MAT 1110 Exam

1st November, 2023

14.00 - 17.00

Instructions:

- Indicate your **Computer Number** on all your answer booklets that you shall submit for marking.
- This paper has **3** pages and **6** questions. All questions carry equal marks
- Attempt any **Five(5)** questions of this paper and **indicate the questions you have attempted on the booklet.**
- Duration is **3 hours.**

-
1. (a) i. Given that $A \subset B$, simplify $[B' \cap (A \cup B)]'$. [3]
ii. Express $-21.737373\dots$ in the form $\frac{a}{b}$ where $a, b \in \mathbb{Z}$ and $\frac{a}{b}$ is in its simplest form. [3]
- (b) i. Let \mathbb{R} be the Universal set and $A = (-1, 7]$, $B = (-3, 7)$, $C = [2, \infty)$. Find the set $A' - (B - C)$ and display it on the number line. [4]
ii. Rationalize the denominator of $\frac{3}{-\sqrt{5}-2}$ and simplify the answer to the form $a + b\sqrt{c}$, where a, b and c are rational numbers. [2]
- (c) i. Given that $z_1 = -3 - 2i$, $z_2 = -1 + i$ and $z_3 = 3 + 2i$. Find $\frac{(\overline{z_2})^2 z_1}{z_3}$ in the form $a + bi$ where $a, b \in \mathbb{R}$. [4]
ii. A relation R is defined on the set of positive integers \mathbb{Z}^+ by $R = \{(a, b) | a^2 + b^2 \leq 16\}$. List all the elements of R . Is R a function? Justify! [4]

Total marks : 20

2. (a) i. Determine whether the function $f(x) = 3x^4 - x$, is even, odd or neither odd nor even. [2]
ii. Given $f(x) = \frac{-5}{x-2}$ and $g(x) = \frac{2x}{3x-2}$. Find $(g \circ f)(x)$ and its domain. [4]
- (b) i. Express the function $f(x) = -3x^2 - 6x + 4$ in the form $f(x) = a(x-h)^2 + k$. [3]

- ii. Hence or otherwise sketch the graph of the function $f(x) = -3x^2 - 6x + 4$ showing clearly the turning point and where the graph cuts the axes. [4]
- (c) In a competition to grow the tallest hollyhock, the heights recorded by 50 primary school children were as follows. Heights were measured to the nearest centimetre.

Height	Frequency
177 - 186	12
187 - 196	16
197 - 206	16
207 - 216	6

- i. Draw a histogram. [3]
- ii. Draw the cumulative frequency curve. [4]

Total marks : 20

3. (a) i. Sketch the graph of $f(x) = \frac{x-2}{-x-1}$, showing the horizontal asymptote and vertical asymptote and where graph cuts the axes if any. [4]
- ii. Solve the inequality $\frac{x-1}{x+2} \leq -\frac{1}{2}$. [3]
- (b) i. Find the values of x that satisfy the equation $|x+1| = x^2 - 1$. [3]
- ii. Prove the trigonometric identity $\frac{\cot x \csc x}{\sec^2 x + \csc^2 x} \equiv \cos^3 x$. [3]
- (c) Two ordinary dice are thrown. Find the probability that the sum of the scores obtained
- i. is a multiple of 5 and is greater than 9. [3]
- ii. at least one six or at least one three is thrown. [4]

Total marks : 20

4. (a) i. Find the first derivative of the function $f(x) = \sqrt{x}$ from the first principles. [4]
- ii. Given that $x^2 - xy^2 + y^3 = 3$, find $\frac{dy}{dx}$ at $(1, 2)$. [4]
- (b) i. Sketch the graph of $y = 3^{-x} + 2$ showing all points where the graph cuts the axes if any. [2]
- ii. Solve the equation $e^{2x} + e^x - 6 = 0$. [3]
- (c) i. Compute the area of the region enclosed by the graph $y = x^3$ and the lines $x = -2$ and $x = 3$. [3]
- ii. Let $f(x) := \begin{cases} \frac{x^2+x-2}{x+2} & \text{if } x \neq -2, \\ -3 & \text{if } x = -2, \end{cases}$ Is $f(x)$ continuous at $x = 1$? Justify! [4]

Total marks : 20

5. (a) i. Evaluate [2]

$$\lim_{x \rightarrow -\infty} \frac{x-1}{\sqrt{4x^2+4}}$$

- ii. Solve the equation $2 \cos^2 x - \sqrt{3} \cos x = 0$ for $0 \leq x \leq 2\pi$. [4]

- (b) i. Sweets are packed into bags with nominal mass of 75g. Ten bags are picked at random from the production line and weighed. Their masses in grams are [6]

76, 74.2, 75.1, 73.7, 72, 74.3 75.4, 74, 73.1, 72

Find the mean and standard deviation.

- ii. Find the equation of the normal to the function $f(x) = (\ln x)^2$ at $x = 1$. [4]

- (c) i. Resolve $\frac{3}{(x-2)(x+1)}$ into partial fractions. [2]

- ii. Hence or otherwise find the indefinite integral $\int \frac{3}{(x-2)(x+1)} dx$. [2]

Total marks : 20

6. (a) i. Given that $x-1$ and $x+1$ are factors of $f(x) = ax^3 + bx^2 - 3x - 7$, find the values of a and b . [4]

- ii. Given that $f(x) = -x^3 + 3x^2$. Find the critical values and determine whether they yield a local maximum, local minimum or inflection point and hence sketch the graph of $f(x)$. [6]

- (b) Given that $y = -2 \sin(2x)$ for $0 \leq x \leq 360^\circ$.

- i. Find the Amplitude and Period. [2]

- ii. Sketch the graph for $0 \leq x \leq 360^\circ$. [2]

- (c) i. In a group of 100 people, 40 own a cat, 25 own a dog and 15 own a cat and a dog. Find the probability that a person chosen at random owns a dog, given that he owns a cat. [3]

- ii. Find $\frac{dy}{dx}$ given that $y = \cos^{-1} x$. [3]

Total marks : 20

End of Exam! Happy Holidays!

The University of Zambia
School of Natural Sciences
Department of Mathematics and Statistics
2022/2023 Final Examination - 6th November, 2023
MAT1100 - Foundation Mathematics

Time allowed : Three (3) hrs

Full marks : 100

Instructions:

- Indicate your **computer number** on all answer booklets.
- There are seven (7) questions in this paper. Attempt **any (5) five** questions.
- Each question carries 20 marks.
- **Full credit** will only be given when **necessary work** is shown.
- Calculators are **not** allowed in this examination.

This paper consists of 5 pages of questions.

1. (a) Use the laws of the algebra of sets to simplify the following expressions involving sets:

(i) $A - (B - A)$.

(ii) $[(A \cap B)' \cup (A - B)]'$.

[2,3]

(b) The equation $4x^2 + 8x - 1 = 0$ has roots α and β .

(i) Find the values of $\alpha^3\beta + \alpha\beta^3$ and $(\alpha^3\beta) \times (\alpha\beta^3)$.

(ii) Find an equation whose roots are $\alpha^3\beta$ and $\alpha\beta^3$.

[6,2]

Turn Over/...

- (c) (i) Given that $\sqrt{2}$ is irrational, show that $\sqrt{2} + 3$ is irrational.
(ii) Express $0.0\overline{810}$ as a fraction in the form $\frac{p}{q}$, where p and q are integers.

[4,3]

2. (a) (i) Simplify $\frac{3 - 2\sqrt{2}}{\sqrt{2} - 1}$, giving your answer in the form $p + q\sqrt{2}$.

- (i) Solve the equation $|3x - 5| = 11 - x$.

[4,4]

- (b) (i) Write $\frac{(4 + 5i) + 2i^3}{(2 + i)^2}$ in the form $a + ib$.

- (ii) Solve the equation $z^2 = i$ for $z = x + iy$.

[4,4]

- (c) The binary operation $*$ on the set of positive rational numbers is defined by

$$x * y = \frac{|y - x|}{1 + xy}.$$

- (i) Show that $*$ is commutative.

- (ii) Find the value of $2 * (3 * 1)$.

[2,2]

3. (a) Let $f(x) = x^2 - x - 6$.

- (i) By completing the square, express $f(x)$ in the form

$$f(x) = a(x - h)^2 + k,$$

where a , h and k are constants.

- (ii) Sketch the graph of $f(x)$ indicating the turning point, x -intercepts and y -intercept.

[2,3]

- (b) (i) Find two numbers x and y whose difference is 10 and whose product is a minimum.

- (ii) Sketch the graph of $f(x) = |x| + |x - 1|$ and state its range.

[3,6]

Turn Over/...

- (c) (i) Solve the following inequality, expressing your answer in interval notation:

$$\frac{x+6}{x+1} < 2.$$

- (ii) Given that $4x^2 - kx + 1$ is positive for all values of x , find the range of possible values of k .

[3,3]

4. (a) (i) Find the quotient $Q(x)$ and the remainder $R(x)$ when $P(x) = -x^4$ is divided by $D(x) = -2x^2 + x - 3$.

- (ii) By factorising, solve the equation $x^3 + x^2 - 5x - 2 = 0$.

[4,4]

- (b) (i) Given that $n \in \mathbb{N}$, solve the equation

$$(n+2)! = 12n!.$$

- (ii) In the expansion of $\left(2x - \frac{1}{2x^2}\right)^{12}$, find the coefficient of the term involving x^3 .

[3,4]

- (c) (i) Expand $\frac{1}{\left(1 + \frac{x}{2}\right)}$ in ascending powers of x upto and including the term involving x^3 .

- (ii) State the interval of values of x for which the expansion in (i) is valid.

[3,2]

5. (a) (i) Differentiate $f(x) = \frac{1}{\sqrt{x+1}}$ from first principles.

- (ii) Find the derivative of $y = \left(\frac{x+2}{x-3}\right)^3$.

[4,3]

- (b) (i) Use an appropriate substitution to evaluate the following integral:

$$\int 2x^3 \sqrt{3x^4 - 8} dx.$$

Turn Over/...

- (ii) Use partial fractions decomposition to evaluate the following integral:

$$\int \frac{x^2 + 1}{(x - 1)(x - 2)(x - 3)} dx.$$

[3,5]

- (c) (i) Sketch the graph of the function $f(x) = |\cos \theta|$ for the interval $0 \leq \theta \leq 2\pi$.

- (ii) Solve the equation $\tan \theta(\tan \theta + 1) = 0$ for $0 \leq \theta \leq 2\pi$.

[2,3]

6. (a) (i) Find $\frac{dy}{dx}$ if $x^2 - xy + y^2 = 3$.

- (ii) Use integration by parts to evaluate the following definite integral:

$$\int_1^e 4x^3 \ln x dx.$$

[3,4]

- (b) (i) Write down the expression $\log_b 12 - \frac{1}{2} \log_b 9$ as a single logarithm and simplify your answer.

- (ii) Prove the identity

$$\frac{1 + \cos x}{\sin x} = 2 \operatorname{cosec} x - \frac{\sin x}{1 + \cos x}$$

[2,4]

- (c) The function $f(x)$ is defined by $f(x) = x^2 - 3$, $x \geq 0$.

- (i) Find $f^{-1}(x)$ and sketch its graph.

- (ii) Solve the equation $f(x) = f^{-1}(x)$.

[4,3]

7. (a) (i) Solve for x in the logarithmic equation $\log(x^8) = (\log x)^4$.

- (ii) Solve the inequality $(e^x - 2)(e^x - 3) < 2e^x$.

[3,4]

- (b) (i) Find the domain of $(f \circ g)(x)$ where

$$f(x) = \frac{1}{x - 2} \text{ and } g(x) = \sqrt{x + 4}.$$

Turn Over/...

- (ii) Sketch the graph of the following rational function indicating all asymptotes and intercepts:

$$f(x) = \frac{6 - 2x}{1 - x}.$$

[4,4]

- (c) (i) Find the limit

$$\lim_{x \rightarrow \infty} \frac{2x + 5}{x^2 - 7x + 3}.$$

- (ii) Determine whether or not the function

$$f(x) = \begin{cases} \frac{|x-4|}{x-4} & \text{if } x \neq 4 \\ 0 & \text{if } x = 4. \end{cases}$$

is continuous at $x = 4$.

[2,3]

END!

The University of Zambia
Department of Mathematics and Statistics

2022/23 Academic Year Examination

MAT 1120 - Introductory Mathematics, Statistics and Probability

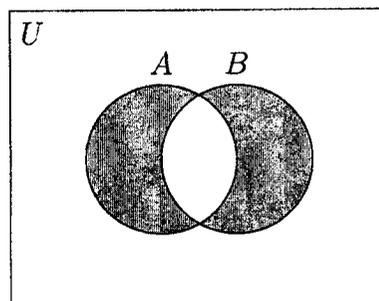
Duration : 3 hours

October 30, 2023

INSTRUCTIONS:

- There are seven (7) questions in this paper.
- All seven questions carry equal marks.
- Answer any five (5) questions.
- Show all necessary working to earn full marks.
- Calculators are not allowed in this exam.
- This paper consists of four (4) printed pages.

1. (a) i. Use set notation to describe the shaded region in the Venn diagram shown below. [2]



- ii. Given that $A = (-\infty, -2] \cup (5, \infty)$ and $B = [-3, 6)$ are subsets of the set of real numbers, find $B - A$ [2]

- (b) i. Given that x and y are real numbers, solve for x and y in the equation [4]

$$\frac{1}{x + yi} + \frac{1}{1 + 3i} = 1$$

- ii. Express [3]

$$\frac{\sqrt{7} + 1}{\sqrt{7} - 1}$$

in the form $a + b\sqrt{7}$, where a and b are rational numbers.

- (c) i. Find the coefficient of x^2 in the expansion of [5]

$$\frac{(1+x)^2}{(1-x)^{-3}}$$

- ii. Find the term independent of x in the expansion of [4]

$$\left(2x^2 - \frac{1}{x}\right)^{12}$$

Total marks : 20

2. (a) The equation $p(x) = -2x^2 + 280x - 1000$, where x represents the number of items sold, describes the profit function for a certain business.

- i. By completing the square, express $p(x)$ in the form $p(x) = a(x+p)^2 + q$, where a, p and q are constants. [3]
 ii. Find the number of items that should be sold to maximize the profit. [2]
 iii. Find the maximum profit of the business. [2]

- (b) i. Find the range of values of k such that the equation [4]

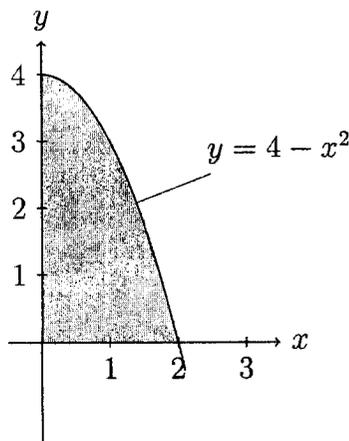
$$kx^2 + 4\sqrt{3}x + k = 1$$

will have complex roots.

- ii. The roots of equation $2x^2 - 4x + 5 = 0$ are α and β . Find the value of $\alpha^2 + \beta^2$. [2]

- (c) i. Use the definition of the derivative (from first principles) to show that the derivative of the function $f(x) = x^2$ is $f'(x) = 2x$. [3]

- ii. Find the area of the shaded region shown in the diagram below. [4]



Total marks : 20

3. (a) i. Using the fact that $x^2 - 3$ is a factor of $x^4 + 2x^3 - 2x^2 - 6x - 3$, find all the real solutions of the equation [4]

$$x^4 + 2x^3 - 2x^2 - 6x - 3 = 0$$

- ii. For what value(s) of k does the function $f(x) = x^3 + 6x^2 + kx - 4$ give the same remainder when divided by $x - 1$ and $x + 2$. [3]
- (b) i. Given that $2x^3 - x^2 - 7x - 5 = (Ax + B)(x - 1)(x + 2) + C$ for all values of x , find the values of A , B and C . [3]
- ii. Factorise completely the polynomial $x^3 - 3x^2 - 4x + 12$. [3]
- (c) Consider the function $f(x) = (x + 1)(x - 2)^2$.
- i. Identify the critical points of the function. [2]
- ii. Determine the nature of the critical points. [2]
- iii. Sketch the graph of the function clearly indicating the x and y intercepts and relative maxima and relative minima. [3]

Total marks : 20

4. (a) i. Find the real values of x such that $x + 2 > \frac{12}{x + 3}$. [5]

ii. Solve the equation $\frac{-2}{1 - x} = x$. [3]

(b) Let $f(x) = \frac{1}{1 - x^2}$ be a function.

i. Sketch the graph of f . [3]

ii. Find $\lim_{x \rightarrow 1^+} f(x)$. [1]

(c) i. Express [5]

$$\frac{1}{(x - 1)^2(x + 1)}$$

as a sum of its partial fractions

ii. Using your answer in i, or otherwise, evaluate the indefinite integral [3]

$$\int \frac{1}{(x - 1)^2(x + 1)} dx$$

Total marks : 20

5. (a) i. Find the domain of the function [2]

$$f(x) = \frac{1}{\sqrt{1 - x}}$$

ii. Find the set of real values of x for which [6]

$$\left| \frac{1 - x}{1 + x} \right| \leq 1$$

(b) Let $f(x) = \sqrt{x - 1} - 1$ be a function

i. Sketch the graph of f [3]

- ii. Find the range of f [1]
 (c) i. Determine whether or not the function [3]

$$f(x) = \begin{cases} 1 - |x| & x < 1 \\ x - 1 & x \geq 1 \end{cases}$$

- is continuous at $x = 1$.
 ii. Find an equation of the tangent line to the curve $y = \sqrt{x}$ that crosses the x -axis at $x = -1$. [5]

Total marks : 20

6. (a) i. Find the value of $\ln(\sqrt{e})$. [1]
 ii. Find the real value (s) of x such that $2 - \log_2(x - 3) = 1$ [2]
 (b) Let $f(x) = e^{-3x} - 4$ for $x \in \mathbb{R}$ and $g(x) = \ln\left(\frac{1}{x+1}\right)$ for $x > -2$.
 i. State the range of f [2]
 ii. Find f^{-1} [3]
 iii. Express $f \circ g$ as a polynomial in x . [4]
 (c) i. Show that the function [4]

$$f(x) = x - \ln x, \text{ for } x > 0$$

- is increasing on the interval $(1, \infty)$.
 ii. Evaluate the indefinite integral [4]

$$\int x e^x dx$$

Total marks : 20

7. (a) i. Find the exact value of $\cos\left(\frac{5\pi}{3}\right)$ [1]
 ii. Solve the trigonometric equation [3]

$$2(\tan x + 3) = 5 + \tan x$$

given that $x \in [0, 2\pi)$.

- (b) i. Given the function [5]
- $$f(x) = 1 + 3 \sin\left(x + \frac{\pi}{2}\right)$$

State the period, the amplitude and the phase shift of the given function and **sketch** its graph

- ii. Prove that for any angle θ , $(\sin \theta + \cos \theta)^2 = 1 + \sin(2\theta)$. [3]

- (c) i. Given that $y = \frac{1}{\cos x} + \tan x$, show that $\frac{dy}{dx} = \frac{1}{1 - \sin x}$. [5]
 ii. Evaluate the definite integral [3]

$$\int_0^{\pi} \cos^2(x) \sin(x) dx$$

Total marks : 20

————— End of Examination —————

The University of Zambia
School of Natural Sciences
Department of Mathematics & Statistics
2022/2023 Academic Year Final Examinations
MAT 2100 - Analytic Geometry and Calculus
November 13, 2023

Time allowed : Three (3) hours

Full marks : 100

Instructions:

- Indicate your **computer number** on all answer booklets.
- There are six (6) questions in this examination. Attempt **any five (5)** questions. All questions carry equal marks.
- **Full credit** will only be given when **necessary work** is shown.

This paper consists of 3 pages of questions.

Q1. (a) A translated conic section is centred at $(-1, 0)$ with eccentricity, $e = \sqrt{\frac{5}{6}}$, and one equation of the directrix given by $y = 6$.

(i) Find the equation of the conic section. [4]

(ii) Hence sketch its graph, clearly stating coordinates of the vertices. [2]

(b) Identify and sketch the conic section given by [5]

$$r = \frac{6}{1 + \cos \theta}.$$

(c) Solve the following differential equations:

(i) $\left(\frac{y}{2} + \frac{1}{4} \sin 2y\right) dx - (x \cos^2 y) dy = 0$ [6]

(ii) $3y'' + 4y' + y = 0$ [3]

Q2. (a) The function [6]

$$f(x) = x^2 e^x - e^x, \quad x \in [-1, 1],$$

satisfies the hypotheses of the Rolle's theorem. Find $c \in \mathbb{R}$ that satisfies the conclusion of the theorem.

Turn Over/...

- (b) A curve is given by [7]

$$y = \ln(\sin x), \quad \frac{\pi}{2} \leq x < \pi.$$

Find an intrinsic equation of the curve in the form $s = g(\psi)$, where s is measured from the point $(0,0)$ and ψ is the angle the tangent to the curve makes with the positive x -axis.

- (c) Find the moment about the y -axis of a thin plate covering the finite region bounded by the curve $y = x - x^2$ and the line $y = -x$ with density ρ . [7]

- Q3. (a) (i) Evaluate the indefinite integral [5]

$$\int \frac{dt}{\cos t + 2(1 + \sin t)}.$$

- (ii) Given that [4]

$$f(x) = \frac{1}{(x+1)^2}, \quad x \in [0, 2],$$

find $c \in \mathbb{R}$ that satisfies the mean value theorem for integrals.

- (b) The region bounded by the curve $y = \frac{1}{x}$, $x \geq 2$ and the line $y = 0$ is rotated about the x -axis. Find the volume of the resulting solid. [4]

- (c) Verify the Euler's theorem for the homogeneous function [7]

$$h(x, y, z) = \left(\sqrt{xy^3}\right)z - \frac{y^5}{\sqrt{x^3z}}.$$

- Q4. (a) (i) Find the equation of a line passing through the points $(4, 0, -2)$ and $(5, 1, -1)$. [2]

- (ii) Given that the distance between the point $S(a, 2a, -a)$ and a line in part (i) above is $\sqrt{14}$, find the coordinates of S . [4]

- (b) (i) Find the equation of a plane containing the lines [4]

$$\frac{x-1}{-2} = y-4 = z$$

and

$$\frac{x-2}{-3} = \frac{y-1}{4} = \frac{z-2}{-1}.$$

- (ii) Given that [4]

$$R(t) = (3 \cos t) i + (3 \sin t) j + tk,$$

find the curvature at $t = \frac{\pi}{4}$.

Turn Over/...

- (c) (i) Rotate the coordinate axes to change the equation [5]

$$x^2 + 2xy + y^2 - 18 = 0$$

into an equation that has no cross product (xy) term.

- (ii) Hence, or otherwise, identify the conic section. [1]

- Q5. (a) (i) Evaluate the following limit: [4]

$$\lim_{(x,y) \rightarrow (4,2)} \left(\frac{x^2 - y^4}{x - 2y} \right).$$

- (ii) Hence, or otherwise, determine the continuity of the function [2]

$$f(x, y) = \begin{cases} \frac{x^2 - y^4}{x - 2y}, & (x, y) \neq (4, 2) \\ -4, & (x, y) = (4, 2) \end{cases}$$

at the point $(4, 2)$.

- (b) Determine the nature of the critical point(s) of the function [7]

$$P(x, y) = x^2 + y^2 + 4x - 2y + 3.$$

- (c) Find the interval and radius of convergence of the power series [7]

$$\frac{(x+3)}{5} + \frac{2(x+3)^2}{5^2} + \frac{3(x+3)^3}{5^3} \dots \frac{n(x+3)^n}{5^n} \dots$$

- Q6. (a) Find a general solution to each of the following differential equations:

(i) $x^2 \frac{dy}{dx} + y = 2$ [4]

(ii) $\frac{d^2y}{dx^2} - 2\frac{dy}{dx} + y = \frac{e^x}{\sqrt{x-1}}$ [7]

- (b) Consider a tank holding 1000 litres of pure water in which is dissolved 20 kilograms of salt. Suppose that 4 litres of brine, each containing 1 kilogram of dissolved salt, run into the tank per minute, and the mixture, kept uniform by high-speed stirring, runs out of the tank at the rate of 3 litres per minute.

- (i) Derive the initial-value problem for this mixture problem. [2]

- (ii) Find the amount of salt in the tank at any time t . [4]

- (c) Find the volume of the parallelepiped determined by the vectors $A = i + j - 2k$, $B = -i - k$ and $C = 2i - 4j - 2k$. [3]

END OF EXAMINATION!

The University of Zambia
Department of Mathematics and Statistics
Academic Year: 2022/2023
MAT2110: ENGINEERING
MATHEMATICS I

Instructions:

- This paper has 6 questions.
 - Attempt any five (5).
 - Show all necessary working.
 - Duration is 3 hours.
-

1. (a) Sketch the graph of each of the following conic sections. In each case, indicate all necessary points and equations.

i. $4(y + 1) = (x - 3)^2$. [2]

ii. $9x^2 + 16y^2 - 32y + 36x - 92 = 0$. [6]

(b) i. Find $\frac{d^2y}{dx^2}$ given that $y = \frac{x-1}{x+1}$. [3]

ii. Given that $xy + y^2 = 1$, show that $\frac{d^2y}{dx^2} = \frac{2}{(x+2y)^3}$. [4]

(c) Evaluate each of the following.

i.

$$\int_0^{\frac{\pi}{12}} \sin^2 3\theta \, d\theta.$$

ii.

$$\int_0^{\frac{\pi}{2}} \frac{1}{1 + \cos \theta} \, d\theta.$$

2. (a) Identify and sketch the conic section given by $4x^2 - 4xy + 7y^2 - 24 = 0$. [10]

(b) i. A rectangular box without lid is to be made from $12 m^2$ of cardboard. Find the maximum volume of such a box. [4]

ii. Use Linearisation to approximate, to two decimal places, the value of $\sqrt{35}$. [4]

(c) i. Determine the reduction formula for

$$\int \tan^m x \, dx.$$

ii. Use the reduction formula to integrate

$$\int \tan^7 x \, dx.$$

3. (a) i. Find the value of

$$\sum_{n=0}^{\infty} \frac{3}{2^n}.$$

ii. Find the n^{th} Taylor polynomial for $f(x) = \ln x$ at $c = 1$. [3]

(b) i. Find the symmetric equations of the line passing $(3, 0, 2)$, and is perpendicular to the lines [5]

$$L_1 : \langle x, y, z \rangle = \langle 5, 2, 7 \rangle + s\langle 1, -1, -2 \rangle \text{ and}$$

$$L_2 : x = 3t + 2, \quad y = 2t + 3, \quad z = 6$$

ii. Find the distance from the point $(1, 0, 5)$ to the line $L : x = 1 + t, \quad y = 3 - t$
• and $z = 2t$. [5]

(c) i. Sketch the region bounded by the graph of $f(x) = \sqrt{x}$, and the lines $y = 1$ and $x = 4$. [2]

ii. Hence, or otherwise, find the volume of the solid formed by revolving the region bounded by the graph of $f(x) = \sqrt{x}$, and the lines $y = 1$ and $x = 4$ about the line $y = 1$. [5]

4. (a) i. Find the equation of the plane containing the line given by $\langle x, y, z \rangle = \langle 1, 2, 4 \rangle + t\langle 4, 1, 11 \rangle$, and is perpendicular to the line with equation $\langle x, y, z \rangle = \langle 4, 15, 8 \rangle + s\langle 2, 3, -1 \rangle$. [3]
 ii. Given that $R(t) = \cos t i + \sin t j + t k$, find $T(t)$, the unit tangent vector, at $t = \frac{\pi}{3}$. [5]

- (b) i. Find the radius of convergence of

$$\sum_{n=0}^{\infty} 3(x-2)^n.$$

- ii. Find the interval of convergence of

$$\sum_{n=1}^{\infty} \frac{x^n}{n}.$$

- (c) i. The power P dissipated in a resistor is given by $P = \frac{E^2}{R}$. If $E = 200$ volts and $R = 8$ ohms, find the change in P resulting from a drop of 5 volts in E and an increase of 0.2 ohms in R . [3]
 ii. Given that $y^2 + xz + z^2 - e^z - 4 = 0$, defines z implicitly as a function of x and y , say $z = f(x, y)$. Compute $\frac{\partial f}{\partial x}$ at the point $(0, e, 2)$. [5]

5. (a) Given that $z = 2x^2 + 3xy + 4y^2$, and $u = x^2 + y^2$ and $v = x + 2y$,
 i. Find $\frac{\partial x}{\partial u}$ and $\frac{\partial y}{\partial u}$. [6]
 ii. Hence, or otherwise, find $\frac{\partial z}{\partial u}$. [4]
 (b) Find the relative extrema for $f(x, y) = -x^3 + 4xy - 2y^2 + 1$. [6]
 (c) i. Find the equation of the curve which passes through $(0, 1)$ and satisfies the equation $\frac{dy}{dx} = \frac{xy}{1+x^2}$. [4]
 ii. Solve the Bernoulli equation $y' + xy = xe^{-x^2}y^{-3}$. [5]

6. (a) i. Verify that $f_{xx} + f_{yy} = 0$ if $f(x, y) = \tan^{-1}(\frac{y}{x})$. [5]
 ii. If $z = \sin(3x + 2y)$, show that $3\frac{\partial^2 z}{\partial y^2} - 2\frac{\partial^2 z}{\partial x^2} = 6z$. [4]
 (b) If $(\cos x - x \sin x + y^2) dx + 2xy dy = 0$,
 i. show that this is an **exact** differential equation. [2]
 ii. hence solve the equation. [5]
 (c) Solve the equation $\frac{d^2 y}{dx^2} + y = \tan x$ using the method of **variation of parameters**. [9]

The University of Zambia
Department of Mathematics and Statistics

2022/23 Academic Year Examination

MAT 3110 - Engineering Mathematics II

Duration : 3 hours

November 2, 2023

INSTRUCTIONS:

- There are six (6) questions in this paper.
- All questions carry equal marks.
- Answer any five (5) questions.
- Show all necessary working to earn full marks.

This paper consists of 4 printed pages.

1. (a) Use Laplace transforms to find the solution to the following initial value problem. [8]

$$y'' - y = u(t - 1), \quad y(0) = 1, \quad y'(0) = 0$$

Note that $u(t - 1)$ is a unit step function.

- (b) Find the Laplace transforms of the following functions:

i. $f(t) = t^2 \sin t$ [3]

ii. $g(t) = \cos(2t) \cos(t)$ [2]

- (c) Find the inverse Laplace transforms of the following functions:

i. $F(s) = \frac{1 - e^{-2\pi s}}{s^2 + 1}$ [3]

ii. $G(s) = \frac{2s}{(s^2 + 1)^2}$ [4]

Total marks : 20

2. (a) Find a power series solution to the given ordinary differential equation [7]

$$(x^2 + 1)y'' - 4xy' + 6y = 0$$

- (b) Find the particular solution to the following initial value problem. [7]

$$2x^2y'' + 3xy' - 15y = 0, \quad y(1) = 0, y'(1) = 1$$

- (c) Find a real general solution to the following system of first order linear differential equations. [6]

$$\begin{aligned}x_1' &= 8x_1 - x_2 \\x_2' &= x_1 + 10x_2\end{aligned}$$

Total marks : 20

3. (a) Evaluate the given double integrals below.

i. [4]

$$\int_0^{2\sqrt{\ln 3}} \int_{\frac{y}{2}}^{\sqrt{\ln 3}} e^{x^2} dx dy$$

ii. [4]

$$\int_{-1}^1 \int_{-\sqrt{1-y^2}}^0 \frac{4\sqrt{x^2+y^2}}{1+x^2+y^2} dx dy$$

- (b) i. Suppose that the area of a region in the polar coordinate plane is given by the double integral [4]

$$A = \int_{\frac{\pi}{4}}^{\frac{3\pi}{4}} \int_{\csc \theta}^{2 \sin \theta} r dr d\theta,$$

sketch the region and find its area.

- ii. Evaluate the integral [4]

$$\int_0^\infty \int_0^\infty \frac{1}{(1+x^2+y^2)^2} dy dx$$

- (c) Use a double integral to determine the volume of the solid that is inside both the cylinder $x^2 + y^2 = 9$ and the sphere $x^2 + y^2 + z^2 = 16$. [4]

Total marks : 20

4. (a) Evaluate the following triple integrals

i.

$$\int_0^{\sqrt{2}} \int_0^{3y} \int_{x^2+3y^2}^{8-x^2-y^2} dz dx dy$$

[3]

ii.

$$\int_0^{2\pi} \int_0^{\frac{\pi}{4}} \int_0^{\sec \phi} (\rho \cos \phi) \rho^2 \sin \phi d\rho d\phi d\theta$$

[4]

(b) Let D be the region in the 3-dimensional space bounded below by the cone $z = \sqrt{x^2 + y^2}$ and above by the paraboloid $z = 2 - x^2 - y^2$.

i. Set up the triple integrals in cylindrical coordinates that gives the volume of D using the order $d\theta dr dz$.

[3]

ii. Evaluate the integral in i.

[4]

(c) Use an appropriate triple integral to find the volume of the solid bounded above by the sphere $x^2 + y^2 + z^2 = 2$ and below by the elliptic paraboloid $z = x^2 + y^2$.

[6]

Total marks : 20

5. (a) i. Evaluate

$$\int_C (x + y + z) ds$$

[3]

where C is the straight-line segment from $(1, 2, 3)$ to $(0, -1, 1)$.

ii. Evaluate

$$\int_C \vec{\mathbf{F}} \cdot d\vec{\mathbf{r}}$$

[4]

where $\vec{\mathbf{F}}(x, y) = xy \mathbf{i} + (x + y) \mathbf{j}$ and C is the curve along $y = x^2$ from $(-1, 1)$ to $(2, 4)$.

(b) Consider the 2-dimensional vector field given below.

$$\vec{\mathbf{F}} = y^2 (1 + \cos(x + y)) \vec{\mathbf{i}} + (2xy - 2y + y^2 \cos(x + y) + 2y \sin(x + y)) \vec{\mathbf{j}}$$

i. Show that the vector field is conservative.

[3]

ii. Find a potential function for the vector field.

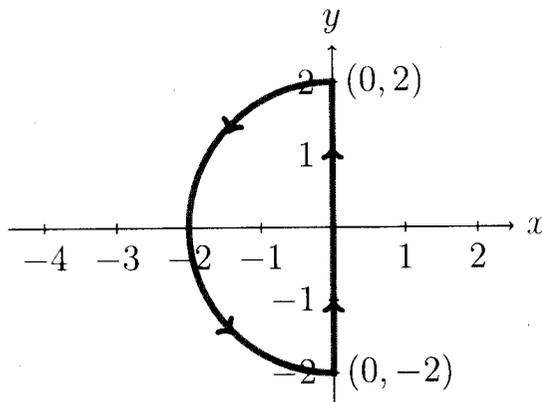
[4]

(c) Evaluate the line integral

[6]

$$\int_C \vec{F} \cdot d\vec{r}$$

where $\vec{F} = (yx^2) \mathbf{i} - (x^2) \mathbf{j}$ and C is the path shown in the diagram below.



Total marks : 20

6. (a) Use a surface integral to find the surface area of the surface S which is the portion of the cone $z = \frac{\sqrt{x^2+y^2}}{3}$ between the planes $z = 1$ and $z = \frac{4}{3}$. [8]
- (b) Find a parametrization of the surface S , which is the portion of the plane $x + y + z = 1$ that is inside the cylinder $y^2 + z^2 = 9$. [4]
- (c) Use an appropriate parametrization to find the flux [8]

$$\iint_S \vec{F} \cdot d\vec{S}$$

where $\vec{F} = \mathbf{i} + z \mathbf{j} + 6x \mathbf{k}$ and S is the portion of the sphere of radius 3 with $x \leq 0$, $y \geq 0$ and $z \geq 0$ oriented inward (that is towards the origin).

Total marks : 20

————— *End of Examination* —————

The University of Zambia
School of Natural Sciences
Department of Mathematics & Statistics
2022/2023 Examinations - November 10 2023
MAT 4119 - Engineering Mathematics III

Time allowed : Three (3) hours

Full marks : 100

Instructions:

- Attempt **any (5) five** questions out of the **(6) six**
- **Full credit** will only be given when **necessary work** is shown.
- Indicate your **computer number** on all answer booklets used.
- Mark allocations are shown in the brackets.
- A formula sheet is attached.

This paper consists of 4 pages of questions.

1. (a) Given the function $f(x) = e^x \sin x$:
 - (i) Use the second degree Maclaurine polynomial to estimate $f(0.5)$. [4]
 - (ii) Find the upper bound for the error incurred when approximating $f(0.5)$ in (i) above. [4]
- (b) Consider the function $f(x) = 3x - e^x + \sin x$:
 - (i) Show that there is a root to the function $f(x)$ on the interval $[0, 1]$. [2]
 - (ii) Approximate the root to three significant figures using the bisection method. [4]

-
- (c) Find a bound for the number of iterations needed to achieve an approximation with accuracy 10^{-3} to the solution of

$$x \sin x - 1 = 0$$

on the interval $[0, 2]$ while using the bisection method.

2. (a) Use the fixed-point iteration to find the unique root of the equation

$$x^3 + 4x^2 - 10 = 0, \quad \text{using } g(x) = x - \frac{x^3 + 4x^2 - 10}{3x^2 + 8x}$$

in the interval $[1, 2]$ with $p_0 = 1.5$ as the initial approximation.

- (b) Given the function

$$f(x) = (x - 1)(e^{x-1} - 1)$$

- (i) Find the multiplicity of $x = 1$ as a zero of $f(x)$.
(ii) Hence, use the Modified Newton-Raphson's method to approximate the same zero starting with $x_0 = 0$.

- (c) Show that the mapping $f(z) = z^2$ maps the strip

$$S = \{z : 1 \leq \operatorname{Re}(Z) \leq 3\}$$

onto a set of parabolas and describe the parabolas.

3. (a) For the nonlinear system

$$x_1 = g_1(x_1, x_2) = \frac{x_1^2 + x_2^2 + 8}{10}, \quad x_2 = g_2(x_1, x_2) = \frac{x_1 x_2^2 + x_1 + 8}{10} :$$

Show that $\mathbf{G} = (g_1, g_2)^t$ mapping

$$D = \{\mathbf{X} = (x_1, x_2)^t : 0 \leq x_i \leq 1.5, i = 1, 2\}$$

into \mathbb{R}^2 has a unique fixed point in D .

- (b) Apply functional iteration to approximate the unique solution in (a) with accuracy of 2 significant figures using Newton's method or the fixed point method .

[8]

- (c) Find

$$\lim_{z \rightarrow -\pi i} e^{\frac{z^2 + \pi^2}{z + \pi i}}.$$

[4]

4. (a) Given the data (1, 0), (2, 3), (3, 2) :

- (i) Fit a quadratic spline to the function $f(x)$ defined by this set of points.

[4]

- (ii) Use the quadratic spline found in (i) to approximate $f(2.5)$.

[2]

- (b) Use the appropriate Newton's interpolation method (forward- or backward-) to find the annual premium at the age of 38, using the data given in the table below:

Age in years	24	28	32	36	40
Annual premium	28.06	30.19	32.75	34.94	40

[10]

- (c) Find all numbers z such that $(z + 1)^3 = 2 + 2i$.

[4]

5. (a) Approximate $f'(0.4)$ using the approximation formula

$$f'(x_0) = \frac{1}{2h} [-3f(x_0) + 4f(x_0 + h) - f(x_0 + 2h)] + \frac{h^2}{3} f^{(3)}(c),$$

and the values of $f(x)$ at

$$x = 0.25, 0.30, 0.35, 0.4, 0.45, 0.5, \quad h = 0.05,$$

and where $x_0 < c < x_0 + 2h$.

[8]

(b) Find a bound for the error in (a) above. [6]

(c) Using the Composite Trapezoidal rule, determine the value of n and h required to approximate

$$\int_0^2 e^x \sin 3x \, dx$$

to within 10^{-4} accuracy. [6]

6. (a) Use Taylor's method of order two to approximate the solution to

$$y' = \frac{1}{t}(y^2 + y), \quad 1 \leq t \leq 3, \quad y(1) = -2, \quad h = 0.5.$$

[10]

(b) Find the image of the semi strip

$$S = \left\{ z = x + iy, \frac{-\pi}{2} \leq x \leq \frac{\pi}{2}, \quad y \geq 0 \right\}$$

under the mapping $f(z) = \sin z$. [10]

(c) Determine whether the function

$$f(z) = \begin{cases} \frac{z-i}{z^2+1}, & \text{if } z \neq i \\ \frac{-i}{2}, & \text{if } z = i. \end{cases}$$

is continuous at the point $z = i$. [4]

End



**The University of Zambia
School of Natural Sciences
Department of Physics
2022/23 Academic Year
Introductory Physics: PHY 1010**

All questions carry equal marks. The marks are shown in brackets. Question 1 is compulsory. Attempt four more questions. Clearly indicate on the answer script cover page which questions you have attempted.

Time: Three hours.

Maximum marks = 100.

Do not forget to write your computer number clearly on the answer book as well as on the answer sheet for Question 1. Tie them together!!

=====

Wherever necessary use:

$$g = 9.8\text{m/s}^2$$

$$P_A = 1.01 \times 10^5 \text{ N/m}^2$$

$$1 \text{ cal.} = 4.18 \text{ J}$$

$$\rho_{\text{water}} = 1000\text{kg/m}^3$$

$$1 \text{ hp} = 746\text{W}$$

$$1 \text{ Pascal} = 1 \text{ N/m}^2$$

$$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$$

$$1 \text{ metric ton} = 1000 \text{ kg}$$

Question 1: Sample answers: F (a), G (d)... etc. **DO NOT guess** the answer. For each correct answer, **2 marks** are given. For each wrong answer, **0.67** will be deducted. For no answer, zero mark. The minimum total mark for Question 1 is zero. [10 × 2 = 20]

- (A) A ball dropped loses potential energy. Gravity is an example of:
- (a) a non conservative force.
 - (b) a conservative force.
 - (c) dissipative force.
 - (d) any of the above, depending on the reference level.
- (B) The magnitude of the resultant of two forces is a minimum when the angle between them is.
- (a) 0 (b) 45 (c) 90° (d) 180°
- (C) The acceleration of gravity on planet Mars is 3.7 m/s². Compared with her mass and weight on Earth, an astronaut on Mars has:
- (a) less mass and less weight.
 - (b) less mass and more weight.
 - (c) the same mass and less weight.
 - (d) less mass and the same weight.
- (D) The coefficient of friction is defined as:
- (a) the ratio of the force needed to induce motion to the force needed to maintain motion.
 - (b) the ratio of the pressure to the force pressing the surfaces together.
 - (c) the ratio of the frictional force to the normal force.
 - (d) the ratio of the normal force to the frictional force.
- (E) An 800 kg car moving at 80 km/hr collides with a 1200 kg car moving at 40 km/hr in the same direction. If the two cars stick together, the wreckage has an initial speed of?
- (a) 8 km/hr
 - (b) 56 km/hr
 - (c) 40 km/hr
 - (d) 60 km/hr
- (F) When a force acts on an object, the stress on it is equal to:
- (a) Young's modulus
 - (b) the relative change in its dimensions
 - (c) the elastic limit
 - (d) the applied force per unit area
- (G) The moment of inertia of an object does not depend on:
- (a) its size and shape.
 - (b) its mass.
 - (c) its angular speed.
 - (d) the location of the axis of rotation.

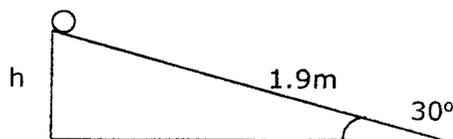
- (H) In an equilibrium problem the point about which torques are computed:
- must pass through the object's centre of gravity.
 - may be located anywhere.
 - must pass through one end of the object.
 - must intersect the line of action of at least one force acting on the object.
- (I) The pressure at the bottom of a vessel filled with a liquid does **not** depend on the:
- liquid density
 - acceleration due to gravity
 - height of the liquid
 - area of the liquid surface
- (J) When an ox pulls a wagon, the force that allows the ox to move forward is the force
- the ground exerts on it
 - it exerts on the wagon
 - it exerts on the ground
 - the wagon exerts on it

ATTEMPT ANY FOUR QUESTIONS FROM BELOW:

Q.2 (a) A vector **A** has a magnitude of 30 m at an angle of 200° with respect to the positive x-axis. If we add a vector **B**, it is found that the resultant is along the positive x-axis and has magnitude of 10 m, what are the components of vector **B** and its direction? [10]

(b) A solid uniform disc with radius 7.5 cm starts from rest and rolls down a frictionless plane 1.9 m long. [$I_{\text{solid disc}} = (1/2)mr^2$]

- What is its linear speed at the bottom?
- What is its angular velocity (in rad/s)?
- How long does it take to reach the bottom? [10]



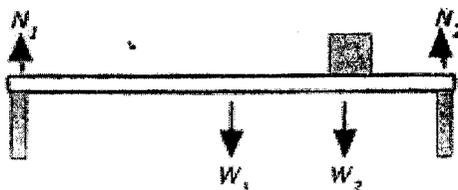
Q.3 (a) A stone is thrown upward from the top of a building at an angle of 25° to the horizontal level of the roof and with an initial velocity of 15 m/s. If the stone is in flight for 3.0 seconds before hitting the level ground, how tall is the building? [10]

(b) A solid wooden cube, 30 cm on each side, can be totally submerged in water if it is pushed with a downward force of 54.0 N. What is the density of the wood? [8]

(c) State Archimedes Principle in words as well as in equation form. [2]

Q.4 (a) A child starts from the top of a slide of height 5 m. If he reaches the bottom with a speed of 8 m/s, what percentage of his energy at the top of the slide has been lost as result of friction? [10]

(b) A uniform bar of length L and $W_1 = 35$ N is supported at its ends as shown below. A block of $W_2 = 10$ N is placed at one quarter distance from the right hand side end. What are the magnitudes of the forces N_1 and N_2 exerted on the bar? [10]

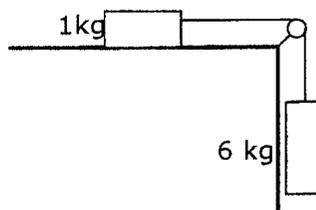


Q.5 (a) Find the minimum amount of ice at -10 °C needed to bring the temperature of 100 g of water at 20 °C down to 0 °C. Given that $c_{ice} = 2.09$ kJ/kg, $H_{ice} = 335$ kJ/kg, and $c_{water} = 4.185$ kJ/kg.°C. [9]

(b) An aluminium wire 3 mm diameter and 4 m long is used to support a mass of 50 kg. What is the elongation of the wire? Aluminium Young's modulus is 7.07×10^{10} Pa. [7]

(c) Define the elastic limit of a material. [3]

Q.6 (a) The coefficient of kinetic friction between the table top and the 1 kg mass on top of it is 0.30. If the pulley is taken to be mass-less and frictionless, and the connecting rope mass-less, use energy methods to calculate the speed of the hanging 6 kg block after it has descended 0.8 m from its starting point at rest. [10]

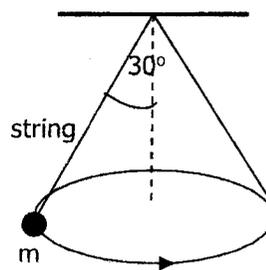


(b) A horizontal disc rotating freely about a vertical axis makes 10 rev/min. A small piece of wax of mass 10 g falls vertically on the disc and sticks to it at a distance of 9 cm from the axis. If the number of rev/min is thereby reduced to 9, calculate the moment of inertia of the disc. Given, the moment of inertia of a disc of radius $r = (1/2)Mr^2$ and the moment of a point mass at a distance b from the axis = mb^2 . [10]

(b) A gun of mass 4 kg recoils with a speed of 0.5 m/s when it fires a bullet of mass 10 gram horizontally.

- i) Find the speed with which the bullet is fired,
- ii) If the bullet embeds itself in a 1.99 kg block of wood at rest on a horizontal table, with what velocity does the block move?
- iii) If the block (+bullet) stops after 10 cm, what is the coefficient of sliding friction between the block and the table? [10]

Q.8 (a) A small body of mass m revolves in a horizontal circle at a constant speed at the end of a string of length 1.2 m. As the body revolves the string describes the surface of a right circular cone. If the angle between the vertical and side of the cone is 30° , calculate the speed of the body both in m/s and rad/s, and the time the body takes to complete one revolution. [10]



(b) A balloon filled with helium gas has a volume of 1500 m^3 . The density of helium is 0.178 kg/m^3 and has a gross weight of 3500 N. Given that the density of air is 1.293 kg/m^3 . What is the maximum load can this balloon lift? [8]

(c) Define the buoyant force. [2]

END OF EXAMINATION

Equations

Uniformly accelerated motion:

$$x = \bar{v}t \quad \bar{v} = \frac{1}{2}(v_f + v_i) \quad v_f = v_i + at \quad v_f^2 = v_i^2 + 2ax$$

$$x = v_i t + \frac{1}{2}at^2$$

Projectile motion:

$$v_x = v_i \cos \theta_i = \text{constant} \quad v_y = v_i \sin \theta_i - gt \quad y = (v_i \sin \theta_i)t - \frac{1}{2}gt^2$$

$$y = (\tan \theta_i)x - \left[\frac{g}{2v_i^2 (\cos^2 \theta_i)} \right] x^2 \quad R = \frac{v_i^2}{g} \sin 2\theta \quad t = \frac{2v_i \sin \theta}{g}$$

Force and motion:

$$F = ma \quad w = mg \quad F_{AB} = -F_{BA} \quad F_f = \mu F_N$$

Energy:

$$PE = wh = mgh \quad KE = \frac{1}{2}mv^2 \quad W = Fx \cos \theta \quad P = \frac{W}{t} = Fv \cos \theta$$

Linear momentum:

$$p = mv \quad F\Delta t = \Delta mv$$

Circular motion and gravitation:

$$T = \frac{2\pi r}{v} \quad a_c = \frac{v^2}{r} \quad F_c = \frac{mv^2}{r} \quad F_{grav} = G \frac{m_A m_B}{r^2}$$

Rotational motion and angular momentum:

$$\theta = \frac{s}{r} = \left(\frac{\omega_i + \omega_f}{2} \right) t \quad \omega = \frac{\theta}{t} \quad \theta = \omega_i t + \frac{1}{2}\alpha t^2 \quad \omega_f = \omega_i + \alpha t$$

$$v = \omega r \quad \omega_f^2 = \omega_i^2 + 2\alpha\theta \quad \alpha = \frac{\Delta\omega}{\Delta t} = \frac{a_T}{r} \quad I = \sum mr^2$$

$$KE_{rot} = \frac{1}{2}I\omega^2 \quad \tau = FL = I\alpha \quad W = \tau\theta \quad P = \tau\omega \quad L = I\omega$$

Properties of matter:

$$\rho = \frac{m}{V} \quad F = -kx \quad \phi = \frac{s}{d} = \frac{1}{s} \frac{F}{A} \quad Y = \frac{F/A}{\Delta L/L}$$



THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF PHYSICS

2022/2023 UNIVERSITY EXAMINATIONS

PHY1015: INTRODUCTORY PHYSICS FOR MEDICAL SCIENCES

DURATION: 3 HOURS

MAXIMUM SCORE: 100

INSTRUCTIONS

The paper contains 7 questions, each carrying 20 marks. Attempt **FIVE (5)** questions only.

SECTION A

Q1 is compulsory and comprises 10 multiple-choice questions (A – J), 2 marks each.

Mark your choice with a cross X on the multiple-choice answer sheet provided.

SECTION B

Choose any **FOUR (4)** questions.

Show all your calculations clearly to earn some credit.

Write your computer number clearly on all the answer sheets used and fasten them together using the string provided in the examination venue in readiness for submission.

Constants and formulas are included at the back of the question paper. Use where necessary.

SECTION A

Q1 (A - J) IS COMPULSORY

- Q1 (A) What is the rotational inertia of a rigid body called? [2]
- (a) Moment of force
 - (b) Moment of inertia
 - (c) Moment of energy
 - (d) Moment of acceleration
- (B) The rotational kinetic energy (KE) of a body is given by [2]
- (a) $KE = I\omega$
 - (b) $KE = \frac{1}{2}I\omega^2$
 - (c) $KE = 2I^2\omega$
 - (d) $KE = \frac{1}{2}I^2\omega$
- (C) A 30 N force acts on a body moving with an initial momentum of 10 kg m/s. Find the body's final momentum after 3 seconds. [2]
- (a) 105 kg m/s
 - (b) 120 kg m/s
 - (c) 110 kg m/s
 - (d) 100 kg m/s
- (D) A body moves on a frictionless inclined table without slipping. The work done by the table surface on the body is [2]
- (a) Positive
 - (b) Negative
 - (c) Zero
 - (d) All the above
- (E) Choose the correct statement about friction. [2]
- (a) Kinetic friction is lesser than the maximum static friction
 - (b) Kinetic friction is equal to the contact force
 - (c) Kinetic friction is equal to the maximum static friction
 - (d) Kinetic friction is greater than the maximum static friction

(F) When a bus at rest moves suddenly, passengers are pushed back.

This is an example of

[2]

- (a) Newton's second law
- (b) Newton's third law
- (c) Newton's first law
- (d) None of the above

(G) What is an average speed of a train travelling at 120 km in 2 hours 30 minutes? [2]

- (a) 48.0 m/s
- (b) 40.0 m/s
- (c) 13.9 m/s
- (d) 13.3 m/s

(H) Find the kinetic energy of a body of mass 2.0 kg and momentum 2.0 kg m/s. [2]

- (a) 2.0 J
- (b) 1.0 J
- (c) 2.5 J
- (d) 1.5 J

(I) A ventilation fan with a moment of inertia of 0.034 kg m^2 has a net torque of 0.11 Nm applied to it. What angular acceleration does it experience? [2]

- (a) 4.0 rad/s^2
- (b) 0.3 rad/s^2
- (c) 3.2 rad/s^2
- (d) 5.3 rad/s^2

(J) A vehicle is moving at a speed of 36 km/h and accelerates uniformly to 54 km/h over a distance of 125 m. What is the time taken to cover this distance? [2]

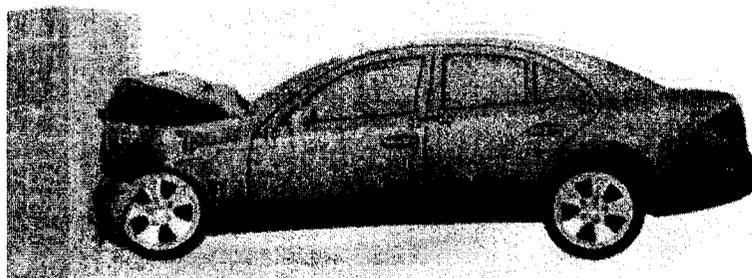
- (a) 10 seconds
- (b) 20 seconds
- (c) 40 seconds
- (d) 30 seconds

SECTION B

CHOOSE ANY FOUR (4) QUESTIONS

- Q2 (a) A cylinder of radius 20 cm is rolling along a horizontal surface with a constant speed of 80 cm/s. What is the rotational speed of the cylinder about its axis? [5]
- (b) Calculate the moment of inertia of a 0.5 kg sphere with a radius of 10 cm about an axis passing through its center. [7]
- (c) An object moves at a constant speed of 9.0 m/s in a circular path of radius 1.5 m. Find the angular acceleration of the object. [8]

- Q3 During an automobile-crash test, a car of mass 1.5×10^3 kg collides with a wall and rebounds as in the figure below.



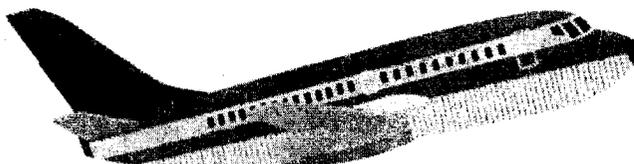
The initial and final speeds of the car are 15.0 m/s and 2.6 m/s, respectively.

If the collision lasts for only 0.15 s, find the

- (a) momentum of the car before impact. [3]
- (b) momentum of the car after impact. [3]
- (c) impulse delivered to the car due to the collision. [7]
- (d) average force exerted on the car during the impact. [7]

Q4 The principle of conservation of energy tells us that we can never lose or gain any energy out of nowhere. Apply this principle and assume that no energy is lost through friction or air resistance. Use $g = 9.81 \text{ m/s}^2$.

- (a) A large jumbo jet air-plane shown below is cruising at a speed of 900 km/h and has a flight mass of 400 tons. What is its kinetic energy in giga-joules (Gj)? [7]

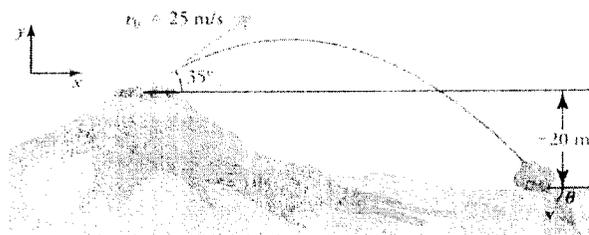


- (b) How fast does a stone hit the ground if it drops from a building of height 830 m above the ground? [6]
- (c) How high does water from a fountain rise if it is ejected vertically upwards from a spout at 13.5 m/s? [7]

Q5 (a) A car undergoes a constant acceleration of 6.0 m/s^2 starting from rest. Calculate the distance travelled in the third second of its journey? [5]

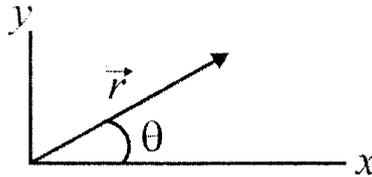
- (b) A projectile's launch speed is five times its speed at the maximum height along its trajectory. Calculate the launch angle of the projectile. [3]

- (c) A rock is ejected from a volcano with a speed of 25 m/s at an angle of 35° above the horizontal direction as shown below.



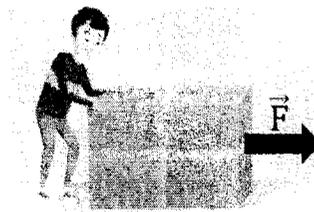
Calculate the time of flight of the rock. Use $g = 9.8 \text{ m/s}^2$. [12]

- Q6 (a) Suppose your hair grows at a rate of 0.079 cm per day. Find the rate at which it grows in nanometers per second (nm/s). [5]
- (b) Table salt has a density of 2.16 g/mL. If you use 2.00 mL on your food, how much in mg is that? [3]
- (c) A displacement vector \vec{r} in the xy plane is 15 m long and directed at an angle $\theta = 30^\circ$. Determine the x and y components of the vector. [4]



- (d) An ampoule contains a solution of drug of $300 \frac{\mu\text{g}}{5 \text{ mL}}$. Convert this dose into $\frac{\text{g}}{\text{L}}$. [8]

- Q7 (a) A worker pushes a 55 000 g box with a horizontal force of 0.220 kN across a level floor as shown in the figure below.



The coefficient of kinetic friction is 0.35.

Calculate the

- (i) frictional force. [4]
- (ii) acceleration of the box. [7]
- (b) The coefficient of static friction between the floor and box is 0.04. Find the smallest angle from the horizontal at which the box begins to slide. [7]
- (c) List two properties of maximum static friction ($f_{s, \text{max}}$). [2]

[END OF PHY1015 END-OF-YEAR FINAL EXAMINATIONS. GOOD LUCK!]

CONSTANTS AND FORMULAS SHEET

Where necessary use

$$1 \text{ ton} = 1000 \text{ kg}$$

$$\rho_{\text{water}} = 1000 \text{ kg/m}^3$$

$$1 \text{ in} = 2.54 \text{ cm}$$

$$1 \text{ d} = 86,400 \text{ s}$$

$$1 \text{ L} = 1000 \text{ mL}$$

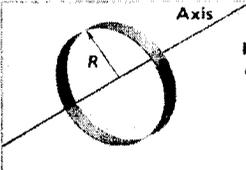
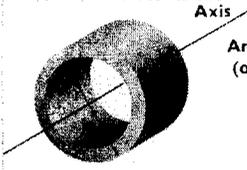
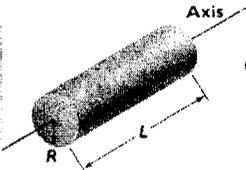
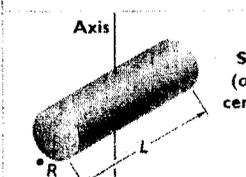
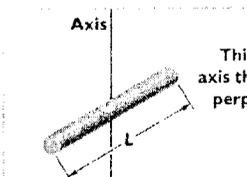
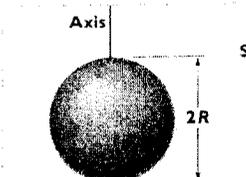
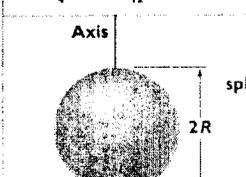
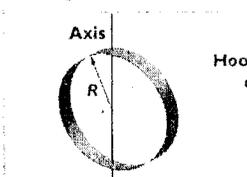
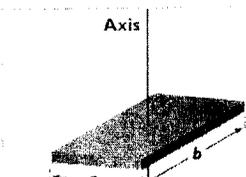
Some equations you may find useful

$$KE = \frac{1}{2}mv^2; PE = mgh; W = F \cdot s = Fs \cdot \cos\theta$$

$$v_f = v_i + at; v_f^2 = v_i^2 + 2as; s = v_i t + \frac{1}{2}at^2; s = \bar{v}t; \bar{v} = \frac{v_i + v_f}{2}; a = \frac{v_f - v_i}{t}$$

$$y = x \tan\theta - \frac{g}{2v_o \cos^2\theta} x^2; R = \frac{2v_i^2 \sin\theta \cos\theta}{g} = \frac{v_i^2 \sin(2\theta)}{g}; t = \frac{2v_i \sin\theta}{g}$$

Moment of Inertia of various objects

 <p style="text-align: center;">Axis</p> <p style="text-align: center;">Hoop about central axis</p>	 <p style="text-align: center;">Axis</p> <p style="text-align: center;">Annular cylinder (or ring) about central axis</p>	 <p style="text-align: center;">Axis</p> <p style="text-align: center;">Solid cylinder (or disk) about central axis</p>
$I = MR^2$	$I = \frac{1}{2}M(R_1^2 + R_2^2)$	$I = \frac{1}{2}MR^2$
(a)	(b)	(c)
 <p style="text-align: center;">Axis</p> <p style="text-align: center;">Solid cylinder (or disk) about central diameter</p>	 <p style="text-align: center;">Axis</p> <p style="text-align: center;">Thin rod about axis through center perpendicular to length</p>	 <p style="text-align: center;">Axis</p> <p style="text-align: center;">Solid sphere about any diameter</p>
$I = \frac{1}{4}MR^2 + \frac{1}{12}ML^2$	$I = \frac{1}{12}ML^2$	$I = \frac{2}{5}MR^2$
(d)	(e)	(f)
 <p style="text-align: center;">Axis</p> <p style="text-align: center;">Thin spherical shell about any diameter</p>	 <p style="text-align: center;">Axis</p> <p style="text-align: center;">Hoop about any diameter</p>	 <p style="text-align: center;">Axis</p> <p style="text-align: center;">Slab about perpendicular axis through center</p>
$I = \frac{2}{3}MR^2$	$I = \frac{1}{2}MR^2$	$I = \frac{1}{12}M(a^2 + b^2)$
(g)	(h)	(i)