THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

EXAM PAPERS 2018/2019

1. BIO 1401 – Biomolecules and Cells
2. BIO 1412 – Molecular Biology and Genetics (Theory paper)
3. BIO 1412 – Molecular Biology and Genetics (Theory paper)
4. BIO 2302 – Basic Microbiology
5. BIO 2701 – Basic Physiology
6. BIO 2801 – Diversity of Plants (Theory paper)
7. BIO 2812 – Diversity of Animals (Theory paper)
8. BIO 3011 – Biological Data Analysis and Experimental Design (Theory paper)
9. BIO 3412 – Genetics 9Theory paper)
10. BIO 5201 – Insect Evolution and Systematics (Theory paper)
11. BIO 5231 – Immature Insects (Theory paper)
12. CHE 1000 – Introduction to Chemistry
13. CHE 3111 – Cellular Biochemistry

14. CHE 3122 – Energy Transportation Systems

15. CHE 3411 – Chemistry of Main Group Elements and Transition Metal Chemistry

16. CHE 4102 – Biochemical Processes and Research Techniques

17. CHE 4411 – Inorganic Spectral Techniques and Application in Group Theory

18. CHE 4422 – Metal Chemistry and its Application in Oganometallics

19. CSC 4035 – Web Programming and Technologies

20. CSC 4822 – Routing and Switching Technologies

21. GES 3330 – Environment and Development

22. GES 4472 – Fundamentals of geographical Information Systems

23. MAT 2602 – Introduction to Statistics

24. MAT 3200 – Abstract Algebra

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 1401: BIOMOLECULES AND CELLS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS.

1. Choose the **best** answer to the questions contained in the question paper.
2. Each question carries 4 marks.
3. A wrong answer carries a negative one (–1) mark.
4. A blank space against a test item on the answer sheet carries a negative one (–1) mark.
5. The option "I do not know" carries zero (0) marks.
6. Use the answer sheet provided to record the answers.
7. Copying and any form of communication will lead to disqualification.
8. (a) Fill in your personal information on the answer sheet.
   (b) Make sure you double-check your computer number on the answer sheet.
9. Hand in to the examiner, both the question paper and answer sheet, at the end of the examination.
10. Cell phones and examination related materials are not allowed in the examination hall.
11. Do not turn this page until requested to do so.

END OF INSTRUCTIONS

1. Identify the **false** statement.
   1. The 3s orbital is the lowest energy orbital in the similar energy shell.
   2. The 2p orbital is higher in energy than the 2s orbital.
   3. There are three 2p orbitals in the second shell.
   4. There are three 3s orbitals in the third energy shell.
   5. The 1s orbital does not belong to the second shell.
   6. I do not know.

2. The valence electrons of representative elements are …
   1. in s orbitals only.
   2. located in the outermost orbital.
   3. located closest to the nucleus.
   4. located in the outermost shell.
   5. located in the innermost occupied shell.
   6. I do not know.

3. Identify the statement that is not **correct.**
   1. For a hydrogen atom, the energy of the 2s orbital is lower than the 2p atomic orbital.
   2. For a C atom, the energies of the 2s and 2p atomic orbitals are different.
   3. For an O atom, the energy of the 1s atomic orbital is lower than that of the 2p orbital.
   4. For any atom, the three-2p atomic orbitals are degenerate.
   5. An atom with more than 2 electrons must use higher energy orbitals.
   6. I do not know.

4. The lone pair of electrons in water are in the …
   1. 1s orbital of hydrogen.
   2. 1s orbital of oxygen.
   3. 1s and 2s orbitals of oxygen.
   4. 2p orbitals of oxygen
   5. 2s and 2p orbitals of oxygen.
   6. I do not know.

5. Phosphorus has an atomic number of 15. Therefore, its valence is ...
   1. 1
   2. 3
   3. 5
   4. 11
   5. 15
   6. I do not know.

TURN OVER

6. An atom of sodium with an atomic number of 11 and a mass number of 23 has … protons … electrons, and …neutrons.
   1. 11, 12, 12
   2. 11, 12, 11
   3. 11, 11, 12
   4. 11, 12 ,12
   5. 12, 11, 11
   6. I do not know.

7. The third shell with 9 orbitals can hold up to … electrons.
   1. 2
   2. 6
   3. 8
   4. 9
   5. 18
   6. I do not know.

8. The character of p-orbitals, which determine the character of atom is …
   1. directional.
   2. non directional.
   3. horizontal.
   4. vertical.
   5. diagonal.
   6. 6. I do not know.

9. An atom with 5 protons, 6 neutrons and a charge of 3+ has an atomic number of …
   1. 5.
   2. 6.
   3. 8.
   4. 11.
   5. 12.
   6. I do not know.

10. Almost the entire mass of an atom is concentrated in the …
    1. protons.
    2. neutrons
    3. electrons
    4. nucleus
    5. protons and electrons.
    6. I do not know.

CONTINUE TO NEXT PAGE

11. How many orbitals are completely filled with electrons in an atom of phosphorus in the ground state?
    1. 6
    2. 9
    3. 12
    4. 15
    5. 18
    6. . I do not know.

12. What is the total number of s-electrons for chlorine with 17 electrons?
    1. 2
    2. 5
    3. 7
    4. 4
    5. 6
    6. I do not know.

13 How many orientations would a p orbital have in space?
    1. 1
    2. 2
    3. 3
    4. 4
    5. 5
    6. I do not know.

14. How many valence electrons does an element with Z = 11 possess?
    1. 1
    2. 2
    3. 3
    4. 4
    5. 5
    6. I do not know.

15. How many valence electrons does the following atom have?
    $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
    1. 2
    2. 4
    3. 6
    4. 8
    5. 10
    6. I do not know.

TURN OVER

16. Water molecules are held together by … in a water body.
    1. covalent bonds.
    2. hydrogen bonds.
    3. hydrostatic forces.
    4. Van der vaal's forces.
    5. hydrophobic interactions.
    6. I do not know.

17. Identify the **false** statement.
    1. Water adheres to the surface of its container.
    2. Water conducts electricity.
    3. Water can dissolve proteins.
    4. Water sticks to glass because of cohesive forces.
    5. Water moves along blood vessels because of cohesive and adhesive forces.
    6. I do not know.

18. Water bodies in lake and oceans have constant surface temperature, because …
    1. water freezes at four degrees Celsius.
    2. of hydrophobic interactions between water molecules.
    3. water shrinks for every degree rise in temperature.
    4. has high specific heat capacity.
    5. has high latent heat capacity.
    6. I do not know

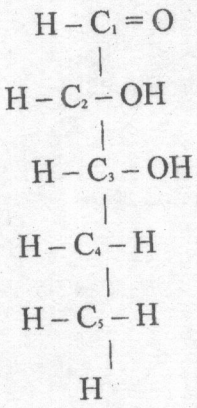
19. When oxygen combines with hydrogen to form water...
    1. there are two lone pairs of unshared electrons.
    2. there is one lone pair of unshared electrons.
    3. ionic bonds are formed between oxygen and hydrogen.
    4. develops a positive charge.
    5. covalent bonds are formed between hydrogen atoms.
    6. I do not know

20. The bonds that are broken when water vaporises are … bonds.
    1. ionic
    2. hydrogen
    3. electrostatic
    4. hydrophobic
    5. glycosidic
    6. I do not know.

CONTINUE TO NEXT PAGE

21. Sucrose is a non – reducing sugar because the … of its fructose ring and the … of its glucose ring are not free.
    1. C1;C2
    2. C2;C1
    3. C1;C1
    4. C4;C1
    5. C1;C4
    6. I do not know.

22. Identify the asymmetric carbon atoms in the molecule below.



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

23. Identify the sugar (s) that does (do) not have the empirical formula (CH_2O).
    1. Lactose
    2. Deoxyribose
    3. Glyceraldehyde
    4. Glucose
    5. 1 and 2 above are correct
    6. I do not know.

TURN OVER

24. Carbon … of glucose combines with carbon … of the same glucose open chain to form a Pyranose ring.
    1. 1 , 2
    2. 1 , 3
    3. 1 , 4
    4. 1 , 5
    5. 1 , 6
    6. I do not know.

25. Identify the functional groups in carbohydrates.
    1. Alcohol and carboxyl groups
    2. Aldehyde and ketone groups
    3. Hydroxyl and amine groups
    4. Carbonyl and hydroxyl groups
    5. 2 and 4 above are correct
    6. I do not know.

26. The cellulose microfibrils are held together by … between adjacent chains.
    1. glycosidic
    2. hydrogen bonds
    3. hydrophobic interactions
    4. ionic bonds
    5. 1 and 2 above are correct.
    6. I do not know.

27. $C_3H_8O_3$ is …
    1. a fatty acid.
    2. a lipid.
    3. an alcohol.
    4. a steroid
    5. a triose
    6. I do not know.

28. β-fructose must turn …degrees in order to make the 1 → 2 glycosidic bond in sucrose.
    1. 50
    2. 90
    3. 150
    4. 180
    5. 360
    6. I do not know.

CONTINUE TO NEXT PAGE

29. Identify the statement(s) that is (are) a/function(s) of carbohydrates.

1. Structural support
2. Immediate energy provision
3. Energy storage
4. Formation of nucleic acids
5. All of the above are correct.
6. I do not know.

30. The helical structure of amylose is stabilised by …

1. covalent bonds
2. hydrophilic attraction
3 hydrophobic forces
4. hydrogen bonds
5. 1 and 4 above are correct
6. I do not know.

31. The only polysaccharide synthesised in the human body …

1. is amylopectin
2. is amylose
3. is glycogen
4. is cellulose
5. are oligosaccharides
6. I do not know.

32. State the constituent unit sugars for sucrose and maltose in any order.

1. Galactose, fructose and glucose.
2. Fructose and glucose
3. Glucose and galactose
4. Mannose, fructose and glucose
5. Galactose and fructose
6, I do not know

33. Identify the incorrect statements.

1. Dihydroxyacetone is a triose sugar.
2. Fatty acids and glycerol are products of the hydrolysis of fats.
3. Triglyceride is an aldehyde.
4. The primary function of carbohydrates is to supply a cell with energy.
5. The functional carbon in fructose is found at carbon 2.
6. I do not know.

TURN OVER

34. The melting point of …

1. saturated fats can be changed by adding hydrogen.
2. un- saturated fats can be increased by the removal of hydrogen atoms.
3. both saturated fats and un -saturated fats are the same.
4. un- saturated fats are lower than those of saturated fats.
5. un – saturated fats are higher than those of saturated fats.
6. I do not know.

35. Lipids are …

1. esters of fats and oils.
2. polymers of fatty acids and glycerol.
3. esters of fatty acids and alcohol.
4. not the same as triglycerides.
5. polymers of phospholipids.
6. I do not know.

36. Lipids are partially soluble in water, because they …

1. are amphoteric.
2 are neutral.
3. have a hydrophilic portion.
4. they do not have a charge on them.
5. have a hydrophobic tail.
6. I do not know.

37. Triglycerides which are made up of … are liquid at room temperature.

1. glycerols only.
2. cholesterol.
3. un- saturated hydrocarbon chains.
4. saturated hydrocarbon chains.
5. fats.
6. I do not know.

38. Identify the molecules, which are highly reduced form of carbon.

1. Monosaccharides
2. Disaccharides
3. Polysaccharides
4. Triglycerides
5. Waxes
6 I do not know.

CONTINUE TO NEXT PAGE

39. Identify the lipid that has a charged component.

1. Phospholipid.
2. Triglyceride
3. Wax
4. Cholesterol
5. Glycerol
6. I do not know.

40. An ester bond is a linkage between …

1. an OH group of carboxylic acid and OH group of an alcohol.
2. C = O group of carboxylic acid and an alcohol of a carbon
3. an OH group of a fatty acid and C = O group of a lipid.
4. a carbon of a fatty acid and OH group of a lipid.
5. OH of a glycerol and the OH of another alcohol.
6. I do not know.

41. Nuclei acids are…..

1. polymers of monomers called pentose sugars.
2. polymers of amino acids.
3. storage macromolecules for inheritance characteristics.
4. polymers of monomers called nitrogenous bases.
5. synthesised from combinations of two types of nucleotides.
6. I do not know.

42. Identify the molecule which is part of DNA.

1. Deoxyribose.
2. Deoxyribulose.
3. Ribose.
4. Glucose.
5. Uracil.
6. I do not know.

43. RNA is important to biological systems because it …

1. is only composed of carbon, hydrogen and oxygen.
2. is made up of deoxyribonucleotides.
3. forms a complex, double-helical structure.
4. contains ribose sugars.
5. plays a role in protein synthesis.
6. I do not know.

TURN OVER

44. A molecule of DNA is made up of repeating units of.....
1. monosaccharides.
2. nucleotides.
3. nucleosides.
4. fatty acids.
5. nitrogenous bases.
6. I do not know.

45. State the difference between DNA and RNA.
1. Thymine in DNA versus uracil in RNA.
2. Deoxyribose sugar in RNA versus ribose sugar in DNA.
3. Phosphodiester bonds in DNA versus hydrogen bonds in RNA.
4. RNA double-stranded structure versus DNA single-stranded structure.
5. Adenine is found in RNA but not in DNA.
6. I do not know.

46. Identify the correct statement about nucleic acids.
1. They are only composed of carbon, hydrogen, oxygen, and sulphur.
2 They are composed of carbon, hydrogen, nitrogen, chlorine and phosphorus.
3. They are composed of carbon, hydrogen, oxygen, nitrogen, and phosphorus.
4. They are composed of carbon, hydrogen, oxygen, nucleotides and sulphur.
5. They are composed of carbon, sodium, oxygen, nitrogen, and phosphorus.
6. I do not know.

47. Identify the type of reaction that joins components of a DNA molecule.
1. Condensation reaction.
2. Hydrolysis reaction.
3. Hydrogenation reaction.
4. Dehydrogenation reaction.
5. Decarboxylation reaction.
6. I do not know.

48. Identify the correct statement.
1. Adenine is a pyrimidine nitrogenous base.
2. Uracil is a purine nitrogenous base. .
3. Guanine is a pyrimidine nitrogenous base.
4. Thymine is a pyrimidine nitrogenous base.
5. Cytosine is a purine nitrogenous base.
6. I do not know.

CONTINUE TO NEXT PAGE

49. In a DNA molecule guanine and cytosine base pairs are held together by…
    1. two hydrogen bonds.
    2. three hydrogen bonds.
    3. two disulphide bonds.
    4. three disulphide bonds.
    5. one hydrogen bond.
    6. I do not know.

50. Identify the **correct** statement.
    1. Nucleotides are made of a hexose sugar, nitrogenous base and phosphate group.
    2. Nucleotides are composed of a nitrogenous base attached to a sugar only.
    3. Nucleotides are made of a pentose sugar, nitrogenous base and phosphate group.
    4. Nucleotides are made of a sugar and a phosphate group.
    5. Nucleotides are made of a triose sugar, nitrogenous base and phosphate group.
    6. I do not know.

51. Identify the **incorrect** statement.
    1. Nitrogenous bases are ring compounds containing nitrogen.
    2. DNA is present in animal cells.
    3. DNA can be used as a template for RNA synthesis.
    4. DNA coiling allows for compact storage of DNA.
    5. DNA is absent in plant cells.
    6. I do not know.

52. DNA is a …
    1. single stranded alpha helical molecule.
    2. double stranded alpha helical molecule.
    3. triple stranded alpha helical molecule.
    4. double stranded peptide.
    5. single stranded glycosidic molecule.
    6. I do not know.

53. RNA transports genetic information in the form of …
    1. tRNA.
    2. rRNA.
    3. mRNA.
    4. cDNA.
    5. DNA.
    6. I do not know.

TURN OVER

54. RNA stands for …
    1. Reverse nucleic acid.
    2. Ribonucleic acid.
    3. Ribulose nucleic acid.
    4. Deoxy ribulose nucleic acid.
    5. Ribose nucleic amino acid.
    6. I do not know.

55. Identify the **correct** statement.
    1: In a DNA strand nitrogenous bases point outward from backbone.
    2. Each of the strands in a DNA molecule does not store the same biological information.
    3. DNA is a long polysaccharide made from repeating units called nucleotides.
    4. Cells do not store information needed to control their activities through nucleic acids.
    5. Nucleic acids do not have chemical polarity.
    6. I do not know.

56. The alpha helix in DNA complementary strands is due to …
    1. Disulphide bonding.
    2. Ionic bonding.
    3. Hydrogen bonding.
    4. Hydrophobic interactions.
    5. Van Der waals forces.
    6. I do not know.

57. DNA complementary strands run …
    1. in the same direction.
    2. parallel to each other and in the same direction.
    3. in unspecified different directions.
    4. anti-parallel to each other.
    5. perpendicular to each other.
    7. I do not know.

58. A nucleoside is made up of a… only.
    1. sugar and a base.
    2. sugar, a base and a phosphate group.
    3. sugar and a phosphate group.
    4. base and phosphate group.
    5. histones
    6. I do not know.

CONTINUE TO NEXT PAGE

59. The three parts of a mononucleotide are joined by …
    1. one condensation reaction.
    2. a hydrolysis reaction.
    3. two condensation reactions.
    4. three condensation reactions.
    5. polymerisation reaction.
    6. I do not know.

60. The number of base pairs for each complete twist of DNA helix is.
    1. one hundred.
    2. ten.
    3. twelve.
    4. two.
    5. three.
    6. I do not know.

61. The repeating units of proteins are …
    1. glucose molecules.
    2. amino acids.
    3. fatty acids.
    4. peptides.
    5. vitamins.
    6. I do not know.

62. Amino acids are joined by …
    1. peptide bonds
    2. hydrogen bonds
    3. ionic bonds
    4. glycosidic bond
    5. london forces
    6. I do not know.

63. The primary structure of protein represents a …
    1. linear sequence of amino acids joined by peptide bonds.
    2. three-dimensional structure of protein.
    3. helical structure.
    4. globular structure of protein.
    5. non-linear sequence molecule.
    6. I don't know

TURN OVER

64. Enzymes are …
1. proteins
2. carbohydrates
3. nucleic acids
4. ketones
5. aldehydes
6. I do not know.

65. The most common folding pattern in protein molecules is the …
1. α-helix
2. α-helix and β-pleated sheet.
3. parallel β-pleated sheet.
4. antiparallel β-pleated sheet.
5. tertiary structures.
6. I don't know.

66. Myoglobin is a protein with a …
1. primary structure.
2. secondary structure.
3. tertiary structure.
4. quaternery structure.
5. linear structure.
6. I do not know.

67. A tertiary structure of proteins is maintained by …
1. peptide bonds.
2. hydrogen bonds.
3. di-sulphide bonds.
4. ionic bonds.
5. All of the above.
6. I do not know.

68. Haemoglobin has a … structure.
1. primary
2. secondary
3. tertiary
4. quaternary
5. linear
6. I do not know.

CONTINUE TO NEXT PAGE

69. The 3 dimensional structure of protein can be determined by …
    1. nuclear magnetic resonance.
    2. x-ray crystallography.
    3. both 1 and 2.
    4. spectroscopy.
    5. microscopy.
    6 I do not know.

70. … is a biocatalyst that increases the rate of the reaction without being changed.
    1. A cofactor
    2. A co-enzyme
    3. An enzyme
    4. An allosteric enzyme
    5. An inorganic catalyst
    6. I do not know.

71. Enzymes increase the rate of chemical reactions by lowering the activation energy.
    1. True
    2. When optimum pH is constant.
    3. False
    4. Both 1 and 2.
    5. When temperature is above 40°C
    6. I don't know.

72. The secondary structure of a protein is stabilized by …
    1. Vander walls forces
    2. Hydrogen bonding
    3. Covalent bond
    4. Hydrophobic bond
    5. Ionic bond
    6. I do not know

73. An apoenzymes is a …
    1. protein portion of an enzyme.
    2. non-protein group.
    3. complete, biologically active conjugated enzyme.
    4. prosthetic group.
    5. an ether.
    6. I don't know.

TURN OVER

74. The relationship between an enzyme and a reactant molecule can best be described as follows:
    1. A temporary association.
    2. An association stabilized by an ionic bond.
    3. One in which the enzyme is changed permanently.
    4. A permanent mutual alteration of substrate.
    5. Non-complementary binding.
    6. I do not know.

75. The active site of an enzyme …
    1. does not change shape.
    2. is found at the center of haemoglobin.
    3. site specific to the substrate.
    4. contains amino acids without sidechains.
    5. is inorganic in nature.
    6. I do not know.

76. 76. Which one of the following statements regarding enzymes is false?
    1. A given enzyme catalyses just one type of reaction.
    2. The activity of enzymes is impaired at high temperature.
    3. They do not alter the outcome of the reaction.
    4. While most enzymes are proteins, some are composed of RNA.
    5. The enzyme itself emerges unchanged from the reaction.
    6. I do not know

77. Which out of the following amino acids carries a net positive charge at the physiological pH?
    1. Valine
    2. Leucine
    3. Isoleucine
    4. Glycine
    5. Arginine
    6. I don't know

78. Two amino acids of the standard 20 contain sulfur atoms. These are:
    1. cysteine and serine
    2. cysteine and threonine
    3. methionine and cysteine
    4. methionine and serine
    5. threonine and serine
    6. I don't know

CONTINUE TO NEXT PAGE

79. Proteins perform the following functions in the body except…
    1. carry genetic information
    2. speed up chemical reactions
    3. digest food
    4. carry oxygen in blood
    5. act as defence agents against microorganisms.
    6. I don't know.

80. Proteins are made in organelles called . . .
    1. mitochondria
    2. ribosomes
    3. lysosome
    4. vesicles
    5. vacuoles
    6. I don't know.

81. A prokaryotic cell is between ... in length.
    1. 10 – 100 μm
    2. 100 – 200 μm
    3. 1 – 10 μm
    4. 100 – 100 μm
    5. 50 – 100 μm
    6. I do not know.

82. Water moves into bacterial cells because ...
    1. cell contents are hypertonic.
    2. cell contents are hypotonic.
    3. the environment outside the cell and cell contents are isotonic.
    4. the environment outside the cell is hypertonic.
    5. water outside the cell is more viscous than water inside the cell.
    6. I do not know.

83. The basic structure of peptidoglycan in a prokaryotic cell wall contains …
    1. polysaccharide chains linked by lipids.
    2. peptide chains linked by lipids.
    3. polysaccharide chains linked to other polysaccharides.
    4. peptide chains linked to other peptides.
    5. polysaccharide chains linked by polypeptides.
    6. I do not know.

TURN OVER

84. Identify the structure which makes it easier for bacterial cells to cause disease.
    1. Plasma membrane
    2. Capsule
    3. Cytoplasm
    4. Flagellum
    5. Cell wall
    6. I do not know.

85. Pili in some bacterial cells can best be described as…
    1. the outer covering.
    2. genetic material.
    3. thread-like projections on the surface.
    4. vesicles in the cytoplasm.
    5. organelles.
    6. I do not know.

86. The main property of a cell membrane is that it …
    1. is permeable to salts only.
    2. is impermeable.
    3. does not allow diffusion to take place.
    4. is a thick monolayer of lipids.
    5. is semi-permeable.
    6. I do not know.

87. Bacterial cells do not burst because the ... offers resistance.
    1. plasma membrane
    2. cell wall
    3. capsule
    4. cytoplasm
    5. nucleoid
    6. I do not know.

88. Choose the statement, which is false about the bacterium *Escherichia coli*.
    1. It can live in the intestines.
    2. Absence of mitochondria
    3. Presence of true nucleus
    4. Absence of chloroplasts
    5. It can cause disease.
    6. I do not know.

CONTINUE TO NEXT PAGE

89. Deoxyribonucleic acid (DNA) in prokaryotic cells is…
    1. straight and not folded.
    2. coiled and not folded.
    3. not present.
    4. coiled and folded.
    5. straight.
    6. I do not know.

90. Chromosomes are … in prokaryotic cells.
    1. not present
    2. in a single circular form
    3. in the form of ribonucleic acid (RNA)
    4. surrounded by a nuclear membrane
    5. composed of proteins only
    6. I do not know.

91. Identify the layer on which the primary cell wall is deposited.
    1. Secondary cell wall
    2. Microfibril layer
    3. Cellulose bundles
    4. Middle lamella
    5. Cell membrane
    6. I do not know.

92. Choose the statement that is false about the nucleus in eukaryotic cells.
    1. It is the largest organelle.
    2. It is surrounded by a nuclear membrane.
    3. It encloses the chromosomes.
    4. The nuclear membrane has pores.
    5. It has a nucleoid..
    6. I do not know.

93. The main role of lignin in secondary cell walls is to …
    1. transport water.
    2. help the cells to divide.
    3. transport dissolved substances.
    4. provide strength to plant stems.
    5. provide metabolic substrate for cells.
    6. I do not know.

TURN OVER

94. Cells with high energy demands ...
    1. have more mitochondria.
    2. have fewer mitochondria.
    3. do not have mitochondria.
    4. are not involved in biochemical reactions.
    5. are found in all parts of an organism.
    6. I do not know.

95. Choose the correct statement about genetic material in the eukaryotic cell.
    1. The nucleus is the only organelle with DNA.
    2. All organelles have DNA.
    3. The nucleus and mitochondria have DNA.
    4. The mitochondrion is the only organelle with DNA.
    5. The plasma membrane has DNA.
    6. I do not know.

96. Identify the structure, which produces microtubules during eukaryotic cell division.
    1. Nucleus
    2. Cell membrane
    3. Centriole
    4. Cell wall
    5. Nucleoid
    6. I do not know.

97. Ribosomes are ...
    1. not organelles.
    2. only present in the cell walls.
    3. responsible for synthesis of proteins.
    4. responsible for production of carbohydrates.
    5. responsible for synthesis of nucleic acids.
    6. I do not know.

98. The folding of an inner membrane of an organelle ....
    1. slows down the movement of substances.
    2. increases the surface area for absorption.
    3. reduces the amount of substances that can enter a cell.
    4. stops biochemical reactions.
    5. facilitates for quicker absorption of proteins.
    6. I do not know.

CONTINUE TO NEXT PAGE

99. Identify the structure which fuses with the cell membrane to release enzymes to the outside of a cell.
    1. Vesicles
    2. Nuclear pore
    3. Microtubules in the cell wall
    4. Vacuole
    5. Chloroplasts
    6. I do not know.

100. Identify the major role of the rough endoplasmic reticulum.
    1. Synthesis of lipids
    2. Storage of lipids
    3. Synthesis of proteins
    4. Transport of lipids
    5. Repackaging carbohydrates.
    6. I do not know.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR
FINAL EXAMINATION

BIO 1412: MOLECULAR BIOLOGY AND GENETICS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS

1. Answer all the 100 questions
2. Use the answer sheet provided to record answers
3. A correct answer carries +4 marks
4. A wrong answer carries –1 mark
5. The option "I do not know" carries 0 marks
6. Use ink to record the answers on the mark sheet
7. Cross out a wrong entry and write the correct one by the side
8. You are not allowed to communicate with anyone either in person or by phone during the examination.
9. The tables of the genetic code and the chi-squared critical values are provided.
10. Handover both the question paper and answer sheet to the invigilator at the end of the examination.

1. Bacteria such as *E. coli* grown on N^{15} medium are transferred to N^{14} medium and allowed to grow for one generation. DNA extracted from these bacteria is centrifuged. What density distribution of DNA would you expect in this experiment?
    1. One high density (N^{15}) and one low density (N^{14})) DNA
    2. One high density (N^{15}) and one hybrid (N^{14}-N^{15}) DNA
    3. Only hybrid (N^{14}-N^{15}) DNA
    4. Half-light (N^{14}) and half hybrid (N^{14}-N^{15})) DNA
    5. Only low density (N^{14}) DNA
    6. I do not know.

2. Initiation of DNA replication takes place at the …
    1. promoter sequence after the binding of the enzyme topoisomerase.
    2. origin of replication after the binding of DnaA protein.
    3. promoter sequence after the binding of DnaA 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.

3. The enzyme(s) and protein(s) involved in the denaturation of DNA during replication are …
    1. helicase and single strand binding proteins.
    2. topoisomerase, DNA polymerase and ligase.
    3. RNA polymerase, helicase and single strand binding proteins.
    4. DNA polymerase, helicase and ligase.
    5. helicase, single strand binding proteins and DNA polymerase.
    6. I do not know.

4. Choose the statement which is **correct**.
    1. The leading DNA strand grows in the opposite direction of the replication fork.
    2. The overall growth of all the Okazaki fragments is opposite to the direction of the replication fork.
    3. Individual Okazaki fragments grow in the opposite direction to the replication fork.
    4. The leading DNA strand is synthesised in the 3′ to 5′ direction.
    5. Each Okazaki fragment is synthesised in the 3′ to 5′ direction.
    6. I do not know.

5. If the sequence of one strand of DNA is 5′ TCGATC 3′, the sequence of its complementary strand would be ...
    1. 5′ AGCTAG 3′
    2. 5′ AGCUAG 3′
    3. 3′ UCGAUC 5′
    4. 5′ CTAGCT 3′
    5. 3′ AGCTAG 5′
    6. I do not know

6. DNA polymerase III adds nucleotides ...
   1. to the 5' end of the RNA primer.
   2. to the 3' end of the RNA primer.
   3. in the place of the primer RNA after it is removed.
   4. on a single stranded template without need for an RNA primer.
   5. to both ends of the RNA primer.
   6. I do not know.

7. The enzyme ligase catalyses the formation of a covalent bond between the ... of one nucleotide and the ... of the adjacent nucleotide.
   1. 3' OH; 5' OH
   2. 5' OH; 3' phosphate
   3. 3' phosphate; 5' phosphate
   4. 5' phosphate; 5' OH
   5. 3' OH; 5' phosphate
   6. I do not know.

8. The enzyme ... removes the supercoils in the DNA helix in front of the replication fork while ... separates double stranded DNA into single strands.
   1. helicase; single strand binding protein
   2. topoisomerase; helicase
   3. ligase; polymerase
   4. polymerase; topoisomerase
   5. ligase; helicase
   6. I do not know.

9. Each Okazaki fragment is synthesized in the... direction.
   1. 5′ to 1′
   2. 5′ to 3′
   3. 3′ to 5′
   4. 1′ to 3′
   5. 3′ to 1′
   6. I do not know.

10. The origin of replication is rich in ... pairs.
   1. UA
   2. GA
   3. AU
   4. CG
   5. TA
   6. I do not know

11. During DNA replication, an RNA primer is …
    1. required for leading strand synthesis and not for lagging strand synthesis.
    2. required for leading strand synthesis and a DNA primer for lagging strand synthesis.
    3. added to the 3' end of the Okazaki fragment.
    4. required for both leading and lagging strand synthesis.
    5. synthesized by the enzyme DNA polymerase
    6. I do not know.

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

13. Which of the following is **correct**?
    1. DNA is a template only for DNA replication.
    2. DNA is a template for synthesis of all RNA types.
    3. Translation takes place before transcription.
    4. RNA is a template for DNA transcription.
    5. DNA replication takes place after translation.
    6. I do not know.

14. The mode of DNA replication in *E. coli* is ...
    1. conservative and unidirectional.
    2. semiconservative and unidirectional.
    3. conservative and bidirectional.
    4. semiconservative and bidirectional.
    5. semiconservative and both uni- and bidirectional.
    6. I do not know.

15. DNA replication starts when...
    1. the phosphodiester bonds between adjacent nucleotides break.
    2. the bonds between the nitrogenous bases and the deoxyribose break.
    3. the leading strand produces short segments of DNA.
    4. the hydrogen bonds between the nucleotide of its two strands break.
    5. DNA polymerises short strands of RNA.
    6. I do not know

16. What is the role of topoisomerase in the replication of DNA?
    1. It binds to the origin of the replication site within double stranded DNA.
    2. It unzips the double stranded DNA at the replication fork.
    3. It relaxes double stranded DNA in readiness for smooth replication.
    4. It joins the DNA nucleotides together through phosphodiester bonds.
    5. It is a single-strand DNA stabiliser.
    6. I do not know.

17. Where along the chromosome is DNA replication initiated?
    1. At the 5' end.
    2. At the 3' end.
    3. At exons.
    4. At introns.
    5. At any random point of the chromosome.
    6. I do not know.

18. Which of the following features is common to both DNA replication and transcription?
    1. Nucleotides are added to the 5' end of the newly synthesized strand.
    2. Deoxyribonucleotides are incorporated into the growing sequence.
    3. Ribonucleotides are added to the 3' end of the growing strand.
    4. Both require a primer.
    5. Both are initiated at the promoter site.
    6. I do not know.

19. Semi-conservative replication of DNA was demonstrated by Messelson and Stahl in...
    1. human beings.
    2. *Escherichia coli*.
    3. onion root tips.
    4. *Drosophila*.
    5. pea plants.
    6. I do not know.

20. The correct sequence of stages of prokaryotic DNA replication is...
    1. Initiation --> activation --> polymerisation.
    2. Initiation --> polymerisation --> termination.
    3. Modification --> activation --> termination.
    4. Initiation --> termination --> modification
    5. Initiation -->modification --> transcription.
    6. I do not know.

21. Choose the molecule which opens double stranded DNA to create a replication fork?
    1. DNA ligase
    2. DNA polymerase
    3. Single strand binding protein
    4. DNA helicase
    5. Topoisomerase
    6. I do not know.

22. At the end of the lagging strand DNA synthesis, ...
    1. phosphodiester bonds between adjacent nucleotides break.
    2. bonds between the nitrogenous base and deoxyribose sugar break.
    3. the leading strand produces Okazaki fragments.
    4. hydrogen bonds between the nucleotides of the two strands break.
    5. the gaps between adjacent DNA fragments are sealed.
    6. I do not know.

23. During the replication of DNA, ...
    1. only one DNA primer is produced during the leading strand synthesis.
    2. many RNA primers are produced during the lagging strand synthesis.
    3. only one RNA primer is produced during the lagging strand synthesis.
    4. only one Okazaki fragment is produced during the leading strand synthesis.
    5. many DNA primers are produced during the lagging strand synthesis.
    6. I do not know.

24. Which of the following enzymes is used to join fragments of DNA?
    1. Endonuclease
    2. RNA primase
    3. DNA polymerase
    4. RNA ligase
    5. DNA ligase
    6. I do not know

25. If the sequence of bases on the template strand of DNA is 3'-TCCGAT-5', the sequence of bases on the mRNA transcript will be…
    1. 5'-AGGCAT-3'
    2. 3'-UCCGAU-5'
    3. 5'-ACCGUA-3'
    4. 5'-UCCGAU-3'
    5. 5'-AGGCUA-3'
    6. I do not know

26. Determine the number of amino acids that would be specified from the mRNA sequence: 5'- AUGAAACGGU-3'.
    1. 2
    2. 3
    3. 4
    4. 5
    5. 6
    6. I do not know.

27. The DNA strand which is transcribed into RNA is the … strand.
    1. complementary
    2. nonsense
    3. template
    4. double
    5. sugar phosphate
    6. I do not know

28. During protein synthesis, an anticodon on tRNA pairs with …
    1. a codon on DNA.
    2. ribosomal RNA nucleotide bases.
    3. nucleotide bases on mRNA.
    4. nucleotide bases on another tRNA.
    5. an amino acid on RNA polymerase.
    6. I do not know.

29. Which one of the following statements is **correct** about RNA polymerase?
    1. It carries out the replication of DNA.
    2. It establishes hydrogen bonds between nucleotides in double stranded DNA.
    3. It acts as an initiation factor during transcription.
    4. It synthesises both introns and exons.
    5. It combines with proteins to form a ribosome.
    6. I do not know

30. Ribosomal RNA…
    1. transports amino acids to the ribosome.
    2. is located in the ribosome where it directs the assembly of polypeptides.
    3. is also called tRNA.
    4. transcribes DNA into RNA.
    5. is present in eukaryotes but absent in prokaryotes.
    6. I do not know.

31. The process of ... cuts introns from the primary mRNA transcript and joins the exons together.
    1. RNA synthesis
    2. RNA translocation
    3. RNA elongation
    4. RNA splicing
    5. RNA initiation
    6. I do not know

32. Which of the following is **not** a property of the genetic code?
    1. Non-overlapping
    2. Almost universal
    3. Comma less
    4. Four nonsense codons
    5. Degenerate
    6. I do not know

33. During translation, the role of the enzyme peptidyl transferase is in …
    1. transfer of phosphate groups.
    2. transfer of nitrogenous bases.
    3. amino acid activation.
    4. peptide bond formation between adjacent amino acids.
    5. binding of ribosome sub-units to mRNA.
    6. I do not know

34. Which one of the followings describes an important experimental strategy in discovering the genetic code?
    1. Comparing the amino acid sequences of proteins with the nucleotide sequences of mRNA.
    2. Analysing the sequence of RNA produced from a known DNA sequence.
    3. Comparing the amino acid sequences of proteins with the nucleotide sequences of mRNA.
    4. Analysing the sequence of DNA that codes for proteins directly.
    5. Examining the polypeptides produced from mRNA.
    6. I do not know.

35. What is a stop codon?
    1. The codon where transcription ends.
    2. The end of a chromosome.
    3. The place where synthesis of DNA ends.
    4. The last amino acid which is translated.
    5. A codon that does not specify any amino acid.
    6. I do not know.

36. The complementary sequence of the initiation codon is …
    1. UAA
    2. UAC
    3. AUG
    4. UGA
    5. UAU
    6. I do not know.

37. Which position of a codon is said to wobble?
    1. First
    2. Second
    3. Third
    4. Fourth
    5. None of the above.
    6. I do not know.

38. Which one of the following bases of the anticodon will pair with the first base of the initiation codon during translation?
    1. A
    2. G
    3. C
    4. T
    5. U
    6. I do not know.

39. The genetic code translates the language of ….
    1. proteins into that of RNA.
    2. amino acids into that of RNA.
    3. DNA into that of RNA.
    4. RNA into that of proteins.
    5. RNA into that of DNA.
    6. I do not know.

40. A piece of double stranded DNA has 30 % Adenine, what will be the percentage (%) of guanine?
    1. 30 %
    2. 70 %
    3. 20 %
    4. 40 %
    5. 50 %
    6. I do not know.

41. You have a piece of DNA with the sequence - ATGC -. What do you know from this?
    1. A is at the 5-prime end of the DNA sequence.
    2. A is at the 3-prime end of the DNA sequence.
    3. C is at the 5-prime end of the DNA sequence.
    4. C is at the 4-prime end of the DNA sequence.
    5. A could be at either the 5-prime end or the 3-prime end of the DNA sequence.
    6. I do not know.

42. One similarity between DNA and transfer RNA molecules is that they both contain...
    1. the same sugar.
    2. the same sugar–phosphate backbone.
    3. a nitrogenous base known as uracil.
    4. genetic codes based on sequences of bases.
    5. double stranded polymers.
    6. I do not know.

43. The synthesis of polyribonucleotide chains is catalysed by the enzyme ....
    1. RNA helicase.
    2. DNA helicase.
    3. DNA polymerase.
    4. RNA polymerase.
    5. DNA gyrase.
    6. I do not know.

44. Which one of the following statements about protein synthesis is **correct**?
    1. All the information in DNA codes for proteins.
    2. The mRNA formed by the transcription of DNA only contains information for a specific protein.
    3. Both strands of DNA are transcribed to form mRNA.
    4. The eukaryotic primary mRNA transcript formed by transcription of DNA undergoes capping, polyadenylation and splicing to form mature mRNA.
    5. Both 2 and 4 are correct.
    6. I do not know.

45. During which stage of bacterial transcription is the sigma factor involved?
    1. Elongation
    2. Termination
    3. RNA capping
    4. Splicing
    5. Initiation
    6. I do not know

46. In Figure **J**, the arrow labelled 1 corresponds to … while the arrow labelled 2 corresponds to …

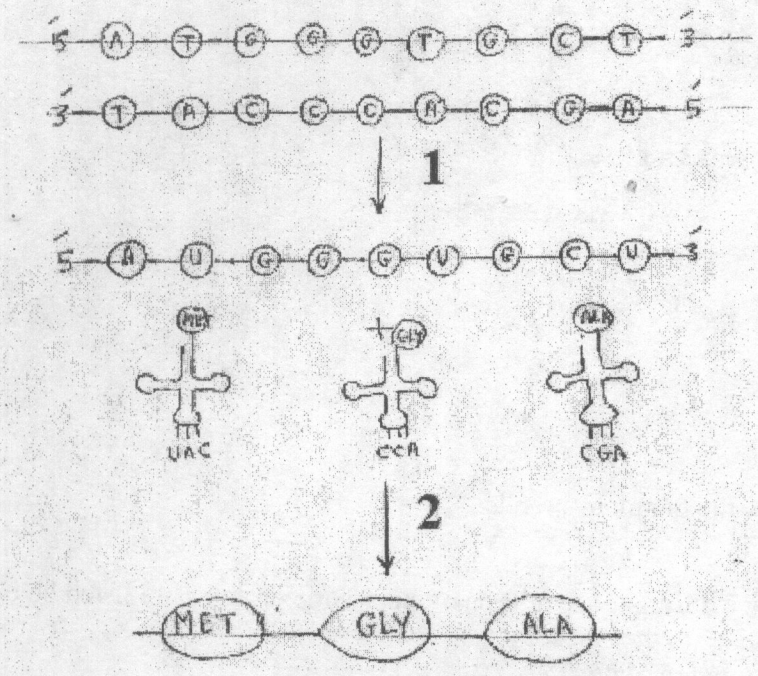


Figure J

1. replication, transcription
2. translation, transcription
3. replication, translation
4. transcription, replication
5. transcription, translation
6. I do not know

47. AUG and GUG code for ... and …amino acids respectively.
1. phenylalanine, tyrosine
2. methionine, alanine
3. methionine, valine
4. lysine, valine
5. phenylalanine, glycine
6. I do not know

48. Mature mRNA from eukaryotes would contain each of the following features **except**….
1. exons
2. 5 prime cap
3. 3 prime poly – A tail
4. introns
5. introns and exons
6. I do not know.

49. In Figure **K** which label(s) on the left refer(s) to the DNA template strand(s)?

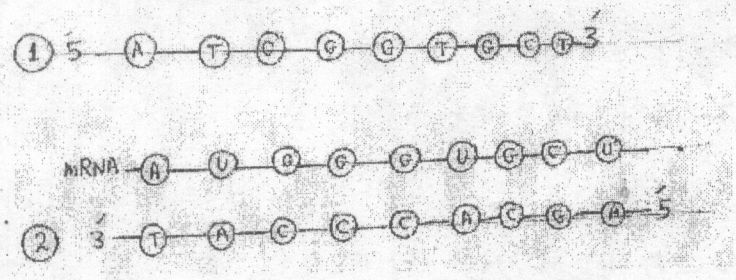


Figure **K**

1. 1
2. 2
3. Both 1 and 2
4. mRNA
5. Both 2 and mRNA are the template strands.
6. I do not know.

50. Some events that take place during the synthesis of eukaryotic proteins are listed below.
    a. Messenger RNA attaches to the ribosome.
    b. RNA is transcribed from template DNA.
    c. Transfer RNA carrying an amino acid binds to a specific codon.
    d. A polypeptide chain is synthesised.
    e. RNA moves from the nucleus to the cytoplasm.

    The correct order of these events is …
    1. a b c d e
    2. b a c d e
    3. b c d e a
    4. b e a c d
    5. b d e a c
    6. I do not know.

51. Which one of the following components is the last to join the initiation complex during the initiation of translation in bacteria?
    1. The mRNA molecule.
    2. The first aminoacyl tRNA.
    3. The second aminoacyl tRNA.
    4. The 30S ribosomal subunit
    5. The 50S ribosomal subunit
    6. I do not know.

52. Which one of the following occurs when the ribosome reaches a stop codon?
    1. A methionine is incorporated.
    2. A peptide bond forms
    3. The P site binds to a charged tRNA.
    4. The A site binds to a release factor.
    5. The ribosomal subunits unite.
    6. I do not know.

53. In the *Lac-operon*, the product of *Lac*A gene is …
    1. β-galactoside permease.
    2. β-galactoside transacetylase.
    3. β-galactosidase.
    4. β-galactoside isomerase.
    5. β-galactoside.
    6. I do not know.

54. Identify the condition in the *Lac* operon which results in increased activity of structural genes.
    1. absence of glucose, presence of lactose.
    2. absence of glucose, absence of lactose.
    3. High glucose, high lactose.
    4. High glucose, low lactose.
    5. Low lactose, low glucose.
    6. I do not know.

55. Choose the correct option regarding the *Lac operon* in *E.coli*.
    1. *Lac* operon is switched on in the absence of lactose.
    2. *Lac* repressor binds to the promoter.
    3. β-galactosidase is produced in large quantities when the *Lac* operon is turned off.
    4. *Lac* operon mRNA is polycistronic.
    5. *Lac* repressor binds to glucose.
    6. I do not know.

56. Identify where the repressor molecule binds.
    1. Promoter
    2. RNA polymerase
    3. Operator
    4. mRNA
    5. *Lac* A
    6. I do not know.

57. In the *lac* operon, permease is encoded by …
1. *Lac*-I
2. *Lac*-Y
3. *Lac*-Z
4. *Lac* A
5. the operator
6. I do not know.

58. The repressor cannot bind to the operator in the presence of …
1. *Lac* A.
2. the promoter.
3. an inducer.
4. glucose.
5. mRNA polymerase.
6. I do not know.

59. Prokaryotes first use all the … in the media to obtain energy before using any other sources.
1. fructose
2. galactose
3. maltose
4. lactose
5. glucose
6. I do not know.

60. Which one of the following sites on *Lac* operon prevents RNA polymerase from binding the structural genes in the presence of glucose?
1. Promoter
2. Operator
3. *Lac* A
4. *Lac* Z
5. *Lac* Y
6. I do not know.

61. Which one of the following parts of the *lac* operon is a structural gene?
1. Inducer
2. Repressor
3. RNA polymerase
4. Operator
5. *Lac* Z
6. I do not know

62. A group of bacterial genes working together is called …
    1. a repressor.
    2. an operon.
    3. an exon.
    4. an operator.
    5. an inducer.
    6. I do not know

63. The *Lac* operon is involved in the metabolism of …
    1. galactose.
    2. permease.
    3. glucose.
    4. lactose
    5. β-galactosidase.
    6. I do not know.

64. The *Lac* operon is most active in the *E. coli* cells present in …
    1. mammals.
    2. plant roots.
    3. young insects.
    4. adult insects.
    5. plant leaves.
    6. I do not know.

65. In the functioning of the *lac* operon in *E. coli*, the *lac* genes are transcribed in the presence of lactose because...
    1. RNA polymerase binds to the operator.
    2. the repressor cannot bind to the structural genes.
    3. some of the lactose binds to the repressor.
    4. lactose is a co-repressor.
    5. glucose is also present.
    6. I do not know

66. Which one of the following is **not** involved in eukaryotic gene control?
    1. DNA replication
    2. Transcription
    3. mRNA processing
    4. Translation
    5. Operator
    6. I do not know

67. Which part of an operon is **incorrectly** matched with its function?
    1. Promoter: Where RNA polymerase binds to the DNA of the operon.
    2. Regulator: Transcribes mRNA for the repressor protein.
    3. Structural genes: Carry information for synthesis of lactose-metabolising proteins.
    4. Operator: Site on the operon where lactose binds.
    5. Operator: Binding site for the repressor molecule.
    6. I do not know.

68. Experiments using the rare white colour of the eyes in *Drosophila* provided evidence…
    1. to link abnormal chromosomes to abnormal characteristics.
    2. that chromosomes occur in homologous pairs.
    3. to explain the shortening of chromosomes during meiosis.
    4. to explain the shortening of chromosomes during mitosis.
    5. t to link abnormal chromosomes to normal characteristics.
    6. I do not know.

69. Which one of the following statements is **false**?
    1. In prokaryotes DNA is found in the cytoplasm.
    2. In prokaryotes, genes are found on the plasmid.
    3. In eukaryotes genes are located in the nucleus.
    4. In eukaryotes genes are located in the plasma membrane.
    5. None of the above is false.
    6. I do not know.

70. Which one of the following is a function of histone 1?
    1. It translates the mRNA.
    2. It packages the synthesized polypeptide.
    3. It packages the nucleosomes into the solenoid fibre.
    4. It splits the sister chromatids during mitosis.
    5. It pulls the sister chromatids towards the opposite poles of the cell.
    6. I do not know.

71. Eukaryotic chromosomes are made up of two….
    1. centromeres.
    2. centrioles.
    3. strands of coiled DNA.
    4. pairs of double stranded DNA.
    5. non-sister chromatids.
    6. I do not know.

72. Which phase of the cell cycle involves DNA replication?
    1. M phase.
    2. G_1 phase.
    3. S phase.
    4. G_2 phase.
    5. G_0 phase.
    6. I do not know.

73. Which one of the following is **false** about meiosis?
    1. Meiosis provides an opportunity for the exchange of the genes causing genetic variations among species.
    2. Meiosis maintains a definite and constant number of chromosomes in the organisms.
    3. Meiosis reduces the amount of DNA in daughter nuclei.
    4. Meiosis results into gamete formation.
    5. All of the above are false about meiosis.
    6. I do not know.

74. Each chromosome is made up of DNA tightly coiled many times around proteins called …
    1. histones.
    2. helicase.
    3. haemoglobin.
    4. glycoproteins.
    5. collagen.
    6. I do not know

75. A(n) … is a sequence of deoxyribonucleotide pairs along …
    1. mRNA, tRNA
    2. nitrogenous base, DNA
    3. gene, DNA
    4. rRNA, mRNA
    5. tRNA, rRNA
    6. I do not know.

76. Which one of the following is **false** about alleles?
    1. Alternative forms of a gene are known as alleles.
    2. Each member of homologous chromosomes carries one of the alleles of each character.
    3. An allele is a particular form of a gene occupying a fixed locus on a chromosome.
    4. Most genes have two alleles, but some have more.
    5. Alleles code for the same form of a trait.
    6. I do not know.

77. Name the stage of cell division shown in the Figure **W**.

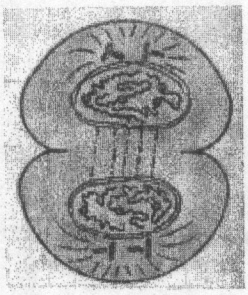


Figure W

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

78. During animal cell division, the cytoplasm divides by …
1. a cleavage furrow formation.
2. cell plate formation.
3. metaphase plate formation.
4. prophase.
5. anaphase.
6. I do not know.

79. The nuclear envelope disappears at the end of …
1. cytokinesis
2. telophase
3. metaphase
4. prophase
5. anaphase
6. I do not know.

80. Which one of the following statements is **not** a characteristic of homologous chromosomes?
1. They have the same length.
2. They have the same centromere position
3. They carry alleles that control the same trait at a given locus.
4. They always have the same type of alleles.
5. They pair up during meiosis 1.
6. I do not know

81. In meiosis, recombination occurs during …
    1. metaphase 1.
    2. prophase 1.
    3. anaphase 1.
    4. telophase 1
    5. metaphase 2.
    6. I do not know.

82. Crossing-over takes place in the …
    1. diakinesis stage.
    2. anaphase stage.
    3. pachytene stage.
    4. leptotene stage.
    5. diplotene stage.
    6. I don't know

83. Repulsion and coupling are two conditions of …
    1. mutation.
    2. chiasmata.
    3. linkage.
    4. independent assortment.
    5. synapsis.
    6. I don't know

84. Traits which show continuous variation are referred to as …
    1. genetic traits.
    2. phenotypic traits.
    3. quantitative traits.
    4. qualitative traits.
    5. mutant traits.
    6. I don't know.

85. If both genotype and phenotype show the same ratio of 1: 2: 1 in the F_2 generation, it indicates that this is the case of …
    1. complete dominance.
    2. incomplete dominance.
    3. a dihybrid cross.
    4. linkage.
    5. a test cross.
    6. I do not know.

86. A test cross is between….
    1. two recessive phenotypes.
    2. two dominant phenotypes
    3. two dominant genotypes
    4. two F_1 hybrids.
    5. a dominant phenotype and a recessive phenotype.
    6. I do not know.

87. Lack of independent assortment of two genes is due to …
    1. recombination.
    2. crossing over.
    3. linkage.
    4. repulsion.
    5. synapsis.
    6. do not know.

88. If two different alleles of a gene are expressed equally in a heterozygous individual, the condition is termed…
    1. recessivity.
    2. dominance.
    3. incomplete dominance.
    4. co-dominance.
    5. gene interaction.
    6. I do not know.

89. … is the genetic makeup of an individual while …is the observable feature of an organism.
    1. Behaviour, appearance.
    2. Appearance. behaviour
    3. Genotype, phenotype.
    4. Phenotype, genotype.
    5. Phenotype, appearance.
    6. I do not know.

90. Mendel's work did not include the concept of …
    1. alleles.
    2. genes.
    3. inheritance.
    4. gene interaction.
    5. dominance.
    6. I do not know.

91. A represents the dominant allele and a represents the recessive allele of a pair. In 1000 offspring, 500 were aa and 500 were of some other genotype. Which of the following were most probably the genotypes of the parents?
    1. Aa and Aa.
    2. AA and Aa.
    3. AA and aa.
    4. Aa and aa.
    5. aa and aa.
    6. I do not know.

92. Which blood group(s) in Table **1** has/have co-dominant genotype(s)?

Table 1

#	Blood group	Genotype
1	A	$I^A I^A$
2	A	$I^A I^O$
3	B	$I^B I^B$
4	B	$I^B I^O$
5	AB	$I^A I^B$
6	O	$I^O I^O$

1. #1 and #2.
2. #3 and #4
3. #5
4. #6
5. #2, #4 and #5
6. I do not know.

93. On which of the following does the critical p-value for a chi–squared test rely?
    1. Dominance.
    2. Co-dominance
    3. The degrees of freedom
    4. The phenotypic ratio
    5. The genotypic ratio
    6. I do not know

94. Using a goodness of fit test, you can assess whether a set of obtained data differs from a set of … data.
    1. mean
    2. expected
    3. observed
    4. variable
    5. fixed
    6. I do not know

95. A cross was carried out between two plants; YyRr (yellow, round seeds) x yyrr (green, wrinkled seeds). Out of 100 progeny, the following results were obtained:

Yellow round	40
Yellow wrinkled	10
Green round	10
Green wrinkled	40

A chi-squared test was then carried out to test the results of the progeny using Table 2

Table 2. Tabulated (critical) chi-squared values for up to four degrees of freedom

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

The calculated chi-squared value is ...

1. 18
2. 36
3. 9
4. 15
5. 25
6. I do not know

96. The tabulated (critical) chi-squared value in Question 95 is ...
    1. 9.5
    2. 7.8
    3. 3.8
    4. 6.0
    5. 2.4
    6. I do not know

97. The results of the test in Question 95 suggest that ...
    1. The difference between the observed and expected results is not significant.
    2. The difference between the observed and expected results is significant.
    3. The two genes are on different chromosomes.
    4. Seed colour and seed shape are controlled by multiple alleles.
    5. Seed colour and seed shape are controlled by polygenes.
    6. I do not know

98. Several black guinea pigs were crossed and produced 31 black and 10 white offspring. What would you predict the genotypes of the parents to be?
    1. BB x BB
    2. BB x Bb
    3. Bb x Bb
    4. bb x bb
    5. Bb x bb
    6. I do not know

99. Which one of the following parental crosses would give the same F_2 phenotypes as the cross AABB x aabb?
1. AaBb x AABB
2. AAbb x aaBB
3. AaBb x AaBb
4. AABB x AABB
5. AaBb x AAbb
6. I do not know

100. Choose the statement which is **true** about the chromosome theory of inheritance.
1. Segregation is explained by the separation of homologous pairs of chromosomes at anaphase of meiosis.
2. Independent assortment comes about due to the random orientation of chromatids (bivalents) on the spindle at telophase.
3. Recombination of linked genes results from crossing over between sister chromatids of homologous chromosomes.
4. All of the above are true.
5. None of the above is true
6. I do not know.

Table of the Genetic Code

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

Table of the Chi-squared critical values

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

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2018 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 1412: MOLECULAR BIOLOGY AND GENETICS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS

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

6. Which of the following contains the genetic information for the synthesis of one specific protein?
   1. messenger RNA.
   2. transfer RNA.
   3. ribosomal RNA.
   4. messenger RNA and transfer RNA.
   5. DNA.
   6. I don't know.

7. During DNA replication, new nucleotides are added to the ...
   1. phosphate group of carbon 5 of the deoxyribose
   2. OH group of carbon 3 of the deoxyribose
   3. phosphate group of carbon 5 of the ribose
   4. OH group of carbon 3 of the ribose
   5. phosphate group on the 3' end of the RNA primer.
   6. I do not know.

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

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

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

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

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

12. During DNA replication, separation of DNA strands requires ...
    1. hydrolysis of phosphodiester bonds.
    2. DNA ligase activity.
    4. hydrolysis of GC and AT bonds.
    3. complementary base-pairing.
    5. topoisomerase activity.
    6. I do not know

13. If the sequence of bases on a non-template DNA is 5'- TAGT - 3', then the corresponding sequence of bases in the transcribed RNA will be...
    1. 5'- ATCG- 3'.
    2. 5'- TAGC- 3'.
    3. 3'-UAGC-5'.
    4. 3'-AUGC- 5'.
    5. 3'-UAGU- 5'.
    6. I do not know.

14. Which of the following occurs in both eukaryotic and bacterial transcription?
    1. 5' capping
    2. Poly A tail
    3. Nucleolus
    4. Splicing
    5. RNA synthesis
    6. I do not know.

15. Which of the following is not part of RNA processing in eukaryotes?
    1. Addition of a 5' cap.
    2. Lagging strand synthesis
    3. Addition of poly A tail
    4. Intron removal.
    5. Joining exons together.
    6. I do not know

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

17. Which position(s) of a codon is(are) said to wobble?
    1. First and second
    2. Second and third
    3. First
    4. Second
    5. Third
    6. I do not know.

18. Which of the following is **not** a property of the genetic code?
    1. Triplet
    2. Degenerate
    3. Overlapping
    4. Universal
    5. Unpunctuated
    6. I do not know.

19. The total number of possible codons of the genetic code is … out of which … are stop codons.
    1. 20, 3
    2. 21, 3
    3. 64, 21
    4. 64, 3
    5. 64, 20
    6. I do not know.

20. During the process of translation, the ...
    1. first amino acid binds to the A site and the second amino acid binds to the P site.
    2. first amino acid binds to formyl methionine.
    3. first amino acid binds to the P site and the second amino acid binds to the A site.
    4. last amino acid binds to the stop codon.
    5. last amino acid binds to the release factor.
    6. I do not know.

21. Identify the complex that is formed when mRNA binds to a ribosomal subunit.
    1. Aminoacyl synthetase
    2. Aminoacyl tRNA complex
    3. 70S initiation complex
    4. 30S initiation complex
    5. 40S initiation complex
    6. I do not know.

22. A messenger RNA is 300 nucleotides long, excluding the start and stop codons. The number of amino acids in the protein translated from this mRNA is ....
    1. 98
    2. 100
    3. 300
    4. 30
    5. 302
    6. I do not know

23. Identify the role of the enzyme peptidyl transferase during translation.
    1. Transfer of peptide from the P site to the A site.
    2. Transfer of peptide from the A site to the P site.
    3. Breakdown of peptide bonds between neighbouring amino acids.
    4. Synthesis of tRNA.
    5. Formation of peptide bonds between neighbouring amino acids
    6. I do not know.

24. The nucleolus is the site where ...
    1. mRNA poly A tail is added.
    2. rRNA is synthesised in prokaryotes.
    3. mRNA is synthesised in prokaryotes.
    4. mRNA is translated.
    5. rRNA is synthesised in eukaryotes.
    6. I do not know

25. The poly-A tail is added to the ...
    1. 3' end of tRNA.
    2. 5' end of mRNA.
    3. 5' end of any RNA.
    4. 3' end of any RNA.
    5. 3' end of mRNA.
    6. I do not know

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

27. Which one of the following molecules contains introns?
    1. Primary mRNA transcript of prokaryotic cells.
    2. Primary mRNA transcript of eukaryotic cells.
    3. Primary tRNA transcript of eukaryotic cells.
    4. Primary rRNA transcript of prokaryotic cells.
    5. Processed prokaryotic mRNA.
    6. I do not know

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

29. Given the DNA sequence CAT-AAG-GGC, AAG-GGC-CAT which of the following polypeptides would be
    the result?
    1. Val-Phe_Pro
    2. Gln-Asn-Gly
    3. Val-Ser-Pro
    4. Phe-Pro-Val
    5. Gly-Leu-Pro
    6. I do not know.

30. All the following materials are required in translation except ...
    1. all the types of RNA.
    2. amino acids.
    3. the RNA primer.
    4. elongation factors.
    5. ribosomes.
    6. I do not know

31. Identify the sequence on the amino acid attachment arm of t-RNA.
    1. 3' CAC 5'
    2. 3' CCA 5'
    3. 5' CCA 3'
    4. 3' ACA 5'
    5. 3' ACC 5'
    6. I do not know

32. The end of translation is signalled by a/an ... which binds a protein called the ...
    1. anticodon, initiation factor
    2. stop codon, release factor
    3. start codon, initiation factor
    4. stop codon, stop factor
    5. stop codon, nonsense codon.
    6. I do not know.

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

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

35. During prokaryotic translation the start codon specifies the amino acid...
    1. methionine.
    2. valine.
    3. glycine.
    4. formyl methionine.
    5. tryptophan.
    6. I do not know.

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

37. The ribosome reads the message on …
    1. mRNA in the 5' to 3' direction.
    2. mRNA in the 3' to 5' direction.
    3. mRNA in both directions.
    4. tRNA in the 5' to 3' direction.
    5. tRNA in the 3' to 5' direction.
    6. I do not know

38. Which one of the following sequences does **not** belong to the genetic code?
    1. AAA GGC AAG CAC
    2. CCC GGG AAA GCA
    3. AUA GGC AUG CAC
    4. GGT CCC GCC GTG
    5. CAA UGA ACA CCA
    6. I do not know.

39. If the sequence of bases on template DNA is ATCG, then the sequences of bases on the RNA transcript will be ...
    1. ATCG
    2. TAGC
    3. AUCG
    4. AUCG
    5. UACG
    6. I do not know.

40. The stages of translation arranged in chronological order are …
    1. Initiation, elongation, activation, termination.
    2. Initiation, activation, elongation, termination.
    3. Elongation, initiation, activation, termination.
    4. Activation, initiation, elongation, termination.
    5. Activation, elongation, initiation, termination.
    6. I do not know.

41. Choose the type(s) of RNA involved in translation.
    1. tRNA
    2. mRNA
    3. rRNA
    4. tRNA and mRNA
    5. all the three types of RNA.
    6. I do not know

42. The codon, anticodon and DNA sequence for methionine are …., …. and …. respectively.
    1. UAG, AUC, ATC
    2. AUG, AUC, ATC
    3. UAG, UAC, TAC
    4. AUG, AUC, CTA
    5. AUG. UAC, TAC
    6. I do not know

43. The *Lac* operon is a group of genes involved in the metabolism of …
    1. galactose.
    2. lactose
    3. permease.
    4. glucose.
    4. lactase.
    6. I do not know.

44. The *Lac* operon is switched on when …
    1. the repressor molecule binds the operator.
    2. glucose is present.
    3. lactose is absent.
    4. RNA polymerase binds to the operator site.
    5. glucose is absent.
    6. I do not know.

45. What is the function of the permease enzyme in the *lac* operon?
    1. Hydrolysis of lactose
    2. Attachment of lactose to the lac repressor protein
    3. Breakdown of lactose
    4. Entry of lactose into the cell
    5. Exit of lactose from the cell
    6. I do not know.

46. The *Lac* repressor dissociates from the operator site when it binds to ...
    1. lactose.
    2. the operator.
    3. the repressor.
    4. glucose.
    5. the regulator gene.
    6. I do not know.

47. In an operon, the function of the promoter is to ...
    1. code for the repressor protein.
    2. bind to the repressor.
    3. code for the regulator gene.
    4. bind with RNA polymerase.
    5. All of the above are correct.
    6. I do not know

48. Choose the item which is **not** part of the lac operon.
    1. Inducer.
    2. Regulator.
    3. Operator.
    4. Promoter.
    5. Structural genes.
    6. I do not know.

49. What is the function of β-galactosidase enzyme in the *lac* operon?
    1. Entry of lactose into the cell.
    2. Synthesis of lactose.
    3. Attachment of lactose to the lac repressor protein.
    4. Breakdown of lactose.
    5. Exit of lactose from the cell.
    6. I do not know.

50. The repressor becomes inactive when it binds to ...
    1. the promoter.
    2. the operator.
    3. the regulator.
    4. glucose.
    5. lactose.
    6. I do not know.

51. What is an operon?
    1. A part of ribosome.
    2. A part of RNA.
    3. A unit made up of linked genes that code for proteins needed to do a specific task.
    4. A special gene used in regulation of gene expression.
    5. A set of unrelated genes located close by on a chromosome.
    6. I don't know.

52. Proteins responsible for compact packaging of chromosomal DNA are called …
    1. haemoglobin.
    2. histones.
    3. myoglobin.
    4. collagen.
    5. glycoprotein.
    6. I don't know

53. What is the name of the sequence of DNA that determines one specific form of a trait?
    1. Allele
    2. Genotype
    3. Centromere
    4. Phenotype
    5. RNA
    6. I don't know

54. The number of pairs of autosomal chromosomes in humans are ….
    1. 23.
    2. 46.
    3. 44.
    4. 48.
    5. 22.
    6. I do not know.

55. What happens during the G2-phase of the cell cycle?
    1. Cell rests and does not need to divide.
    2. Cell grows and synthesizes enzymes and other proteins.
    3. Cell grows and synthesizes organelles in preparation for division.
    4. DNA is replicated.
    5. The whole cell divides.
    6. I do not know.

56. Cytoplasmic division of a cell is called…
    1. S-phase
    2. Cytokinesis
    3. Mitosis
    4. Synapsis
    5. G-phase
    6. I don't know

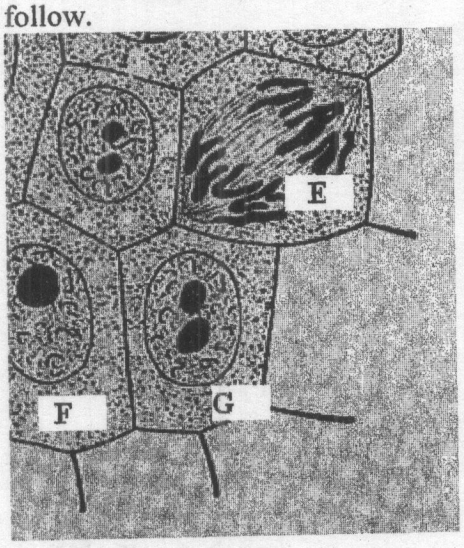
57. What is the role of the centromere during mitosis?
    1. It makes the chromosomes visible.
    2. It holds chromosomes in place.
    3. It holds non-sister chromatids together.
    4. It duplicates DNA.
    5. It holds sister chromatids together.
    6. I do not know

58. During the process of _____, two daughter cells will be produced with identical DNA.
    1. Mitosis
    2. Protein Synthesis
    3. Meiosis
    4. DNA Replication
    5. Interphase
    6. I don't know.

59. Choose the **false** statement.
    1. Meiosis is a reductional division.
    2. Synapsis takes place during meiosis II.
    3. Meiosis produces four haploid daughter cells.
    4. Meiosis is a source of genetic variation.
    5. Through meiosis daughter cells with recombinant chromosomes may be produced.
    6. I do not know.

60. Which of the following is **not** a characteristic of meiosis?
    1. Chromosomes arrange themselves in pairs.
    2. Daughter cells with half the normal number of chromosomes produced.
    3. One cell undergoing two cell divisions, one after the other.
    4. Division of diploid mother cells.
    5. Recombination of alleles during prophase II.
    6. I do not know.

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



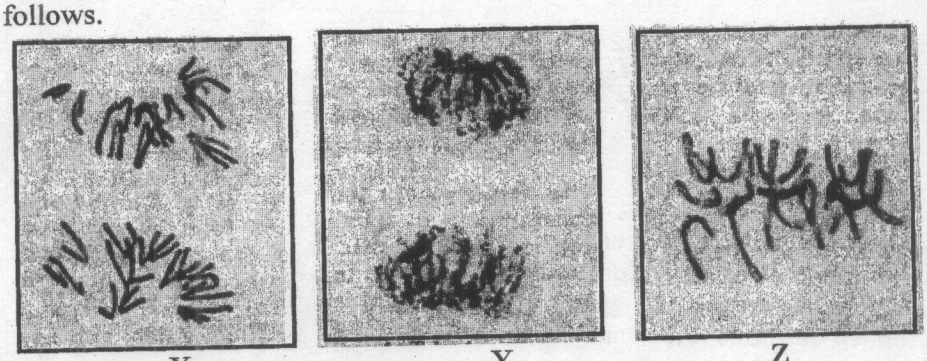
61. Identify the stage labelled E.
    1. Interphase.
    2. Prophase.
    3. Metaphase.
    4. Anaphase.
    5. Telophase.
    6. I do not know.

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

63. The exchange of segments of 2 non-homologous pair of chromosomes is called…
    1. Recombination
    2. Linkage
    3. Chiasma
    4. Metaphase
    5. Telophase
    6. I don't know.

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

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



X Y Z

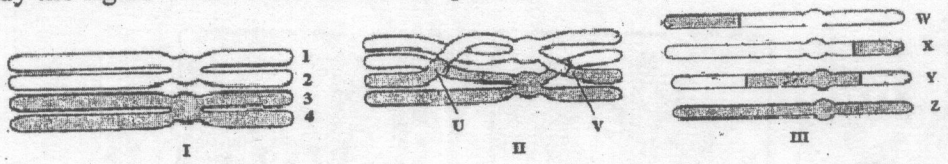
65. Identify the stages labelled X, Y and Z.
    1. X is anaphase, Y is telophase, Z is metaphase
    2. X is telophase, Y is interphase, Z is prophase
    3. X is prophase, Y is telophase, Z is anaphase
    4. X is anaphase, Y is interphase, Z is metaphase
    5. X is interphase, Y is telophase, Z is metaphase
    6. I do not know.

66. Crossing over between chromatids takes place during ...
    1. interphase of meiosis.
    2. prophase II of meiosis.
    3. prophase of mitosis.
    4. metaphase of mitosis.
    5. prophase I of meiosis.
    6. I do not know.

67. Synapsis is a process ...
    1. during mitosis whereby chromosomes exchange their material.
    2. during meiosis whereby sister chromatids exchange their material.
    3. whereby daughter cells with half the genetic material of the parent cell are produced.
    4. whereby homologous chromosomes separate and migrate to opposite poles.
    5. homologous chromosomes become closely associated.
    6. I don't know.

68. Crossing-over occurs during ....
    1. prophase
    2. interphase
    3. prophase I
    4. prophase II
    5. metaphase I.
    6. I do not know

Study the figure below and answer the question that follows.



69. The letter **U** in diagram II represents ...
    1. a chiasma between chromatids 1 and 2.
    2. the behaviour of chromosomes during metaphase.
    3. a chiasma between chromatids 1 and 3.
    4. the behaviour of chromosomes during anaphase.
    5. recombinant gametes.
    6. I do not know.

70. The structures in diagram III represent...
    1. a chiasma between chromatids 1 and 2.
    2. the behaviour of chromosomes during metaphase.
    3. a chiasma between chromatids 1 and 3.
    4. the behaviour of chromosomes during anaphase.
    5. recombinant gametes.
    6. I do not know.

71. Which one of the following statements is **not** a characteristic of homologous chromosomes?
    1. They have the same length.
    2. They have the same centromere position.
    3. The carry genes that control any given trait at the same location.
    4. They always have the same type of alleles that code for the exact same type of a trait.
    5. They pair up during meiosis I.
    6. I do not know.

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

73. Which alleles are responsible for the A and O blood groups?
    1. Dominant and recessive alleles.
    2. Codominant alleles.
    3. Codominant and recessive alleles.
    4. Incompletely dominant alleles.
    5. Dominant alleles.
    6. I do not know.

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

75. Alternative forms of a gene occupying the same position on a pair of homologous chromosomes are known as …
    1. double strands.
    2. templates.
    3. nucleosomes.
    4. alleles.
    5. histones.
    6. I do not know.

76. The allelic combination of an individual is described as the …
    1. phenotype.
    2. genotype.
    3. nucleus.
    4. chromosomes.
    5. genes.
    6. I do not know.

77. A test cross is a cross between …
    1. two F_1 individuals.
    2. two recessive phenotypes
    3. a dominant phenotype and a recessive phenotype.
    4. two dominant phenotypes.
    5. a dominant genotype and a recessive genotype.
    6. I do not know

78. Mendel's second law states that …
    1. alleles of different genes assort independently.
    2. genes of different alleles assort independently.
    3. alleles of a gene segregate in equal numbers.
    4. genes of an allele segregate in equal numbers.
    5. genes of an allele segregate in unequal numbers.
    6. I do not know

79. If two organisms are crossed and the trait being studied displays incomplete dominance, one may expect the following monohybrid phenotypic ratio in the offspring:
    1. 3:1
    2. 1:2:2
    3. 1:2:1
    4. 9:3:3:1
    5. 1:1
    6. I do not know.

80. In a monohybrid cross the …
    1. dominant phenotype disappears in the F_1 generation.
    2. dominant phenotype disappears in the F_2 generation.
    3. recessive phenotype re-appears in the F_1 generation.
    4. recessive phenotype re-appears in the F_2 generation.
    5. co-dominant phenotype disappears in the F_1 generation.
    6. I do not know.

81. In a cross between red-flowered and white-flowered parental plants, the offspring had red flowers with white spots, indicating that the alleles for flower colour exhibit…
    1. complete dominance.
    2. recessive behaviour.
    3. incomplete dominance.
    4. codominance.
    5. dominant and recessive behaviour.
    6. I do not know.

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

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

83. What is the probability that one of the children will be an albino child?
    1. ½
    2. $^1/_3$
    3. ¼
    4. $^1/_8$
    5. $^1/_{16}$
    6. I do not know.

84. What is the probability that both the children will be albino?
    1. ½
    2. $^1/_3$
    3. ¼
    4. $^1/_8$
    5. $^1/_{16}$
    6. I do not know.

85. Choose the option which best represents a monohybrid testcross.
    1. TT/tt x TT
    2. Tt/TT x Tt
    3. TT/Tt x TT
    4. TT/Tt x tt
    5. TT/tt x Tt
    6. I do not know

86. In guinea pigs black coat is a dominant trait and white is a recessive trait. When a heterozygous black guinea pig is crossed to a white one, what fraction of the F_2 is expected to be heterozygous?
    1. ¼
    2. $^2/_3$
    3. $^1/_3$
    4. ¾
    5. ½
    6. I do not know.

87. Root shape in radishes is a result of two alleles in which L_1L_1 produces long roots. L_1L_2 produces oval root shape and L_2L_2 produces round root shape. What genotypic ratio would you expect in the F_2 generation?
    1. 1:1
    2. 3:1
    3. 9:3:3:1
    4. 1:2:1
    5. 3: 0
    6. I do not know

88. A cross between a pure breeding red-flowered plant and a pure breeding white-flowered plant gave a progeny of pink-flowered variety only. This example illustrates …
    1. incomplete dominance.
    2. polygenic inheritance.
    3. co-dominance.
    4. multiple alleles.
    5. complete dominance.
    6. I do not know

89. Albinism is due to a recessive allele. If an albino male is married to a heterozygous normal female, the children produced will be …
    1. 100% normal homozygous
    2. 100% normal heterozygous
    3. 50% albino: 50% normal heterozygous
    4. 50% normal homozygous: 50% heterozygous
    5. None of the above
    6. I do not know.

90. In pea plants, axial flowers are dominant over terminal flowers. What phenotypic ratios would you expect in offspring from a cross between two heterozygous axial-flowered plants?
    1. 3 axial: 1 terminal
    2. 3 terminal: 1 axial
    3. 1 axial: 1 terminal
    4. All axial.
    5. All terminal.
    6. I do not know

91. Several black guinea pigs were crossed among themselves and they produced a mixture of 151 black and 49 white offspring. Which cross represent these results?
    1. BB x BB
    2. BB x Bb
    3. bb x bb
    4. BB x bb
    5. 3. Bb x Bb
    6. I do not know

One type of red flower colour in pea plants is controlled by two alleles **R** and **r**. The dominant allele **R** is responsible for red colour while the recessive allele **r** is responsible for white colour. A cross was carried out between two heterozygous red plants. The progeny plants consisted of 166 red flowered plants and 34 white flowered plants. A chi-squared test was carried out on the results of the progeny phenotypes. Use the information below to answer questions that follow.

92. The expected Mendelian progeny phenotypic ratio of this cross is ...
    1. 1:1
    2. 4:1
    3. 1:2:1
    4. 9:3:31
    5. 3:1
    6. I do not know.

93. The calculated χ^2 value is ...
    1. 1.71
    2. 5.12
    3. 3.8
    4. 6.8
    5. 5.0
    6. I do not know.

94. The tabulated χ^2 value at 0.05 probability is ...
    1. 1.7
    2. 5.1
    3. 3.8
    4. 6.8
    5. 5.0
    6. I do not know.

95. From the results of the chi-squared test it can be concluded that ...
    1. the calculated χ^2 value is not significant.
    2. the difference between the observed ratio and the expected ratio is not significant.
    3. there are 2 degrees of freedom.
    4. the progeny phenotypes are in the expected Mendelian monohybrid ratio.
    5. the progeny phenotypes are not in the expected Mendelian monohybrid ratio.
    6. I do not know.

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

Use the information below to answer the questions that follow.

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

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

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

97. The calculated chi-squared value is...
    1. 45
    2. 46.2
    3. 180.
    4. 43.8.
    5. 7.8.
    6. I do not know.
98. The degrees of freedom are...
    1. 2.
    2. 3.
    3. 4.
    4. 9.
    5. 16.
    6. I do not know.

99. The results of this cross suggest that...
    1. The gene with alleles R, r and the gene for Y, y are on different chromosome.
    2. The four genes are on different chromosomes.
    3. The two genes are linked.
    4. The three genes are on the same chromosomes.
    5. The three genes are controlled by multiple alleles.
    6. I do not know.

100. If the blood group of a child is A, which of the following couples could not be biological parents of the child?

1. Mother group A and father group B.
2. Both mother and father group A.
3. Mother group AB and father group O.
4. Mother group B and father group O.
5. Mother group A and father group O.
6. I do not know.

CHI-SQUARED TABLE FOR UP TO FOUR DEGREES OF FREEDOM

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

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 2302: BASIC MICROBIOLOGY
THEORY PAPER

TIME: TWO HOURS

INSTRUCTIONS
ANSWER **ALL** QUESTIONS FROM SECTION A. ANSWER **ONE** QUESTION FROM SECTION B AND C. USE PROVIDED ANSWER SHEET FOR SECTION A AND USE SEPARTE ANSWER BOOKS FOR SECTION B AND C.

SECTION A

1. Lipopolysaccharide in cell walls is characteristic of..
(a) Gram-positive bacteria.
(b) Gram-negative bacteria.
(c) Fungi.
(d) Algae.

2. Growth of microbes in a solid media is identified by the formation of..
(a) pellicle at the top of media.
(b) colonies.
(c) sediment at the bottom.
(d) turbidity.

3. The correct order of taxonomic groups from higher to lower rank is..
(a) Kingdom—Order—Class—Family.
(b) Order—Class—Division—Family—Genus—Species.
(c) Kingdom—Order—Division—Family—Class—Genus—Species.
(d) Kingdom—Division—Class—Order—Family—Genus—Species.

4. Which of the following are characteristics of archaebacteria different from eubacteria.
(a) methane-producers.
(b) extreme halophiles.
(c) thermoacidophiles.
(d) methane-producers, extreme halophiles, and thermoacidophiles.

5. According to Bergey's Manual of Systematic Bacteriology, prokaryotes that lack a cell wall belong to the group..
(a) Gracilicutes.
(b) Firmicutes.
(c) Tenericutes.
(d) Mendosicutes.

6. What is the approximate size of the bacterial cell..
(a) 2mm in diameter.
(b) 1mm in diameter.
(c) 2 micrometers in diameter.
(d) 0.5 to 1.0 micrometer in diameter.

7. When rod shaped bacteria appears in pairs, it is known as..
(a) Diplobacilli.
(b) Streptobacilli.
(c) Diplococci
(d) Staphylococci.

8. Bacteria with less than a complete twist or comma shaped is known as..
(a) spirilla.
(b) helical.
(c) vibrioid.
(d) spirochetes.

9. Bacteria having clusters of flagella at both poles of cells are known as..
(a) Lophotrichous.
(b) Peritrichous.
(c) Amphitrichous.
(d) Monotrichous.

10. Peptidoglycan layer is present in large quantity in..
(a) Gram-positive bacteria.
(b) Gram-negative bacteria.
(c) Fungi.
(d) Algae.

11. Teichoic acid present in Gram-positive bacteria can bind to which ion..
(a) Fe^{2+} ions.
(b) Phosphorus ions.
(c) Mg^{2+} ions.
(d) Sulphur ions.

12. The organisms which can use reduced inorganic compounds as electron donors are known as…
(a) chemotrophs.
(b) organotrophs.
(c) lithotrophs.
(d) phototrophs.

13. The isolation of gonorrhea-causing organism, Neisseria gonorrhoeae by the use of certain antibiotics in media is an example of which of the following?
(a) Selective media.
(b) Differential media.
(c) Enriched media.
(d) Assay media.

14. The optimum pH for the growth of most bacteria lies between _____
(a) 4.5-5.0.
(b) 6.5-7.5.
(c) 2-3.5.
(d) 9-9.5.

16. Which of the following methods is used for determining the decrease in the amount of growth?
(a) test done on agar medium plate.
(b) test done into an agar medium or broth.
(c) test done by transfering water-soluble substances to sterile media.
(d) by phenol-coefficient method.

17. Which of the following is not the characteristic of a growth curve?
(a) Shows development of microbial population under relatively stable environmental Conditions.
(b) Plotted with logarithmic numbers.
(c) Graphs numbers of microbes versus time.
(d) Each growth curve consists of four distinct phases.

18. The organism which grows best above 45°C are called
(a) psychrophilic.
(b) mesosphilic.
(c) thermophilic.
(d) Halophilic.

19. Which of the following is used for the proper maintenance and preservation of pure cultures?
(a) Periodic transfer to fresh media.
(b) Preservation by overlaying cultures with mineral oil.
(c) Preservation by lyophilization.
(d) All of the above.

20. A cluster of polar flagella is called
(a) lophotrichous.
(b) amphitrichous.
(c) monotrichous.
(d) petritrichous.

21.An increase in the number of microbial cells is called …
(a) population.
(b) fertilization.
(c) growth.
(d) community.

22. Binary fission is a form of …
(a) sexual reproduction.
(b) conjugation.
(c) asexual reproduction.
(d) meiosis.

23. FtsZ is not an important cell division protein …
(a) Archaea.
(b) prokaryotes.
(c) eukaryotes.
(d) Escherichia coli.

24. Full FtsZ ring forms as the bacterial cell …
(a) elongates.
(b) shrinks.
(c) rotates.
(d) fragments.

25. The divisome orchestrates synthesis of new cytoplasmic membrane and cell wall material, called the …
(a) metaphase plate.
(b) division septum.
(c) spindle fibre.
(d) cytoplasmic fibres.

26. Name the type of bacterial endospore shown in the figure below.
(a) Terminal spores.
(b) Central spores.
(c) Subterminal spores.
(d) Cytoplasmic spores.

27. Which one of the following statements is not true?
(a) Endospores are highly differentiated cells that are extremely resistant to heat, harsh chemicals, and radiation.
(b) Endospores function as survival structures, enable the organism to endure unfavorable growth conditions, including but not limited to extremes of temperature, drying, or nutrient depletion.
(c) Endospores can be thought of as the dormant stage of a bacterial life cycle.
(d) Endospore-forming bacteria are only found in soil.

28. Which one of the following is not found in bacterial endospores?
(a) DNA.
(b) Exosporium.
(c) Cortex.
(d) Cytoplasm.

29. The reduction of the microbial populations to levels that are considered safe for public health standards is achieved by …
(a) disinfection.
(b) sanitization.
(c) sterilization.
(d) antisepsis.

30. Which one of the following is a chemical method for controlling microbial growth?
(a) Radiation.

(b) Disinfection.
(c) Filtration.
(d) Pasturisation

31. Chemical substances produced by certain microorganisms that inhibit and kill other microorganisms are called …
(a) aldehydes.
(b) phenols.
(c) antibiotics.
(d) halogenes.

32. Fungal thali without division of vegetative and reproductive structures are called …
(a) holocarpic.
(b) eucarpic.
(c) coenocytic.
(d) multinucleate.

33. Chemical analysis of the fungal cell wall shows that 80-90% are …
(a) proteins.
(b) lipids
(c) lignins
(d) polysaccharides

34. In fungi, the plasmalemma invaginates and forms a pouch like structure called …, enclosing the granular or vesicular materials.
(a) lomasome.
(b) golgi body.
(c) rough endoplasmic reticulum.
(d) smooth endoplasmic reticulum.

35. A virion consists of nucleic acids surrounded by a protective coat of protein called capsid, formed from identical proteins called
(a) capsomeres.
(b) albumin.
(c) globulin.
(d) Tubulin.

36. Which one of the following is the correct symmetry of Tobacco Mosaic Virus (TMV)?
(a) Icosahedral symmetry.
(b) Helical symmetry.
(c) Complex symmetry.
(d) Spherical symmetry.

37. According to Baltimore classification system of viruses, RNA viruses belong to classes…
(a) II, IV, V and VI.
(b) I, III, IV, V, VI
(c) III, IV, V, VI
(d) I, IV, V, VI

38. … contain a ssRNA genome, half of which is in the plus orientation (and can thus be used as mRNA) and half in the minus configuration (which cannot).
(a) Retroviruses.
(b) Segemented viruses.
(c) Ambiviruses.
(d) Reoviruses.

39. When T4 DNA enters a host cell, it is first replicated as a unit, and then several genomic units are recombined end to end to form a long DNA molecule called a …
(a) concatemer.
(b) nucleoid.
(c) chromosome.
(d) genome.

40. Which one of the following is not a mechanical method for transmitting plant viruses?
(a) Transmitted from diseased to health plants by rubbing leaves together, injecting plant extracts, and action of animals.
(b) Use of these tools first on infected plants then healthy plants facilitates viral transmission.
(c) Viruses attached on animal bodies are transmitted when animals rub their body on infected plants and later on healthy plants.
(d) When pollen grains with virus fall on stigma of female plants they germinate and eventually facilitate the virus to infect the ovule of plants.

SECTION B

1.(a) Describe the significance of the microbial growth curve in medical research.
(b) Outline factors that influence bacteria ecological preferences.
(c) Describe the major contributions of Robert Koch to modern microbiology.

2.(a) A basic microbiology student was told to prepare 280 culture plates of thio-citrate bile salt (TCBS) agar for the isolation of *Vibrio cholerae*. It is estimated that each culture plate holds 11.4 mls of the agar. Calculate the mass of TCBS powder required to make the agar (47.01g/1litre). Explain the uses of selective media.
(b) Describe bacterial classification based on the cell wall and flagella.
(c) With reference to culture medium preparation, describe sterilization.

SECTION C

3. Summarise four of the following:
(a) Types of septa in fungi.
(b) Symptoms of tobacco mosaic virus.
(c) Complex virus structure.
(d) Viral proteins.
(e) Cultivation and quantification of bacteriophages.
(f) Viroid structure.

4. Compare and contrast lytic and lysogenic life cycles of bacteriophages

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 2701: BASIC PHYSIOLOGY
THEORY PAPER

TIME: THREE HOURS

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

SECTION A: Plant physiology

1. Discuss the chemiosmotic mechanism for polar auxin transport in stems and coleoptiles.

2. (a) Explain the terms *climacteric* and non-*climacteric* as applied to fruit ripening.
   (b) Group the following fruit types into *climacteric* and non-*climacteric* categories: Apple, strawberry, grape, mango, pineapple, watermelon, banana, avocado, tomato.

3. Carbon dioxide fixation in the Calvin cycle (C_3) proceeds in three phases: Carboxylation, reduction and regeneration. Write a scheme for chemical reaction steps involved in carboxylation, reduction and regeneration phases of C_3 photosynthesis.

4. Discuss physiological effects of abscisic acid.

SECTION B: Animal physiology

5. Discuss the absorption of carbohydrate and fat digestion end-products in humans.

6. Explain the roles of the following primary and secondary tissues in the endocrine system:
   (a) Thyroid gland.
   (b) Pituitary gland.
   (c) Kidney.
   (d) Digestive tract.

7. Discuss generation and transmission of action potentials in vertebrate nerve cells.

8. Describe each of the following with respect to animal reproduction:
   (a) Oogenesis.
   (b) Spermatogenesis.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 2801: DIVERSITY OF PLANTS
THEORY PAPER

TIME: TWO HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS FROM SECTION **A**, **ONE** QUESTION FROM SECTION **B**, AND **ONE** QUESTION FROM SECTION **C**. USE THE PROVIDED ANSWER SHEET FOR SECTION **A** AND **SEPARATE ANSWER BOOKS** FOR SECTIONS **B** AND **C**.

SECTION A: MULTIPLE CHOICE QUESTIONS

1. Cell division in *Ulothrix* is.....
   (a) Apical.
   (b) Basal.
   (c) Intermediate.
   (d) Diffuse.
2. Presence of an annular cap is a feature of.....
   (a) Spirogyra.
   (b) Chaetophora.
   (c) Cladophora.
   (d) Oedogonium.
3. Sexual reproduction occurs through the formation of antheridia and oogonia in.....
   (a) Cladophora.
   (b) Ulothrix.
   (c) Oedogonium.
   (d) Spirogyra.
4. Presence of alternation of generations is a common feature in.....
   (a) Oedogonium.
   (b) Chara.
   (c) Cladophora.
   (d) Ulothrix.
5. Which of the following genera produce macrandrous and nannandrous species?
   (a) Cladophora.
   (b) Chaetophora.
   (c) Oedogonium.
   (d) Chara.

TURN OVER

6. An akinete is formed under drought conditions by the modification of.....
   (a) A zoospore.
   (b) An aplanospore.
   (c) A photosynthetic cell.
   (d) A isogamete.

7. An androspore is a.....
   (a) A male reproductive cell.
   (b) A female reproductive cell.
   (c) A progenitor of nannandrium.....
   (d) A zygote.

8. *Spirogyra* thallus is.....
   (a) Branched and filamentous.
   (b) Heterotrichous.
   (c) Colonial.
   (d) A simple filament.

9. Sexual reproduction in *Spirogyra* is achieved by.....
   (a) Oogamy.
   (b) Gametangial contact.
   (c) Conjugation.
   (d) Union of sex cells.

10. Chloroplast structure in *Ulothrix* is.....
   (a) Laminate.
   (b) Parietal.
   (c) Reticulate.
   (d) Girdle (band)-shaped.

11. The presence of a rhizoidal cell can be seen in.....
   (a) Riccia.
   (b) Anthoceros.
   (c) Funaria.
   (d) Ulothrix.

12. The term "*oedos*" means.
   (a) A reproductive structure.
   (b) A zoospore.
   (c) An akinete.
   (d) Swollen.

13. Desmids are classified in the order of green algae called.....
   (a) Ulotrichales.
   (b) Cladophorales.
   (c) Conjugales.
   (d) Charales.

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14. The sexual reproduction in *Vaucheria* is described as.....
    (a) Isogamous.
    (b) Anisogamous.
    (c) Oogamous.
    (d) Gametangial contact.

15. *Chara* species belong to the division of algae called.....
    (a) Xanthophyta.
    (b) Phaeophyta.
    (c) Charophyta.
    (d) Chlorophyta.

16. Pyrenoids found in cells of some green algae are made of.....
    (a) Protein.
    (b) Cellulose.
    (c) Starch (in the form of a storage glucose).
    (d) Pectin.

17. *Marchantia* species are described in a class of liverworts known as.....
    (a) Anthocerotopsida.
    (b) Bryopsida.
    (c) Hepaticopsida.
    (d) None of the above.

18. The sex organs of bryophytes are known as.....
    (a) Nucule.
    (b) Globule.
    (c) Antheridia and Archegonia.
    (d) Isogametangia.

19. The simplest sporophyte among Bryophyta occurs in.....
    (a) Marchantia.
    (b) Anthoceros.
    (c) Riccia .
    (d) Polytrichum.

20. The pseudoelaters are found in the sporophytes of.....
    (a) Marchantia.
    (b) Funaria.
    (c) Anthoceros.
    (d) Riccia.

21. Rhizoids found on the lower side of the thallus of liverworts are.....
    (a) Multicellular.
    (b) Brown coloured.
    (c) Smooth-walled and tuberculate.
    (d) Nutrient transporting structures.

TURN OVER

22. Elaterophore occurs in.
    (a) Antheridium of mosses.
    (b) Archegonium.
    (c) The sporophyte of some bryophytes.
    (d) Seta of mosses.

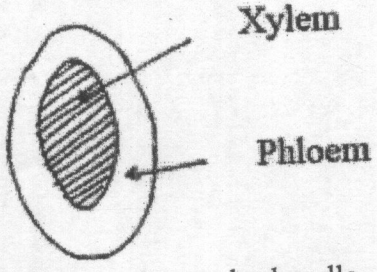
23. The common photosynthetic pigments of green algae are.....
    (a) A unique chlorophyll c.
    (b) Chlorophyll a and b.
    (c) Chlorophyll a and c.
    (d) Chlorophyll a and d.

24. A spermocarp develops following sexual reproduction in.....
    (a) *Oedogonium.*
    (b) *Chara.*
    (c) *Draparnaldia.*
    (d) *Coleochaete.*

25. Quadriflagellate zoospores are produce by.....
    (a) *Spirogyra.*
    (b) *Oedogonium.*
    (c) *Cladophora.*
    (d) *Vaucheria.*

26. The type of stele where the central core is occupied by pith, surrounded by discrete vascular bundles is called.....
    (a) Ectophloic siphonostele.
    (b) Eustele.
    (c) Dictyostele.
    (d) Protostele.

27. The vascular bundle shown in the figure below is known as.....



    (a) Bicollateral vascular bundle.
    (b) Amphivasal vascular bundle.
    (c) Amphicribral bundles.
    (d) Collaterla vascular bundle.

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28. Zygotic meiosis is characteristic of which type of life cycle?
    (a) Haplontic life cycle
    (b) Diplontic life cycle.
    (c) Diplohaplontic life cycle.
    (d) Isomorphic alternation of generations.

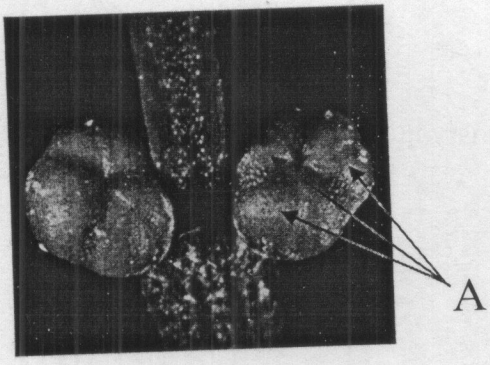
29. Leptosporangia of ferns are often aggregated into a cluster known as a sorus, which is sometimes covered by a flap of tissue, known as.....
    (a) A stipe.
    (b) An indusium.
    (c) A rachis.
    (d) An operculum.

30. There are three extant families of Cycadales are.....
    (a) Zamiaceae, Osmundaceae and Stangeriaceae.
    (b) Stangeriaceae, Podocarpaceae and Zamiaceae.
    (c) Cycadaceae, Malvaceae and Stangeriaceae.
    (d) Cycadaceae, Zamiaceae and Stangeriaceae.

31. Asexual reproduction in the order Sellaginelales happens by
    (a) Sporocarps.
    (b) Bulbs.
    (c) tissue culture.
    (d) Fragmentation and tubers.

32. *Psilotum* and *Tmesipteris* belong to the order.....
    (a) Jungermanniales.
    (b) Psilotales.
    (c) Isoetales.
    (d) Selaginellales.

33. The figure below shows part of a stem of a Psilotum species. Identify the structures labelled "A" on the stem.



    (a) Elators.
    (b) Megaspores.
    (c) Sporangia.
    (d) Fruits.

TURN OVER

34. The stamens of the flower are referred to collectively as.....
    (a) Androecium.
    (b) Gynoecium.
    (c) Sporophylls.
    (d) Tepals.

35. An ovuliferous scale is located on the.....
    (a) Gynoecium.
    (b) Megasporangiate strobilus.
    (c) Microsporangiate strobilus.
    (d) Male cone.

36. The tissue which when added to fruits may make them rigid for seed protection or for the formation of structures that attach to animals, or to cause fruits to burst open and eject seeds is known as.....
    (a) Collenchyma.
    (b) Aerenchyma.
    (c) Epidermis.
    (d) Sclerenchyma.

37. In angiosperms diploid cells called microsporocytes divide by meiosis to produce haploid microspores, which undergo mitotic division to produce.....
    (a) immature male gametophytes.
    (b) mature microgametophytes.
    (c) mature megagametophytes.
    (d) pollen tubes.

38. Gymnosperms are similar to Angiosperms (flowering plants) in that they both.....
    (a) Produce an ovule, which develops into a seed.
    (b) Have seeds enclosed in an ovary.
    (c) Have seeds that grow on a strobilus or cone.
    (d) Have pollen grains that directly come in contact with the ovule after pollination.

39. The reproductive structures of the Pinales are.....
    (a) Flowers.
    (b) Strobili.
    (c) Ovaries.
    (d) Roots .

40. The major character that is considered as an evolutionary novelty that unites the spermatophytes is.....
    (a) Coronas.
    (b) Segmented stems.
    (c) Homospory.
    (d) The seed.

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41. The largest of any major group of Green plants are the.....
    (a) Pteridophytes.
    (b) Bryophytes.
    (c) Angiosperms.
    (d) Algae.

42. Aquatic ferns are considered unique among the leptosporangiate due to their.....
    (a) Having simple leaves.
    (b) Being heterosporous.
    (c) Possessing a false indusium.
    (d) Polycyclic siphonostele.

43. *Selaginella* plants are known as a resurrection plants because.....
    (a) They are creeping or ascendant plants with simple, scale-like leaves on branching stems from which roots also arise.
    (b) They become folded up like a ball in dry conditions but immediately become unfolded and normal when exposed to water.
    (c) Their prominent or dominant generation is the sporophyte.
    (d) They were found at the resurrection site.

44. A plant that has both male and female reproductive structures on one individual is ..... where as one that has male and female reproductive structures on separate individuals is .....
    (a) Monoecious, dioecious.
    (b) Dioecious, monoecious.
    (c) Diplohaplontic, haplontic.
    (d) Homosporous, heterosporous.

45. Which of the following statements is not true?
    (a) Gametophytic Generation is the Dominant Generation in bryophytes, but as we move to so called higher plants, the sporophytic generation becomes dominant.
    (b) The Bryophytes lack true roots but have rhizoids.
    (c) Bryophytes like other land plants possess multicellular sporangia that also have a sterile layer of jacket cells, which protects the spores from desiccation.
    (d) Bryophytes have well developed internal transport tissues (vascular tissues) similar to those of vascular plants.

46. The sporangia of *Equisetum* species are found in groups of five to ten in umbrella-like structures known as .....
    a. Sori.
    b. Sporagiophores.
    c. Sporophytes.
    d. Antheridia.

47. Which of the following represent a homosporous and a heterosporous plant?
    (a) *Psilotum* sp. and *Isoetes* sp.
    (b) *Isoetes* sp. and *Salvinia* sp.
    (c) *Pinus* sp. and *Azolla* sp.
    (d) *Psilotum* sp. and *Lycopodium* sp.

TURN OVER

48. The function of the annulus of the leptosporangium is .....
    (a) To protect spores from dehydration.
    (b) To provide nutrients to the sporangium.
    (c) To help disperse spores.
    (d) None of the above.

49. The sori of *Marsilea* species are located within hard bean or pea-shaped bodies knows as.....
    (a) Sorus.
    (b) Sporocarp.
    (c) Rachis.
    (d) Bulb.

50. What are the two types of leaves that occur on stems of *Salvinia* species?
    (a) Simple and compound leaves.
    (b) Circinate and broad leaves.
    (c) Floating and submerged leaves.
    (d) Sporophylls and cataphylls.

SECTION B

1. Describe reproduction in sporophytic and gametophytic phases in the life of *Cladophora* and explain how the change from sporophytic to gametophytic state occurs.

2. (a) Describe thallus morphology and thallus growth in *Oedogonium.*
   (b) Describe asexual reproduction in *Oedogonium.*

SECTION C

3. Compare and contrast the strobilus structure, spores and gametophytes of the genera *Lycopodium* and *Selaginella.*

4. Describe the principle stele types of Tracheophytes and their various derivatives.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 2812: DIVERSITY OF ANIMALS
THEORY PAPER

TIME: THREE HOURS

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

SECTION A

1. Describe the main features of the gut, coelom and hemal system in bilaterians.

2. Summarise each of the following:
   (a) The colonial theory on the origin of metazoans.
   (b) Function of the parenchyma in turbellarians.
   (c) The life cycle of cestodes.
   (d) Role of the coelenteron in cnidarians.

3. Explain how parasitic nematodes that require one host differ from those that have two hosts.

4. Compare and contrast external morphology of the subphyla Chelicerata and Crustacea.

SECTION B

5. Summarise characteristics of each of the following vertebrate groups:
   (a) Agnatha.
   (b) Osteichthyes.
   (c) Anguillidae
   (d) Anura.
   (e) Metatheria.

6. Compare and contrast classes Cyclostoma and Chondrichthyes.

TURN OVER

7. Explain how the class Amphibia is true representative of the subphylum Gnathostomata.

8. Summarise functions of each of the following in specified vertebrate groups:
   (a) Lungs in the family Protopteridae.
   (b) Swim bladder for the family Clupeidae.
   (c) Pharynx in subphylum Cephalochordata.
   (d) Chromatophores in Sauria.
   (e) Placenta in subclass Prototheria.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3011: BIOLOGICAL DATA ANALYSIS AND EXPERIMENTAL DESIGN
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS

---

1. Measurements of heights (cm) of brother and sister were made in each of 8 two-child families, giving results presented in table 1. Calculate the correlation coefficient of the heights and test the significance of the departure of rho (r) from zero.

Table 1. Height measurements (cm) of brother and sister in two-child families.

Family	1	2	3	4	5	6	7	8
Brother	73	70	74	68	70	67	69	68
Sister	69	67	63	66	67	64	66	71

2. (a) Given, p = ½, as the probability that a baby taken at random is a boy, calculate the expected probabilities for all possible kinds of family a newlywed couple can have, if it plans to have a family size of 6 children.
   (b) Determine the probability of having three children of each sex in the family.
   (c) Calculate the probability of having at least one child of each sex.
   (d) Determine the probability of all children in the family being of the same sex.

3. Data for a completely randomized design experiment with 3 treatments and 4 replications per treatment are shown in Table 2. The data represent protein percentage in maize at 2, 4 and 9 weeks (= treatments) after December 1 (2019) in Lusaka for the 2019/20 crop-growing season.

Table 2. Protein percentage in maize at different periods of growth.

Replications	**Weeks after December 1, 2019 (= Treatments)**		
	2	**4**	**9**
1	30	16	13
2	24	22	7
3	28	18	10
4	29	14	13

TURN OVER

Test the Null Hypothesis that there were no significant differences in protein content of the maize at the different stages of growth.

4. Display data presented in Table 3 below in a scatter diagram and:
   (a). Fit a regression line to the scatter plot.
   (b). Test the significance of the relationship between the two variates.

Table 3. Regression analysis data.

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

5. In a study on fish species diversity in four African lakes, the following data (Table 4) were collected on the number of different species caught from each lake.

Table 4. Number of different fish species caught in four African Lakes.

	LAKE			
CATCHES	**Tanganyika**	**Victoria**	**Malawi**	**Chirwa**
1	64	78	75	55
2	72	91	93	66
3	68	97	78	49
4	77	82	71	64
5	56	85	63	
6		77	76	
7			78	
8			70	

Test the N.H. that the four lakes have the same fish species diversity.

6. Heights (m) of pine trees from three sites of Zambia Forestry Corporation (ZAFICO) Plantation in Ndola are presented in Table 5 below. Test the null hypothesis that the mean pine tree heights of the three sites are not significantly different from each other.

Table 5. Heights (m) of pine trees from three ZAFICO sites un Ndola.

Number	Site A	Site B	Site C
1	3.4	4.5	5.6
2	4.5	3.6	5.1
3	2.8	5.7	4.6
4	9.8	4.0	3.9
5	3.1	4.2	4.9
6	2.9	3.8	5.3
7	6.8	3.7	3.9
8	4.5	4.6	5.9

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

Table 6. Lengths of the root systems (cm) of the Kafue weed plants collected between Mazabuka town and Kafue Gorge Dam.

SAMPLE 1	SAMPLE 2
97	88
108	101
17	87
121	67
31	95
98	43

(a) Examine the significance of the difference between the mean root lengths, assuming that population variances are equal.

(b) Indicate what your conclusion would be regarding the difference between the mean root lengths, if population variances were unequal.

8. A study of car speeding violations by divers while using cell phones when driving produced data presented in Table 7 below. Test the null hypothesis that there is no association between speeding violations and cell phone use by car drivers.

Table 7. Data on car speeding violation and cell phone use by drivers.

	Speed violation in the last year	No speed violation in the last year	Total
Cell phone user	25	280	305
Not cell phone user	45	405	450
Total	70	685	755

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3011: BIOLOGICAL DATA ANALYSIS AND EXPERIMENTAL DESIGN
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS

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TURN OVER

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THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3412: GENETICS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS; **TWO** FROM EACH SECTION AND THE **FIFTH** FROM EITHER SECTION. ILLUSTRATE YOUR ANSWER WHERE NECESSARY. USE **SEPARATE ANSWER BOOKS** FOR EACH SECTION. A CHI-SQUARED TABLE IS PROVIDED.

SECTION A

1. (a) Explain homologous conjugation.
   (b) Describe the three (3) methods of natural recombination in bacteria.
   (c) Using illustrations, explain the process of Hfr conjugation.

2. Describe each of the following processes:
   (a) Generalized Transduction.
   (b) Specialized Transduction.
   (c) Transformation.

3. Explain the process of formation of a tetraploid organism via:
   (a) sexual polyploidization
   (b) asexual polyploidization

4. Summarise each of the following:
   (a) Cri du chat syndrome
   (b) Down's syndrome.
   (c) Plaque Morphology
   (d) Temperate phage

TURN OVER

SECTION B

5. (a) Show how the Poisson distribution can be used to estimate chiasma frequency from RF data.
   (b) List the assumptions made in the Poisson distribution.
   (c) Give reasons why estimation of genetic distance using centimorgans is more reliable than using map units.
   (c) Briefly explain four types of gene maps.

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

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

Phenotype	ABC	abc	Abc	aBC	ABc	abC	AbC	aBc
Progeny number	1751	1763	95	90	180	135	10	8

Study Table 1 and:

   (a) Establish whether the three genes are linked or not.
   (b) Estimate the map distances in map units.
   (c) Estimate the map distances in Centimorgans.
   (d) Calculate the value of interference.

7. (a) List the assumptions made in the Hardy-Weinberg Equilibrium.
   (b) Explain how sex-linked genes result in deviation from the expected Hardy-Weinberg Equilibrium.
   (c) Derive the formula for calculating the fixation index (F) from data of a population with genetotypes AA, Aa and aa.
   (d) Explain what it means when the value of F = 0.

8. The following data were generated in a quantitative genetic study of body mass (kg) in a population of chickens:

Total genetic variance = 120
Variance due to dominance effects = 30
Variance due to epistatic effects = 15
Total environmental effects = 210

   (a) Calculate the broad-sense heritability from these variance estimates.
   (b) Calculate the narrow-sense heritability from these variance estimates.
   (c) Explain the importance of heritability of a trait in crop and livestock breeding.
   (d) Name one other concept that is also important in breeding programmes.

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CHI SQUARED TABLE

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

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 5201: INSECT EVOLUTION AND SYSTEMATICS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS.

---

1. Discuss the Paranotal and Gill theories on the origin of insect wings and explain which of the two has greater backing among entomologists.

2. Using specific examples, distinguish the following kinds of natural selection observed in insect populations and explain their consequences.
   (a) Stabilizing selection.
   (b) Directional selection.
   (c) Disruptive selection.

3. Explain why the Protura, Diplura and Collembola are presently considered as non-insect hexapods.

4. Discuss mechanisms that lead to the development of allopatric and sympatric insect species.

5. Explain how the operative principles of nomenclature are employed to determine the name by which a given insect taxon should be properly known.

6. Discuss components of a biological classification system and explain why the seven-mandatory-ranks Linnaean hierarchy introduced in 1758 is still relevant today.

7. (a) State the stages at which the study of systematics of major groups of insects in Zambia is today.
   (b) Explain tasks of systematics.

8. Compare and contrast the approaches of the Phenetics and Cladistics schools of thought on insect classification.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 5231: IMMATURE INSECTS
THEORY PAPER

TIME: THREE HOURS

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

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1. Explain what immature insects are and why it is important for entomologists to know and study them.

2. Discuss problems encountered by entomologists when classifying immature insects and how these problems are resolved.

3. Discuss the classification of the principal types of insect larvae in terms of body form and structure.

4. Describe the taxonomic features that are used in the ordinal classification of immature insects.

5. "No way can a caterpillar give rise to a butterfly or moth, caterpillars are caterpillars and nothing else. Caterpillars are food to people, butterflies and moths are not", one marketeer selling edible caterpillars was heard saying at the Intercity Bus Station in Lusaka. Argue for or against this statement.

6. With the aid of well labelled diagrams, describe the principal kinds of pupae found in Class Insecta.

7. Distinguish between pre-pupa and pharate adult in insect life cycles and explain the biological significance of the pupal stage in holometabolous insects.

8. Compare and contrast the structure and development of an exarate adecticous pupa and a coarctate pupa in holometabolous insects.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2018/2019 ACADEMIC YEAR
FINAL EXAMINATIONS

CHE1000: INTRODUCTION TO CHEMISTRY

TIME: THREE (3) HOURS

INSTRUCTIONS TO THE CANDIDATES

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

   ANSWER ALL QUESTIONS IN SECTION A IN THE MAIN ANSWER BOOKLET
4. Section **B** has five **(5)** long answer questions. Questions carry equal marks. (Total marks = **60**).

   ANSWER QUESTION B1 and ANY THREE QUESTIONS, EACH QUESTION IN A SEPARATE ANSWER BOOKLET.
6. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.**
7. Please be reminded that it is your responsibility to **ENSURE** that you have nine (9) printed pages containing questions A1 to A10 and B1 to B5.

ADDITIONAL INFORMATION TO THE CANDIDATES:

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

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

Question A1

Hemoglobin is the protein that transports oxygen through the blood from the lungs. In doing so, each molecule of haemoglobin combines with four molecules of oxygen. If 1.00 g of haemoglobin combines with 1.53×10^{-6} m^3 of O_2 at 310 K and 99059 Pa, what is the molar mass of haemoglobin? **[4 Marks]**

Question A2

(a) Two factors can determine the size (radius) of an atom. State any one of them and explain in *three lines or less*, how it influences the size of an atom.

(b) Is it more difficult to remove a valence electron from a magnesium atom or a chlorine atom? Explain in *three lines or less*.

[4 Marks]

Question A3

The following standard electrode potentials are needed for this question:

	$E°/V$
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2 + H_2O$	+ 0.81
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+ 0.34

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

Question A4

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

(a) Write the integrated rate law for this reaction.

(b) Calculate the half-life for this reaction.

(c) Find the concentration after 1.0×10^{-3} s has elapsed.

[4 Marks]

Question A5

A solution contains 1.0×10^{-5} mol dm^{-3} of Na_3PO_4 . What is the required concentration of $AgNO_3$ that would cause precipitation of Ag_3PO_4 ($K_{sp} = 1.8 \times 10^{-18}$)?

[4 Marks]

Question A6

(a) The enthalpy of formation of NH_3 is - 46 kJ/mol. Calculate the enthalpy change for the reaction $2NH_3\ (g) \rightarrow N_2\ (g) + 3H_2\ (g)$

(b) When 285 J of heat is added to 33.6 g of hexane, (M_r. 86.06 g/mol), the temperature increases by 3.74°C. Calculate the molar heat capacity of hexane.

[4 Marks]

Question A7

(a) The vapor pressure above a solution of a nonvolatile solute at 25.0 °C is 19.3 mm Hg. What is the mole fraction of the solute? (The vapor pressure of pure water is 23.8 torr at 25.0 °C.)

(b) List the following molecules in order of increasing surface tension: C_3H_8, CH_4, CH_3COOH and C_2H_6.

(c) Which substance has the higher vapor pressure: $C_{20}H_{42}$ or $C_{30}H_{62}$?

[4 Marks]

Question A8

(a) Identify the strongest intermolecular force present in the following molecules:

(i) CH_3CH_2OH

(ii) CH_3CH_2Cl

(b) Predict which will have the higher boiling point: ICl or Br_2. Explain your answer in not more than two lines.

[4 Marks]

Question A9

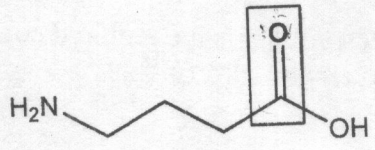
(a) For compound **A**, 5-isopropyl-2,3-dimethyloct-2-ene:

(i) Draw a line-bond formula.

(ii) Give molecular formula.

(iii) State the number of allylic hydrogens in **A**.

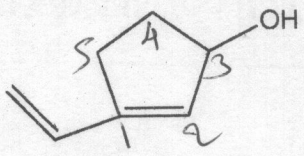
(b) Classify the molecule shown below and describe the bonding of the group in the box.



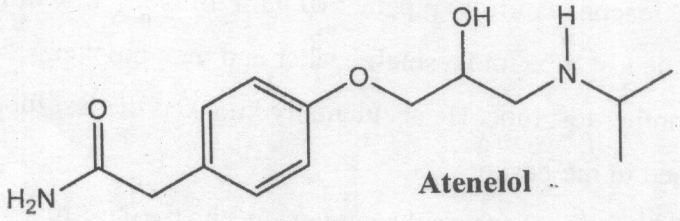
[4 Marks]

Question A10

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



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



Atenolol

[4 Marks]

SECTION B

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

Question B1

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

(a) Another student, Joseph, carefully pipettes 10.0 mL of 0.525 mol dm^{-3} NaOH into a test tube. He places the test tube into a small beaker and then pipettes 7.50 mL of 0.355 mol dm^{-3} HCl into another test tube. He accidentally knocked the test tubes, while placing, contents combined in the beaker.

(i) Is the solution formed from the contents of the two test tubes acidic or basic?

(ii) If he added few drops of Methyl Orange indicator what would be the colour of the solution?

(7 marks)

(b) You are carrying out an acid base titration to determine the concentration of the acid. The endpoint of the neutralization is reached but the stopcock on the burette sticks slightly and allows a few more drops of acid to fall into the solution. Will this small amount of ~~base~~ acid have any effect on the determined value for the concentration of the acid? If so, how is it affected (***Not more than 4 lines***)?

(4 marks)

(c) A few small drops of water are left in a burette that is then used to titrate a base into an acid solution to determine the concentration of the acid. Will this small amount of water have any effect on the determined value for the concentration of the acid? If so, how is it affected (***Not more than 4 lines***)?

(4 marks)

[TOTAL: 15 Marks]

Question B2

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

$$2MnO_4^-(aq) + 5H_2O_2(aq) + 6H^+(aq) \rightarrow 5O_2(g) + 2Mn^{2+}(aq) + 8H_2O(l)$$

(i) How many moles of MnO_4^- were required for the titration if 43.2 ml of 0.015 M $KMnO_4$ was needed to reach the end point? **(1 mark)**

(ii) How many moles of H_2O_2 were present in the 15.8 g of hair bleach? **(2 marks)**

(iii) How many grams of H_2O_2 were present in the hair bleach? **(1 mark)**

(iv) What is the mass percent H_2O_2 in the hair bleach? **(2 marks)**

(v) What is the reducing agent in the redox reaction? **(1 mark)**

(b) Consider the following precipitation reaction:

$$Hg_2(NO_3)_2(aq) + KI(aq) \rightarrow Hg_2I_2(s) + KNO_3(aq)$$

(i) Balance the reaction. **(2 marks)**

(ii) Write the **net** ionic reaction. **(2 marks)**

(iii) Identify the spectator ions. **(2 marks)**

(c) Determine the oxidation number of the underline atom in each of the following:

(i) $H_2\underline{S}O_4$ (ii) $\underline{Sb}Cl_3$ **(2 marks)**

[TOTAL: 15 Marks]

Question B3

(a) Use standard electrode potential, $E°$, data to calculate the cell potential for the following reaction: **(2 marks)**

$$Cl_2 + 2OH^- \leftrightharpoons Cl^- + ClO^- + H_2O$$

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

$$3ClO^- \rightleftharpoons 2Cl^-(aq) + ClO_3^-(aq)$$

(i) Calculate the oxidation number of chlorine in each species. **(3 marks)**

(ii) In terms of electron transfer, state what happens to chlorine in the reaction. **(1 marks)**

(c) A half-equation involving bromate(V) ions, BrO_3^-, and bromide ions is shown.

$$BrO_3^-(aq) + 3H_2O(l) + 6\,e^- \rightleftharpoons Br^-(aq) + 6\,OH^-(aq) \quad E^0 = +0.58\,V$$

(i) An alkaline solution of chlorate (I), ClO^-, can be used to oxidise bromide ions to bromated (V) ions. Write the equation for the spontaneous reaction. **(2 marks)**

(ii) Draw a cell in which this reaction will occur and label all the parts. **(5 marks)**

(iii) Write the shorthand notation for the cell. **(2 marks)**

[TOTAL: 15 Marks]

Question B4

(a) Calculate the maximum Kinetic Energy (in joules) and velocity (3 significant figures) of an electron ejected from zinc by a 275 nm photon. The threshold energy or work function for Zn = 4.31eV. **(3 marks)**

(b) (i) The nitrogen atom in ammonium ion is sp^3 hybridized. Use a suitable hybridization scheme to show the hybridization on the nitrogen atom. **(3 marks)**

(ii) Show using a sketch diagram that NH_3 is a polar molecule. **(3 marks)**

Please Turn Over

(c) Ethene is a planar shaped molecule. Draw a fully labelled diagram showing the bonding (σ - sigma and π - pie) in the molecule. **(3 marks)**

(d) (i) How would you expect the first ionization energy to change as you go across a period in the periodic table. **(1 mark)**

(ii) State any two factors that influence the ease of removing an electron from an element. **(2 marks)**

[TOTAL: 15 Marks]

Question B5

(a) Several constitutional isomers can be written for molecular formula C_4H_7OCl.

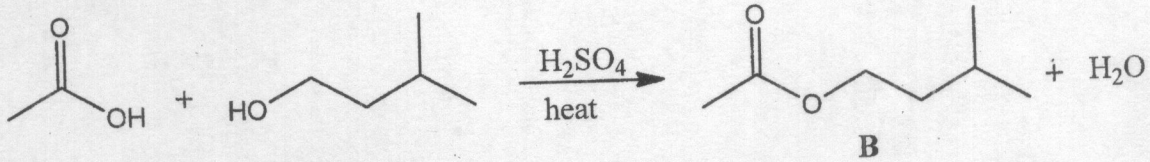
(i) Calculate the IHD and state all possible interpretations. **(2 marks)**

(ii) Draw line-bond formula and give IUPAC name for an isomer that is a straight chain acyl chloride (acid chloride). **(3 marks)**

(iii) Draw line-bond formulae for two (2) isomers with cyclobutane as parent chain and state their isomeric relationship as chain, positional or functional isomers. **(3 marks)**

(iv) One of the isomers decolorizes bromine water. Interpret this result and state two (2) other functional groups that could be present in this isomer. **(2 marks)**

(b) Esters are pleasant sweet-fruity smelling substances frequently used in perfumery and food industry. One common banana flavor **B** used for candy products is prepared by the reaction shown below:

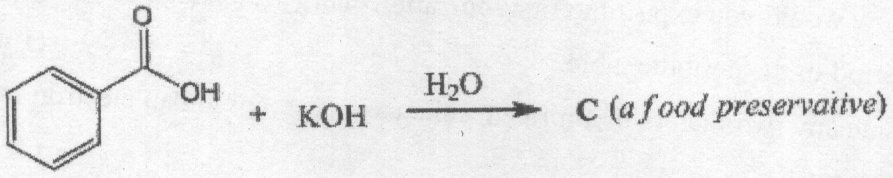


B

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

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

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



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

(2 marks)

[TOTAL: 15 Marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR EXAMINATIONS

CHE3111: CELLULAR BIOCHEMISTRY

INSTRUCTIONS:

TIME: THREE HOURS

1. Answer any **FIVE (5)** questions
2. All questions carry **EQUAL MARKS** (20 marks each question)
3. There are **FOUR (4)** printed pages in this examination

P.T.O

Question 1

a) A biochemistry student was given the following peptide DPMMHKCWLRTE. In one experiment the student subjected this peptide to chymotrypsin digestion and obtained three fragments. In another separate experiment the student subjected a different sample of the same peptide to trypsin digestion resulting in three fragments. The resultant three fragments in the second experiment were treated with β-mercaptoethanol and hydrolysed.

i) At **what** site in the peptide shown above does the enzyme;
   1) chymotrypsin act on? **[2 marks]**

   2) trypsin act on? **[2 marks]**

ii) **List** the primary structures of the three fragments produced from the first experiment. **[4 marks]**

iii) **Describe** the detailed chemical mechanism of action of β-mercaptoethanol in the reaction mentioned above (Include chemical structures). **[5 marks]**

b) Answer these questions in bullet form.
   i. **List** three reagents that may be used to determine the N-terminal of a peptide. **[3 marks]**

   ii. **Which** of the three reagents mentioned in part b i) is the best and **why**? **[4 marks]**

Question 2

Glycolysis begins with the phosphorylation of glucose to glucose -6-phosphate. The enzyme for this reaction is hexokinase which has an isozyme called glucokinase. Glucose -6-phosphate through a series of steps is eventually phosphorylated to 1,3-bisphosphoglycerate, (1,3-BPG). 1,3-BPG is used in the substrate level phosphorylation of ADP. 1,3-BPG is eventually converted through a series of steps to pyruvate.

a) **What** is the importance of the first reaction of glycolysis? **[2 marks]**

b) **What** is meant by substrate level phosphorylation? **[2marks]**

c) In red blood cells 20-30% of 1,3-BPG is converted to 2,3-Bisphosphoglycerate. **State** two significant roles of 2,3-BPG in the human body. **[2 marks]**

d) **Compare** and **contrast** glucokinase and hexokinase. **[6marks]**

e) Step six of glycolysis leads to synthesis of 1,3-BPG. **Write** the chemical equation of this step including chemical structures of reactants, products and coenzymes of this step. Include the name of the enzyme. **[8 marks]**

Question 3

An enzyme-catalysed reaction was found to be affected by two inhibitors A and B. The following were obtained at fixed total enzyme concentration:

Substrate conc	Initial velocity (absorbance units per minute)		
($mmolL^{-1}$)	Uninhibited	With 1 $mmolL^{-1}$ A	With 1 $mmolL^{-1}$ B
50	0.684		
20	1.08		
10	1.43	1.01	0.653
5	1.02	0.649	0.468
3.3	0.798	0.476	0.363
2.5	0.657	0.374	0.296
2	0.549	0.311	0.25

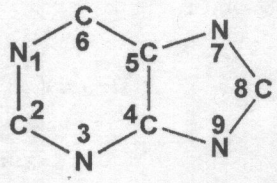
a) **Make** a Lineweaver Burk plot the results on a graph paper. **[6 marks]**

b) **Calculate** the V_{max} and K_M values for both uninhibited and inhibited reactions. **[10 marks]**

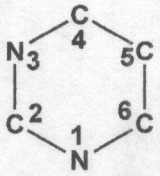
c) **Comment** on these results **[4 marks]**

Question 4

a) **What** is the source of the numbered atoms in structures **(a)** and **(b)**? **[8 marks]**



(a)



(b)

b) **Explain** oxidative deamination using the **structure of glutamate**. **[3 marks]**

c) **What** is peculiar about the enzyme catalyzing the reaction in part "b"? **[1 mark]**

d) **Explain** the defective process, stating the defective enzyme and symptoms that arise in phenylketonuria (PKU). **[3 marks]**

e) When you randomly sample blood from children in Kabwe town, **what** enzyme in heme biosynthesis is likely to be affected and what will cause this effect ? **[2 marks]**

f) **Copy** and **complete** the following table in your answer booklet. **[3 marks]**

	CPS I	CPS II
Site		
Pathway		
Source of N		

Question 5

a) Using palmitate, **outline** β-oxidation (**1 cycle only** with **structures** and **enzymes**) **[12 marks]**

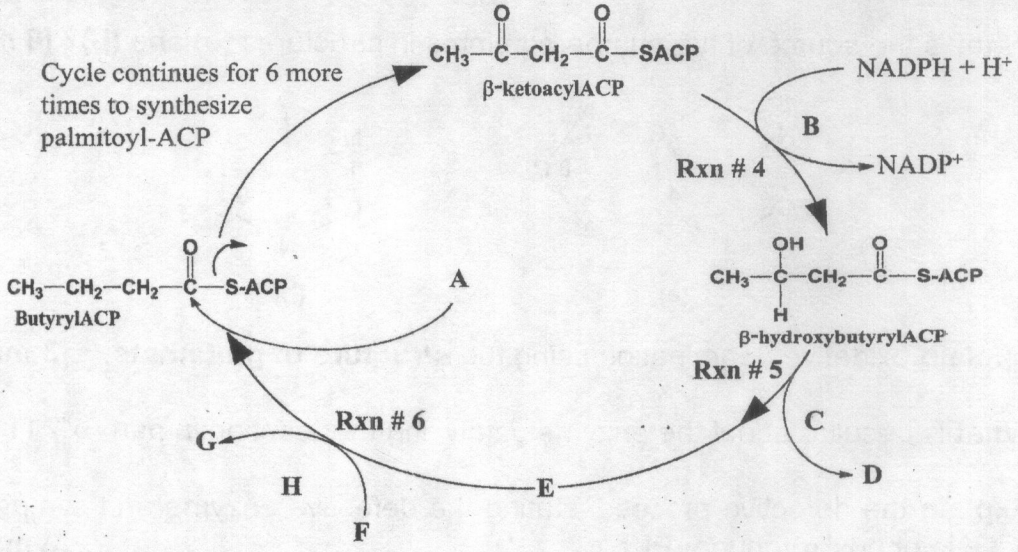
b) **Account** for the 129 moles of ATP formed after complete oxidation of palmitate in part "a". **[5 marks]**
(*Hint: 1 NADH=3 ATP, 1 $FADH_2$= 2 ATP and 1 Acetyl-CoA= 12 ATP produced.*)

c) What is the **significant** difference between cytosolic HMG-CoA synthase and the mitochondrial isozyme? **[2 marks]**

d) **Which** isozyme in part "c" is a target of **statins**? **[1 mark]**

Question 6

a) The following is part of the fatty acid synthesis pathway. In tabular form, **name** all parts labelled A to H. **[18 marks]**



b) **What** is the limiting step in cholesterol synthesis? **[2 marks]**

END OF CHE 3111 FINAL EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR FINAL YEAR EXAMINATIONS

CHE 3122: ENERGY TRANSDUCTION SYSTEMS

INSTRUCTIONS:

TIME: THREE HOURS

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

P.T.O

Question 1

a) With the aid of a diagram, **describe** the structure of the cell membrane. **[15 marks]**

b) The cell membrane is asymmetrical. **Explain** the meaning of this statement. **[5 marks]**

c) **Write** short notes on secondary transport. **[5 marks]**

Question 2

a) **What** is meant by the term oxidative phosphorylation? **[3 marks]**

b) **Draw** a neat diagram of the ATP synthase complex labelling all components clearly. **[10 marks]**

c) **Explain** in detail how ATP is formed by the ATP synthase in (b). **[8 marks]**

d) **List any** two substances that would uncouple oxidative phosphorylation. **[2 marks]**

e) **How** many ATP molecules are formed when 3 protons are pumped into the mitochondrial matrix? **[2 marks]**

Question 3

a) **Explain** cyclic photophosphorylation using a neat diagram. **[10 marks]**

b) Assuming a light source has speed of 2.998×10^{8} ms^{-1}, Planks constant of 6.626×10^{-34} J.s and Avogadro's number of 6.022×10^{23} mol^{-1}, $\Delta G^{o'}$ for ATP synthesis is +30.5 kJ mol^{-1}

i) **How** many moles of ATP can be synthesized at 100% efficiency by a photosynthetic organism upon absorption of 1 mol of photons of red light of 700 nm? **[8 marks]**

ii) **How** many molecules of ATP can be produced from 1 photon? **[1 mark]**

iii) **Calculate** the overall efficiency of energy conversion if 1 mole of ATP is formed per 2 equivalents of electrons excited by red light (i.e per 2 mol photons). **[6 marks]**

P.T.O

Question 4

a) **Explain** the first three Calvin cycle reactions with clear chemical structures.
[10 marks]

b) **True** or **False**

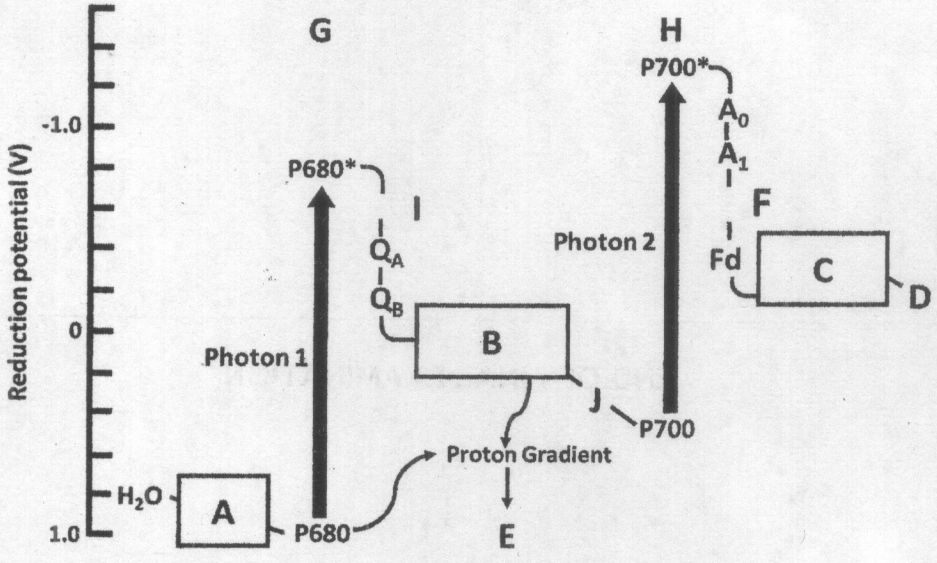
i) Atrazine inhibits PS II by blocking the transfer of electrons to QH_2 **[1 mark]**

ii) Dark reactions occur in the stroma **[1 mark]**

iii) The catalytic efficiency of rubisco low **[1 mark]**

iv) 2-carboxyarabinitol-1-phosphate is a regulator of PSII **[2 marks]**

c) In tabular form, **Identify** the species or process in the diagram labelled A to J
[10 marks]



P.T.O

Question 5

a) **Describe** a detailed microscopic structure of a skeletal muscle. **[10 marks]**

b) **Explain** in detail the cycle of skeletal muscle contraction. **[10 marks]**

c) **How** does nerve gas effect muscle contraction? **[5 marks]**

END OF FINAL EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Chemistry

2019 Academic year Term 2 Final Examination

CHE3411

Chemistry of Main Group Elements and Transition Metal Chemistry

Instructions: Answer any four questions

All questions carry equal marks **Duration: 3 hours**

Question 1

a) A method of synthesizing ammonia directly from nitrogen and hydrogen was developed by Fritz Haber. On an industrial scale, this synthesis requires a high temperature, a high pressure and a catalyst and is very expensive to operate.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

A manager in charge of ammonia production wished to increase the daily production of ammonia and reduce the production costs. How would a chemist explain the factors that would influence the commercial efficiency of this production process?

b) Nitric acid HNO_3 is an important industrial chemical. State the two major industrial uses of nitric acid.

c) Describe briefly the key major steps for the production of sulphuric acid by the contact process (Include the key chemical equations involved)

d) Some elements in the periodic table exist as allotropes.

(i) Define what an allotrope is.

(ii) Draw Lewis structures for each of the allotropes of oxygen

(iii) Mention any two allotropes of Phosphorus

Question 2

a) XeO_3 is a colourless explosive solid and has a pyramidal molecular structure $XeOF_4$ is a colourless volatile liquid and has a square pyramidal molecular structure. These two Xenon-Oxygen compounds are prepared by the hydrolysis of XeF_6 under different conditions.

(i) Draw the structures these two Xenon-Oxygen compounds

(ii) Write the chemical equation in the preparation of these two Xenon-Oxygen compounds

b) Oxygen is the most abundant of all the elements on earth. However, it can also be prepared in the laboratory and on major scale production in industries.

(i) State one laboratory preparation of oxygen gas with the chemical equation involved

(ii) How is oxygen gas obtained industrially?

(c) Chlorine, a group member of halogen family is a greenish yellow gas with pungent and suffocating odour. The Deacon's process is used industrially to manufacture chlorine gas which involve the oxidation of hydrogen chloride gas by atmospheric oxygen in the presence of $CuCl_2$ (catalyst) at 723 K.

(i) Write the chemical equation for the manufacture of chlorine gas by the Deacon's process.

(ii) Chlorine water on standing loses its yellow colour due to the formation of oxoacids HOCl and $HOClO_3$. Which of these will be a strong acid? Give reason for you answer.

(iii) Mention any two poisonous gases which can be prepared from chlorine gas.

Question 3

(a) Consider the complex dichlorodioxalatochromium(III), $[Cr(Cl_2)(OX)_2]^{3-}$. What is the primary and secondary valencies of chromium in the ion?

(b)Two isomers X and Y with the formula $Cr(H_2O)_5ClBr_2$ were taken for experiment on depression in freezing point. It was found that one mole of X gave depression corresponding to 2 moles of particles and one mole of Y gave depression due to 3 moles of particles. Propose structural formula for X and Y.

(c) Ammonia gas does not evolve from the complex $FeCl_3.4NH_3$ but it gives white precipitate with aqueous $AgNO_3$. Write the formula of the complex and its IUPAC name if the coordination number of central metal ion in the above complex is 6.

Question 4

(a) Draw the complex carbonylchlorobistransphosphineiridium(I), specifying the position of ligands.

(b) Write the IUPAC name of the compound $K_3[Fe(CN)_5NO]$. Comment on the charges of the ligands.

(c) Draw the two geometric isomers possible with $Co(en)Cl_3Br^-$.

Question 5

(a) Comment on the fact that, although an aqueous solution of cobalt(III) sulfate is diamagnetic, the solution becomes paramagnetic when a large excess of fluoride ion is added.

(b) Explain $[Co(NH_3)_6]^{3+}$ is an inner orbital complex whereas $[Ni(NH_3)_6]^{2+}$ is an outer orbital complex.

(c) Explain the differences in values of the ligand field splittings ($\Delta = \Delta_o$ or Δ_T) for the cobalt complexes below: Complex Δ (cm^{-1}) $[Co(NH_3)_6]^{3+}$ 22,900 $[Co(H_2O)_6]^{3+}$ 18,200 $[Co(NH_3)_6]^{2+}$ 10,200 $[Co(NH_3)_4]^{2+}$ 5,900

Question 6

(a) With reference to the Jahn-Teller theorem, rank the following compounds in terms of their degree of deviation from idealized octahedral structure: $[Cr(CN)_6]^{4-}$, $[Cu(OH_2)_6]^{2+}$, and $[Cr(OH_2)_6]^{3+}$. Explain your reasoning and indicate what type of distortion can be expected (use drawings as required).

(b) (i) 10Dq is found to be 17400 cm^{-1} for $[Cr(H_2O)_6]^{3+}$. a) Predict λ_{max} in units of nm for the lowest energy d-d transition. b) Will this wavelength be longer, shorter, or the same if all of the water ligands are substituted with fluoride? Explain.

(ii) Why are the d-d transitions weak? Why are the absorptions observed at all if they are Laporte (orbitally) forbidden?

(c) For each of the following, find the LFSE (in terms of Dq and P), estimate the magnetic moment in terms of Bohr-Magnetons, predict the stability based on the 18 and/or 16 electron rule, and indicate if the complex will be Jahn-Teller active. If the complex is Jahn-Teller active, indicate the nature of the distortion. Indicate which bonding theory is the better choice for each species.

a. $Ru(bpy)_2Cl_2$
b. $Ni(NH_3)_4Br_2$
c. $Mo(CO)_6$

END OF EXAMINATION

PERIODIC TABLE OF ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
hydrogen 1 H 1.00794																	helium 2 He 4.002602
lithium 3 Li 6.941	beryllium 4 Be 9.012182											boron 5 B 10.811	carbon 6 C 12.0107	nitrogen 7 N 14.00674	oxygen 8 O 15.9994	fluorine 9 F 18.9984	neon 10 Ne 20.1797
sodium 11 Na 22.98977	magnesium 12 Mg 24.3050											aluminium 13 Al 26.981538	silicon 14 Si 28.0855	phosphorus 15 P 30.97376	sulphur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.984
potassium 19 K 39.0983	calcium 20 Ca 40.078	scandium 21 Sc 44.95591	titanium 22 Ti 47.867	vanadium 23 V 50.9415	chromium 24 Cr 51.9961	manganese 25 Mn 54.93805	iron 26 Fe 55.845	cobalt 27 Co 58.9332	nickel 28 Ni 58.6934	copper 29 Cu 63.546	zinc 30 Zn 65.409	gallium 31 Ga 69.723	germanium 32 Ge 72.64	arsenic 33 As 74.9216	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.798
rubidium 37 Rb 85.4678	strontium 38 Sr 87.62	yttrium 39 Y 88.90585	zirconium 40 Zr 91.225	niobium 41 Nb 92.90638	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.9055	palladium 46 Pd 106.42	silver 47 Ag 107.8682	cadmium 48 Cd 112.411	indium 49 In 114.818	tin 50 Sn 118.710	antimony 51 Sb 121.760	tellurium 52 Te 127.60	iodine 53 I 126.9045	xenon 54 Xe 131.293
caesium 55 Cs 132.90545	barium 56 Ba 137.327	lutetium 71 Lu 174.967	hafnium 72 Hf 178.49	tantalum 73 Ta 180.9479	tungsten 74 W 183.84	rhenium 75 Re 186.207	osmium 76 Os 190.23	iridium 77 Ir 192.217	platinum 78 Pt 195.078	gold 79 Au 196.96655	mercury 80 Hg 200.59	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]	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	darmstadtium 110 Ds [271]	roentgenium 111 Rg [272]	ununbium 112 Uub [285]		ununquadium 114 Uuq [289]				

key

element name
atomic number
symbol
atomic mass

lanthanum 57 La 138.9055	cerium 58 Ce 140.116	prasodymium 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]

TABLE OF USEFUL PHYSICAL CONSTANTS

Substituent	HAMMETT CONSTANTS			
	σ_m	σ_p	σ^+	σ^-
$-NH_2$	-0.09	-0.66	-1.3	
-OH	0.13	-0.38	-0.92	
CH_3SO_2-	0.64	0.73		1.05
$-OCH_3$	0.10	-0.12	-0.78	
$-C(CH_3)_3$	-0.09	-0.15	-0.26	
$-CH_3$	-0.06	-0.14	-0.31	
$-CH_2CH_3$	-0.08	-0.13	-0.30	
$-OCH_2CH_3$	0.10	-0.14	-0.82	
$Si(CH_3)_3$	-0.04	-0.17		
H	0.00	0.00	0.00	0.00
$-NHC(O)CH_3$	0.14	0.00	-0.60	0.47
-Ph	0.05	0.05	-0.18	0.08
-I	0.35	0.18	0.13	
-Br	0.37	0.26	0.15	
-Cl	0.37	0.24	0.11	
-F	0.34	0.15	-0.07	
$-C(O)CH_3$	0.36	0.47		0.82
$-CO(O)CH_3$	0.39	0.31	0.18	
-C(O)OH	0.35	0.44		0.73
$-CF_3$	0.46	0.53		0.74
-CN	0.62	0.70		0.99
$-CO_2Et$	0.37	0.45	0.48	0.68
$-NO_2$	0.71	0.81		1.23
$-N(CH_3)_3$	0.99	0.96		

TABLES OF DATA: ^{1}H and ^{13}C CHEMICAL SHIFTS & COUPLING CONSTANTS

(Source: Spectroscopic Methods in Organic Chemistry, 6th Edition, Dudley Williams and Ian Fleming, McGraw Hill Education, Berkshire (UK), 2008, pages 155-173)

1. Proton Chemical Shifts (δ ppm)

Table 1: ^{1}H Chemical Shifts in Methyl, Methylene and Methine Groups

	Methyl protons	δ_H	*Methylene protons*	δ_H	*Methine protons*	δ_H
C	R—CH_3	0.9	R—CH_2—R	1.4	R—CHR_2	1.5
	C=C—C—CH_3	1.1	C=C—C—CH_2—R	1.7		
	O—C—CH_3	1.3	O—C—CH_2—R	1.9	O—C—CHR_2	2.0
	N—C—CH_3	1.1	N—C—CH_2—R	1.4		
	O_2N—C—CH_3	1.6	O_2N—C—CH_2—R	2.1		
	C=C—CH_3	1.6	C=C—CH_2—R	2.3		
	Ar—CH_3	2.3	Ar—CH_2—R	2.7	Ar—CHR_2	3.0
	O=CC=C—CH_3	2.0	O=CC=C—CH_2—R	2.4		
	O=CC(CH_3)=C	1.8	O=CC(CH_2—R)=C	2.4		
	C≡C—CH_3	1.8	C≡C—CH_2—R	2.2	C≡C—CHR_2	2.6
	RCO—CH_3	2.2	RCO—CH_2—R	2.4	RCO—CHR_2	2.7
	ArCO—CH_3	2.6	ArCO—CH_2—R	2.9	ArCO—CHR_2	3.3
	ROOC—CH_3	2.0	ROOC—CH_2—R	2.2	ROOC—CHR_2	2.5
	ArOOC—CH_3	2.4	ArOOC—CH_2—R	2.6		
	N—CO—CH_3	2.0	N—CO—CH_2—R	2.2	N—CO—CHR_2	2.4
	N≡C—CH_3	2.0	N≡C—CH_2—R	2.3	N≡C—CHR_2	2.7
N	N—CH_3	2.3	N—CH_2—R	2.5	N—CHR_2	2.8
	ArN—CH_3	3.0	ArN—CH_2	3.5		
	RCON—CH_3	2.9	RCON—CH_2—R	3.2	RCO—N—CHR_2	4.0
	N^+—CH_3	3.3	N^+—CH_2—R	3.3		
	O_2N—CH_3	4.3	O_2N—CH_2—R	4.4	O_2N—CHR_2	4.7
O	HO—CH	3.4	HO—CH_2—R	3.6	HO—CHR_2	3.9
	RO—CH_3	3.3	RO—CH_2—R	3.4	RO—CHR_2	3.7
	C=CO—CH_3	3.8	C=CO—CH_2—R	3.7		
	ArO—CH_3	3.8	ArO—CH_2—R	4.3	ArO—CHR_2	4.5
	RCOO—CH_3	3.7	RCOO—CH_2—R	4.1	RCOO—CHR_2	4.8
			$(RO)_2CH_2$	4.8	$(RO)_3CH$	5.2
Hal	F—CH_3	4.3	F—CH_2—R	4.1	F—CHR_2	3.7
	Cl—CH_3	3.1	Cl—CH_2—R	3.6	Cl—CHR_2	4.2
	Br—CH_3	2.7	Br—CH_2—R	3.5	Br—CHR_2	4.3
	I—CH_3	2.1	I—CH_2—R	3.2	I—CHR_2	4.3
S	RS—CH_3	2.1	S—CH_2—R	2.4	S—CHR_2	3.2
	RSO—CH_3	2.5	RSO—CH_2—R	2.7		
	RSO_2—CH_3	2.8	RSO_2—CH_2—R	2.9		
			$(RS)_2CH_2$	4.2		
P	R_2P—CH_3	1.4	R_2P—CH_2—R	1.6	R_2P—CHR_2	1.8
Si	R_3Si—CH_3	0.0	R_3Si—CH_2—R	0.5	R_3Si—CHR_2	1.2
Se	RSe—CH_3	2.0				

R = alkyl group. These values will usually be within ±0.2 p.p.m. unless electronic or anisotropic effects from other groups are strong. An obsolete scale used τ values; these are related to δ values by the equation $\tau = 10 - \delta$.

Estimation of Proton Chemical Shift in Alkanes

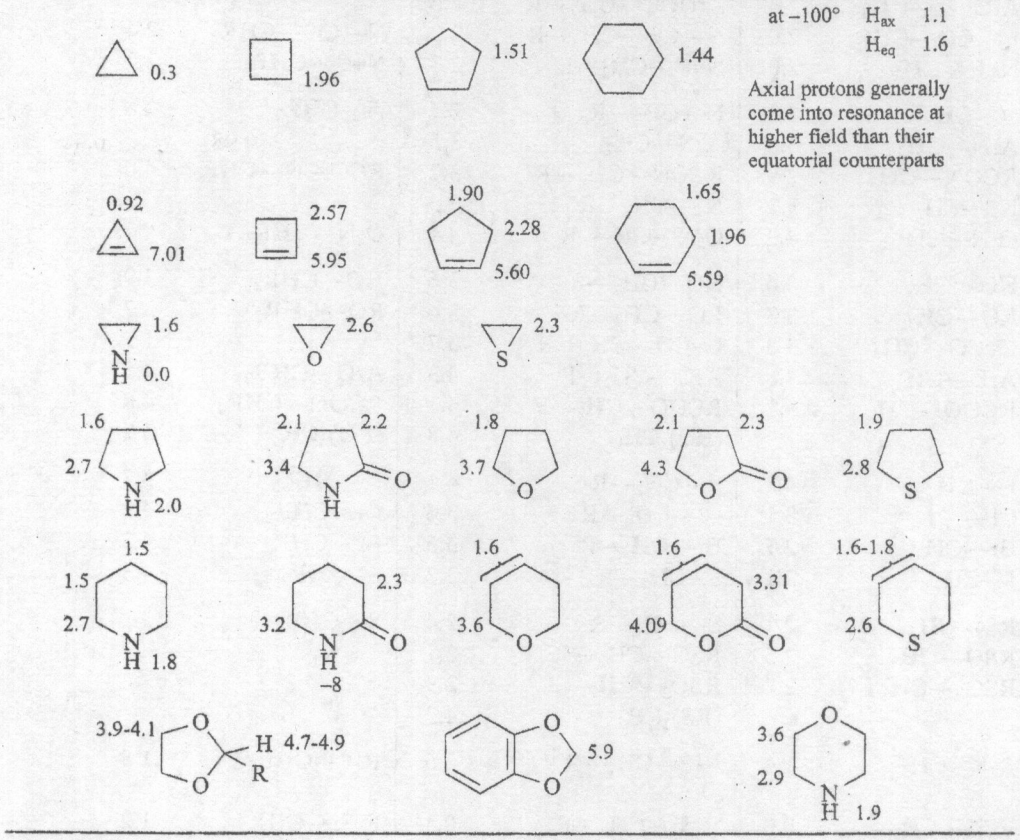
For $R^1R^2R^3C\text{-}H$ $\quad \delta_H = 1.50 + \sum z_i$, where z_i is substituent constant (1)

Table 2: Substituent constants z for equation (1)

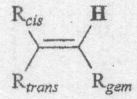
R^i	z	R^i	z	R^i	z
H—	–0.3	HC≡C—	0.9	MeO—	1.5
Alkyl—	0.0	OHC—	1.2	PhO—	2.3
CH_2=$CHCH_2$—	0.2	MeCO—	1.2	AcO—	2.7
$MeCOCH_2$—	0.2	RO_2C—	0.8	Cl—	2.0
$HOCH_2$—	0.3	NC—	1.2	Br—	1.9
$ClCH_2$—	0.5	H_2N—	1.0	I—	1.4
CH_2=CH—	0.8	O_2N—	3.0	MeS—	1.0
Ph—	1.3	HO—	1.7	Me_3Si—	0.7

Table 3: ^{1}H Chemical Shifts for –CH_2- and =CH- Groups in Some Aliphatic Cyclic Compounds

Table 3.21 ^{1}H Chemical shifts of -CH_2- and =CH- groups in some aliphatic cyclic compounds



Estimation of ^{1}H chemical shifts in alkenes



$$\delta_H = 5.25 + \Sigma z_{gem} + \Sigma z_{cis} + \Sigma z_{trans} \quad (2)$$

Table 4 Substituent constants z for Eq. (2)

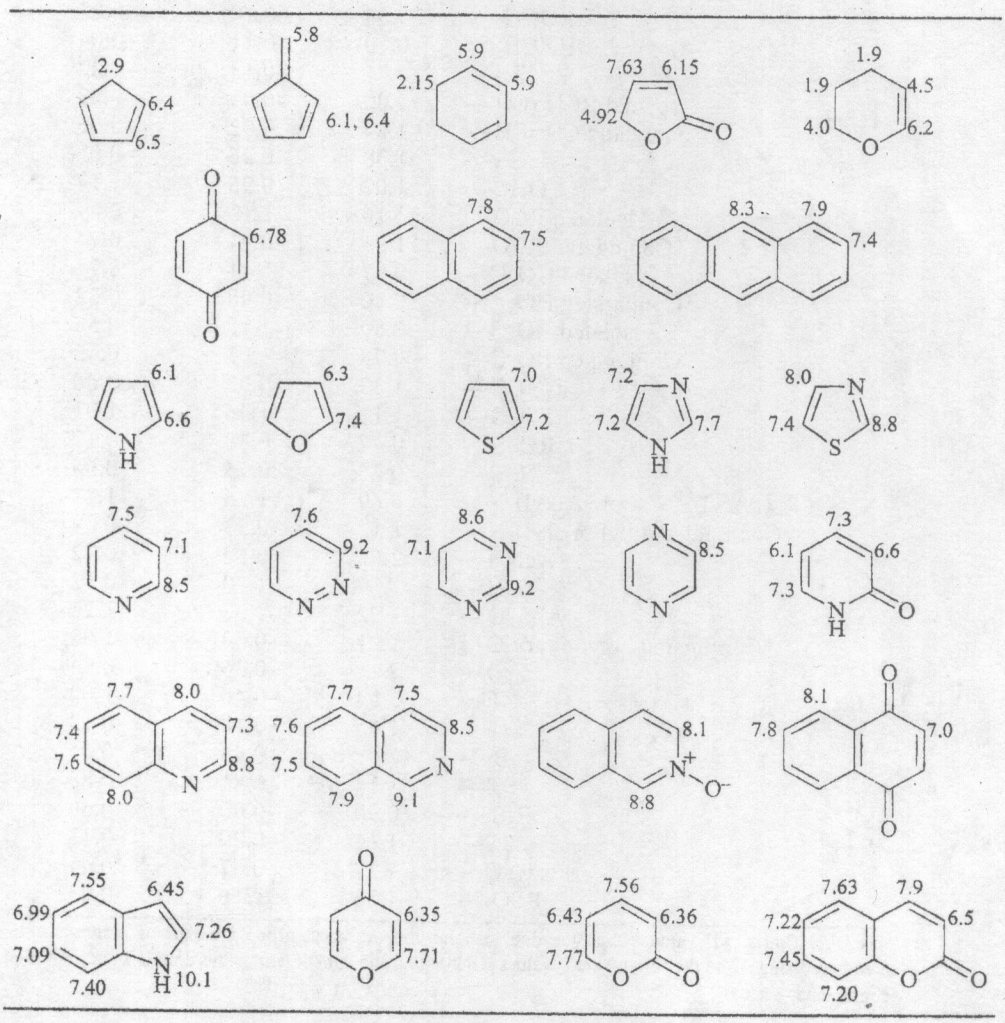
	Substituent R	z_{gem}	z_{cis}	z_{trans}
H	H—	0	0	0
C	Alkyl—	0.45	–0.22	–0.28
	[a]Ring-alkyl—	0.69	–0.25	–0.28
	$N{\equiv}CCH_2$— or $RCOCH_2$—	0.69	–0.08	–0.06
	$ArCH_2$—	1.05	–0.29	–0.32
	R_2NCH_2—	0.58	–0.10	–0.08
	$ROCH_2$—	0.64	–0.10	–0.02
	$HalCH_2$—	0.70	0.11	–0.04
	$RSCH_2$—	0.71	–0.13	–0.22
	Isolated RCH=CH—	1.00	–0.09	–0.23
	[b]Conjugated CH=CH—	1.24	0.02	–0.05
	Ar—	1.38	0.36	–0.07
	OHC—	1.02	0.95	1.17
	Isolated RCO—	1.10	1.12	0.87
	[b]Conjugated RCO—	1.06	0.91	0.74
	Isolated HO_2C—	0.97	1.41	0.71
	[b]Conjugated HO_2C—	0.80	0.98	0.32
	Isolated RO_2C—	0.80	1.18	0.55
	[b]Conjugated RO_2C—	0.78	1.01	0.46
	R_2NCO—	1.37	0.98	0.46
	ClCO—	1.11	1.46	1.01
	$RC{\equiv}C$—	0.47	0.38	0.12
	$N{\equiv}C$—	0.27	0.75	0.55
N	(Alkyl)HN— or $(Alkyl)_2N$—	0.80	–1.26	–1.21
	[b](Conjugated alkyl or aryl)$_2$N—	1.17	–0.53	–0.99
	AcNH—	2.08	–0.57	–0.72
	O_2N—	1.87	1.30	0.62
O	AlkylO—	1.22	–1.07	–1.21
	[b]Conjugated alkyl or arylO—	1.21	–0.60	–1.00
	AcO—	2.11	–0.35	–0.64
Hal	F—	1.54	–0.40	–1.02
	Cl—	1.08	0.18	0.13
	Br—	1.07	0.45	0.55
	I—	1.14	0.81	0.88
Si	R_3Si—	0.90	0.90	0.60
S	RS—	1.11	–0.29	–0.13
	RSO—	1.27	0.67	0.41
	RSO_2—	1.55	1.16	0.93

[a]Use the 'ring-alkyl' values when the double bond and the alkyl group are part of a five- or six-membered ring. [b]Use the 'conjugated' values when either the substituent or the double bond is further conjugated.

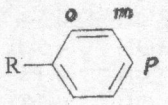
Table 5: ^{1}H Chemical Shifts of Protons Attached to Multiple Bonds – Acyclic Systems
(such as -CHO, RC CH, R_2C=C=HR, ArH, R_2C=CHR etc.)

Structure	δ_H	*Structure*	δ_H
RCHO	9.4-10.0	R_2C=CHR	4.5-6.0
ArCHO	9.7-10.5	R_2C=CH—COR	5.8-6.7
ROCHO	8.0-8.2	RHC=CR—COR	6.5-8.0
R_2NCHO	8.0-8.2	RHC=CR—OR	4.0-5.0
RC≡CH	1.8-3.1	R_2C=CH—OR	6.0-8.1
R_2C=C=CHR	4.0-5.0	RHC=CR—NR_2	3.7-5.0
ArH	6.0-9.0	R_2C=CH—NR_2	5.7-8.0

Table 6: Chemical Shifts of Protons Attached to double Bonds - Unsaturated Cyclic Systems
(for simple cycloalkenes, see Table 3)



Estimation of ^{1}H chemical shifts in substituted benzenes



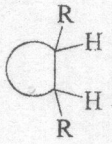
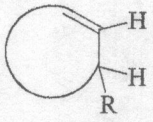
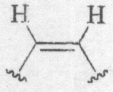
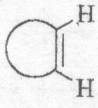
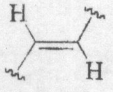
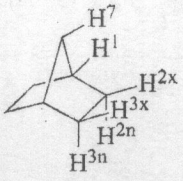
$$\delta_H = 7.27 + \Sigma z_i \qquad (3.22)$$

Table 7 Substituent constants z for Eq. 3.22

	Substituent R	z_{ortho}	z_{meta}	z_{para}
H	H—	0	0	0
C	Me—	–0.20	–0.12	–0.22
	Et—	–0.14	–0.06	–0.17
	Pr^i—	–0.13	–0.08	–0.18
	Bu^t—	–0.02	–0.08	–0.21
	H_2NCH_2— or $HOCH_2$—	–0.07	–0.07	–0.07
	$ClCH_2$—	0.00	0.00	0.00
	F_3C—	0.32	0.14	0.20
	Cl_3C—	0.64	0.13	0.10
	CH_2=CH—	0.06	–0.03	–0.10
	Ph—	0.37	0.20	0.10
	OHC—	0.56	0.22	0.29
	MeCO—	0.62	0.14	0.21
	H_2NCO—	0.61	0.10	0.17
	HO_2C—	0.85	0.18	0.27
	MeO_2C—	0.71	0.10	0.21
	ClCO—	0.84	0.22	0.36
	HC≡C—	0.15	0.02	–0.01
	N≡C—	0.36	0.18	0.28
N	H_2N—	–0.75	–0.25	–0.65
	Me_2N—	–0.66	–0.18	–0.67
	AcNH—	0.12	–0.07	–0.28
	O_2N—	0.95	0.26	0.38
O	HO—	–0.56	–0.12	–0.45
	MeO—	–0.48	–0.09	–0.44
	AcO—	–0.25	0.03	–0.13
Hal	F—	–0.26	0.00	–0.04
	Cl—	0.03	–0.02	–0.09
	Br—	0.18	–0.08	–0.04
	I—	0.39	–0.21	0.00
Si	Me_3Si—	0.22	–0.02	–0.02
	$(MeO)_2P(=O)$—	0.48	0.16	0.24
S	MeS—	0.37	0.20	0.10

These parameters are simply those measured on the corresponding monosubstituted benzene ring; they are not accurately taken over to polysubstituted benzenes, but the estimation of chemical shift is usually fairly good. Errors are particularly likely to occur when substituents *ortho* to one another interfere with conjugation to the ring.

Table 11: Vicinal ($^3J_{HH}$) Coupling Constants in Hz in Some Aliphatic Compounds

Open-chain compounds			*Cyclic compounds*			
Structure	$^3J_{HH}$ *range*	*Typical value*	*Structure*	*Geometry*	*Ring size*	$^3J_{HH}$ *range*
$CH_3—CH_2—$	6-8	7		*cis*	3	7-13
				trans	3	4.0-9.5
CH_3-CH<	5-7	6		*cis*	4	4.0-12.0
				trans	4	2.0-10.0
$—CH_2—CH_2—$	5-8	7		*cis*	5	5.0-10.0
				trans	5	5.0-10.0
>CH-CH<	0-8	7		*cis*	6	2.0-6.0
				trans	6	8.0-13.0[b]
>=CH—CH<	4-11	6			3	1.8[c]
					4	−0.8[c]
>=CH—CH=<	6-13	11[a]			5	0.5[c]
					6	1.5[c]
>CH·CHO	0-3	2			7	3.7[c]
					8	5.3[c]
>=CH—CHO	5-8	7			3	0.5-2
					4	2.5-4.0
	0-12	8			5	5-7
					6	8.5-10.5
					7	9-12.5
					8	10-13
	12-18	15			1-2x	3-4
					1-2n	0-2
					2x-3x	9-10
					2n-3n	6-7
					2x-3n	2-5
					1-7	0-3

[a] Found in dienes adopting the s-*trans* conformation.

[b] J_{aa}=8-13, J_{ee} = 2-5; note that J_{ee} is usually 1 Hz smaller than J_{ae}.

[c] Value for the unsubstituted cycloalkene.

Table 14: Long-range ($^4J_{HH}$ and $^5J_{HH}$) Coupling Constants in Hz in Aliphatic Compounds

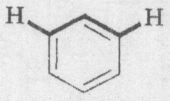
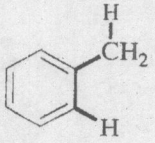
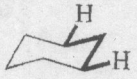
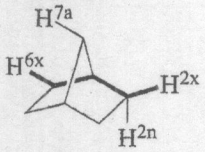
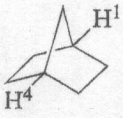
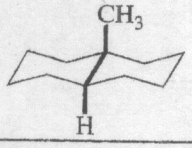
Structure	$^4J_{HH}$	*Structure*	$^5J_{HH}$
—CH=C—CH<	0-3	>CH-C=C-CH<	0-2
—CH=C=CH—	4-6	—CH=C=C—CH<	2-3
H—C≡C—CH<	1-3	>CH-C≡C-CH<	1-3
	1-3		8-10
	0.6-0.9 (small, because not W)		
	1-2		0-1
	7-8		
	7a-2n 3-4 2x-6x 1-2		1-1.5
	Signal perceptibly broadened by ^4J coupling		

Table 3.33 Eu(dpm)$_3$-induced shifts of protons in some common environments[a]

Functional group	*Shift p.p.m./mol of Eu(dpm)$_3$ per mol of substrate*	*Functional group*	*Shift p.p.m./mol of Eu(dpm)$_3$ per mol of substrate*
RCH$_2$N*H*$_2$	~150	RC*H*$_2$CHO	11
RCH$_2$O*H*	~100	RC*H*$_2$OCH$_2$R	10
RC*H*$_2$NH$_2$	30-40	RC*H*$_2$CO$_2$CH$_3$	7
RC*H*$_2$OH	20-25	RCH$_2$CO$_2$C*H*$_3$	6.5
RC*H*$_2$COR	10-17	RC*H*$_2$CN	3-7
RCH$_2$C*H*O	19		

[a]The shifts refer to the protons in italics.

2. ^{13}C CHEMICAL SHIFTS (δ ppm) & COUPLING CONSTANTS (Hz)

(Source: Spectroscopic Methods in Organic Chemistry, 6th Edition, Dudley Williams and Ian Fleming, McGraw Hill Education, Berkshire (UK), 2008, pages 155-173)

Table 1: ^{13}C Chemical Shifts in Some Alkanes

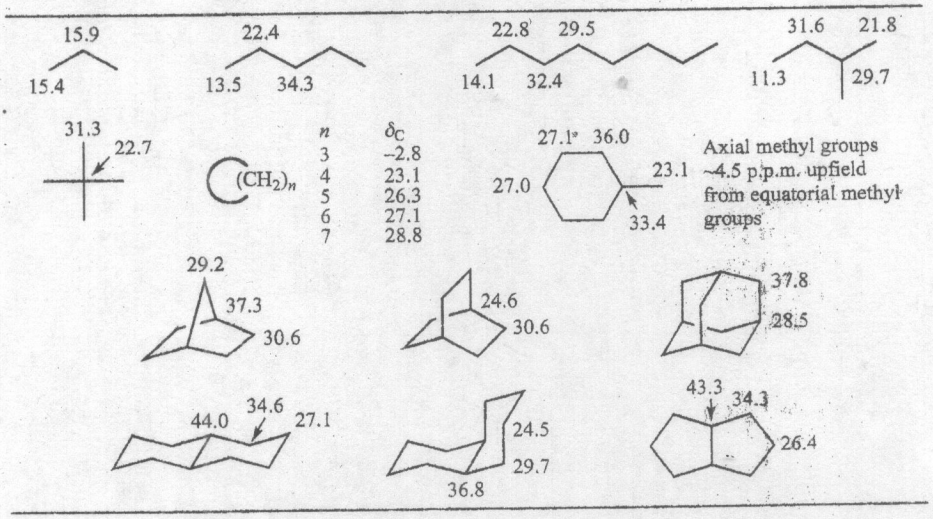


Table 2: ^{13}C Chemical Shifts in Some Alkenes, Alkynes and Nitriles

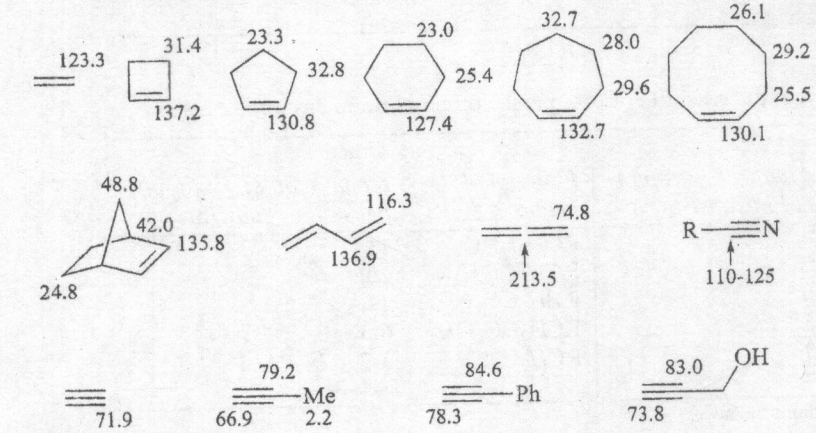
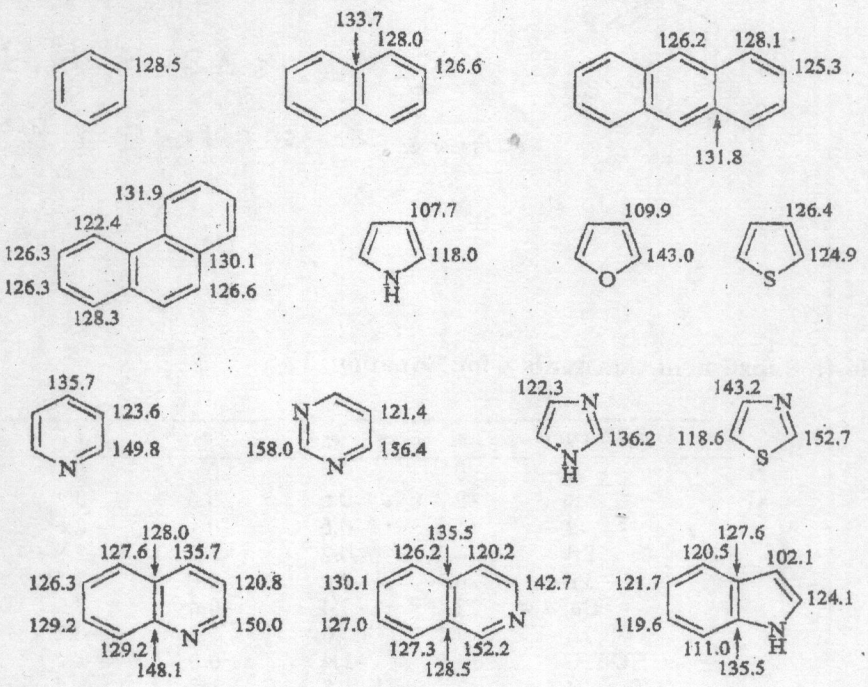
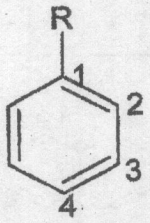


Table 3: ^{13}C Chemical Shifts in Some Arenes

Table 3.11 ^{13}C Chemical shifts in some arenes



Estimation of 13C Chemical Shifts in Substituted Benzenes



$\delta_C = 128.5 + \Sigma z_i$

where z is effect of substituent

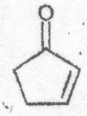
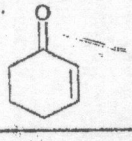
(1)

Table 4: Substituent Constants z_i for Equation 1

	Substituent R	z_1	z_2	z_3	z_4
H	H—	0	0	0	0
C	Me—	9.3	0.6	0.0	–3.1
	Et—	15.7	–0.6	–0.1	–2.8
	Pr^n—	14.2	–0.2	–0.2	–2.8
	Pr^i—	20.1	–2.0	0.0	–2.5
	Bu^t—	22.1	–3.4	–0.4	–3.1
	$ClCH_2$—	9.1	0.0	0.2	–0.2
	$HOCH_2$—	13.0	–1.4	0.0	–1.2
	CH_2=CH—	7.6	–1.8	–1.8	–3.5
	Ph—	13.0	–1.1	0.5	–1.0
	HC≡C—	–6.1	3.8	0.4	–0.2
	OHC—	9.0	1.2	1.2	6.0
	MeCO—	9.3	0.2	0.2	4.2
	RO_2C—	2.1	1.2	0.0	4.4
	N≡C—	–16.0	3.5	0.7	4.3
N	H_2N—	19.2	–12.4	1.3	–9.5
	Me_2N—	22.4	–15.7	0.8	–11.8
	AcNH—	11.1	–16.5	0.5	–9.6
	O_2N—	19.6	–5.3	0.8	6.0
O	HO—	26.9	–12.7	1.4	–7.3
	MeO—	30.2	–14.7	0.9	–8.1
	AcO—	23.0	–6.4	1.3	–2.3
Hal	F—	35.1	–14.3	0.9	–4.4
	Cl—	6.4	0.2	1.0	–2.0
	Br—	–5.4	3.3	2.2	–1.0
	I—	–32.3	9.9	2.6	–0.4
Si	Me_3Si—	13.4	4.4	–1.1	–1.1
P	Ph_2P—	8.7	5.1	–0.1	0.0
S	MeS—	9.9	–2.0	0.1	–3.7

Table 5: ^{13}C Chemical Shifts of Carbonyl Carbons

Table 3.13 ^{13}C Chemical shifts of carbonyl carbons

R^1	R^2	δ_C
Me—	—H	199.7
Et—	—H	206.0
Pr^i—	—H	204.0
CH_2=CH—	—H	192.4
Ph—	—H	192.0
Me—	—Me	206.0
Et—	—Me	207.6
Pr^i—	—Me	211.8
Bu^t—	—Me	213.5
$ClCH_2$—	—Me	200.7
Cl_2CH—	—Me	193.6
Cl_3C—	—Me	186.3
CH_2=CH—	—Me	197.2
Ph—	—Me	197.6
—$(CH_2)_3$—		208.2
—$(CH_2)_4$—		213.9
—$(CH_2)_5$—		208.8
—$(CH_2)_6$—		211.7
		209.0
		198.0

R^1	R^2	δ_C
Me—	—OH	178.1
Et—	—OH	180.4
Pr^i—	—OH	184.1
Bu^t—	—OH	185.9
CH_2=CH—	—OH	171.7
Ph—	—OH	172.6
Me—	—OMe	170.7
Et—	—OMe	173.3
Pr^i—	—OMe	175.7
Bu^t—	—OMe	178.9
CH_2=CH—	—OMe	165.5
Ph—	—OMe	166.8
—$(CH_2)_3O$—		177.9
—$(CH_2)_4O$—		175.2
Me—	—NH_2	172.7
CH_2=CH—	—NH_2	168.3
Ph—	—NH_2	169.7
—$(CH_2)_3NH$—		179.4
—$(CH_2)_4NH$—		173.0
Me—	—OAc	167.3
Ph—	—OAc	162.8
Me—	—Cl	168.6
CH_2=CH—	—Cl	165.6
Ph—	—Cl	168.0
Me—	—$SiMe_3$	247.6
Ph—	—$SiMe_3$	237.9
Me—	—$SiPh_3$	240.1

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR FINAL EXAMINATIONS

CHE 4102 **BIOCHEMICAL PROCESSES AND RESEARCH TECHNIQUES**

TIME: **THREE HOURS**

INSTRUCTIONS:
1. Answer any **FIVE (5)** questions
2. There are **THREE (3)** printed pages in this examination paper
3. Each question carries **TWENTY (20)** marks

QUESTION 1

Metabolism of biomolecules includes catabolism and anabolism. Both processes are highly regulated. These processes may be regulated hormonally, by enzymes, covalent modification or by gene regulation. Catabolism is generally convergent in character. Glycogen anabolism and catabolism may be regulated hormonally.

i) All metabolic pathways have various features in common. In bullet form **describe** five features which are common in metabolic pathways. **[6 marks]**

ii) **Name** two (2) main hormones that regulate anabolism of glycogen. **[2 marks]**

iii) Using any one (1) of the hormones named in Q1 ii), **discuss** in detail the hormonal regulation of glycogen breakdown. (Include positive and negative regulation). **[12 marks]**

QUESTION 2

i) Suppose you are using radioisotope techniques. In an instance where you are given pure ^{32}P in your research laboratory, **calculate**;

a) the number of radioactive atoms and
b) the weight in grams of phosphorus ^{32}P in 1 Ci of pure ^{32}P
c) the specific activity of pure ^{32}P

[1Ci = 3.7×10^{10} dps; half life for ^{32}P = 14.3 days; Avogadro no. = 6.023×10^{23}]

[15 marks]

ii) **State** any one (1) danger associated with ^{32}P and **state** how you might minimize it. **[5 marks]**

QUESTION 3

Eukaryotic systems often have to deal with xenobiotics.

i) **Define** the word 'xenobiotic'. **[3 marks]**

ii) In the case of humans (an example of eukaryotic system), **what** is the primary organ responsible for xenobiotic metabolic reactions? **[3 marks]**

iii) **Where** in the cells of the organ you have cited in Question 3 ii) above do drug metabolic reactions take place? **[2 marks]**

iv) **What** mechanisms exist in the cell for xenobiotic transformation? **[4 marks]**

v) **What** cellular mechanism in the cell is responsible for getting these xenobiotic transformation products out of the cell into the blood stream? **[2 marks]**

vi) After the drug has undergone metabolic transformation, **what** might happen to its therapeutic activity, and **what** might happen to its toxicity? **[6 marks]**

QUESTION 4

i) **Explain** what is meant by the following: **[8 marks]**

a) Paracrine signaling
b) Catecholamines
c) Receptor enzyme
d) Oncogene

ii) **What** is agromegaly and **explain** why Pegvisomant, a growth hormone receptor antagonist, can be used to treat this condition. **[6 marks]**

iii) Discuss the main limitations of using Scatchard analysis to investigate receptor-hormone interactions. **[6 marks]**

QUESTION 5

i) With the aid of a diagram, **illustrate** the signaling mechanism for the estrogen receptor. **[5 marks]**

ii) Using an example of the thyroid hormones T3 and T4, **explain** how negative feedback regulation is able to control hormone secretion. **[5 marks]**

iii) Hypothyroidism and Grave's disease are both endocrine disorders.

(a) **Compare** and **contrast** the two disorders. **[4 marks]**
(b) For each of the 2 disorders **list** any 3 of the major associated symptoms. **[6 marks]**

QUESTION 6

(i) **Differentiate** between the following: **[8 marks]**

(a) the innate immune response and the adaptive immune response
(b) The classical pathway and the mannose binding lectin pathway of the complement system

ii) **Explain** in detail how B-cells generate antibody diversity. **[12 marks]**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Chemistry

2019 Academic year Term 2 Final Examination

CHE4411

Inorganic Spectral Techniques and its application in Group Theory

Instructions: Answer any four questions

All questions carry equal marks **Duration: 3 hours**

Question 1

(a) Calculate the μ_S and μ_{S+L} of Lu^{3+} ion. Comment on its μ_{eff}.

(b) Describe antiferromagnetism with an example. Sketch its variation of magnetic susceptibility with temperature and label Neel temperature.

(c) A compound with Mr 112 is transparent in UV spectrum. In infrared spectrum, it shows two bands 2941 cm^{-1} and 1464 cm^{-1} corresponding to C-H and C-C stretch. In the NMR, it forms a singlet at 8.4 τ. Deduce its structural formula.

Question 2

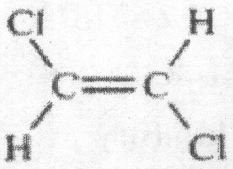
(a) Predict the ESR spectrum of $(SO_3)_2NO^-$. Show the transitions and the relative intensities of the peaks.

(b) Sketch the stick diagram of the peaks observed in the mass spectrum of CH_2Br_2, if Br^{79} and Br^{81} are of 50% abundance.

(c) At 25°C, the molar magnetic susceptibility, χ_m of NH_3 is -18.3×10^{-6} cm^3/mol and its density is 0.86 g/cm^3. Calculate its specific magnetic susceptibility, χ and magnetic permeability, μ

Question 3

For trans-1,2-dichloroethylene, of C_{2h} symmetry



(a) List all the symmetry operations for this molecule

(b) Write a set of transformation matrices that describe the effect of each symmetry operation in the C_{2h} group on a set of coordinates x, y, z for a point.

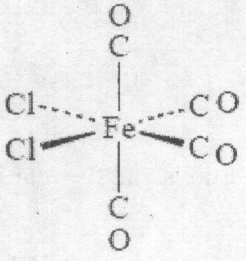
(c) Using the C_{2h} character table, verify that the irreducible representations are mutually orthogonal

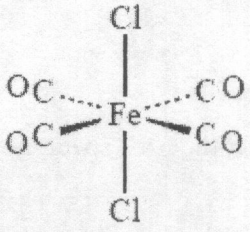
(d) Reduce the following representations to their component irreducible representation and determine which representation are IR or Raman active'

C_{2h}	E	C_2	i	σ_h
Γ	4	0	0	0

Question 4

(a) The following isomer molecules, are the cis-$Fe(CO)_4Cl_2$ with C_{2v} symmetry and trans-$Fe(CO)_4Cl_2$ has D_{4h} symmetry.





(i) Use group theory to determine the number of IR-active and Raman-active C-O stretching vibrations.

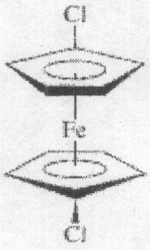
(ii) How many peaks do you expect to observe in the IR and Raman spectra, respectively for each isomer

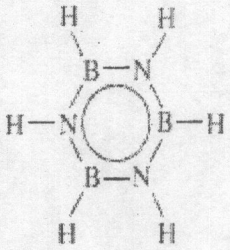
(iii) How can the basis C-O stretching vibrations be used to distinguish this two isomer.

(b) Assign the point groups of following compounds, and determine any of the species is optically active

(i) H_2O_2 (ii) CBrClFI (iii) $XeOF_2$

(iv) 1,1 – Dichloroferrocene (v) Borazine (planar)





Question 5

(a) Determine the symmetry elements of :
(i) an s orbital, (ii) a p_x orbital, (iii) a d_{xy} orbital, and (iv) a d_z^2orbital.

(b) A molecule of PH_3
(i) Determine the shape and its draw structure
(ii) List all the symmetry elements present
(iii) Assign a point group
(iv) State the symmetry representations under which the **s, p** and **d** orbitals of the central atom would transform.
(v) Using the group theory, determine the symmetry allowed hybridization schemes for the valence orbitals of the central atom. Ignore the contribution of d orbitals

(c) Draw sketches to identify the following symmetry elements:
(i) A C_3 axis and a σ_v plane in the NH_3 molecule,
(ii) A C_4 axis and a σ_h plane in the square-planar $[PtCl_4]^{2-}$ ion.

END OF EXAMINATION

PERIODIC TABLE OF ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
hydrogen 1 **H** 1.00794																	helium 2 **He** 4.002602
lithium 3 **Li** 6.941	beryllium 4 **Be** 9.012182											boron 5 **B** 10.811	carbon 6 **C** 12.0107	nitrogen 7 **N** 14.00674	oxygen 8 **O** 15.9994	fluorine 9 **F** 18.9984	neon 10 **Ne** 20.1797
sodium 11 **Na** 22.98977	magnesium 12 **Mg** 24.3050											aluminium 13 **Al** 26.981538	silicon 14 **Si** 28.0855	phosphorus 15 **P** 30.97376	sulphur 16 **S** 32.065	chlorine 17 **Cl** 35.453	argon 18 **Ar** 39.984
potassium 19 **K** 39.0983	calcium 20 **Ca** 40.078	scandium 21 **Sc** 44.95591	titanium 22 **Ti** 47.867	vanadium 23 **V** 50.9415	chromium 24 **Cr** 51.9961	manganese 25 **Mn** 54.93805	iron 26 **Fe** 55.845	cobalt 27 **Co** 58.9332	nickel 28 **Ni** 58.6934	copper 29 **Cu** 63.546	zinc 30 **Zn** 65.409	gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.64	arsenic 33 **As** 74.9216	selenium 34 **Se** 78.96	bromine 35 **Br** 79.904	krypton 36 **Kr** 83.798
rubidium 37 **Rb** 85.4678	strontium 38 **Sr** 87.62	yttrium 39 **Y** 88.90585	zirconium 40 **Zr** 91.225	niobium 41 **Nb** 92.90638	molybdenum 42 **Mo** 95.94	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.9055	palladium 46 **Pd** 106.42	silver 47 **Ag** 107.8682	cadmium 48 **Cd** 112.411	indium 49 **In** 114.818	tin 50 **Sn** 118.710	antimony 51 **Sb** 121.760	tellurium 52 **Te** 127.60	iodine 53 **I** 126.9045	xenon 54 **Xe** 131.293
caesium 55 **Cs** 132.90545	barium 56 **Ba** 137.327	lutetium 71 **Lu** 174.967	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.9479	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.207	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.217	platinum 78 **Pt** 195.078	gold 79 **Au** 196.96655	mercury 80 **Hg** 200.59	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]	lawrencium 103 **Lr** [262]	rutherfordium 104 **Rf** [261]	dubnium 105 **Db** [262]	seaborgium 106 **Sg** [266]	bohrium 107 **Bh** [264]	hassium 108 **Hs** [269]	meitnerium 109 **Mt** [268]	darmstadtium 110 **Ds** [271]	roentgenium 111 **Rg** [272]	ununbium 112 **Uub** [285]		ununquadium 114 **Uuq** [289]				

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
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

Department of Chemistry

2019 Academic year Term 2 Final Examination

CHE4422

Metal Chemistry and its application in Organometallics

Instructions: Answer any four questions

All questions carry equal marks **Duration: 3 hours**

Question 1

(a) The oxygen saturation curve for haemoglobin is sigmoidal, whereas a similar plot for myoglobin is hyperbolic. Discuss the above fact based on their binding equilibria.
(b) Explain how LD_{50} is used in studying the toxicity of a chemical?
(c) Discuss the advantages and disadvantages of the treatment of lead poisoning with chelating agents.

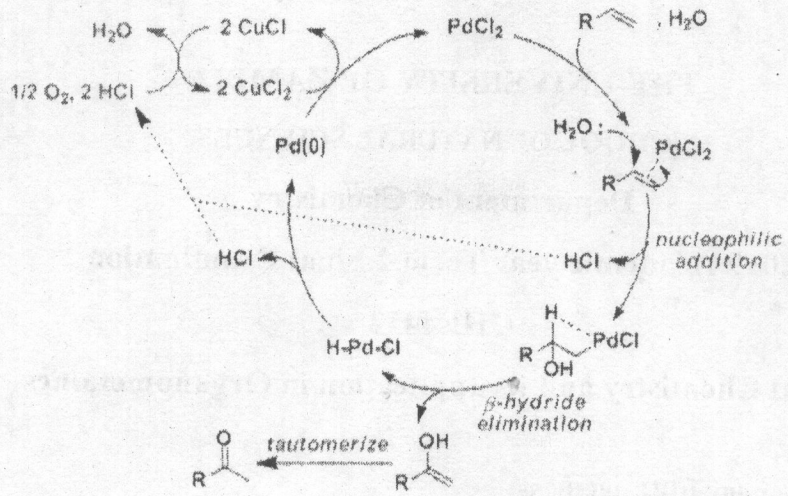
Question 2

(a) Discuss how zeolites are used in (i) aquaculture (2) agriculture
(b) The famous expression 'mad as hatter' originated in France, where hat makers used mercury salt to soak animal hides. Name three chelating agents which can act as antidote against heavy meatal poisoning and explain briefly their mode of action.
(c) Mention the main components of cobalamine and its functions in human body.

Question 3

(a) $[W(\eta^6 - C_6H_6)_2(CO)_2]$ is an example of a sandwich compound.
  (i) What are sandwich compounds
  (ii) Draw the structure of this compound

(b) The catalytic cycle is that of the Wacker process



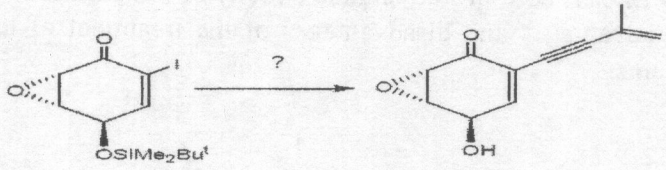
(i) Write the general reaction equation for the Wacker process

(ii) What is the role of $CuCl_2$ in the process?

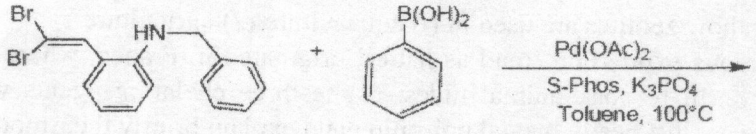
(iii)Explain what is β- Hydrogen elimination

(c) Draw the structure missing in the following reactions and indicate the named reactions happening

(i)



(ii)



Question 4

(a) What charge, **z**, would be necessary for the following to obey the *18-electron rule*?

(i) $[Ru(CO)_4(Cl)\ (Me_3)]^z$

(ii) $Cr(\eta^6 - C_6H_6)(CO)_z(CH_3)$

(b) The reaction of $CH_3Mn(CO)_5$ with PPh_3 produces $(CH_3CO)Mn(CO)_4(PPh_3)$. Draw the geometry of the product acetyl-complex and explain the term migratory insertion reaction

(c) $Re(CO)_5Br$ reacts with the ion $BrCH_2\ CH_2O^-$ to give compound Y + Br^-.

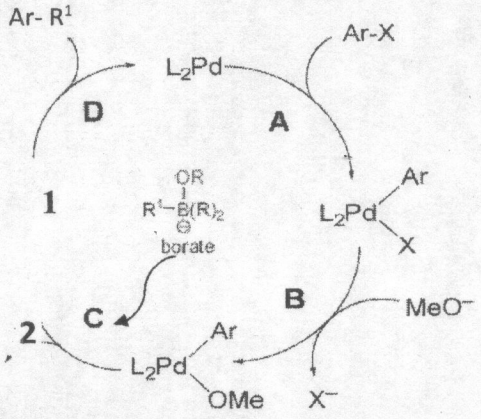
(i) What is the most likely site of attack of this ion on $Re(CO)_5Br$?

(ii) Using the following information, propose a structural formula of Y, and account for each of the following:

- Y obeys the 18-electron rule.
- No gas is evolved in the reaction.
- ^{13}C NMR indicates that there are five distinct magnetic environments for carbon in Y.
- Addition of a solution of Ag+ to a solution of Y gives a white precipitate

Question 5

Examine the scheme below showing a typical example of a Suzuki organopalladium catalyzed reaction. (L = phosphine and X = Cl).



(a) Write down the overall reaction equation.
(b) Name reactions **A**, **B**, **C** and **D**
(c) Give electron counts and oxidation states for all palladium complexes.
(d) Write the appropriate missing structures **1** and **2**

END OF EXAMINATION

PERIODIC TABLE OF ELEMENTS

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

hydrogen 1 H 1.00794																	helium 2 He 4.002602
lithium 3 Li 6.941	beryllium 4 Be 9.012182											boron 5 B 10.811	carbon 6 C 12.0107	nitrogen 7 N 14.00674	oxygen 8 O 15.9994	fluorine 9 F 18.9984	neon 10 Ne 20.1797
sodium 11 Na 22.98977	magnesium 12 Mg 24.3050											aluminium 13 Al 26.981538	silicon 14 Si 28.0855	phosphorus 15 P 30.97376	sulphur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.984
potassium 19 K 39.0983	calcium 20 Ca 40.078	scandium 21 Sc 44.95591	titanium 22 Ti 47.867	vanadium 23 V 50.9415	chromium 24 Cr 51.9961	manganese 25 Mn 54.93805	iron 26 Fe 55.845	cobalt 27 Co 58.9332	nickel 28 Ni 58.6934	copper 29 Cu 63.546	zinc 30 Zn 65.409	gallium 31 Ga 69.723	germanium 32 Ge 72.64	arsenic 33 As 74.9216	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.798
rubidium 37 Rb 85.4678	strontium 38 Sr 87.62	yttrium 39 Y 88.90585	zirconium 40 Zr 91.225	niobium 41 Nb 92.90638	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.9055	palladium 46 Pd 106.42	silver 47 Ag 107.8682	cadmium 48 Cd 112.411	indium 49 In 114.818	tin 50 Sn 118.710	antimony 51 Sb 121.760	tellurium 52 Te 127.60	iodine 53 I 126.9045	xenon 54 Xe 131.293
caesium 55 Cs 132.90545	barium 56 Ba 137.327	lutetium 71 Lu 174.967	hafnium 72 Hf 178.49	tantalum 73 Ta 180.9479	tungsten 74 W 183.84	rhenium 75 Re 186.207	osmium 76 Os 190.23	iridium 77 Ir 192.217	platinum 78 Pt 195.078	gold 79 Au 196.96655	mercury 80 Hg 200.59	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]	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	darmstadtium 110 Ds [271]	roentgenium 111 Rg [272]	ununbium 112 Uub [285]		ununquadium 114 Uuq [289]				

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
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]

Question 1 [25 marks]

1. (a) (6 points) For each of the following three common security attacks, briefly describe the attack, and outline a suitable countermeasure that could be used to minimise risk or impact:
   i. Man in the middle attack
   ii. Buffer overrun
   iii. SQL Injection

   (b) (2 points) Another risk to network security is packet sniffing. Briefly describe the attack, and explain why this is a particularly important risk to wireless networks.

   (c) (2 points) Users often access Internet services using other devices such as mobile phones and home video games consoles (e.g. mobile phones, tablets).
   State ONE risk specific to accessing Internet services using mobile phones, and ONE risk specific to Internet services using home video games consoles.

   (d) Some people believe that web services should not require users to log in or authenticate in any way, and should instead be open for all to use.
   i. (1 point) With a suitable example, briefly explain why authentication may be necessary.
   ii. (2 points) One traditional method of restricting user access to web pages is the use of `htaccess` and `htpasswd`. State TWO features that `htaccess` offers for restricting access to pages.
   iii. (6 points) A company is currently using `htaccess` files to restrict access to sensitive pages, but a recent visit from an IT consultant has suggested this technique is old fashioned and insecure. Your manager would like to understand some alternatives.
   Briefly explain the following three methods of authentication, and provide a drawback of using each method.
   A) Biometric data alone
   B) 2-factor authentication (not using biometric data)
   C) Personal digital certificates using public key infrastructure

   (e) (6 points) Using any real-life examples that may support your argument, discuss the statement "It is ethical for Courts of Law to restrict access to websites." You should ensure that you present a balanced argument (considering situations when blocking access might have positive and negative consequences) and come to a clear conclusion.

Question 2 [25 marks]

2. Web developers face a number of technical choices when developing a website.

   (a) A solution stack is a complete set of software components required to run an application.
   i. (4 points) LAMP is a well-known solution stack for dynamic web sites. Give the name of every component in this stack, and explain their role within the stack.
   ii. (1 point) Give an example of an alternative to LAMP

   (b) Server-side scripting can be performed using a variety of programming languages.
   i. (2 points) Give the names of FOUR different server-side scripting languages.
   ii. (3 points) Give THREE distinct factors which may lead a web developer to choose (or avoid) a particular server-side scripting language when embarking on a brand new project.
   Clearly explain the impact (risk/cost or benefit) of each factor on the project.
   iii. (2 points) Are there any different factors that must be considered when choosing a client-side scripting language? Justify your answer with a clear explanation.

   (c) When developing complex web applications, it is often advised to reuse existing code (and supporting tools).
   These additional software components are typically distributed as libraries or structured as frameworks.
   An alternative to using these well-established solutions would be writing all the code yourself.

i. (1 point) Give the name of a well-known web application framework (indicate the language it is written in)

ii. (4 points) Explain, with appropriate justification, when it is preferable to reuse external code, and when it is preferable to write your own.
Give at least TWO arguments in favour of each approach.

(d) (8 points) Your company intends to launch a database driven website. A senior manager has suggested the company should buy its own server and host the website itself, using its existing broadband connection.
Write a short pararaph analysing this proposal. The paragraph should:

- consider one or more alternatives
- compare and contrast available options, considering a range of business and technical factors
- conclude with a recommendation

Question 3 [25 marks]

3. You are developing a simple web-based application to manage a collection of web bookmarks.
N.B. This question involves server-side scripting. The preferred language is PHP. Clearly state which server-side scripting language you will be using for the whole question (if you decide to use another languauge), and make sure all relevant files are named accordingly.

(a) Web addresses are often referred to as "URL".

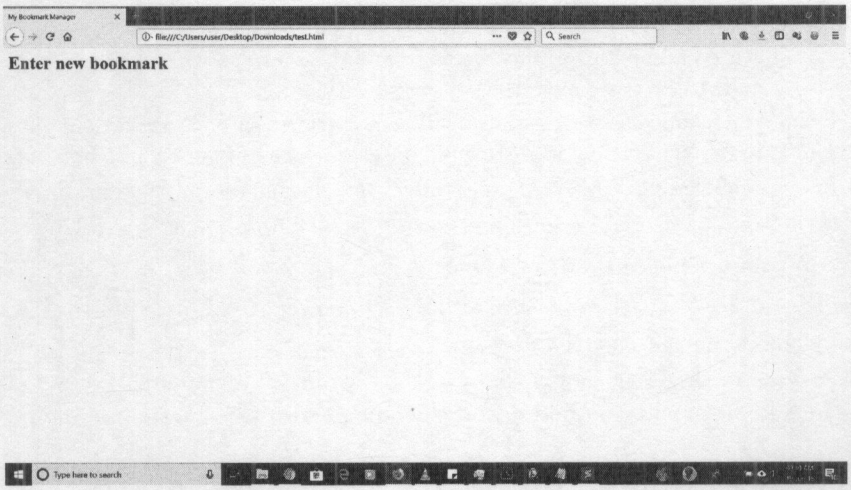
i. (1 point) What does this abbreviation mean?

ii. (2 points) A typical URL takes the following format:
`http://www.example.com/products/index.php?ref=4263&cur=gbp`
Briefly explain what each of the following parts represent:

- `http://`
- `www.example.com`
- `/products/index.php`
- `?ref=4263&cur=gbp`

(b) First, you will build a simple front-end in a file named bookmarkinput.html

i. (1 point) Write HTML to construct the page as indicated in the figure?



ii. (3 points) Add a simple form to your code. This form must take the following input parameters:

- a single-line string representing the location of a web page, named `address`
- a single-line text description, named `title`

These two parameters must be sent to a script named `savebookmarks.php`. When doing so, the parameters should not be visible in the address bar of the web browser.

(c) The URL entered in the `address` field might be incorrect.

i. (3 points) We wish to add some basic client-side validation to the address field. The validator should check that:

- the first part of the URL is present (`http://` or `https://`)
- the second part contains at least one character

Write the corresponding code.

ii. (1 point) If you were to write code to check the existence of a URL, should it be written on the client side, or on the server side? Explain why.

(d) (3 points) You have access to a database called `BOOKMARKMANAGER`, which contains a single table named `Bookmarks`. The database is hosted remotely at `mywebhost.com`. The administrator username is `db_admin` and the password is `foobar4263` Using the server-side scripting language of you choice, write a function called `connectToDatabase`, which:

- takes no input parameters
- establishes an authorised connection with the database host
- gets access to the database itself
- displays relevant error messages when necessary
- returns a connection handle, to be used in future database queries

This function will be saved in a file called `myfunctions.inc`

(e) You will now write the back-end of your application.

i. (3 points) In a file called `savebookmark.php`, write a function called `savebookmark`, which:

- takes 2 strings called `myAddress` and `myTitle` as an input
- gets access to the `Bookmarks` table described earlier, by referring, via an appropriate mechanism, to the function `connectToDatabase` defined in d)
- saves `myAddress` and `myTitle` in the `Bookmarks` table
- returns `true` if the operation was a success, `false` if it failed

ii. (3 points) Still in `savebookmark.php`, write code to:

- generate a full, valid web page entitled "Saving Bookmark"
- check that the input parameters obtained from the form in `bookmarkinput.html` (see question b) ii)) have been set; if not, display an error message linking back to `bookmarkinput.html`
- use the `savebookmark` function to save the input parameters in the database
- display a relevant message regarding the success or failure of the operation

(f) (5 points) Write another file called `displaybookmarks.php`:

- the page should display, ordered by `id`, all the web addresses contained in the database
- the results should appear as a HTML table
- the first column of the table should contain the title of each bookmark
- the second column should contain the corresponding address, formatted as a hyperlink

The following SQL syntax may be useful to accomplish some this question's tasks:

```
INSERT INTO tbl_name (col1, ...) values (val1, ...);
SELECT * FROM tbl_name WHERE col1 = val1;
```

where `tbl_name`, `col1`, `val1` are replaced with appropriate values.

Question 4 [25 Marks]

4. (a) (3 points) Explain, with reference to XML, the purpose of the Document Type Definition and the Document Type Declaration.

   (b) (3 points) Explain how an XML document would call:

   i. an internal DTD

   ii. an external DTD

   iii. an XML schema

   (c) (4 points) The XML document in figure 4.2 contains precisely FOUR errors when validated against the DTD in figure 4.1. Identify all the errors, and provide a solution for each one.
   (Note: the line numbers are for your benefit and are not part of the XML code.)

Figure 4.1 - Simple XML DTD

```
1: <?xml version = "1.0" encoding="ISO-8859-1"?>
2 : <!ELEMENT JournalCatalogue (Journal*)>
3 : <!ELEMENT Journal (Journal_title,Journal_url)>
4 : <!ATTLIST Journal ISBN CDATA "0-000-0000-0">
5 : <!ELEMENT Journal_title (#PCDATA)>
6 : <!ELEMENT Journal_url EMPTY>
7 : <!ATTLIST Journal_url page CDATA #REQUIRED>
```

Figure 4.2 - XML doument with Errors

```
1 : <?xml version="1.0" encoding="ISO-8859-1" standalone="no"?>
2 : <!DOCTYPE JournalCatalogue SYSTEM "journal-initial.dtd">
3 : <?xml-stylesheet type="text/xsl" href="journal.xsl"?>
4 : <JournalCatalogue>
5 : <Journal IBSN="0-123-4567-1">
6 : <Journal_Title>Nature</Journal_Title>
7 : <Journal_url>
8 : </Journal>
9 : </JournalCatalogue>
```

   (d) (15 points) Write an external DTD for the XML file in figure 4.3:

   - The element **trainlog** may contain, in any order, one or more **session** and **progress_report** elements.
   - A **session** element must first contain a **duration** element, followed by **distance** element, followed by a **location** element, followed optionally by a **comment** element, followed by zero or more **photo** elements.
   - The **date** and **heartrate** attributes in **session** are optional.
   - The **type** attribute in **session** must be present but allow only 3 values – running, swimming, cycling - with default set to running.
   - A **photo** element must contain a **url** attribute, but may not contain any text.
   - A **progress_report** element must contain one or more comment elements.

Figure 4.3 - XML trainlog document

```
<?xml version="1.0"?>
<trainlog>
   <session date="11/01/10" type="running" heartrate="158">
      <duration units="minutes">50</duration>
      <distance units="miles">5.5</distance>
      <location>Hyde Park</location>
      <comment>Mid-morning run, a little winded throughout.</comment>
      <photo url="http://www.bcs.org/cloud.jpg" />
      <photo url="http://www.bcs.org/london.jpg" />
```

```
</session>
<session date="16/01/10" type="cycling" heartrate="153">
  <duration units="hours">1.5</duration>
  <distance units="miles">26.4</distance>
  <location>Crystal Palace</location>
  <comment>Hilly ride, felt strong as an ox.</comment>
</session>
<session date="23/01/10" type="running" heartrate="156">
  <duration units="hours">2.5</duration>
  <distance units="miles">16.8</distance>
  <location>Regents Park</location>
  <comment>Afternoon run, felt reasonably strong.</comment>
</session>
<progress_report>
  <comment> Performance improved significantly</comment>
</progress_report>
</trainlog>
```

Question 5 [25 marks]

5. (a) (5 points) Internet of things (IoT) is defined as "the infrastructure of the information society." Briefly explain what this means using appropriate examples.

   (b) (5 points) What key issues will need to be addressed for IoT to be fully accepted?

   (c) (5 points) Briefly explain virtualisation, citing suitable examples.

   (d) (10 points) A Small Medium Enterprise company is reviewing its IT requirements and is considering using a Cloud solution as opposed to investing in existing infrastructure.
   You are required to make an essay to company board outlining the potential benefits and drawbacks of both approaches.
   Your answer should be in the form of a bullet points to the client (focussing on the key issues). The essay should differentiate between IaaS, PaaS and SaaS.

Question 6 [25 marks]

6. (a) (3 points) Define the term API and state the purpose it serves.

   (b) (4 points) Companies such as eBay™ and Google™ provide public APIs. State FOUR benefits of APIs.

   (c) (4 points) Identify the stages and issues when creating an API from a producer's viewpoint.

   (d) (4 points) Data can be returned as XML or JSON by an API call. As a developer, give two distinct examples where each of these is most suitable, based on the type of device in use during the API call.

   (e) (10 points) As a Web Engineer, identify at least FIVE major challenges in the design and development of an image-hosting site, where users can upload their images to a central server and the images can be retrieved via a web link or an API. Initially you are to focus on two aspects only:

   NOTE: Your answers should focus on the various technologies and challenges in using those technologies. No credit will be given for "text book" answers that follow the Software Development Life Cycle Model (SDLC).

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF COMPUTER SCIENCE
CSC4035 WEB PROGRAMMING AND TECHNOLOGIES
FINAL EXAM

Friday 13th July, 2018

Time: 14:00 - 17:00HOURS

Duration: 3 HOURS

Venue: P207

INSTRUCTIONS

- This paper has a total of SIX(6) questions
- You must answer a total of FOUR(4) questions
- All questions carry equal marks (25 marks each)
- Clearly number all your answers
- Use the marks as a guide to the detail required in your answers while keeping your answers concise and relevant

Question 1 [25 marks]

1. (a) (6 points) For each of the following three common security attacks, briefly describe the attack, and outline a suitable countermeasure that could be used to minimise risk or impact:
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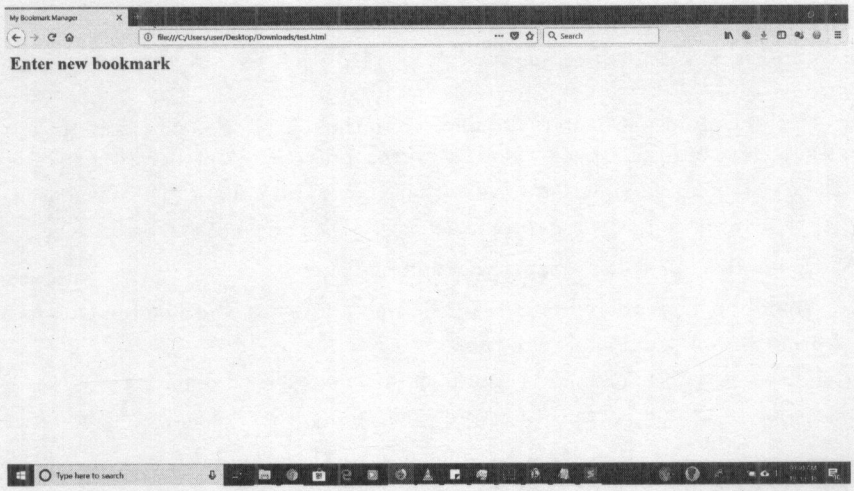

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- a single-line string representing the location of a web page, named `address`
- a single-line text description, named `title`

4. (a) (3 points) Explain, with reference to XML, the purpose of the Document Type Definition and the Document Type Declaration.

   (b) (3 points) Explain how an XML document would call:

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   ii. an external DTD

   iii. an XML schema

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5 : <Journal IBSN="0-123-4567-1">
6 : <Journal_Title>Nature</Journal_Title>
7 : <Journal_url>
8 : </Journal>
9 : </JournalCatalogue>
```

   (d) (15 points) Write an external DTD for the XML file in figure 4.3:

   - The element `trainlog` may contain, in any order, one or more `session` and `progress_report` elements.
   - A `session` element must first contain a `duration` element, followed by `distance` element, followed by a `location` element, followed optionally by a `comment` element, followed by zero or more `photo` elements.
   - The `date` and `heartrate` attributes in `session` are optional.
   - The `type` attribute in `session` must be present but allow only 3 values – running, swimming, cycling - with default set to running.
   - A `photo` element must contain a `url` attribute, but may not contain any text.
   - A `progress_report` element must contain one or more comment elements.

Figure 4.3 - XML trainlog document

```
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<trainlog>
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    <duration units="minutes">50</duration>
    <distance units="miles">5.5</distance>
    <location>Hyde Park</location>
    <comment>Mid-morning run, a little winded throughout.</comment>
    <photo url="http://www.bcs.org/cloud.jpg" />
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```

```
    </session>
    <session date="16/01/10" type="cycling" heartrate="153">
      <duration units="hours">1.5</duration>
      <distance units="miles">26.4</distance>
      <location>Crystal Palace</location>
      <comment>Hilly ride, felt strong as an ox.</comment>
    </session>
    <session date="23/01/10" type="running" heartrate="156">
      <duration units="hours">2.5</duration>
      <distance units="miles">16.8</distance>
      <location>Regents Park</location>
      <comment>Afternoon run, felt reasonably strong.</comment>
    </session>
    <progress_report>
      <comment> Performance improved significantly</comment>
    </progress_report>
</trainlog>
```

Question 5 [25 marks]

5. (a) (5 points) Internet of things (IoT) is defined as "the infrastructure of the information society." Briefly explain what this means using appropriate examples.

   (b) (5 points) What key issues will need to be addressed for IoT to be fully accepted?

   (c) (5 points) Briefly explain virtualisation, citing suitable examples.

   (d) (10 points) A Small Medium Enterprise company is reviewing its IT requirements and is considering using a Cloud solution as opposed to investing in existing infrastructure.
   You are required to make an essay to company board outlining the potential benefits and drawbacks of both approaches.
   Your answer should be in the form of a bullet points to the client (focussing on the key issues). The essay should differentiate between IaaS, PaaS and SaaS.

Question 6 [25 marks]

6. (a) (3 points) Define the term API and state the purpose it serves.

   (b) (4 points) Companies such as eBay™ and Google™ provide public APIs. State FOUR benefits of APIs.

   (c) (4 points) Identify the stages and issues when creating an API from a producer's viewpoint.

   (d) (4 points) Data can be returned as XML or JSON by an API call. As a developer, give two distinct examples where each of these is most suitable, based on the type of device in use during the API call.

   (e) (10 points) As a Web Engineer, identify at least FIVE major challenges in the design and development of an image-hosting site, where users can upload their images to a central server and the images can be retrieved via a web link or an API. Initially you are to focus on two aspects only:

   NOTE: Your answers should focus on the various technologies and challenges in using those technologies. No credit will be given for "text book" answers that follow the Software Development Life Cycle Model (SDLC).

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC 4822
ROUTING AND SWITCHING TECHNOLOGIES

Date:	18th NOVEMBER 2019
Time:	09:00hrs – 11:00hrs
Duration:	2 Hours
Venue:	NSLT

Instructions

1. There are **two (2) Sections** in this exam, **Section A** and **Section B**.
2. In Section A, **answer all the questions** and in Section B **choose any three (3) questions**.

THE UNIVERSITY OF ZAMBIA

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SECTION A [40 marks]

ANSWER ALL QUESTIONS IN THIS SECTION

Question 1 [20 marks]

a) List four switch LED indicators. **[4 marks]**

b) List two beneficial functions of the Routers. **[4 marks]**

c) Which command do you use when you want to name the device? **[4 mark]**

d) What is the AD for RIP and OSPF? **[4 marks]**

e) Which command displays the contents of the IPv4 routing table stored in RAM? **[4 marks]**

Question 2 [20 marks]

a) When do we use the default static routes? **[4 marks]**

b) What is the metric of RIP and OSPF? **[4 mark]**

c) A router can learn about remote networks in one of two ways. Name the ways. **[4 marks]**

d) Why is a separate VLAN needed to support Voice over IP (VoIP)? **[4 marks]**

e) Name two switch forwarding methods? **[4 marks]**

SECTION B [60 marks]

ANSWER ANY THREE (3) QUESTIONS IN THIS SECTION

Question 3 [20 marks]

a) List and discuss the three inter-VLAN routing options. **[7.5 marks]**
b) Differentiate static from dynamic routing. **[5 marks]**
c) Discuss the purpose of dynamic routing protocols. **[7.5 marks]**

Question 4 [20 marks]

a) Explain the implementation restrictions of EtherChannel. **[7.5 marks]**
b) Discuss the primary uses of static routing. **[5 marks]**
c) Discuss the disadvantages of static routing. **[7.5 marks]**

Question 5 [20 marks]

a) List and discuss STP timers and port states. **[7. 5 marks]**
b) User productivity and network adaptability are important for business growth and success. VLANs make it easier to design a network to support the goals of an organization. Discuss the primary benefits of using VLANs **[5 marks]**
c) EtherChannels can be formed through negotiation using one of two protocols, PAgP or LACP. Discuss the protocols PAgP and LACP. **[7.5 marks]**

Question 6 [20 marks]

a) Discuss the different versions of STP. **[7.5 marks]**
b) Explain the advantages of EtherChannel. **[5 marks]**
c) In 1993, RIPv1 was updated to a classless routing protocol known as RIP version 2 (RIPv2). RIPv2 included a number of improvements. Discuss the improvements. **[7.5 marks]**

THE END

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2018/2019 ACADEMIC YEAR FINAL EXAMINATIONS

GES 3330: ENVIRONMENT AND DEVELOPMENT

TIME: Three Hours

INSTRUCTIONS: Answer any three questions. All questions carry equal marks. Candidates are encouraged to use illustrations wherever appropriate.

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1. 'Foundations for the Green Revolution technology were laid by 20th century landmark scientific discoveries that have made modern agriculture environmentally destructive'. Elucidate.

2. Write short explanatory notes on all of the following:

   (a) Effects of invasive alien species on economies and the environment.
   (b) Poverty and the environment
   (c) Household energy choices in developing countries
   (d) Environmental Kuznet curve
   (e) Debates on effects of human populations on the environment.

3. 'Outline the major obstacles to achieving sustainable development for a developing country like Zambia'.

4. Describe an environmental problem that you feel is the most urgent worldwide and suggest solutions.

5. Explain three gaseous pollutants giving their sources, environmental effects, and what can be done to reduce the production or emission of each one.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2018/2019 ACADEMIC YEAR FINAL EXAMINATIONS

GES 4472: FUNDAMENTALS OF GEOGRAPHICAL INFORMATION SYSTEMS

TIME: Three Hours

INSTRUCTIONS: Answer questions **1** and any other **two**. All questions carry equal marks. Candidates are encouraged to make use of illustrations wherever appropriate.

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1. Write short explanatory notes on All of the following:
   a) GIS as a decision support tool
   b) Bilinear Interpolation
   c) Forward and inverse mapping equations
   d) Local versus international datums
   e) Vector and Raster
   f) Significance of Geo-referencing

2. Identify an environmental problem and explain how GIS can be used to address it.

3. Identify the different data errors and explain why these should be corrected prior to further processing or analysis in a GIS.

4. Demonstrate how the GIS process is important in solving spatial challenges.

5. You have been hired as a Geospatial Consultant. Explain how you would use GIS to select a suitable location for a new Filling Station in Lusaka.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR
FINAL EXAMINATIONS

MAT2602 INTRODUCTION TO STATISTICS

Time Allowed: Three (3) Hours

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

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1. (a) Define the following:
   (i) a parameter
   (ii) descriptive statistics

   (b) The number of hours that 50 employees of a certain organization spend in the office in a week is given in the following grouped cumulative distribution table:

Hours	Cumulative frequency
15 – 17	2
18 – 20	6
21 – 23	13
24 – 26	22
27 – 29	32
30 – 32	44
33 – 35	50

   (i) Construct a grouped frequency distribution table.
   (ii) Construct a histogram on the absolute frequency scale.
   (iii) Construct a frequency polygon on the relative frequency scale.
   (iv) Describe the distribution of the number of hours spent in the office.

   (c) The time taken to run a road race is normally distributed with a mean of 180 minutes and a standard deviation of 14 minutes.
   (i) Find the probability that a randomly selected runner completes the race between 170 and 215 minutes.
   (ii) If 11.9% of the runners complete the race in less than k minutes, find the value of k.

2. (a) Define the following:
   (i) a random sample
   (ii) a stratified sample

(b) The number of kilometres 30 taxi drivers cover on a given day are:

11	8	26	31	62	19	7	3	14	75
33	30	42	15	18	23	29	13	16	6
50	9	10	17	12	20	22	24	32	25

   (i) Prepare an ordered stem and leaf plot for the data.
   (ii) Construct a boxplot for the data and identify the outliers, if any.

(c) Delivery times for all food orders at a fast food restaurant during lunch hour are normally distributed with a mean of 8.4 minutes and a standard deviation of 1.8 minutes. Find the probability that the mean delivery time for a random sample of 16 such orders at this restaurant is
   (i) between 8 and 9 minutes.
   (ii) within 1 minute of the population mean.

3. (a) (i) Define response bias
   (ii) State two causes of response bias.
   (iii) Define a probability sample.

(b) A politician claims that the percentage of female voters exceeds that of male voters by more than 5%. A random sample of 500 female registered voters showed that 300 of them voted in the last presidential election. Another independent random sample of 400 male voters showed that 208 of them voted in the same election.
   (i) Construct a 98% confidence interval for the difference between the true proportions of female and male voters in the last election.
   (ii) Test the politician's claim at the 5% level of significance.

(c) A medical expert claims that the average age of first-time mothers in Zambia is 25 years or less. The standard deviation of the age of first-time mothers is known to be 4.8 years. Ministry of Health officials take a random sample of 57 first-time mothers and decide the claim should be rejected if the mean age is greater than 27 years.
   (i) Explain how one can commit a type I error in this context.
   (ii) Find the probability of a type I error if the claim is true.
   (iii) Find the probability of a type II error if the true mean age of first-time mothers is 28 years.

4. (a) Define the following:
   (i) a statistical hypothesis
   (ii) a type II error

(b) A consumer agency wanted to find out if the mean time taken by each of three brands of medicine to provide relief from a headache is the same. The following table gives the time (in minutes) taken by each patient to get relief from a headache for patients randomly assigned to the three drugs.

Drug

1	2	3
25	15	44
38	21	39
42	19	54
65	25	58
47		73
52		

   (i) What design was used in the experiment?
   (ii) Write down a model for the above design. **Explain** all the terms in your model. **State** all the assumption(s).
   (iii) Is the mean relief time the same for each of the three drugs? Use $\alpha = 0.05$ level of significance.

(c) A sample of 13 cans of brand A diet soda gave a mean number of 23 calories with a standard deviation of 3 calories. Another independent sample of 11 cans of brand B diet soda had a mean of 25 calories with a standard deviation of 5 calories. Assume the amounts of calories of diet soda are normally distributed.
   (i) Is there a difference in the mean number of calories for the two brands? Carry out a test to answer the question using a 5% level of significance assuming the variances of the two brands are equal.
   (ii) Construct a 90% confidence interval for the ratio of variances of the two brands.

5. (a) (i) State two properties of a normal distribution curve.
(ii) Define a sampling distribution.

(b) The following data give the experience (in years) and annual salaries (in millions of Kwacha) of 9 randomly selected employees of a certain organization.

Experience (x)	14	3	5	6	4	9	18	5	16
Annual salary (y)	62	29	37	43	35	60	67	32	60

(You may use the following summary statistics:

$\sum_{i=1}^{6} x_i = 80,\ \sum_{i=1}^{6} x_i^2 = 968,\ \sum_{i=1}^{6} y_i = 425,\ \sum_{i=1}^{6} y_i^2 = 21841,\ \sum_{i=1}^{6} x_i y_i = 4404$)

(i) Draw a scatter diagram. Comment on the pattern.
(ii) Estimate the simple linear regression equation.
(iii) Explain the meaning of the estimated parameters.
(iv) Copy and complete the following ANOVA table.

Source of variation	Sum of squares (SS)	Degrees of freedom (df)	Mean square (MS)	F*
Regression				
Error			35.000	
Total				

(v) Is there a significant linear relationship between experience and annual salary? Use a 5% level of significance.
(vi) Compute a 95% confidence interval for the slope parameter.

6. (a) (i) Define the coefficient of determination.
(ii) State two properties of the correlation coefficient.

(b) Recent recession and bad economic conditions forced many people to hold more than one job to make ends meet. A sample of 500 persons who held more than one job produced the following two way table.

	Marital status		
Gender	Single	Married	Other
Male	65	230	25
Female	40	120	20

Test at the 10% level of significance whether gender and marital status are related for all people who hold more than one job.

(c) A computer company claims that the mean time to learn how to use its new software is not more than 2 hours. A random sample of 12 persons took the following times (in hours) to learn how to use the software:

1.75	2.25	2.40	1.90	1.50	2.75
2.15	2.25	1.80	2.20	3.25	2.60

(i) Test at the 1% level of significance whether the company's claim is true. Assume the times are normally distributed.

(ii) Construct a 98% confidence interval for the population standard deviation of times taken to learn the software. Is it significantly different from 0.5 hour? Explain.

END OF EXAMINATION

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

2019 Academic Year Final Examinations — 19^{th} November, 2020
MAT 3200 Abstract Algebra

Total time allowed: Three (3) hours
Instructions:

- There are seven questions in this paper; answer any five (5).
- All questions carry equal marks.
- Show detailed working to earn full marks.

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1. (a) (i) Define a generalized eigenvector of type m. [3]
   (ii) State the Ideal Test. [3]

   (b) In $\mathbb{Z}[\sqrt{-7}]$, determine whether or not $3+2\sqrt{-7}$ and $-59+10\sqrt{-7}$ are associates. [5]

   (c) Given that $A = \begin{pmatrix} 2 & 5 \\ 3 & 5 \end{pmatrix}$ is an element of the general linear group $\mathrm{GL}(2, \mathbb{Z}_7)$, find the inverse of A. [5]

   (d) Prove that if p is a prime that divides the product hk, then either p divides h or p divides k. [4]

2. (a) (i) Define a $p-$group, where p is a prime. [2]
   (ii) State The Division Algorithm. [3]

   (b) Find $\gcd(288, 164)$ and then find integers m and n such that the equation $288m + 164n = \gcd(288, 164)$ is satisfied. [5]

   (c) The function $f : \mathbb{C}^* \to \mathbb{C}^*$ defined by $f(x) = x^2$ is a group homomorphism from the group $\mathbb{C}^*$ to itself. Find the pre-images of the element $z = -7 - 24i$. [5]

   (d) State and prove Lagrange's Theorem. [5]

3. (a) (i) Define a prime ideal of a commutative ring R. [2]
   (ii) State Sylow's First Theorem. [2]

(b) Consider the group $U(21) = \{1, 2, 4, 5, 8, 10, 11, 13, 16, 17, 19, 20\}$.

(i) Find all the distinct left cosets of the subgroup, $H = \langle 4 \rangle$, which is generated by the element 4 in $U(21)$.

(ii) Construct the Cayley table for the quotient group $U(21)/H$, where $H = \langle 4 \rangle$. Hence, find the inverse of every element in the quotient group $U(21)/H$. [4]

(c) Determine whether or not the matrix $A = \begin{pmatrix} 0 & 1 & 2 \\ 0 & -2 & 0 \\ 2 & 1 & 0 \end{pmatrix}$ is diagonalizable. [5]

(d) Let x and y be elements of a commutative ring R with characteristic 3. Then expand and simplify $(x+y)^6$. [4]

4. (a) Define the following terms:

(i) the symmetric group on a set A. [3]

(ii) a zero-divisor of a commutative ring R. [3]

(b) Find the greatest common divisor of the Gaussian integers $1 - 5i$ and $7+4i$. [4]

(c) Show that the matrix $A = \begin{pmatrix} 1 & 2 \\ 3 & 6 \end{pmatrix}$ is a zero-divisor in the ring, $M_2(\mathbb{Z})$, of 2×2 matrices with integer entries. [4]

(d) State and prove Bezout's Identity. [6]

5. (a) (i) Define a ring homomorphism. [3]

(ii) State the Fundamental Theorem of Arithmetic. [3]

(b) Consider the permutation $\beta = (1\ 2\ 3\ 5\ 6)(1\ 3\ 4\ 7)(5\ 7)$ in the Symmetric group S_7. Write β as a single cycle or as a product of disjoint cycles. Hence, find the inverse of β and give your answer in cycle notation. [4]

(c) (i) Find the matrix representation for the linear operator $T : \mathbb{U} \to \mathbb{U}$ from the set of upper triangular matrices to itself defined by

$$T\begin{pmatrix} a & b \\ 0 & c \end{pmatrix} = \begin{pmatrix} 3a + 2b + c & 2b \\ 0 & a + 2b + 3c \end{pmatrix}$$

with respect to the basis $B = \left\{ \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix}, \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}, \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix} \right\}$

[5]

(ii) Find the eigenvectors of the linear operator T corresponding to each eigenvalue of T. [5]

6. (a) (i) Define a chain propagated by a generalized eigenvector of type m. [3]

(ii) State Cauchy's Theorem for Abelian Groups. [2]

(b) Find the Jordan canonical form of the matrix $A = \begin{pmatrix} 6 & 2 \\ -2 & 2 \end{pmatrix}$ [6]

(c) Consider the dihedral group

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

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

(d) Prove that if v is an eigenvector of a linear operator T corresponding to the eigenvalue λ, then $\text{span}\{v\}$ is invariant under the linear operator T. [4]

7. (a) Define the following terms:

(i) an integral domain, [2]

(ii) a Jordan block. [3]

(b) Let $S = \left\{ \begin{pmatrix} a & b \\ -a & -b \end{pmatrix} \mid a, b \in \mathbb{Z} \right\}$. Prove or disprove that S is a subring of $M_2(\mathbb{Z})$. [4]

(c) Find the Jordan canonical basis of the matrix $A = \begin{pmatrix} 3 & 0 & 0 \\ -1 & 3 & 0 \\ 0 & 1 & 3 \end{pmatrix}$.

[7]

(d) Find the matrix representation with respect to the basis $E = \{(2,2),\ (1,-1)\}$ in $\mathbb{R}^2$ for the linear operator $T : \mathbb{R}^2 \to \mathbb{R}^2$ defined by $T \begin{pmatrix} a \\ b \end{pmatrix} = \begin{pmatrix} 3a + b \\ a - b \end{pmatrix}$. [4]

END OF EXAM