THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – 1999

FIRST SEMESTER

SCHOOL OF NATURAL SCIENCES

1. BS 111 - Cell Biology and genetics theory paper.
2. BS 211 - Practical paper
3. BS 211 - Cell molecular biology and genetics theory paper
4. BS 221 - Form, fountain and diversity of plants theory paper
5. BS 319 - Brostatistics
6. BS 321 - Ethology and evolution paper II - practical
7. BS 321 - Ethology and evolution paper I - theory
8. BS 331 - Theory paper
9. BS 341 - (Microbiology) practical paper
10. BS 341 - (Microbiology) Theory paper
11. BS 351 - Entomology practical paper
12. BS 351 - Entomology Theory paper
13. BS 361 - Molecular biology (paper I)
14. BS 361 - Molecular biology (paper II)
15. BS 411 - Insect behaviour and ecology. Theory paper I
16. BS 375 - Invertebrate Zoology Theory: paper I
17. BS 411 - Paper II
18. BS 431 - Advanced parasitology I
19. BS 441 - Advanced molecular biology (paper I)
20. BS 441 - Advance Molecular Biology (paper II)
21. BS 471 - Enviromental microbiology practical paper
22. BS 471 - Enviromental microbiology
23. BS 475 - Population Ecology paper II
24. BS 491 - Freshwater biology Theory paper
25. BS 530 - (Bacteria and Fungi)
26. BS 531 - (Epidemiology and Genetics of pathogens) Theory paper

27.	BS	532	-	(plant disease Management and crop loss) Theory paper
28.	BS	591	-	Animal population and behavioural ecology – practical paper II
29.	BS	592	-	Fish and wildlife management practical paper
30.	BS	592	-	Fish and wildlife management theory paper I
31.	BS	915	-	Biology of seed plants – Theory paper
32	BS	935	-	Plant pathology – Theory paper
33.	C	101	-	Introductory chemistry I
34.	C	205	-	Analytical - Inorganic chemistry
35.	C	205	-	Dreferred/supplementary
36.	C	225	-	Deferred/Supplementary
37.	C	245	-	Inorganic Chemistry
38.	C	251	-	Organic Chemistry I
39.	C	311	-	Deferred/Supplementary
40.	C	321	-	Spectral analytical method
41.	C	341	-	Inorganic Chemistry
42.	C	341	-	Inorganic Chemistry II
43.	C	351	-	Organic Chemistry III - Sup
44.	C	361	-	Physical chemistry
45.	C.	411	-	Advanced biochemistry
46.	C	421	-	Applied analytical chemistry paper I
47.	C	445	-	Bio-inorganic chemistry
	C	451	—	Advanced Organic Chemistry
48.	C	461	-	Quantum chemistry
49.	C	481	-	Industrial chemistry
50.	C	491	-	Organic Technology
51	CAV	251	-	Analytical/Organic chemistry
52.	GEO	111	-	Introduction to human geography I
53.	GEO	175	-	Introduction to mapping techniques geography paper I
54.	GEO	175	-	Introduction to mapping techniques in geography paper II
55.	GEO	211	-	The geography of Africa
56.	GEO	271	-	Quantitative techniques in geography I
57.	GEO	451	-	Land resources survey
58.	GEO	481	-	Environment and development II

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS
FIRST SEMESTER EXAMINATION - MAY 1999

BS111
CELL BIOLOGY AND GENETICS
THEORY PAPER

TIME:　　　**THREE HOURS**
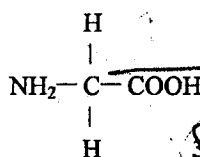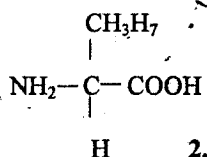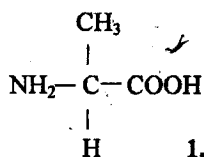
ANSWER:　　ALL Questions in any order using the ANSWER SHEET PROVIDED.

MARKS:　　Correct answer = 4;　　Wrong answer = -1;　　I do not know = 0.

NOTE:　　Submit this question paper, along with your answer sheet, to the Invigilator in the Examination Room.

CELL BIOLOGY AND GENETICS

1.　The isoelectric point, otherwise known as the zwitterion form of proteins, is

　　1.　When the net charge of the molecule is at zero.
　　2.　When the molecule donates more hydrogen ions than it can accept
　　3.　When the molecule accepts more hydrogen ions than it can lose
　　4.　When the net charge of the molecule is at a maximum positive value
　　5.　When the net charge of the molecule is at a minimum positive charge
　　6.　I do not know.

2.　The amphoteric nature of amino acids is useful biologically because it makes proteins act as

　　1.　enzymes
　　2.　catalysts
　　3.　buffers
　　4.　co-enzymes
　　5.　chemical reaction regulators
　　6.　I do not know

3.　Which of the following molecules is an amino acid?

$$CH_3$$
$$|$$
$$NH_2-C-COOH$$
$$|$$
$$H \quad 1.$$

$$CH_3H_7$$
$$|$$
$$NH_2-C-COOH$$
$$|$$
$$H \quad 2.$$

$$H$$
$$|$$
$$NH_2-C-COOH$$
$$|$$
$$H$$

　　1.　1 only
　　2.　1 and 2 only
　　3.　all of them
　　4.　none of them

5.   1 and 3 only
6.   I do not know

4.   Which of the following statements is **CORRECT**?

1.   Proteins are insoluble in water Y
2.   Proteins are insoluble in organic solvents ✓
3.   Proteins are made up of subunits of glucose
4.   Proteins are good solvents
5.   Proteins are never found in an ionic state
6.   I do not know

5.   What is adipose tissue?

1.   Tissue which stores more reactive organic molecules
2.   This is tissue which stores proteins
3.   Special tissue which specialises in the storage of polypeptides
4.   Specialised tissue which stores fat
5.   Specialised tissue which transforms proteins into carbohydrates
6.   I do not know

6.   Which of the following statements is **CORRECT?**

1.   Lipids are insoluble in polar solvents.
2.   Water is not a good solvent for non-polar molecules.
3.   Chloroform and ether are poor lipid solvents.
4.   Benzene is the only poor solvent for lipids.
5.   Polar solvents readily dissolve lipid molecules.
6.   I do not know.

7.   Which of the following molecules releases more biological energy for metabolism?

1.   Fats
2.   Proteins
3.   Glucose
4.   Polypeptides
5.   Polysacchadides
6.   I do not know

8.   Metabolic energy is readily released from

1.   amino acids
2.   glucose
3.   sugars
4.   lipids →
5.   glycerol
6.   I do not know

9.   Glycerol and fatty acids combine to form a triglyceride. Which of the following statements is **CORRECT** about their molecular structure?

1.   Glycerol has three carbons, four hydrogens and two nitrogens
2.   Glycerol has four carbons, eight hydrogens and three oxygens
3.   Glycerol has five carbons, five hydrogens and three oxygens

2

4.   Fatty acid has one hydroxyl group
5.   Fatty acid has three amide groups
6.   I do not know

10. /   The reactive sites for glycerol and fatty acid are

    1.   But glycerol and fatty acids are not reactive
    2.   double bond positions of carbon
    3.   Hydrogen ends of the molecules
    4.   alkyl group for fatty acid and hydroxyl group for glycerol
    5.   hydroxyl groups
    6.   I do not know

11.   given the structure of a triglyceride as

$$O$$
$$\|$$

Glycerol $- O - C - CH_2 - CH_2 - \ldots\ldots CH_2$. This is an example of a

    1.   liquid at room temperature
    2.   solid at freezing temperature
    3.   saturated fat
    4.   fat which is not saturated
    5.   phospholipid
    6.   I do not know

12.   Which of the following organic molecules is associated with genetic make up of an organism?

    1.   Nucleic acids
    2.   Fattay acids
    3.   Polysaccharides
    4.   Phospholipids
    5.   Amino acids
    6.   I do not know

13.   RNA has three components in its structural formula. These are:

    1.   deoxyribose sugar, ribose sugar and a purine base
    2.   a base, a pyrimidine base and ribose sugar
    3.   a base, ribose sugar and phosphoric acid
    4.   phosphoric acid, a base and deoxyribose sugar
    5.   phosphoric acid, a pyrimidine and deoxyribose sugar.
    6.   I do not know

14.   What is a nucleoside?

    1.   a combination of phosphoric acid with deoxyribose sugar
    2.   a combination of a disaccharide with a nucleotide
    3.   a synthesis of phosphoric acid with a base
    4.   condensation of a ribose sugar with a base
    5.   synthesis of a DNA backbone
    6.   I do not know

15.   A phosphoester bond in a DNA molecule links together

    1.   a base and a sugar
    2.   phosphoric acid and a base
    3.   a base and another base
    4.   a sugar and an amide
    5.   phosphoric acid and a sugar
    6.   I do not know

16.   In a DNA molecule, two nucleotides whose bases are guanine and cytocine are held together through a

    1.   single covalent bond
    2.   double covalent bond
    3.   triple covalent
    4.   a triple hydrogen bond
    5.   a single hydrogen bond
    6.   I do not know

17.   Louis Pasteur was a vitalist, who believed that

    1.   chemical reactions in a cell could not be reproduced outside the cell
    2.   conversion of fruit juice by yeast cells to wine was a pehnomerion exclusively for cells to perform
    3.   living cells had a special spirit which made them perform chemical activities which could not be repeated under laboratory situations
    4.   that improved chemical knowledge only discovers new biomolecules which are not part of a living cell
    5.   all (1-4) statements
    6.   I do not know

18.   Thermodynamic equilibrium is reached when in a chemical reaction the/there

    1.   reactants and the products are in equal concentration.
    2.   reactants are in higher concentration.
    3.   is no enzyme to catalyse the reaction.
    4.   amount of products are higher than the reactants.
    5.   is no energy to drive the reaction.
    6.   I do not know.

19.   An allosteric enzyme is one which

    1.   allows reactions to go faster
    2.   binds to an enzyme and reduces its catalylic activity
    3.   makes a reaction go in both directions
    4.   is an efficient calalyst
    5.   occurs in two forms
    6.   I do not know

20.   Given that a tropical plant exists under the following conditions:

    Set A   { 25° C, 4 moles enzyme, 10 moles reactants}

    Set B   {25° C, 8 moles enzymes, 6 moles reactants}

4

Set C ～ {40°C, 8 moles enzymes, 10 moles reactants}

Set D ～ {28°C, 8 moles enzymes, 6 moles reactants}.

Which set of conditions would give the best chemical reactions?

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

21. Give the name of the enzyme which helps with the catalysis of a reaction involving the substrate lactose

1. maltase
2. Lactase
3. lactase
4. maltoase
5. malteose
6. I do not know

22. Which of the following is considered to be an organic co-enzyme?

1. Zinc
2. metallic ion
3. Nicotinamide adenine dinucleotide
4. Nicotinamide diphosphate
5. Fumaric acid
6. I do not know

23. In the hypothetical chemical reaction given below (where H is a hydrogen atom)

$SBH_2 + PE \longrightarrow$ Coenzyme - H + PEH + SB
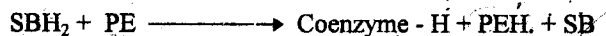
1. the substrate SB has lost electrons
2. The reactant PE has been oxidised
3. The co-enzyme has lost electrons
4. coenzyme is an oxidising agent
5. all the products have gained electrons
6. I do not know

24. Given the following information about a cell type. Which of the cell type is the smallest?

	Area	Volume
1.	$36mm^2$	$6mm^3$
2.	$24mm^2$	$8mm^3$
3.	$54mm^2$	$27mm^3$
4.	$66mm^2$	$35mm^3$
5.	$80mm^2$	$40mm^3$
6.	I do not know	

25. Which of the following statement(s) is **CORRECT?**

    1.   Organic molecules of life are themselves living entities
    2.   ALL living organisms are made up of cells
    3.   The nucleus is the smallest organelle in a cell
    4.   The nucleolus is found outside the nucleus during cell division
    5.   The endoplasmic reticulum and golgi body are the same in function
    6.   I do not know

26. Robert Hooke used a self constructed microscope in the

    1.   13th century
    2.   15th century
    3.   17th century
    4.   19th century
    5.   18th century
    6.   I do not know

27. Which of the following pairs is **NOT CORRECTLY** matched?

    1.   Microtubule - chromosome translocation during cell division
    2.   microfilament - cell motility
    3.   mitochondrion - energy generation
    4.   microtrabeculae - dynamic support framework of cell
    5.   cytoskeleton - disassembles cell duirng cell division.
    6.   I do not know

28. Which of the following is a **CORRECT** match?

    1.   microtubule - made up of protein.
    2.   intermediate fibres - made up of protein.
    3.   microfilament - made up of protein.
    4.   microtrabeculae - composition still unknown.
    5.   cytoskeleton - mostly calcium.
    6.   I do not know.

29. Which of the following statement is **CORRECT**

    1.   A simple sugar like glucose obeys the general formula $(CH_2O_2)_n$
    2.   Hexose sugars can be disaccharides
    3.   The sweetest sugar is a hexose
    4.   a hexose is a result of condensation between two simple sugars.
    5.   Lactose is an example of a disaccharide
    6.   I do not know

30. Which of the following routes is the most logical sequence

    1.   protein ------> mRNA ------> DNA -------> tRNA
    2.   DNA ------> mRNA --------> tRNA -------> protein
    3.   tRNA -------> mRNA --------> DNA -------> protein
    4.   DNA -------> tRNA --------> mRNA -------> protein
    5.   mRNA -------> tRNA --------> protein -------> DNA

31.   Which of the following is correct about a nucleosome (where H = Histone).

	H1	H2A	H2B	H3	H4
1.	2	2	1	2	2
2.	1	2	2	2	2
3.	2	1	2	2	2
4.	2	2	2	1	2
5.	2	2	2	2	1
6.	I do not know.				

32.   Approximately how may nucleosomes make up a gene?

1.   one to two
2.   two to three
3.   three to four
4.   four to five
5.   five to six
6.   I do not know

33.   Which of the following is an **INCORRECT** match?
1.   Plant - starch
2.   animal - glycogen
3.   Golgi apparatus - glycoprotein and lipoproteins
4.   animal - dictyosome
5.   cell - vesicles
6.   I do not know

34.   Which of the following arranges the components of a chloroplast is some logical sequence?

1.   stroma --------> grana --------> thylakoid --------> intergranal thylakoid
2.   grana ---------> thylakoid --------> intergranal thylakoid ------> stroma
3.   thylakoid --------> grana ---------> stroma ---------> intergranal thylakoid
4.   intergranal thylakoid ---------> grana ---------> thylakoid ---------> stroma
5.   chloroplast ---------> stroma --------> intergranal thylakoid -------> grana
6.   I do not know

35.   Carbon dioxide and oxygen .... across the plasma membrane.

1.   diffuse freely
2.   use temporal apertures to move
3.   use permanent apentures to move
4.   use carrier proteins to move
5.   use active transport to move
6.   I do not know.

36.   Plasmodesmata are associated with

1.   animal cells
2.   cell vacuoles
3.   plastids
4.   plant cell walls
5.   membranes.
6.   I do not know

37.   The longest phase during cell division is the ....

    1.   G1 phase
    2.   G2 phase
    3.   synthesis phase
    4.   mitosis
    ⁵5.   interphase
    6.   I do not know

38.   Which phase during cell division most suits the following description: Cell contents have all been doubled.

    1.   G1 phase
    2.   G2 phase
    3.   synthesis phase
    4.   mitosis
    5.   cytokinesis
    6.   I do not know

39.   Chiasma formation takes place during.......

    1.   middle prophase
    2.   metaphase
    3.   anaphase
    4.   telophase
    5.   meiosis II
    6.   I do not know

40.   Which of the following is the correct spelling of the acronym ATP.

    1.   Adenine Triphosphate
    2.   Adenine Triosephosphate
    3.   Adenosine Triphosphate
    4.   Adenosine Triosephosphate
    5.   Adenine Trinucleotide phosphate
    6.   I do not know

41.   The molecule which enters the glycolysis path of metabolism is ....

    1.   Fructose
    2.   Glucose
    3.   Adolase
    4.   sucrose
    5.   Maltose
    6.   I do not know

42.   The addition of inorganic phosphate to glyceraldehyde phosphate yields

    1.   2 - phosphoglyceric acid
    2.   Hydroxy acetone
    3.   glyceraldehyde
    4.   1,3 diphosphoglycerate
    5.   fructo - 1-6 - diphosphate
    6.   I do not know

43. The enzyme responsible for the conversion of 2-phosphoglyceric acid to phosphoenolypyruvic acid is

    1.   Adolase
    2.   phosphoglycerate kinase
    3.   enolase ·
    4.   glyceraldehyde phosphatase
    5.   protease
    6.   I do not know

44. The chemical analysis of pyruvic acid is as follows:

    1.   Three carbons, three oxygens, 5-single covalent bonds
    2.   Three carbons, four hydrogens, three oxygens, 5 - double covalent bonds
    3.   Two carbons, four hydrones, two oxygens, 2 - single bonds, 2 - double covalent bonds
    4.   Two carbons, five hydrogens, three oxygens, 1 - single covalent bond, 1 - double covalent bond
    5.   Three carbons, four hydrogens, three oxgens, 3 - single covalent bonds, 2 - double covalent bonds
    6.   I do not know

45. The Kreb's cycle reactions take place in the

    1.   Cytoplasm
    2.   mitochondrion
    3.   stroma of the chloroplast
    4.   stroma of the leucoplast
    5.   cisternae membrane of the golgi body
    6.   I do not know

46. The end products of respiration are:

    1.   water, carbon dioxide and oxygen
    2.   Oxygen, water and ATP
    3.   Glucose, water and ATP
    4.   ATP, water and chemical energy
    5.   chemical energy, water and carbon dioxide
    6.   I do not know

47. Which molecule is harvested during the citric acid cycle and becomes very useful for the generation of energy during the electron carrier system?

    1.   carbon dioxide
    2.   NADH :
    3.   ATP
    4.   NAD+
    5.   oxaloacetic acid
    6.   I do not know

48. Name the final electron acceptor molecule in respiration

    1.   FADH
    2. $FADH_2$
    3.   NADH
    4. H_2O

5. O_2
6. I do not know

49. The first formed cell must have been a(n)

    1. autotroph
    2. parasite
    3. heterotroph
    4. multicellular organism
    5. autotrophic unicellular organism
    6. I do not know

50. The largest vacuole is commonly found in

    1. the cells of an adult plant
    2. the cells of an adult animal
    3. the old cells of a plant
    4. the old cells of an animal
    5. the youngest cells of both animal and plant cells
    6. I do not know

51. In *Drosophila*, the gene for long wings is dominant to the gene for vestigial wings. Two heterozygous long-winged flies were mated, and the female laid a batch of 92 eggs. Approximately how many of these would you expect to develop into long-winged flies?

    1. 92
    2. 70
    3. 45
    4. 25
    5. 46
    6. I do not know

52. Of the long-winged flies developing from the eggs mentioned in question 51, approximately what proportion would be homozygous for wing length?

    1. 0%
    2. 25%
    3. 331/3%
    4. 50%
    5. 75%
    6. I do not know

53. In humans, the gene for the ability to roll the tongue (R) is dominant to the gene for the inability to roll the tongue (r). Two brothers, whose parents were both tongue-rollers, also have the ability to roll their tongues. One of the grandfathers could not roll his tongue. What are the genotypes of the two brothers?

    1. RR and RR
    2. Rr and Rr
    3. RR and Rr
    4. 2 and 3 above
    5. impossible to tell from the information given
    6. I do not know

10

54. What would be the genotype of the two brothers mentioned in question 53 if neither grandfather could roll his tongue?

    1. RR and RR
    2. Rr and Rr
    3. RR and Rr
    4. rr and rr
    5. impossible to tell from the information given
    6. I do not know

55. In pea plants, the gene for red flowers is dominant to the gene for white flowers. A heterozygous red-flowered plant was crossed with a white flowered plant. What were the ratios of the progeny phenotypes?

    1. all red
    2. 1 red:2 pink:1 white
    3. 3 red : 1 white
    4. 1 red: 1 white
    5. 1 red: 1 white
    6. I do not know

56. The following diagram shows four stages in a type of nuclear division. Two pairs of chromosomes are illustrated.
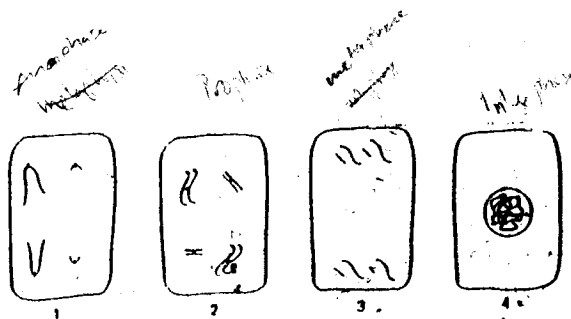
    Which of the following gives the correct order for the four stages?

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

57. An adopted child (blood type O) has located her biological father and discovered that he has blood type B. Which blood type does she know her biological mother does not have?

    1. A
    2. B
    3. AB

11

4.   O
5.   None of the blood types can be eliminated; the biological mother could have any of them.
6.   I do not know

58.   In the ABO blood system, there are six possible genotypes but only four phenotypes. An explanation for this is that the ABO blood groups are controlled by

1.   one gene locus with three codominant alleles
2.   one gene locus with two codominant alleles and two recessive alleles
3./ one gene locus with two codominant alleles and one recessive alleles
4.   only two alleles of a gene can present in a diploid individual
5.   two of the above
6.   I do not know

59.   Which of the following is not a characteristic of meiosis?

1.   chromosomes arrange themselves in pairs
2.   produces daughter cells with half the normal number of chromosomes
3.   consists of two divisions, one after the other
4.   occurs in cells throughout the body
5.   allows the reassortment of characteristics in the offspring
6.   I do not know

60.   What are the phenotypes of the parents of a colour-blind son and a non-carrier daughter with normal colour vision?

1.   a carrier father and normal mother
2.   a colour-blind father and carrier mother
3.   a colour-blind father and a colour-blind mother
4.   a normal father and a carrier mother
5.   a normal father and a colour-blind mother
6.   I do not know

61.   The following pedigree is concerned with an inherited dental abnormality, *amelogenesis imperfecta*. Deduce the most likely mode of inheritance.
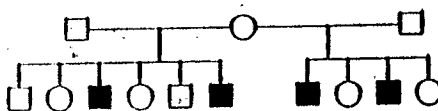
1.   autosomal recessive
2.   autosomal dominant
3.   sex-linked recessive
4.   sex influenced
5.   sex limited
6.   I do not know

12

62. Down's syndrome can exist in two forms. The mosaic form arises from the presence of two or more cell types in the body with differences in chromosome number and structure. Classic Down's syndrome affects all cells and is very severe. How does the classic condition arise?

    1. non-disjunction of chromosomes in mitosis in early fetal development
    2. non-disjunction of chromosomes in meiosis during formation of ova
    3. non-disjunction of chromosomes in meiosis during formation of sperm
    4. both 2 and 3 above
    5. translocation of one chromosome to chromosome 21
    6. I do not know

63. Which of the following statements is **false** about continuous variation?

    1. environmental influence is larger than gene effect
    2. gives in a Guassian Curve distribution
    3. they are determined by a single pair of alleles
    4. they are determined by several genes
    5. they are influenced by both genes and environment
    6. I do not know

64. What is the sex chromosome content of a human egg cell?

    1. X0
    2. AX
    3. X
    4. XX
    5. two of the above
    6. I do not know

65. Hemophilia is caused by

    1. a dominant gene carried on the X chromosome
    2. a dominant gene carried on the Y chromosome
    3. a recessive gene carried on the X chromosome
    4. a recessive gene carried on the Y chromosome
    5. a recessive gene carried on both the X and the Y chromosomes
    6. I do not know

66. A couple who are both carries (heterozygous) for a fatal genetic disorder might be advised not to have children because

    1. all their children are certain to show the disorder
    2. the mother would be harmed during pregnancy
    3. the children could inherit a recessive gene from each parent
    4. the children's genes are likely to mutate
    5. they cannot have normal children
    6. I do not know

67. A couple have 2 sons and are expecting a third child. What is the probability that this child will be another son?

    1. 12.5%
    2. 50%
    3. 25%
    4. 33.3%

13

5. 100%
6. I do not know

68. Which of the following human characteristics are controlled by a single pair of alleles?

1. height
2. —sickle cell anemia
3. skin colour
4. — tongue rolling ability
5. two of the above .
6. I do not know

Questions 69 and 70 refer to the list below

1. allele
2. bivalent
3. chromatid
4. diploid
5. genotype
6. haploid
7. heterozygote
8. homozygote
9. phenotype
10. homogametic

69. An organism which has two different alleles of the same gene

1. 2
2. 4
3. 7
4. 9
5. 10
6. I do not know

70. A description of an organism in terms of what can be seen or measured.

1. 1
2. 2
3. 5
4. 7
5. 9
6. I do not know

71. Which of the following are advantages of pea plants over fruit flies as material for experimental work in genetics?

1. self ferlilisation possible
2. less space needed ,
3. large numbers of offspring
4. shorter generation time
5. all of the above
6. I do not know

72. An F1 progeny from a parental cross; AABB x aabb produces four gametes, i.e., two parental types and two recombinants. Which set of gametes represents recombinants.

14

1. AB and ab
2. Ab and aB ·
3. AB and aB
4. aB and ab
5. Ba and AB
6. I do not know

73.   XY males will have how many bar bodies in their cell nucleus?

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

74.   In the test of Goodnes of fit, if a calculated chi-sqaure value corresponds to a probability of less than 0.05 this means that

1.   there is a signifiacnt difference between observed results and the expected results
2.   the null hypothesis should be accepted
3.   the null hypothesis should be rejected
4.   the difference between observed and expected results is not significant
5.   two of the above are correct
6.   I do not know

75.   Normal leg size, characteristic of kerry type of cattle, is produced by homozygous genotype (DD). The short legged type cattle possess the heterozygous genotype (Dd)-. The homozygous genotype (dd) is lethal, producing grossly deformed stillborn calves called "bulldog calves". The presence of horns in cattle is governed by the recessive allele of another gene locus 'p', the polled condition (absence of horns) being produced by its dominant allele 'P'. In matings between polled dexter cattle of genotype DdPp, what phenotypic ratio is expected in the adult progeny?

1.   3:1:6:2:1 ·
2.   3:1:6:2
3.   3:1:6:2:4
4. ·   9:3:3:1 ·
5.   none of the above
6.   I do not know

76.   In pigeon, the grizzle colour pattern depends on a dominant autosomal gene G. A mating of two grizzle birds produced one nongrizzle youngster. If this pair of pigeons produces more youngsters next year, what percentage would be expected to be grizzles?

1.   100%
2.   75%
3.   50%
4.   25%
5.   0%
6.   I do not know

77.   Which further cross would a pigeon breeder carry out in order to confirm the exact genotype of grizzle birds which were used in the mating in question 76 above.

15

1. GG x Gg
2. GG x gg
3. Gg x gg
4. GG x GG
5. 2 of the above
6. I do not know

78. In the cross(es) carried out in question 77 above in what proportions are the offspring expected to be?

    1. 3 grizzle:1 nongrizzle
    2. all grizzle
    3. all non grizzles
    4. 1 grizzle:1nongrizzle
    5. 2 of the above
    6. I do not know

79. What name do you give to the special type of cross (es) carried in question 77 above?

    1. back cross
    2. test cross
    3. monohybrid cross
    4. reciprocal cross
    5. 1 and 2 above
    6. I do not know

80. In rabbits, full colour (C), Himalayan (c^h), and albinism (c) form a series of multiple alleles with dominance in the order given. What will be the appearance of the offspring of the cross between a homozygous coloured rabbit and a homozygous himalayan rabbit.

    1. full coloured offspring only
    2. coloured and himalayan offspring
    3. himalayan offspring only
    4. offspring with intermediate colour between full colour and himalayan
    5. offspring with patches of himalayan and full colour
    6. I do not know

81. What will be the appearance of the F2 from question 80 above.

    1. full coloured offspring only
    2. himalayan offspring only
    3. offspring with intermediate colour between full colour and himalayan
    4. full colour and himalayan offspring in a 1:1 ratio
    5. coloured and himalayan offspring in a ratio of 3:1
    6. I do not know

82. Only pink tulips results from a cross between homozygous red and homozygous white tulips. This illustrates the principle of

    1. independent assortment
    2. segregation
    3. codominance
    4. incomplete dominance
    5. dominance
    6. I do not know

16

Questions 83, 84 and 85 are based on the following information:

In chickens, the character of comb is determined by two pairs of independently segregating genes P, p and R, r. The gene P produces a pea comb in the absence of R; the gene R produces a rose comb in the absence of P. When both P and R are present, they produce a walnut comb. pprr produces a single comb.

83. Which one of the following crosses would produce only walnut and rose progeny?

    1. RrPP x rrPp
    2. RrPp x rrPp
    3. RRPp x rrPP
    4. RrPP x rrPp
    5. RRPp x rrPp
    6. I do not know

84. Which one of the following results may not be obtained by crossing a rose combed bird with a pea combed bird?

    1. walnut, rose, pea and single
    2. rose and pea only
    3. walnut and pea only
    4. walnut and rose only
    5. all walnut
    6. I do not know

85. When a walnut comb bird was crossed with a pea comb bird, the progeny was all walnut-combed. The probable genotypes of the parents were

    1. RRPp x rrPP
    2. RrPp x rrPp
    3. RrPP x rrPp
    4. RrPp x rrPP
    5. RRPp x rrPp
    6. I do not know

86. From a certain back cross, Mendel obtained 315 yellow, smooth seeds, 312 yellow, wrinkled seeds, 320 green, wrinkled seeds and 317 green, smooth seeds. What would you predict the genotypes of this back cross to be?

    1. YYWW x yyWW
    2. YYWW x yyww
    3. YyWw x yyww
    4. YyWw x YyWwy
    5. YyWw x YYWw
    6. I do not know

87. In Andalusian fowls, the heterozygous condition of alleles for black plumage (B) and white (b) is blue. What offspring will a blue Andalusian fowl have if bred to birds of blue plumage colour.

    1. Black and blue only
    2. Black and white only
    3. Blue and white only
    4. Black only
    5. Black, blue and white

6. I do not know

88. In the cross MmNnOo x MmNnOo what will be the expected frequency of MmNnOO individuals in the progeny

1. 16/64
2. 8/64
3. 4/64
4. 1/64
5. 2/64
6. I do not know

89. Colour blindness is a sex-linked condition caused by a recessive allele. Which one of the following correctly gives the percentage probability of a colour blind man and his normal wife, whose father was.colour blind, producing a colour blind child?

1. 50%
2. 75%
3. 100%
4. 25%
5. 0%
6. I do not know

90. The allele for pea comb (P) in chickens is dominant to that for single comb (p), but the alleles black (B) and white (B') for feather colour show partial dominance, B/B' individuals having "blue" feathers. If birds heterozygous for both alleles are mated, what proportion of the offspring are expected to be black-feathered and single -combed?

1. 1/16
2. 3/16
3. 4/64
4. 8/16
5. 9/16
6. I do not know

91. Mendel's second law states that

1. different segregating alleles assort independently
2. independent assorting alleles occur in same numbers
3. different segregating alleles assort equally
4. alleles assort from each other in equal frequency
5. 1 and 4 together
6. I do not know

92. In human, sex is determined at fertilisation by

1. 11 pairs of autosomes
2. two pairs of sex chromosomes
3. 23 pairs of chromosomes
4. 22 pairs of autosomes
5. one pair of sex chromosomes
6. I do not know

93. Which of the following genetic scenario explains abortion in certain pregnancies due to the rhesus factor.

18

1. Father Rh-, mother Rh+, fetus Rh-
2. Father Rh-, mother Rh+, fetus Rh-
3. Father Rh+, mother Rh+, fetus Rh+
4. Father Rh-, mother Rh-, fetus Rh+
5. None of the above
6. I do not know

94. Which is the genetic disease in which abnormal hemoglobin leads to fragile red blood cells and obstructed blood vessels?

1. leukemia
2. agglutination of red blood cells due to mixing of incompatible blood groups
3. sickle cell anemia
4. phenylketonuria
5. erythroblastosis fetalis
6. I do not know

95. A sublethal gene is one that

1. kills the carrier before birth
2. expresses itself only in certain heterozygous carriers
3. kills the carrier just after birth
4. modifies the expression of certain traits
5. kills carrier in his adult life
6. I do not know

96. Which of the following is an example of a sex influenced trait

1. milk production in cows
2. beard development
3. non-functional sweat glands
4. pattern baldness
5. defective tooth enamel
6. I do not know

97. The degree to which a given gene expresses itself in the phenotype is termed

1. variable expressivity
2. hypostatis
3. penetrance
4. dominance
5. hypostatic
6. I do not know

The following introduction belongs to questions 98-100. Tomato plants with purple stems are produced by the action of a dominant allele P, and plants with green stems by its recessive allele p. Hairy stems are produced by a dominant gene H, and hairless by its recessive allele h. A double heterozygous plant with a purple, hairy stem is test crossed. The progeny were observed to be:

Phenotype	Number
Purple, hairy stem	179
Green, hairless stem	181
Purple, hairless stem	44
Green, hairy stem	46

Carry out a chi-aquare analysis of these data and answer the following questions. The chi-square table is appended to this exam paper.

98.   The chi-square value is:

1.   3.2
2.   1.6
3.   112.5
4.   96.1 ·
5.   283.8
6.   I do not know

99.   The probability is :

1.   between 1 and 5 %
2.   1%
3.   less than 1%
4.   5%
5.   greater than 5 %
6.   I do not know

100.   The conclusion that can be drawn from this analysis is that:

1.   the genes are segregating independently
2.   the genes are linked
3.   the genes are not linked
4.   the counting was not accurate because two classes are over represented
5.   accept the null hypothesis
6.   I do not know

****

END OF EXAMINATION

Table 4 The probabilities associated with values of χ^2

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

20

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER SUPP/DEFERRED EXAMS - DECEMBER 1999

BS 111

THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS:

1.   ANSWER ALL QUESTIONS IN ANY ORDER

2.   ALL QUESTIONS CARRY EQUAL MARKS (+4)

3.   A WRONG ANSWER CARRIES -1 MARK

4.   'I DON'T KNOW' CARRIES ZERO MARK

5.   DON'T GUESS

CELL BIOLOGY

1
.
.
.
50

51   GENETICS
.
.
.

100

END OF EXAMINATION

CELL BIOLOGY

1. Which of the following organelles of a cell is the largest?

    1. mitochondrion
    2. ribosome
    3. chloroplast
    4. endoplasmic reticulum
    5. rough endoplasmic reticulum
    6. I don't know

2. The organelle in a cell with a highly folded inner membrane is called the ...

    1. mitochondrion
    2. nuclear envelope
    3. golgi vesicle
    4. lysosome
    5. cytoskeleton
    6. I don't know

3. The smooth endoplasmic reticulum constitutes part of a cell's extensive membrane transport system. This statement is ....

    1. false
    2. only true for the eukaryotic cell
    3. only true for the prokaryotic cell
    4. true for both the prokaryotic and eukaryotic cells
    5. true and false depending on the cell in question
    6. I don't know

4. Which of the following statements is **FALSE**?

    1. DNA consists of two antiparallel polynucleotide chains twisted about each other in the form of a right-handed double helix
    2. The sugar phosphate backbone spirals around the outside of the bases
    3. The complementary bases between the backbone are held together by a hydrogen bond
    4. Adenine is always paired with thymine
    5. Guanine is always paired with adenine
    6. I don't know

5. In biological systems, organic molecules may lose their hydrogen atoms. The organic compound which has lost a hydrogen atom is said to have been...

1. oxidized
2. reduced
3. synthesised
4. gained electrons
5. strengthened with a hydrogen bond
6. I don't know

6. Glycolysis is the part of cellular respiration which takes place...

1. inside the mitochondrion
2. outside the mitochondrion
3. inside the membrane of the mitochondrion
4. between the inner and outer membranes of the mitochondrion
5. all the above statements above do not apply
6. I don't know

7. The hydrogen bond in water is strongest in ...

1. water vapour
2. liquid water
3. water in the form of ice
4. all of the above
5. none of the above
6. I don't know

8. Pyruvic acid has ... in its structural formula

1. two hydrogens and two carbons
2. three hydrogens and three carbons
3. four hydrogens and two carbons
4. four hydrogens and three carbons
5. five hydrogens and five carbons
6. I don't know

9. The fate of hydrogen atoms from respiratory intemediates during glycolysis and Kreb's cycle are ultimately ...

   1. oxidized to oxaloactecic acid
   2. oxidized to water by molecular oxygen
   3. reduced to oxygen by hydrogen
   4. reduced to succinic acid
   5. oxidized to ATP
   6. I don't know

10. Which of the following processes yields more ATP?

   1. respiratory chain
   2. Kreb's cycle —
   3. glycolysis
   4. citric acid cycle
   5. all of the above
   6. I don't know

11. The fossil record indicates that prokaryotes reigned supreme for at least ... years

   1. one billion
   2. seven billion
   3. five billion
   4. forty thousand years
   5. two billion
   6. I don't know

12. The biological success of the prokaryotes on earth, can be attributed to their ...

   1. non-ability to divide under favourable conditions
   2. rather high number of neclei in the cytoplasm
   3. rapid rate of cell division and their great metabolic rate
   4. ability to swim around
   5. rather low rate of ATP production during cell division
   6. I don't know

13. The structure which is partly responsible for movement in unicellular organisms is the ....

    1. microfilament
    2. microtubule
    3. microtrabeculae
    4. vacuole
    5. ribosome
    6. I don't know

14. Structures associated with protein synthesis in cells are called ...

    1. vesicles
    2. lysosomes
    3. nucleoli
    4. ribosomes
    5. none of the above
    6. I don't know

15. Prokaryotic cells analysed so far show the presence of ...

    1. a nucleus
    2. DNA enclosed in a nuclear envelope
    3. a nucleolus as the control centre of the cell
    4. several nuclei
    5. DNA as a single strand without a nuclear envelope
    6. I don't know

16. An ester bond is characteristic of ...

    1. carbohydrate condensation
    2. amino acid condensation
    3. glycosidic condensation
    4. lipid condensation
    5. none of the above
    6. I don't know

17. Cell membranes are generally composed of ...

    1. cholesterol
    2. inorganic phosphorus
    3. lipid and protein complexes
    4. inorganic phosphates
    5. carbohydrate complexes only
    6. I don't know

5

18. The cell components with very powerful hydrolytic ensymes are called ...

    1. ribosomes
    2. vesicles
    3. lysosomes
    4. transfer vesicles
    5. ribosomal vesicles
    6. I don't know

19. Protein and DNA are the main constituents of ...

    1. chromosomes
    2. the plasmalemma
    3. the inner membrane of mitochondria
    4. cell membranes
    5. the 'sol' part of the cell
    6. I don't know

20. The final electron acceptor in respiration is

    1. oxygen
    2. carbon dioxide
    3. water
    4. NaOH
    5. FADH
    6. I don't know

21. During glycolysis, glucose is broken down to two, 3-carbon molecules. One of these molecules is shunted down the respiratory path for further processing. This molecule is called

    1. hydroxy acetone
    2. phosphogluco isomerase
    3. adolase
    4. glyceral aldehyde
    5. fructo diphosphate
    6. I don't know

22.   Which of the following statements is **CORRECT**?

    1.   phospholipids are bipolar ✓
    2.   polar regions are insoluble in water γ
    3.   non polar regions are hydrophilic ×
    4.   plasma membranes are exclusively made up of phospholipids ·
    5.   all the above statements are correct
    6.   I don't know

23.   Which of the following statements is **FALSE**?

    1.   When proteins are dispersed evenly in a liquid, the condition is called a 'sol'
    2.   When, in a colloid the solute adheres together forming a network within a liquid, the condition is referred to as a 'jel'
    3.   Most cells have their cytoplasm in a colloidal state
    4.   All the statements above are accurate
    5.   All statements above are not correct
    6.   I don't know

24.   Glycerol structural formula is as follows:

    1.   2 carbons, 2 oxygens, 8 hydrogens
    2.   3 carbons, 3 oxygens, 8 hydrogens
    3.   3 carbons, 2 hydroxyl ions, 8 hydrogens
    4.   2 carbons, 8 hydroxyl ions, 3 hydrogens
    5.   1 carbon, 1 hydroxyl ions, 1 hydrogen
    6.   I don't know

25.   Condensation of glycerol and fatty acid produces

    1.   acetone
    2.   triglyceride
    3.   oleic acid
    4.   stearic acid
    5.   glycerol
    6.   I don't know

26. The energy given off in respiration is harvested in the form of chemical energy stored in the ...

    1. first phosphate bond of NAD
    2. third pyro-phosphate bond of ATP
    3. high energy bond of FAD
    4. double bonds of carbon dioxide
    5. high energy bond of pyruvic acid
    6. I don't know

27. The term hexokinase if analysed closely means ...

    1. a six carbon sugar molecule
    2. an enzyme which helps to synthesise an eight carbon sugar
    3. an enzyme whose substrate is a six carbon substance
    4. an eight carbon sugar substrate
    5. only 3 and 4 above are correct
    6. I don't know

28. Which of the following statement is **FALSE?**

    1. The electrons in the covalent bonds of water are shared equally between hydrogens and oxygen
    2. Water content in cells is around 75%
    3. Water is a bipolar molecule
    4. Most of the oxygen and hydrogen in organisms is accounted for by water
    5. Given a water body, some hydrogen bonds in the water are stronger than others
    6. I don't know

29. One of the following sugars has been assigned a WRONG FUNCTION. Identify it.

    1. Trioses (e.g. glyceraldehyde) - play a major role as intermediates in respiration
    2. Pentoses (e.g. ribose) - important in synthesis of nucleic acids etc.
    3. Hexoses (e.g. fructose) - acts as a source of energy in respiration
    4. monosaccharides - utilized as molecules for synthesis of larger sugar molecules
    5. all the statements above are not correct
    6. I don't know

30. One of the following items is not present in an amino acid. Can you identify it?

1. alkyl group
2. amino group
3. carboxyl group
4. a phosphate group
5. hydrogen
6. I don't know

31. The simplest amino acid is ...

1. alanine
2. haemoglobin
3. valane
4. glycine
5. sulphur
6. I don't know

32. Which of the following parts together constitute a nucleotide.

1. ribose, glucose, appropriate base
2. hydroxyl group, hydrogen, phosphoric acid
3. deoxyribose, phosphoric acid, alkyl group
4. phosphoric acid, ribose, appropriate base ,
5. disaccharide, adenine, triose
6. I don't know

33. The DNA model was published by ... in ...

1. Oparin, 1920
2. Watson and Crick, 1953
3. Mendel, 1949
4. Daniel, 1817
5. Darwin, 1517
6. I don't know

34. The substance in which the nucleoli of the nucleus are suspended is called

1. cytoplasm
2. protoplasm
3. nucleoplasm
4. ectoplasm
5. endoplasm
6. I don't know

35. How many histones are found in a nucleosome of a chromosome

   1. eight
   2. four
   3. six
   4. five
   5. two ✓
   6. I don't know

36. Which of the following cells could contain numerous rought endoplasmic reticulum?

   1. skin cells
   2. cells of the digestive system of animals
   3. nasal cavity cells
   4. cells of the eyes
   5. all of the above
   6. I don't know

37. Which of the following stages in cell division is the shortest?

   1. interphase
   2. mitosis
   3. cytokinesis
   4. meiosis
   5. synthesis phase
   6. I don't know

38. Chiasma formation usually occurs during the ... stage of meiosis

   1. prophase
   2. leptotene
   3. pachytene
   4. anaphase
   5. interphase
   6. I don't know

39. The molecule which forms the link between glycolysis and the Kreb's cycle is called ...

    1. ATP
    2. NAD
    3. pyruvic acid
    4. coenzyme
    5. acetyl CoA
    6. I don't know

40. Pioneers involved in the development of the first types of microscopes in the 17th century include

    1. Antoni van Lesuwenhoek and Robert Hooke
    2. W. Flemming and E. Strasburger
    3. J. Purkinje and T. Huxley
    4. Mathias Schleiden and Abbe Dutrochet
    5. none of the above
    6. I don't know

41. Essential inorganic elements, found in the majority of living systems are ...

    1. P, N, H, O and C
    2. Na, Mg, S, Cl, K, ca and Fe
    3. Li, Si, Ni, Mo and he
    4. amino acids, sugars and carbohydrates
    5. all salts
    6. I don't know

42. Mitochondria are functionally involved in ...

    1. RNA synthesis
    2. translocation of chromosomes during mitosis
    3. energy transformations involving ATP
    4. cell secretion process
    5. entry and exit of lipids in cell membranes
    6. I don't know

43. Cell membranes are generally composed of

    1.   steroids, terpenes and carbohydrate polymers
    2.   fatty acids and amino sugars
    3.   sphingosine and cholesterol
    4.   phospholipids, glycoproteins
    5.   none of the above
    6.   I don't know

44. One of the following is **NOT** a macromolecule. Which one?

    1.   DNA
    2.   glycine
    3.   starch
    4.   oleic acid
    5.   glycogen
    6.   I don't know

45. The elements arsenic, copper, lead and zinc are all poisonous to man. Yet two of them are essential in the diet in very small quantities. Which are these?

    1.   As, Pb
    2.   As, Zn
    3.   Cu, Pb
    4.   As, Cu
    5.   Cu, Zn
    6.   I don't know

46. Transcription of the DNA molecule involves copying the base sequence onto ...

    1.   RNA polymerase
    2.   tRNA
    3.   mRNA
    4.   amino acids
    5.   all of the above
    6.   I don't know

47. The organelles responsible for 'packaging' synthesized protein and exporting it to the outside of the cell are known as:

    1. microtubules
    2. lysosomes
    3. mitochondria
    4. peroxisomes
    5. golgi apparatus
    6. I don't know

48. The internal structure(s) of the cell responsible for movement and for maintaining its shape is the ...

    1. endoplasmic reticulum
    2. vacuole
    3. nuclear membrane
    4. cytoskeleton
    5. plasmalemma
    6. I don't know

49. One of the following is not a carbohydrate. Which one?

    1. glycerol
    2. ribose
    3. starch
    4. glucose
    5. glycogen
    6. I don't know

50. The largest organelle (in diameter) in a biological cell is the ...

    1. nucleus
    2. nucleoli
    3. endoplasmic reticulum
    4. mitochondriom
    5. chloroplast
    6. I don't know

GENETICS

51. In which of the following is mitosis **not** involved?

    1. egg production in the ovary
    2. replacement of epidermis in the skin
    3. production of identical daughter cells
    4. growth
    5. tissue repair
    6. I do not know

52. Fruit fly eggs contain 4 chromosomes; dividing cells of onion root tips contain 16 chromosomes; cabbage pollen grains have 10 chromosomes and human squamous epithelia cell nuclei have 46 chromosomes. Which one of the following correctly lists the diploid (2n) number of chromosomes in the organism listed above in the corresponding order?

    1. 4, 8, 20, 46
    2. 8, 8, 20, 23
    3. 8, 16, 20, 46 -
    4. 8, 16, 20, 23
    5. 4, 8, 10, 23
    6. I do not know

53. Which of the following is the advantage of *Drosophila* over pea plants as material for experimental work in genetics.

    1. controlled crosses possible
    2. shorter generation time
    3. large numbers of offspring
    4. fewer chromosomes
    5. 2 and 4 above
    6. I do not know

54. If an organism with a diploid number of chromosomes of 16 produced four cells by meiosis, how many chromosomes would each cell have?

    1. 16   2. 8   3. 32   3. 48   5. 4   6. I do not know

55. Which of the following human variations **cannot** be inherited?
    1. blood group
    2. length of hair
    3. language spoken
    4. (sex)
    5. left-handedness
    6. I do not know

56. The term genotype is best defined as:

    1. the alleles carried by an organism
    2. the chromosomes carried by an organism
    3. the inherited appearance of an organism
    4. a heterozygous organism
    5. the dominant genes of an organism
    6. I do not know

57. A dominant gene is one which:
    1. dominates behaviour
    2. influences the phenotype
    3. is only found in a homozygous condition
    4. always partners a recessive gene
    5. is only found in a heterozygous condition
        6. I do not know

58. Colour blindness is a sex-linked condition caused by a recessive allele. Which one of the following correctly gives the percentage probability of a colour blind man and his wife who has normal vision (none carrier) having a son who is colour blind?

    1. 25%   2. 50%   3. 75% 4. 100%   5. 0% 6. I do not know

59. Knowledge of the blood-type genotypes of a certain couple leads us to say that if they were to have many children, the ratios of the children's blood types would be expected to approximate 1/2 type A and 1/2 type B. It follows that the blood types of the couple are:

    1. A and B 2. AB and AB   3. AB and B   4. AB and A 5. AB and O
    6. I do not know

60. The allele for pea comb (P) in chickens is dominant to that for single comb (p), but the alleles black (B) and white (B') for feather colour show partial dominance, B/B' individuals having "blue" feathers. If birds heterozygous for both alleles are mated, what proportion of the offspring are expected to be white-feathered and pea-combed?

15

1. 1/16 2. 3/16 3. 4/64 4. 8/16 5. 9/16 6. I do not know

61. The light colour variation in the peppered moth is inherited as a simple recessive characteristic. If a light moth is crossed with a dark moth which had a light parent, what percent of their offspring will be light?

   1. 25% 2. 33% 3. 50% 4. 75% 5. 100% 6. I do not know

62. In a parental cross, an AABBCC individual is paired with an aabbcc individual. Assuming independent assortment, what will be the expected frequency of AaBbCc individuals in the F2 generation?

   1. 16/64 2. 8/64 3. 4/64 4. 2/64 5. 27/64 6. I do not know

63. An F1 progeny from a parental cross; WWYY x wwyy produces four gametes, i.e. two parental types and two recombinants. Which ones are parental types.

   1. WY and yw
   2   yW and wY
   3. YW and yW
   4. wY and yw
   5. yw and wy
   6. I do not know

64. If hairy ears (hypertrichosis) is a holandric trait, what kind of children can be produced by a woman married to a man with smooth (no-hairy) ears?

   1. all children will have hairy ears
   2. all daughters and none of sons will have hairy ears
   3. all the sons and none of the daughters will have hairy ears
   4. all children will have smooth ears
   5. half the male children will have hairy ears and none of the daughters.
   6. I do not know

65. A mutant insulin gene will adversely affect sugar uptake by cells, glycogen levels in the liver and muscles, and the amount of sugar in the blood. Such a gene shows:

   1. epistasis
   2. multiple dominance
   3. multiple allelism
   4. pleiotropism
   5. variable expressivity
   6. I do not know

66. XXY males will have how many bar bodies in their cell nucleus?

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

67. Based on the gene chromosome theory, the law of independent assortment assumes that certain genes are

    1.   formed by chromosomal mutations
    2.   located on the same chromosome
    3.   formed in the germline cells
    4.   located on separate chromosomes .
    5.   influenced by the environment
    6.   I do not know

68. Klinefelter's syndrome is a condition which occurs as a result of

    1.   crossing over
    2.   abnormal mitosis
    3.   gene mutations
    4.   abnormal meiosis
    5.   polyploidy
    6.   I do not know

69. A colour blind man marries a woman with normal vision. Her mother was colour blind. They have one child. What is the chance that this child is colour blind?

    1. 0% 2. 25%   3. 50% 4. 100%   5. 75%   6. I do not know

70. In a particular variety of corn, the kernels tun red when exposed to sunlight. In the absence of sunlight, the kernels remain yellow. Based on this information, it can be concluded that the colour of these corn kernels is due to the

    1. effect of sunlight on photosynthesis
    2. effect of sunlight on transpiration
    3. law of incomplete dominance
    4. principle of sex linkage
    5. effect of environment on gene expression
    6. I do not know

17

71. A sex-linked allele c produces a red-green colour blindness in humans. A normal woman whose father was colour blind marries a colour blind man. What are the chances that the first child from this marriage will be a colour blind boy?

1. 25% 2. 50% 3. 100% 4. 75% 5. 0% 6. I do not know

72. In pea plants, the gene for red flowers is dominant to the gene for white flowers. A heterozygous re-flowered plant was crossed with a white flowered plant. What were the ratios of the progeny phenotypes?

1. all red
2. 1 red:2 pink:1 white
3. 3 red : 1 white
4. 1 red: 1 white
5. 1 red: 1 white
6. I do not know

73. Which of the following represents a test cross:

1. aABb x aaBB
2. AABB x aabb
3. aAbb x aaBB
4. aAbB x aabb
5. None of the above
6. I do not know

74. Skin colour in humans shows quantitative inheritance and is determined by two pairs of polygenes. What fraction of the F2 progeny of the cross AABB x aabb would be expected to show a phenotype identical to one of the parents in the parental generation.

1. 9/16 2. 1/16 3. 6/16 4. 4/16. 5. 3/16 6. I do not know

75. In your genetics practical I, you determined the relative lengths of the various stages of mitosis. Which one did you find to be the longest stage.

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

76. In *Drosophila*, the gene for long wings is dominant to the gene for vestigial wings. Two heterozygous long-winged flies were mated, and the female laid a batch of 92 eggs. Approximately how many of these would you expect to develop into short-winged flies?

1. 92
2. 70
3. 45
4. 25
5. 46
6. I do not know

77. Of the long-winged flies developing from the eggs mentioned in question 76, approximately what proportion would be homozygous for wing length?

1. 0%
2. 25%
3. 33 1/3%
4. 50%
5. 75%
6. I do not know

78. An adopted child (blood type O) has located her biological father and discovered that he has blood type B. Which blood type does she know her biological mother does **not** have?

1. A
2. B
3. AB
4. O
5. None of the blood types can be eliminated; the biological mother could have any of them.
6. I do not know

79. Which of the following is not a characteristic of meiosis?

1. chromosomes arrange themselves in pairs
2. produces daughter cells with half the normal number of chromosomes
3. consists of two divisions, one after the other
4. occurs in cells throughout the body
5. allows the reassortment of characteristics in the offspring
6. I do not know

19

80. What is the sex chromosome content of a human sperm cell?
    1. XO
    2. XY
    3. X
    4. Y
    5. two of the above
    6. I do not know

81. A couple who are both carries (heterozygous) for a fatal genetic disorder might be advised not to have children because

    1. all their children are certain to show the disorder
    2. the mother would be harmed during pregnancy
    3. the children could inherit a recessive gene from each parent
    4. the children's genes are likely to mutate
    5. they cannot have normal children
    6. I do not know

82. A couple have 3 daughters and are expecting a fourth child. What is the probability that this child will be another daughter?

    1. 12.5%
    2. 50%
    3. 25%
    4. 33.3%
    5. 100%
    6. I do not know

83. Which of the following human characteristics is **not** controlled by a single pair of alleles?

    1. sickle cell anemia
    2. Haemophilia
    3. tongue rolling ability
    4. cotyledon colour in peas
    5. None of the above
    6. I do not know

84. Normal leg size, characteristic of kerry type of cattle, is produced by homozygous genotype (DD). The short legged type cattle possess the heterozygous genotype (Dd)-. The homozygous genotype (dd) is lethal, producing grossly deformed stillborn calves called "bulldog calves". The presence of horns in cattle is governed by the recessive allele of another gene locus 'p', the polled condition (absence of horns) being produced by its dominant allele 'P'. In matings between polled dexter cattle of genotype DdPp, what phenotypic ratio is expected in the adult progeny?

   1. 3:1:6:2:1
   2. 3:1:6:2
   3. 3:1:6:2:4
   4. 9:3:3:1
   5. none of the above
   6. I do not know

85. In pigeon, the grizzle colour pattern depends on a dominant autosomal gene G. A mating of two grizzle birds produced one nongrizzle youngster. If this pair of pigeons produces more youngsters next year, what percentage would be expected to be grizzles?

   1. 100%
   2. 75%
   3. 50%
   4. 25%
   5. 0%
   6. I do not know

86. Which further cross would a pigeon breeder carry out in order to confirm the exact genotype of grizzle birds which were used in the mating in question 85 above.

   1. GG x Gg
   2. GG x gg
   3. Gg x gg .
   4. GG x GG
   5. 2 of the above
   6.   I do not know

87. In the cross(es) carried out in question 86 above in what proportions are the offspring expected to be

  1. 3 grizzle:1 nongrizzle
  2. all grizzle
  3. all non grizzles
  4. 1 grizzle:1nongrizzle
  5. 2 of the above
  6. I do not know

88. In rabbits, full colour (C), Himalayan (c^h), and albinism (c) form a series of multiple alleles with dominance in the order given. What will be the appearance of the offspring of the cross between a homozygous coloured rabbit and a homozygous himalayan rabbit.

  1. full coloured offspring only
  2. coloured and himalayan offspring
  3. himalayan offspring only
  4. offspring with intermediate colour between full colour and himalayan
  5. offspring with patches of himalayan and full colour
  6. I do not know

89. What will be the appearance of the F2 from question 88 above.

  1. full coloured offspring only
  2. himalayan offspring only
  3. offspring with intermediate colour between full colour and himalayan
  4. full colour and himalayan offspring in a 1:1 ratio
  5. coloured and himalayan offspring in a ratio of 3:1
  6. I do not know

90. Only pink tulips results from a cross between homozygous red and homozygous white tulips. This illustrates the principle of

  1. independent assortment
  2. segregation
  3. codominance
  4. incomplete dominance
  5. dominance
  6. I do not know

Questions 91 and 92 are based on the following information:

In chickens, the character of comb is determined by two pairs of independently segregating genes P, p and R, r. The gene P produces a pea comb in the absence of R; the gene R produces a rose comb in the absence of P. When both P and R are present, they produce a walnut comb. pprr produces a single comb.

91.   Which one of the following crosses would produce only walnut and rose progeny?

        1.   RrPP x rrPp
        2.   RrPp x rrPp
        3.   RRPp x rrPP
        4.   RrPP x rrPp
        5.   RRPp x rrPp
        6.   I do not know

92.   Which one of the following results may not be obtained by crossing a rose combed bird with a pea combed bird?

        1.   walnut, rose, pea and single
        2.   rose and pea only
        3.   walnut and pea only
        4.   walnut and rose only
        5.   all walnut
        6.   I do not know

93.   When a walnut comb bird was crossed with a pea comb bird, the progeny was all walnut-combed. The probable genotypes of the parents were

        1.   RRPp x rrPP
        2.   RrPp x rrPp
        3.   RrPP x rrPp
        4.   RrPp x rrPP
        5.   RRPp x rrPp
        6.   I do not know

94. A particular sex-linked recessive disease of humans is usually fatal. Suppose that by chance a boy with the disease lives past puberty and marries a woman heterozygous for the trait. If they have a daughter, what is the probability that she will have the disease?

    1. 0%
    2. 75%
    3. 25%
    4. 100%
    5. 50%
    6. I do not know

95. Which is the genetic disease in which abnormal hemoglobin leads to fragile red blood cells and obstructed blood vessels?

    1. leukemia
    2. agglutination of red blood cells due to mixing of incompatible blood groups
    3. sickle cell anemia
    4. phenylketonuria
    5. erythroblastosis fetalis
    6. I do not know

96. A sublethal gene is one that

    1. kills the carrier before birth
    2. expresses itself only in certain heterozygous carriers
    3. kills the carrier just after birth
    4. modifies the expression of certain traits
    5. kills carrier in his adult life
    6. I do not know

97. The degree to which a given gene expresses itself in the phenotype is termed

    1. variable expressivity
    2. hypostatis
    3. penetrance
    4. dominance
    5. hypostatic
    6. I do not know

98. Four of the following statements are part of both meiosis and mitosis, but one is only meiotic. Which one?

    1.   Spindle formation
    2.   Chromatid formation
    3.   Chromosome pairing
    4.   Chromosome condensation
    5.   Chromosome movement to poles
    6.   I do not know

99. Baldness is a sex-influenced character. If heterozygous parents produce four girls what will be the ratio of the bald and normal children?

    1.   Bald 3:Normal 1
    2.   Baled 1: Normal 3
    3.   Baled 1 : Normal 1
    4.   Baled 0 : Normal 4
    5.   Baled 4 : Normal 0
    6.   I do not know

100. Which of the following aberrations (chromosomal changes) cause "CRI DU CHAT" (Cat cry) Sydrome?

    1.   Translocation
    2.   Inversion
    3.   Dificiency
    4.   Non-dysjunction
    5.   Duplication
    6.   I do not know

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THE UNIVERSITY OF ZAMBIA
UNIVRSITY FIRST SEMESTER EXAMINATIONS – MAY 1999

BS 211

CELL MOLECULAR BIOLOGY AND GENETICS

PRACTICAL PAPER

TIME: **THREE** HOURS

ANSWER: 1) **ALL** QUESTIONS

2) SECTION A AND SECTION B SHOULD BE ANSWERED IN **SEPARATE** ANSWER BOOKLETS.

SECTION A: CELL MOLECULAR BIOLOGY

After reading the question carefully, proceed to answering it.

SECTION B: GENETICS

After reading the question carefully, proceed to answering it.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS - MAY 1999

BS 211 PRACTICAL PAPER

SECTION A

In an experiment to determine the absorption spectrum for ether extract of chlorophyll a, the following data were obtained:

λ(nm)	%T	λ(nm)	%T
400	27.00	560	83.00
410	13.00	570	79.25
420	13.25	580	70.75
430	8.50	590	75.75
440	6.75	600	72.25
450	20.00	610	63.00
460	79.25	620	56.25
470	85.00	630	57.50
480	77.50	640	60.25
490	79.25	650	39.75
500	83.00	660	22.50
510	85.00	670	10.75
520	83.00		
530	79.25	680	70.75
540	74.00	690	77.50
550	79.25	700	85.00

Using the information provided in Table 1-3, A and B do the following:

a.   Plot the absorbance spectrum of chlorophyll a

b.   Identify the wavelength(s) at which chlorophyll a absorbs maximally.

c.   Why do leaves of those plants in which chlorophyll is the predominant pigment appear green?

A.

TABLE 1-3 Conversion of percent transmittance (%T) into absorbance (A)

%T	Absorb (A)				%T	Absorb (A)			
		1	2	3			1	2	3
	(.00)	(.25)	(.50)	(.75)		(.00)	(.25)	(.50)	(.75)
1	2.000	1.903	1.824	1.757	51	.2924	.2903	.2882	.2861
2	1.699	1.648	1.602	1.561	52	.2840	.2819	.2798	.2777
3	1.523	1.488	1.456	1.426	53	.2756	.2736	.2716	.2696
4	1.398	1.372	1.347	1.323	54	.2676	.2656	.2636	.2616
5	1.301	1.280	1.260	1.240	55	.2596	.2577	.2557	.2537
6	1.222	1.204	1.187	1.171	56	.2518	.2499	.2480	.2460
7	1.155	1.140	1.126	1.112	57	.2441	.2422	.2403	.2384
8	1.097	1.083	1.071	1.059	58	.2366	.2347	.2328	.2310
9	1.046	1.034	1.022	1.011	59	.2291	.2273	.2255	.2236
10	1.000	.989	.979	.969	60	.2218	.2200	.2182	.2164
11	.959	.949	.939	.930	61	.2147	.2129	.2111	.2093
12	.921	.912	.903	.894	62	.2076	.2059	.2041	.2024
13	.886	.878	.870	.862	63	.2007	.1990	.9173	.1956
14	.854	.846	.838	.831	64	.1939	.1922	.1905	.1888
15	.824	.817	.810	.803	65	.1871	.1855	.1838	.1821
16	.796	.789	.782	.776	66	.1805	.1788	.1772	.1756
17	.770	.763	.757	.751	67	.1739	.1723	.1707	.1691
18	.745	.739	.733	.727	68	.1675	.1659	.1643	.1627
19	.721	.716	.710	.704	69	.1612	.1596	.1580	.1565
20	.699	.694	.688	.683	70	.1549	.1534	.1518	.1503
21	.678	.673	.668	.663	71	.1487	.1472	.1457	.1442
22	.658	.653	.648	.643	72	.1427	.1412	.1397	.1382
23	.638	.634	.629	.624	73	.1367	.1352	.1337	.1322
24	.620	.615	.611	.606	74	.1308	.1293	.1278	.1264
25	.602	.598	.594	.589	75	.1249	.1235	.1221	.1206
26	.585	.581	.577	.573	76	.1192	.1177	.1163	.1149
27	.569	.565	.561	.557	77	.1135	.1121	.1107	.1083
28	.553	.549	.545	.542	78	.1079	.1065	.1051	.1037
29	.538	.534	.530	.527	79	.1024	.1010	.0996	.0982
30	.532	.520	.516	.512	80	.0969	.0955	.0942	.0928
31	.509	.505	.502	.498	81	.0915	.0901	.0888	.0875
32	.495	.491	.488	.485	82	.0862	.0848	.0835	.0822
33	.482	.478	.475	.472	83	.0809	.0796	.0783	.0770
34	.469	.465	.462	.459	84	.0757	.0744	.0731	.0719
35	.456	.453	.450	.447	85	.0706	.0693	.0680	.0667
36	.444	.441	.438	.435	86	.0655	.0642	.0630	.0617
37	.432	.429	.426	.423	87	.0605	.0593	.0580	.0568
38	.420	.417	.414	.412	88	.0555	.0543	.0531	.0518
39	.409	.406	.403	.401	89	.0505	.0494	.0482	.0470
40	.398	.395	.392	.390	90	.0458	.0446	.0434	.0422
41	.387	.385	.382	.380	91	.0410	.0398	.0386	.0374
42	.377	.374	.372	.369	92	.0362	.0351	.0339	.0327
43	.367	.364	.362	.359	93	.0315	.0304	.0292	.0281
44	.357	.354	.352	.349	94	.0269	.0257	.0246	.0235
45	.347	.344	.342	.340	95	.0223	.0212	.0200	.0188
46	.337	.335	.332	.330	96	.0177	.0166	.0155	.1044
47	.328	.325	.323	.321	97	.0132	.0121	.0110	.0099
48	.319	.317	.314	.312	98	.0088	.0077	.0066	.0055
49	.310	.308	.305	.303	99	.0044	.0033	.0022	.0011
50	.301	.299	.297	.295	100	.0000	.0000	.0000	.0000

DISPERSION OF WHITE LIGHT BY A DIFFRACTION GRATING

←SHORT ——————— WAVELENGTH (nm) ——— LONG ——→

400
VIOLET BLUE   500   600   700
                       ORANGE RED
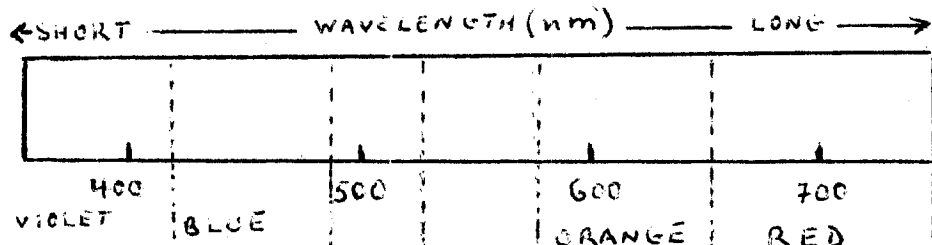
Allow the slide to dry, then heat the slide as directed by your instructor for 2 or 3 minutes.

The amino acids in the hydrolysate will react with the ninhydrin and appear as colored spots on the slide. The ninhydrin test yields purple colors with most amino acids and a yellow color with the amino acid proline. Record the colors of the spots on your chromatogram in Table 1-4.

Estimate the center of each amino acid spot and measure the distance it has traveled up the slide from its point of application. This distance, divided by the total distance traveled by the solvent from the origin line is known as the R_f value. Because two substances with the same R_f are probably identical, this value can be used to identify amino acids separated from a mixture.

Record your observations and those of students who were given other known amino acids in Table 1-4.
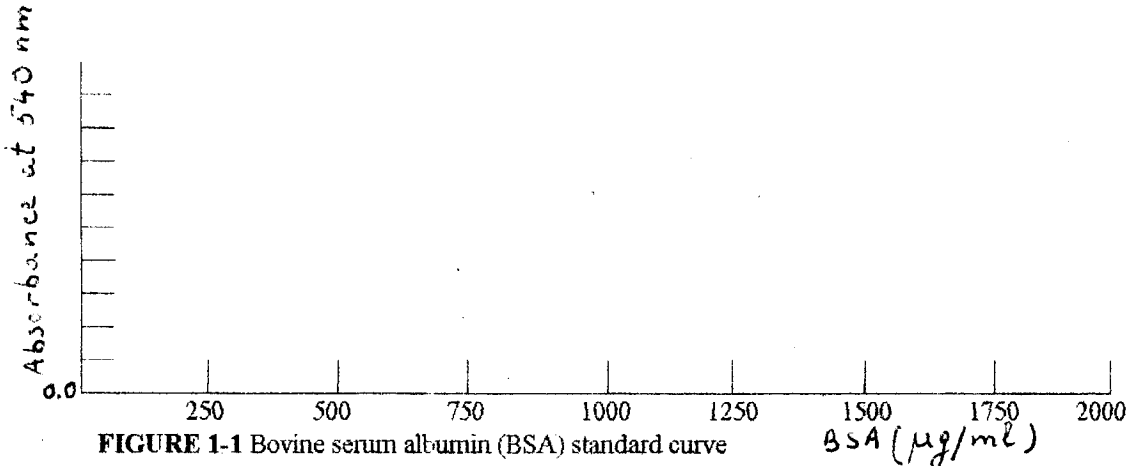
FIGURE 1-1 Bovine serum albumin (BSA) standard curve $BSA\ (\mu g/ml)$

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

1998/99 SEMESTER I DEFERRED/SUPPLEMENTARY EXAMINATIONS

BS 211: CELL MOLECULAR BIOLOGY AND GENETICS

THEORY PAPER

INSTRUCTIONS:

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS, TWO FROM SECTION A AND TWO FROM SECTION B, AND ONE FROM EITHER SECTION A OR SECTION B.

ANSWER SECTION A AND SECTION B IN SEPARATE BOOKLETS.

SECTION A : CELL MOLECULAR BIOLOGY

1. With the help of clearly labeled diagrams, explain briefly what led researchers from the Unit Membrane Hypothesis to the Fluid Mosaic Model of the biological membrane.

2. Write short concise notes on the following topics :

    (a) Difference between prosthetic groups and coenzymes.

    (b) Forces involved in the binding of the substrate to the active site of its enzyme.

3. Explain in detail how external factors influence the activity of an enzyme.

4. Explain in detail how the inherited condition of sickle-cell anemia exemplifies the significance of the protein primary structure.

5. With the help of clearly labeled diagrams, explain in detail why cell walls have been rather aptly compared to reinforced concrete.

SECTION B : GENETICS

1. (a) Describe chromosome behaviour in Prophase of meiosis I.
(b) Discuss the genetic consequences of meiosis.

2. Discuss the genetic and environmental issues surrounding obesity in humans.

3. Discuss the double helical structure of DNA. Show its significance in the inheritance of genetic information.

4. Discuss diversity, evolution and species formation.

5. Discuss assumptions related to the Hardy-Weinberg (H-W) model. Demonstrate how the H-W law can be used to measure gene frequencies or genotype frequencies.

-END-

BS 319
BIOSTATISTICS

TIME: **THREE (3) HOURS**
INSTRUCTIONS: **ANSWER ALL QUESTIONS.**
                     STATISTICAL TABLES WILL BE PROVIDED.
                     USE OF SCIENTIFIC CALCULATORS IS ALLOWED.

---

1. At the 11th International Conference on STDs and AIDS in Africa (ICASA) held recently in Lusaka, Zambia, Chinsembu and co-workers disclosed that the number of HIV+ persons seen in 1998 at the STD Clinic at UTH averaged 20 per hour, with a standard deviation of 3 per hour. In May 1999 after UNZA was closed "normally", the research team started a community-based IEC campaign targeting commercial sex workers- now popularly called "friends of ICASA". Chinsembu and his colleagues believe that this will result in a decrease in the number of HIV+ persons at the clinic. Last week, a random sample taken over 15 hours showed that the mean number of HIV+ persons per hour was now 18.7. Do you think, at the 5% significance level, that the research team's belief is correct?

(7%)

2. Air with varying concentrations of carbon dioxide is passed over wheat leaves at a temperature of 35 degrees C and the uptake of carbon dioxide is measured. Results for eleven leaves at different concentrations (x) of uptake (y) are obtained and are as follows:

Concentration	Uptake ("z" units)
75	0.00
100	0.65
100	0.50
120	1.00
130	0.95
130	1.30
160	1.80
190	2.80
200	2.50
240	4.30
250	4.50

(a) Calculate the corrected sums of squares and products.
(b) What is the fitted regression line?
(c) Calculate the regression sum of squares.
(d) Calculate the standard error of the regression coefficient.

(e) Calculate the t-value for the deviation of the regression coefficient from zero.

(8%)

3. Students in Natural Resources Management at UNZA have been studying the distribution of endangered tree species in Zambia. In an investigation into the spatial distribution of Mukwa trees in a forest in Zambezi, North-western province, counts of the numbers of Mukwa trees in 60 randomly placed quadrats, were made as follows:

Count of trees	Number of quadrats (frequency)
0	6
1	18
2	7
3	13
4	2
5	3
6	2
7	5
8	3
9	1

Verify whether the Mukwa trees are randomly distributed or not?   **(10%)**

4. Consider an experiment on cabbage in which there are eight treatments arranged in four randomised blocks of eight plots each. The experiment was to compare three sources of nitrogen, each at two levels, with a control treatment of no nitrogen, there being two replicates of the control in each block. The data were as follows:

	Level	I	II	III	IV
				Blocks	
Nitro-chalk	1	70.3	72.5	79.0	86.2
	2	61.0	75.1	71.3	65.2
Ammonia	1	75.5	63.0	65.4	67.7
	2	64.7	66.0	64.3	68.8
Nitrate	1	85.2	80.5	83.6	92.3
	2	65.9	78.7	71.1	76.8
Control	1	35.7	39.6	45.5	50.5
	2	38.5	36.3	42.1	61.4

(a) Conduct a simple analysis of variance.
(b) Subdivide the treatment sum of squares so that you compare: control vs nitrogen; nitrogen sources; levels of ammonia; levels of nitrate; and levels of nitro-chalk. For each comparison, calculate the F- ratio and make <u>intelligent</u> comments.   **(10%)**

2

5. An experiment was conducted on the survival of *Salmonella typhimurium* to investigate the effects of three levels of sorbic acid (sa) and six levels of water activity (wa). A randomised block design was used, with three blocks and eighteen treatment combinations. The data analysed are log (density/ml) measured seven days after the imposition of treatments.

```
Sa         wa    I     II    III

0          0.98  8.19  8.37  8.33
           0.94  6.65  6.70  6.25
           0.90  5.87  5.98  6.14
           0.86  5.06  5.35  5.01
           0.82  4.85  4.31  4.52
           0.78  4.31  4.34  4.20
100ppm     0.98  7.64  7.79  7.59
           0.94  6.52  6.19  6.51
           0.90  5.01  5.28  5.78
           0.86  4.85  4.95  4.29
           0.82  4.29  4.43  4.18
           0.78  4.13  4.39  4.18
200ppm     0.98  7.14  6.92  7.19
           0.94  6.33  6.18  6.43
           0.90  5.20  5.10  5.43
           0.86  4.41  4.40  4.79
           0.82  4.26  4.27  4.37
           0.78  4.93  4.12  4.15
```

(a) Calculate analysis of variance while ignoring the factorial structure of treatments.
(b) Convert the data into a two-way interaction table for sa x wa levels.
(c) Conduct a full analysis of variance to account for variation due to blocks, wa, sa, and the interaction sa x wa.
(d) What conclusions can you make from your results?

(15%)

—*END*—
GOOD LUCK !!!

SECTION B: GENETICS

Answer <u>both</u> questions in a separate Answer Booklet which you should label as "Section B".

1. Mutant strains of *Drosophila melanogaster* are commonly used in Freshman Biology practicals to illustrate the principles of genetics. Genetics researchers also use this species. Often, mutant flies are used in biology lab classes. Cross A and Cross B were performed and produced the following results:

F1: 1/2 females; red eyed, normal wings 1/2 males: red eyed, normal wings

F2:
6/16 females; red eyed, normal wings   3/16 males; red eyed, normal wings
2/16 females; red eyed, vestigial wings   1/16 males; red eyed, vestigial wings
3/16 females; white eyes, normal wings   1/16 males; white eyed, vestigial wings

Assume the red eyed allele is "R" and the allele for normal wings is "N".

(a) What type of flies were crossed to produce both the F1 and F2 results depicted above?
(b) Use Punnet squares to represent the F1 and F2 results.
(c) What type of flies were crossed to produce an F1 generation that has 1/2 females red eyed with normal wings, and 1/2 males white eyed with normal wings?
(d) If flies in the F1 in (c) above were crossed, describe the genotypes and phenotypes of the ensuing F2?

2. Using the slides labelled G190 (*Drosophila*, wing mutations) and G180 (*Drosophila*, eye mutations), draw (if possible) and describe the following mutations:
- Dischaete
- Miniature
- Dumpy
- Curly
- Curved
- Plexus
- Sepia
- Plum
- Double bar
- Cinnabar

GOOD LUCK COS' YOU NEED IT!!!

SECTION B: GENETICS

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GOOD LUCK COS' YOU NEED IT!!!

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER UNIVERSITY EXAMINATIONS - MAY 1999

BS221

FORM, FUNCTION AND DIVERSITY OF PLANTS

THEORY PAPER

THREE HOURS

INSTRUCTIONS:

1. Answer **FIVE** questions, at least **TWO** from each SECTION.

- 2. Questions selected from **Section A** (i.e. Q1-Q4) must be written in separate answer books and those selected from **Section B** (i.e. Q5-Q8) to be written in another set of separate answer books.

3. **Tie-up** all answer books in one (single) bundle.

SECTION A

1. Describe the xeromorphic features revealed in some vegetative organs of the genus *Pinus*.

2. Compare and contrast the unique features of the reproductive structures associated with species of *Equisetum* and *Lycopodium*.

3. Give an account of the processes involved in the development of the bark in woody angiosperm plants.

THE UNIVERSITY OF ZAMBIA

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UNIVERSITY FIRST SEMESTER EXAMINATIONS MAY, 1999

BS 321

ETHOLOGY AND EVOLUTION

PAPER II - PRACTICAL

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TIME: THREE HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS

ILLUSTRATE YOUR ANSWERS WHERE NECESSARY. ~~ALL QUESTIONS.~~
~~CARRY EQUAL MARKS.~~

===

1. Study the diagram provided, and answer the following questions:

    Give the name and behavioural functions of the structures marked
    A, B, C, and D.   (20 marks)

2. A survey of four District Hospitals gave the following data on the occurrence
    of sickle cell anaemia in parts of Zambia.

District	Urban Cases	Rural Cases
Samfya	30	20
Serenje	50	45
Katete	90	70
Monze	90	50

    On the basis of these data, discuss

    (i)   the distribution of the gene responsible for sickle cell anaemia. (10 marks)

    (ii)   Heterozygous in this gene are resistant to malaria. Discuss. (10 marks)

3. According to Jarman (1974), the specimen provided is classified as E-class.
    Describe the group: (i) social behaviour (ii) characteristics of communication.
    (10 marks)

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATION MAY, 1999

BS 321

ETHOLOGY AND EVOLUTION

PAPER I - THEORY

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE (5) QUESTIONS. QUESTION ONE(1) IS COMPULSORY. ANSWER QUESTION ONE (1) AND TWO (2) QUESTIONS FROM EACH SECTION. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY. ALL QUESTIONS CARRY EQUAL MARKS.

1. Write short notes on the following terms as discussed in this course:

    (i)   character displacement

    (ii)   Focal sampling

    (iii)   Australopithecus

    (iv)   Genetic drift

    (v)   Hypothalamus

SECTION A: ETHOLOGY

2. Define and discuss the main features of sexual selection in animal species, and briefly explain the role of a territory in monogamous species.

3. Describe the main differences between group selection and kin selection as related to species fitness.

4. Discuss the main characteristics of chemical communication in animal species, and explain how such communication could be an essential social mechanism in prey species.

SECTION B: EVOLUTION

5.   Define natural selection and explain how it promotes and reduces genetic variability.

6.   What are the main differences between Lamarckism and Darwinism as they relate to the evolution of grouping in social species.

7.   Compare and discuss sympatric and allopatric speciation in animal species.

END OF EXAMINATION

1998/99 SEMESTER I DEFFERED/SUPPLEMENTARY EXAMINATIONS

BS 331 THEORY PAPER

TIME : THREE HOURS

INSTRUCTIONS : ANSWER FIVE QUESTIONS

1. (a) By means of an equation, express the relationships between volume flow density, Jv, of water passing through the stem and the water potential gradient, $\Delta\psi$, the hydraulic resistance, R, of the conducting tissue and the cross section area, A, of the conducting tissue.

   (b) In an experiment to study coupling of leaf water potential to transpiration in maize seedlings, hydraulic resistance of the root, Rr, was found to be 1.3×10^9 MPa S m^{-3} for a root surface area of 7.5×10^{-3} m^2.
   Calculate the hydraulic conductivity, Lpr, of the root.

2. What is the significance of electrical potentials in the ionic relations of plant roots? Support your answer with appropriate equations.

3. Light drives photosynthesis and also regulates it. What mechanisms are involved in the regulation of the pentose reduction cycle by light?

4. One method by which the solute potential of plant cells may be estimated is that of "limiting plasmolysis".

   (a) Under what circumstances is this method applied?

   (b) What are the limitations of this method?

   (c) Briefly describe how you would use the method to estimate the solute potential of plant cells.

5. Outline the major evidence which established the involvement of two light reactions in photosynthesis.

6. Write on the physiological role of calcium (Ca^{2+}) ions in plant cells.

7. How does light affect the growth of plants other than through its roles in photosynthesis?

8. How do chloroplast antenna pigments capture light energy in photosynthesis and transfer it to the reaction centres?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS - MAY, 1999

BS 341 (MICROBIOLOGY) PRACTICAL PAPER

TIME: THREE(3) HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS. TABULATE YOUR
                RESULTS WHEREVER POSSIBLE.

===

1.   Examine provided 24 hours broth cultures marked 1A and 1B for motility or non motility using hanging drop method.

       Prepare heat-fixed smear of each culture and stain with methylene Blue. Observe under microscope and report on the shape and cell grouping of examined culture.

2.   Using provided milk sample marked 2C, proceed to stain by Gram's technique.

       Observe under microscope and report on any Gram positive or Gram negative form observed, its shape and grouping pattern.

       Explain the basis of Gram staining.

3.   Two (2) disinfectant samples A and B have been tested for their antimicrobial strength in comparision with phenol as control, and have shown the following results:

       Disinfectant A

Exposure Time in minutes	2.5	5.0	7.5	10.0
Dilutions:				
1/400	+	+	-	-
1/600	+	+	+	-
1/800	+	+	+	-
1/1000	+	+	+	-
Phenol 1/100	+	+	-	-

Precentral gyrus
(primary motor cortex)

Central
sulcus

Postcentral gyrus
(primary somatosensory cortex)

B

C

D

A
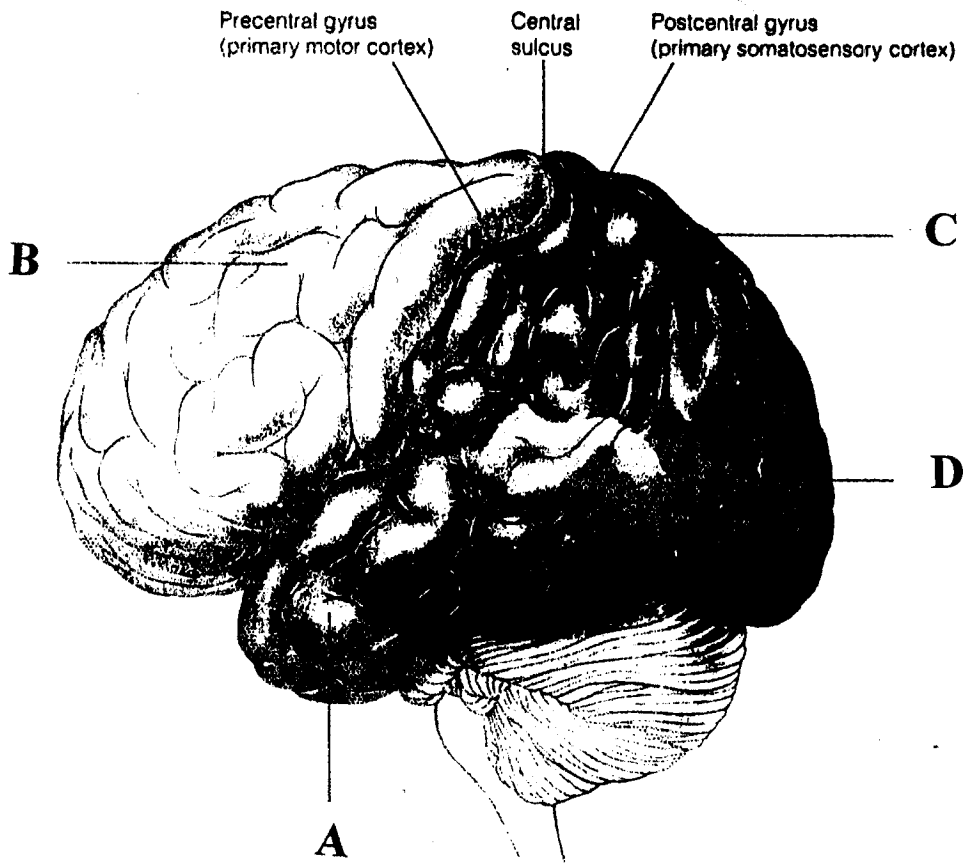
Some major subdivisions of the human cerebral cortex, with indications of
a few of their primary functions

4.	Describe the diversity of vertebrate species in the Kafue Flats, Southern Zambia, and explain factors, including habitat structure, which could have led to the development of animal species association as observed in the area. (30 marks)

5.	Briefly describe the Lekking behaviour in the Kafue Lechwe *(Kobus leche kafuensis)* as discussed in the field. (20 marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS - MAY, 1999

BS 341 (MICROBIOLOGY) THEORY PAPER

TIME: THREE(3) HOURS

INSTRUCTIONS: ANSWER ANY FIVE (5) QUESTIONS, THREE(3) FROM SECTION A AND TWO (2) FROM SECTION B. ANSWERS MAY BE ENHANCED BY INCLUDING RELEVANT DIAGRAMS, GRAPHS OR CHEMICAL REACTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

==

SECTION A

1. All organisms, including microorganisms, have in common certain characteristics
by   which they are refered to as <u>living</u> organisms.

    a)   List up these characteristics and explain briefly their respective meanings.

    b)   Discuss the particular case of viruses.

2. Write a short note on the physiological role of the following elements in microbial metabolism.

    a)   Nitrogen

    b)   Phosphorus

    c)   Zinc

    d)   Iron

    e)   Molybdenum

3. Comparatively to ordinary Bacteria, outline the general morphological and biological characteristics of Rickettsiales as an order, and name, at least one (1) important species of:

    a)   Rickettsia

    b)   Chlamydia

c) Mycoplasma

and disease caused.

4. By concise diagrams, summarize relationships between the following metabolic processes:

   a) Glycolysis and aerobic Respiration;

   b) Glycolysis and Fermentation.

5. Microorganisms constitute an important factor of Nitrogen cycling in the nature. Discuss the major assimilative process of Nitrogen by different groups of microorganisms with indication of the most active species involved in each case.

SECTION B

6. What would be the general characteristics of viruses with regards to:

   a) Morphology

   b) Structure

   c) Life-cycle

7. Bacteriophages can be "virulent" or "temperate".

   a) Explain the meaning of these terms: "virulent" and "temperate" phage.

   b) Taking as example E. coli phages T_4 and Lambda (λ), show the difference between a typical replication cycle and lysogenic cycle.

8. AIDS virus is a typical retrovirus of humans.

   a) Tell its morphological structure.

   b) Explain the mechanisms of its attachment to target T_4 lymphocyte cells.

   c) List up the most common opportunistic HIV infections.

END OF EXAMINATION - GOOD LUCK

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY, 1999

BS 351 : ENTOMOLOGY

PRACTICAL PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS.

1. Identify specimens A – J to Order and list <u>four</u> taxonomic features that distinguish each specimen from other insects.

2. Construct a dichotomous taxonomic key that can be used to identify specimens K – T to Order.

3. Using the equipment and chemicals provided, conduct an experiment to test for the enzyme Amylase in the alimentary canal of the Armoured Ground Cricket, *Acanthoplus speiseri* Brancsik provided. In your report include a drawing of the alimentary canal of your specimen, labeling all parts and indicating the subanatomical divisions used in your experiment.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY, 1999

BS 351 : ENTOMOLOGY

THEORY PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER <u>FIVE</u> QUESTIONS. <u>TWO</u> QUESTIONS FROM SECTION A, <u>TWO</u> QUESTIONS FROM SECTION B AND THE <u>LAST</u> QUESTION FROM <u>EITHER</u> SECTION.

SECTION A.

INSECT MORPHOLOGY, ANATOMY AND ORDERS.

1. Discuss vision in insects. What is the basis of colour perception in insects like the honey bee?

2. A grasshopper has just ingested some food. Trace the path that this food will take in this insect until it is ejected as feacal matter. What kind of processing is involved and in which part of this path.

3. Discuss the unique modifications that are exhibited by the body structure in the Housefly from the generalized condition. In your answer, also explain the biological significance of these structural changes exhibited.

4. The obvious function of wings in insects is flight. Apart from flight, what other functions do wings perform in named insect groups?

SECTION B.

INSECT PHYSIOLOGY AND BIOCHEMISTRY.

5. With the aid of well labeled diagrams, describe the structure of the insect body wall and explain how temperature and water loss are controlled by its components.

6. Discuss the roles of Juvenile hormone and Ecdysone in controlling insect moulting and metamorphosis.

7. Discuss dormancy in insects and explain factors that induce and terminate it. What is the biological significance of dormancy in animals?

8. Describe methods of respiration exhibited by aquatic insects that take up gaseous oxygen from the air.

END OF EXAMINATION

BS 361 MOLECULAR BIOLOGY
DEPARTMENT OF BIOLOGICAL SCIENCES
UNIVERSITY OF ZAMBIA

FINAL EXAM QUESTIONS (PAPER I)

Answer all questions

1. In 1953 James Watson and Francis Crick deduced the three dimensional structure of DNA.
(a) Describe the major components of DNA.
(b) What are the most important features of the Watson and Crick model ?
(c) How do A-DNA and Z-DNA deviate from this classic model ?

2.(a) Explain the phenomena of denaturation and hyperchromic effect of DNA.
(b) How does the base composition of DNA affect its melting temperature?
(c) Describe the processes of filter and liquid hybridisation in molecular biology. What sort of information can be derived from a hybridisation experiment?

3.(a) DNA replication is said to be proceed by a semi-conservative mechanism. Explain this and describe the classical experiment that led to this discovery.
(b) Describe in detail the events leading to DNA replication at the replication fork of prokaryotic *E.coli.*

4. (a) Transcription of genetic material begins at promoters on a DNA template. Describe an experiment that you could conduct to identify these promoter sites. How do these sites differ in prokaryotic and eukaryotic organisms?
(b) When an abrupt elevation of temperature is effected an *E. coli* bacterium is able to respond by synthesising heat shock proteins. How is this achieved and what critical factors are required?
(c) In the absence of a hairpin loop how is termination of transcription effected in prokaryotes?

5. Briefly explain the following terms:

(a) Degenerate genetic code
(b) Leaky mutant
(c) Enhancers
(d) Gene splicing
(e) Frame shift

6.(a) Describe the structure of a prokaryotic ribosome and explain how translation is initiated in prokaryotes.

(b) What role is played by the protein EF-Tu and how it is cycled in prokaryotic translation?

(c) When the rho protein is not required how is translation termination achieved in prokaryotes?

THE UNIVERSITY OF ZAMBIA

DEFFERED FIRST SEMESTER EXAMINATION, NOVEMBER 1999

BS361 MOLECULAR BIOLOGY
PAPER (II)

TIME: THREE (3) HOURS

Use diagrams where appropriate

SECTION A

Answer **all** questions

1. (a) Describe the classical model of the prokaryotic operon of gene regulation.
(b) Define gene induction. How is the bacterium *E.coli* able use this mechanism to its advantage when transferred from glucose to lactose?
(c) Give the experimental procedure you would use to identify the lac operator of *lac* operon.

2. Regulation of repressible and inducible genes may fall under negative or positive control.
(a) Describe how genes are regulated under each type of control.
(b) Give a detailed account of regulatory mechanism of <u>specific</u> genes operating under the following types of control:
(i) An inducible gene operating under negative control
(ii) A repressible gene under negative control
(c) Eukaryotic chromosomes are much larger than those of prokaryotes. How is this DNA packaged efficiently and how are its genes organised?

3. In humans, different haemoglobin are synthesised in development.
(a) Give an explanation for the above observation with respect to gene regulation.
(b) What role do pseudogenes play in this regulation?
(c) Describe the eukaryotic cell cycle. What molecular activities must exist for its proper regulation?

4. (a) Describe the <u>humoral</u> response of an animal cell when it encounters foreign proteins known as antigens.
(b) The human body does not produce antibodies against itself. Explain how this is possible. How does this contrast with production of antibodies against foreign antigens?
(c) What is meant by the term class switching? What biological purpose does it serve?

SECTION B

Answer only **one** question

5. Cell differentiation results in cells acquiring specialised functions.
(a) Why is it that in most nuclear transplantation experiments specialised cells do not support the development of a complete normal animal?
(b) Describe yeast sporulation. What molecular mechanisms of differentiation are crucial in this process?
(d) Write short notes on the following:
(i) Transformed cell cultures
(ii) Primary cell cultures
(iii) cell determination

6. (a) How is the human body able to combat cancer cells and virally infected cells?
(b) Name and describe the T-cells present in the human body. How are antigens presented to the T-cells and how do the T-cells actually recognise their targets?
(c) Name the five-immunoglobulin classes and their functions.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

First Semester Examinations
May/June, 1999.

BS 375 Invertebrate Zoology (Theory)

Time: **Three (3) Hours**

INSTRUCTIONS: **ANSWER** Question One (1) and <u>FOUR</u> other Questions. Question 1 carries 28 marks, while other Questions carry equal marks.

1.   (a)   The classification of the members of the Metazoan sub-kingdom of the Animal Kingdom has followed a number of schemes, including the one that breaks down this sub-kingdom into the Diploblastic and Triploblastic Divisions. Discuss the basis and structure of this scheme.

(b)   Describe the distinguishing features of the following invertebrate orders. Give an example of a member of each order.

   (i)   Phytomonadina
   (ii)   Protomonadina
   (iii)   Homoptera
   (iv)   Acarina
   (v)   Stylommatophora
   (vi)   Filobranchia
   (vii)   Haplosderina
   (viii) Opisthopora
   (ix)   Digenea
   (x)   Plesiopora

2.   (a)   Define and differentiate between "movement" and "locomotion".
       (b)   Discuss the various locomotory arrangements seen in the invertebrates and highlight the sources of energy and muscle types used in locomotion.

3.   (a)   Define and briefly describe the processes of <u>Osmo-regulation</u> and <u>Homeostasis</u> in <u>invertebrates</u>.
       (b)   What are the various excretory mechanisms seen in aquatic and terrestrial invertebrates?

4.   (a)   Give illustrated descriptions of the life histories of <u>Taenia</u> <u>Saginata</u> and <u>Fasciola</u> <u>hepatica</u>.
       (b)   What are the major adaptations seen in parasitic invertebrates?

5. Write brief notes on the following topics:

   (a) Reproduction in the Coelenterates
   (b) Sense organs in the invertebrates
   (c) Evolution of the blood sucking habit in invertebrates
   (d) The skeletal systems of invertebrates

6. Trace the evolution and significance of cephalisation in invertebrates with special reference to the structures and functioning of sense organs.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY, 1999

BS 411 : INSECT BEHABIOUR AND ECOLOGY

THEORY : PAPER I.

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS

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1. One Biologist at UNZA was heard saying that, "Diapause in insects occurs as a result of the onset of unfavourable environmental conditions such as storms, drought and extremes of temperature". Argue for or against this statement.

2. Describe the modes of pair formation during reproduction in the Acridoidea. In your view, why is there such a diversity of behavior patterns when any one of them could serve adequately for the whole group?

3. Faining death is one defensive strategy employed by several insect species. Surely, when an organism fains death it is still available to the predator. How effective is this mode of defense in these insects and why?

4. What are the characteristics of a named fully-fledged insect society and how do these compare to those of the human society?

5. Distinguish between Orientation patterns and Fixed action patterns in insect behaviour and in your answer, using specific examples, discuss the adaptive significances of both types of behaviour.

6. Assuming that you are a honey bee and you are required to go outside the hive to collect pollen and nectar, discuss the kinds of behaviour patterns that you will exhibit in order to successfully do so.

7. Discuss the patterns of behaviour exhibited by a sexually responsive male moth upon perceiving a female sex pheromone, up to copulation.

8. Can insects learn? If so, what kind of learning are they capable of and what is its survival value to the learners?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY, 1999

BS 411 : INSECT BEHABIOUR AND ECOLOGY

THEORY : PAPER II.

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS

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1. Discuss the role of insect pests in ecosystems and in your view, do you think it would be logical for man to eradicate from the environment insects like mosquitoes and tse tse flies?

2. Discuss methods used to estimate absolute insect population densities and indicate how accurate they are in doing so and whether there are ways in which they could be improved.

3. The thermal unit model for the development of the Armoured Ground Cricket (AGC), *Acanthoplus speiseri* Brancsik is presented below:

Major Biological Event	Cumulative Number of Thermal Units (degree-days or TU) required For the Biological Event to Occur
Hatching	351.49
Beginning of 1st Instar Nymph	351.49
Beginning of 2nd Instar Nymph	527.23
Beginning of 3rd Instar Nymph	677.87
Beginning of 4th Instar Nymph	815.95
Beginning of 5th Instar Nymph	966.58
Beginning of 6th Instar Nymph	1117.23

....

    a. Suppose you went out in the field for your first sampling of this grain pest of crops in Zambia, on the day when 2nd Instar nymphs are emerging and suppose you decide to go back to the field for your second sampling when a further 600 thermal units have been accumulated. Predict the developmental stage which you will find in the field when you go for second sampling.

    b. Of what advantage would possession and use of this model be to the Zambian farmer in controlling the AGC?

    c. In your view, what would be the difficulties the farmer would encounter in adopting this model for use?

4. Using a flow chart, illustrate the components of an insect life system. How are the interactions of its component assessed?

5. Suppose the following two situations regarding birth- and death-rates existed in two separate insect populations:

    a. where both rates are constant with increasing population density but mortality is higher than natality.

    b. Where natality is decreasing with increasing population density but mortality is constant.

What will be the consequences of this to population density with passage of time? And in your answer, indicate which relationship of natality, mortality and population density would produce a stable population.

6. What is a Life table? Of what value is it to an insect ecologist? and in your view, is it worth all the time and effort involved in developing it in the study of insects?

7. Distinguish between Contest and Scramble types of competition and explain under which conditions it is possible for two species competing for the same resource in the environment will co-exist.

8. Discuss the significance of Sampling in making estimates of insect population densities.

-----------------------END OF EXAMINATION-----------------------

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - MAY 1999

BS 431

ADVANCED PARASITOLOGY I

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS

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1.   Parasites are the benefiting partners in the parasitic relationship. Relate these benefits against the hazards they face from their mode of life. What protective mechanisms do they have for survival as endoparasites?

2.   Explain how schistosomes have been successful in maintaining high prevalence of infection in communities. Base your discussion on parasite and host related factors.

3.   Discuss how man's influence can easily precipitate the burden due to parasitic diseases in farm animals.

4.   Discuss how parasitism has been maintained as an essential regulatory relationship without causing severe consequences in hosts.

5.   Children harbouring heavy worm burdens may have anaemia, cough and show stunted growth, among other manifestations. Discuss how these conditions result giving hookworm infections as an example.

6.   Resistance to infection is a state of the host rather than the parasite. Explain this situation and further give factors which influence susceptibility to infection.

7.   Giving specific examples, discuss four common routes of parasite entry and exit in definitive hosts. Continue this discussion for nematodes by describing their development to adulthood.

8.   Explain how hermaphrodism is beneficial to parasites in terms of improved fecundity and acquired survival mechanisms. Briefly discuss asexual reproduction in multicellular parasites.

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATIONS, MAY, 1999

BS 441 ADVANCED MOLECULAR BIOLOGY

FINAL EXAM (PAPER I) QUESTIONS

TIME: THREE (3) HOURS

ANSWER ALL QUESTIONS

==

1. (a)   Describe the four levels of protein structure.

    (b)   Studies have revealed two additional levels known as super secondary
          structure and domains. What are the characteristics of these?

2. Give a brief account of the principles of the following protein purification
    techniques:

    (i)   Iso-electric focusing
    (ii)   SDS-Gel electrophoresis
    (iii) Zonal Centrifugation

3. (i)   Describe the technique known as Edman Degradation.
    (ii)   Prior to using the Edman degradation what additional technique
           is essential for sequencing ribonuclease, a protein of 129
           residues, and why is it necessary?

4. (i)   Give a detailed diagram of a mitochondrion
    (ii)   Diagramatically show the flow of electrons through oxidative
           phosphorylation pathway indicating the sites of proton pumping.

5. What are the major differences between prokaryotic and eukaryotic ribosomes?

6. Write brief notes on any <u>three</u> of the following:

    (a)   radioimmunoassay
    (b)   the scanning electron microscopy
    (c)   transmission electron microscopy
    (d)   protein folding
    (e)   protein solubility and viscosity

7.   What is the Calvin cycle? Give an account of this cycle, what it achieves and a balanced net equation for the cycle.

SECTION B

Answer any two questions

8.   (a)   How is initiation of translation achieved in prokaryotes?
      (b)   The protein factor EF-Tu plays an essential role in prokaryotic translation. What is its role and how is it cycled during translation?
      (c)   Once a polypeptide has been completely synthesised how is termination effected?

9.   (a)   Give a detailed diagram of a chloroplast. How is a chloroplast able to achieve absorption of incident light of varying wavelength?
      (b)   Describe the electron flow in photosystems I and II of a chloroplast. How does this produce a proton gradient sufficient for ATP synthesis?

10.   (a)   Describe the components and principles of radioimmunoassays. Why are these assays referred to as 'saturation' assays?
      (b)   Give a schematic diagram of the transmission electron microscope and a detailed account of specimen processing for observation under such a microscope.
      (c)   Give an account of how a radioisotopic method was used to show that DNA replication proceeds by a semi-conservative mechanism.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS –MAY, 1999.

BS 441 – ADVANCED MOLECULAR BIOLOGY I

PAPER II

TIME THREE HOURS

SECTION A – ANSWER ALL QUESTIONS

1. Write short notes o each of the following :
   a) The target theory of mutation
   b) Conjugation
   c) SOS repair
   d) A-DNA
   e) Biochemical mutations

2. Briefly discuss human diseases associated with DNA repair.

3. Describe the various haemoglobin genes found in the human genome.

4. How is the specimen prepared for viewing when using an electron microscope?

5. Illustrate the formation of Lepore and anti-Lepore haemoglobin.

6. How does an F- cell become an F'

7. Differentiate between the following :
   a) Deamination and depurination
   b) Nonsense and missense mutations
   c) Transitional and transversal mutations
   d) Induced and spontaneous mutations
   e) DNA and chromosomes.

SECTION B

ANSWER ANY THREE QUESTIONS

8. Write a short essay about the evolution of haemoglobins and myoglobin.

9. Describe the steps involved in general recombination and state the major enzymes involved , mentioning the function(s) of each enzyme.

10. Use the Holliday model to illustrate general recombination.

11. Outline the evolution of the present day myoglobin and haemoglobin genes from common ancestral genes.

12. Discuss mutation at the chromosome level . Highlight the medical and economic importance of this type of mutation.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - MAY 1999

BS 471 (ENVIRONMENTAL MICROBIOLOGY)

PRACTICAL PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS. TABULATE YOUR
RESULTS WHEREVER POSSIBLE.

---

1.   You are provided with three cultures labelled as A, B and C.
Using Kovac's and Methyl-Red reagents, determine which culture is
referable to as:

    (i)   Typical faecal E. coli,
    (ii)   Atypical coliform,
    (iii) Non-coliform bacteria,

    Knowing that culture A is VP and citrate negative, whereas cultures B and C are
VP and citrate positive.   (45 marks).

2.   A sewage water sample has been analyzed for detection and identification of E.
coli and mesophilic aerobic microorganisms.

    Descibe fully the whole procedure followed in this test up to the confirmation step
of E. coli.   (30 marks)

3.   Using the same sample as above, calculate the total load of microorganisms per
milliliter, if inoculated petri dishes in triplicate from dilution 1/100.000 showed
64, 70 and 59 colonies respectively. (25 marks)

END OF PRACTICAL EXAMINATION
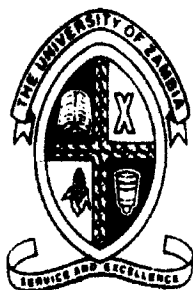
UNIVERSITY OF ZAMBIA

BACHELOR OF SCIENCE DEGREE

IN

BIOLOGICAL SCIENCES

FOURTH YEAR

FIRST SEMESTER DEFERRED/SUPPLEMENTARY EXAMINATIONS

BS 471 (ENVIRONMENTAL MICROBIOLOGY)

Thursday, 9th December, 1999   **14:00-17:00**

Instructions

1. FIVE (5) questions should be answered from this paper. Illustrate your answer by using relevant diagrams, graphs or chemical reactions. All questions carry equal marks.

2. At the end of the examination, the complete answer books should be handed in all tied together.

3. Time allowed: Three (3) hours only.

[Turn Over

UNIVERSITY OF ZAMBIA

FOURTH YEAR FIRST SEMESTER DEFERRED/SUPPLEMENTARY EXAMINATIONS

BS 471 (ENVIRONMENTAL MICROBIOLOGY)

Thursday, 9th December, 1999   14:00-17:00

<u>Instructions</u>:
1. THREE (3) questions should be answered from this paper. Illustrate your answer by using relevant diagrams, graphs or chemical reactions. All questions carry equal marks.
2. At the end of the examination, the complete answer books should be handed in all tied together.
3. Time allowed: Three (3) hours only.

---

1. Microorganisms cause the deterioration of various materials. Briefly explain how microorganisms affect the following items.
   a) wood
   b) paints
   Give examples of active organisms in each case.

2. Give an account of the role of microorganisms in soil.

3. Discuss the role of microorganisms in the degradation of herbicides and pesticides

4. Briefly describe the distribution and role of microorganisms in the aquatic environment.

5. Discuss the importance of air and water in the transmission of human pathogens.

6. Biological Oxygen Demand (BOD) is a good indicator of the amount of organic material in a water body. Give an account of how the BOD test is carried out and the implications of dumping large amounts of organic material into fresh water bodies.

7. Discuss the uses and limitations of *Escherichia coli* in the monitoring of microbiological quality of water.

8. What major treatment steps do the water companies employ to ensure the bacteriological safety of water supplies?

Good Luck and have a Merry Christmas and a very Happy New Year!

THE UNIVERSITY OF ZAMBIA

May/June First Semester Examinations, 1999.

BS 475
Population Ecology Paper II

Time: **Three (3) Hours**

INSTRUCTIONS: **ANSWER** Questions 1 and 2, and any other THREE Questions. All questions carry equal marks.

1. (i)   Define and distinguish between "Population Index" and "Population Density".
    (ii)   Briefly discuss the factors that regulate population growth of a species.
    (iii) What population dynamics events are represented by A - J in Figures 1 - 4.

2. (a)   Define and distinguish between "Population Density" and "Carrying Capacity.
    (b)   The Wanga Wildlife Authority wanted to establish a wildlife ranch which would include 300 elands, 150 duikers, 170 giraffes, and 200 elephants under a system of paddocks. The average optimum stocking densities of these animals were estimated, respectively, at 0.50, 0.25, 0.35 and 0.75 hectares/animal.

    (i)   Calculate the total hectarage required for the whole ranch.
    (ii)   If, after 3 years of use, the elephant paddock was reduced by 50%, but its carrying capacity is increased by 30% through land improvement techniques, how many elephants would be culled given a birth rate of 10% and a death rate of 30%?

    (c)   What factors cause fluctuations in natural populations?

3. Write brief notes on the following topics:

    (i)   Population parameters and their uses
    (ii)   The food cycle and the pyramid of numbers
    (iii) Reproductive rates and reproductive value
    (iv)   Survivorship curves and their value in the human population
    (v)   Correlates of r and k selection

4. (i)   Develop a matrix showing the pro- and counter selected behaviours in natural populations.
    (ii)   Discuss with examples, the social behaviour and kin selection patterns seen in natural populations.

5. (i)   Define and distinguish between "environment" and "habitat".
    (ii)   How do the various physical and biological factors of the environment influence

the population dynamics of a species?

6.   (a)   What is an ecological island?
        (b)   Compare the various annual ecological succession events occuring in modern and monocultural agro-ecological systems to those occuring in natural woodlands.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGICAL SCIENCES

FIRST SEMESTER   **MAY 1999**

BS 491 Freshwater Biology Final Examination: Theory Paper.

Maximum Time allowed.   **Three Hours**

Instructions.

Attempt all the three questions in **Section A** and one question in section **B**. At the end of this examination, please hand in the question papers and all the answers.

SECTION A

1. Briefly define the following terms and concepts and indicate how each term is used in the classification of aquatic environments.

   i. thermal stratification.

   ii. eutrophic

   iii. salinity

   iv. lotic.

   v. tectonic lakes

   25 Marks

2. A well known Freshwater Biologist, Hutchinson, is reported to have said that " a perceptive limnologist can assess the relative productivity of a lake simply by determining depth profiles of oxygen concentration during summer stratification". Explain the rational behind this statement and comment on it's validity.

   25 marks

3. The carbon dioxide content of the hypolimnion, in lakes, is often used to estimate organic production in the trophogenic zone. Explain the underlying principles for using this method in determining organic production. What are the major sources of error when this method is used for determining production or productivity in lakes.

   25 Marks

SECTION B

4. Provide a detailed explanation as to why physical properties of water make aquatic environments suitable habitats for a variety of life forms particularly the less evolved organisms.

   25 Marks

5. Discuss forms of Silica in freshwaters and illustrate how Silica concentrations affect the composition and seasonal succession of phytoplankton populations in freshwater ecosystems.

   25 marks

   END OF THE EXAMINATION.

THE UNIVERSITY OF ZAMBIA
END OF SEMESTER EXAMINATIONS, NOVEMBER, 1999

THEORY PAPER

BS 530 (BACTERIA & FUNGI)

TIME ALLOWED: THREE HOURS

ANSWER: **ANY FIVE QUESTIONS**

1.   Discuss powdery mildews as pathogens of crop plants and describe all the known anamorphs of these fungi.

2.   Define damping-off symptoms and discuss the importance of the pathogens responsible for pre-and post- emergence mortality of seeds and seedlings. What control measures would you recommend to control these pathogens?

3.   Briefly explain the importance of *Taphrina* in plant diseases of stone fruits. Describe symptoms and disease cycle of peach-leaf curl with suitable recommendations for its control.

4.   Give appropriate reasons to explain the increasing importance of post-harvest pathology of fruits and vegetables. Identify the associated organisms and explain how to reduce post-harvest losses in conventional agriculture.

5.   Define late blight and describe symptoms of the disease on potato explaining how the disease recurs and spreads in the field. Suggest measures that will contain the epidemic development of the disease.

6.   Describe the active and inactive phases of *Ustilago scitaminae* on sugarcane in Zambia and explain how the pathogen affects the plant.

7.   Describe in detail the pathology of *Claviceps* and *Ceratocystis* and comment on their taxonomy.

8.   Write informative notes on any **FOUR** of the following:

i.	Haustorium	ii.	*Uromyces*
iii.	Anthracnose	iv.	Plasmodium
v.	Biotrophy	vi.	*Polymyxa*

END OF EXAMINATION

THEORY PAPER

BS 531 (EPIDEMIOLOGY & GENETICS OF PATHOGENS)

TIME ALLOWED: THREE HOURS

ANSWER: TWO QUESTIONS FROM EACH SECTION AND THE 5th QUESTION FROM EITHER SECTION A OR B. ANSWER EACH SECTION SEPARATELY IN DIFFERENT ANSWER BOOKS.

SECTION A

1. Differentiate between disease epidemic and epiphytotics. Discuss the dynamics of plant disease induced by a named polycyclic pathogen, from the time of infection to the time when the whole field is completed infected.

2. Knowledge of organisms that predispose plants to disease is important in the dynamics of disease. Discuss this statement using named host, vector and /or pathogen interactions.

3. Explain the formula; $dx/dt = QR$, as given by Van der Plank in epidemiological terms. How is this formula different from the following expression; $dx/dt = QR (1-X)$?

4. What is plant disease diagnosis? Describe in detail the procedure followed in the diagnosis of diseases caused by nematodes, fungi and bacteria.

SECTION B

5. Define variability and explain in detail the general basis of genetic variability of plant pathogens.

6. Discuss the various special mechanisms of variability shown by pathogenic organisms.

7. Distinguish between horizontal and vertical resistance of plants and explain which of the two types of resistance would be preferred by you and why.

8. Define disease escape and discuss the various ways that enable the plant to escape disease.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATIONS, MAY, 1999

BS 591: ANIMAL POPULATION AND BEHAVIOURAL ECOLOGY

===

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE (5) QUESTIONS

ILLUSTRATE YOUR ANSWERS WHERE NECESSARY. ALL QUESTIONS
CARRY EQUAL MARKS.

===

1.   Define and discuss the main features of sexual selection in animals, and briefly
       explain the role of sex ratio in

       (i)   semelparous populations

       (ii)   iteroparous populations

2.   Describe characteristics of chemical communication in animal species and discuss
       how such communication could be an essential social mechanism in

       (i)   African Antelopes

       (ii)   among large carnivores.

3.   Using examples from prey species, discuss the main differences between learned
       behaviour and instinctive behaviour.

4.   "The great object in the life of an organisms such as an Oyster is to convert
       the whole earth into Oysters. The biotic potential of an Oyster is limted by a
       number of factors and more by outside forces than by its own lack of biotic
       ambition."

       Based on this statement above, provide a detailed biological rationale for such
        a statement, and refute any aspects of the statement with which you
       do not agree.

5.   Define the following terms as discussed in this course:

       (i)   character displacement

(ii)   stable age distribution

(iii)   Discrete population growth model

(iv)   True metalizable energy

(v)   Altruistic behaviour.

6.   Using the clutch size hypotheses, discuss the main differences between the r-selection and K-selection in animal species populations.

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER EXAMINATIONS, MAY, 1999

BS591: ANIMAL POPULATION AND BEHAVIOURAL ECOLOGY

PAPER II: PRACTICAL

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS.

ILLUSTRATE YOUR ANSWERS WHERE NECESSARY

1. Biologists monitoring population of Impala *(Aepyceros melampus)* on Chete insland in lake Kariba, Sinazongwe between 1958 and 1985 gave figures as indicated in the table below. The island is approximately 5km^2 and is generally covered by a thicket of *Combretum* sp. Mean annual rainfall is 900mm. The island is a protected area and is regularly patrolled by game scouts. However, artisanal fishermen in the lake are allowed to land fish in certain parts of the island. For nearly 12 years the island was exposed to liberation war between 1968 and 1980, and part of the island was defoliated with herbicides. Impalas are polygamous and only a male breeds with a herd of females. Non breeding males form a banchelor herd.

   Using the information and data provided, explain the population trends, and discuss factors which could be most significant to the dynamics of this population on the island (30 marks).

Table. Impala population at Chete island, lake Kariba, based on transect ground counts.

Year of Census	Juveniles	Males	Females
1958	8	20	47
1968	6	54	76
1972	10	40	100
1975	40	58	210
1980	20	67	138
1985	15	53	95

2.   The figure below shows a territorial distribution of breeding male Uganda Kob
      (*Adenota kob thomasi*) under the lekking system as given in the study in Uganda,
      Toro game reserve in 1966.

      The most conspicuous features in the social system of the *Kob* population
      studied are selected mating areas, consisting of a tight cluster of small territories,
      each occupied by one adult male. Buechner in 1963 first described these arenas,
      leks, or territorial breeding grounds, hereafter abbreviated 'TGs'. They contain
      10-20 central territories, each 15-34 m in diameter, with contiguous
      boundaries, and a similar number of slightly larger and more widely
      spaced peripheral territories; a whole TG is ordinarily 200-400 m in
      diameter. Males compete for the possession of territories through
      ritualized fighting; frequent inter changes between territorial males and
      males from the 'bachelor herds' associated with each TG are the rule.

      Estrous females enter the TG for mating which is accompanied by an
      elaborate series of postcoital displays apparently unique to the Kob.

      As there is no breeding season, the composition of the herds remains largely the
      same throughout the year. Males and females usually occur in separate herds.

From the above information answer the following questions:

(a)   Discuss factors influencing the distribution of territorial breeding grounds
      (TG) in this habitat.   (15 Marks)

(b)   How could this behaviour affect species dispersion and population growth.
      (15 Marks)

3.   The energy available, to and utilized by, an animal can serve many different
      functions. Suppose you have a juvenile, an adult male and an adult female from
      the same species. How would their energy demands be partioned over the course
      of the year if the species were   (a) Impala (*Aepyceros melampus*) (b) Leopard
      (*Panthera pardus*). Detail the patterns of energy from the environment to these
      animals showing those resulting in either positive or negative energy balance and
      explain why each has been so categorized. (30 Marks)

4.   Study the figure provided in this picture and answer the following questions:

      (i)   Describe this habitat type (15 marks)

      (ii)   List five (5) species of mammals common in this habitat (5 marks)

END OF EXAMINATION
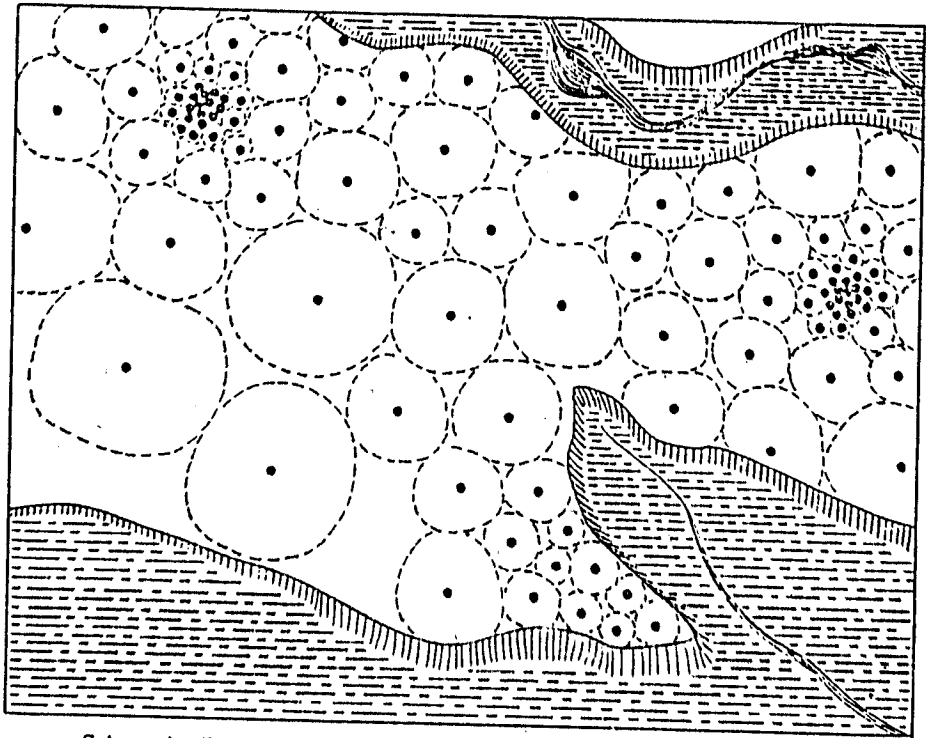
Schematic distribution of territories, illustrating the — irregular — gradients in size and density from the centers of two TGs. Along the swamp (upper part) the STs are slightly concentrated; on a raised, level area (lower right) they form a cluster. The central parts of the territories   are marked with black dots; their exact boundaries are unknown (broken outline).

BS 592: Fish and Wildlife Management

TIME: 3 HOURS

Paper I: Theory (Answer all questions)

Section A.

1. Give and explain the principles underlying the determination of the size and the age at maturity of a fish population (**5 marks)**

2. Explain the following terms as applied to fish stock assessment **(5 marks):**

(i) Year-class; (ii) Recruitment; (iii) The absolute partial fecundity; (iv) Fishery; (v) Age-group.

3. Give the main methods and related indices commonly employed to assessing the food selection and the food item preferences and importance in fish. State their advantages and disadvantages in using them **(10 marks)**

Section B.

1. Discuss the management application of the following terms used in wildlife management:

(i) Habitat evaluation and habitat improvement; (ii) King census method.

2. Give the characteristics of a population which is being overexploited. Discuss the limitations associated with Maximun Sustainable Yield in wildlife species.

3. State the main advantages and disadvantages in using: (a) Chemical methods and (b) Mechanical methods in animal capture; list difficulties associated with translocation and restocking operations in wildlife management.

END OF EXAMINATION

GOOD LUCK

University Second Semester Examinations

BS 592: Fish and Wildlife Management
TIME: 3 HOURS
Paper II: Practical (Answer all questions)

Section A.

1. The following table gives the age-length key of a fish species.

Length-groups (cm)	Age (yrs)	1	2	3	4	5	6	7	8
28-9			13	2					
30-1			18	2	2				
32-3			12	10	10		4		
34-5			3	14	11		12		
36-7				15	9		16		
38-9				9	16	1	14		
40-1				4	16		19		1
42-3				4	15	1	18	2	
44-5					8		29		
46-7					5		25	3	
48-9					1		17	1	
50-1					1	5	2		
52-3						4			
54-5						2	1		

Determine the age composition of total landings if the total number of fish landed in successive length groups are: 8100; 13147; 21248; 39068; 40502; 48540; 28351; 28351; 15204; 20251; 8100; 3302; 1246; 2306. **(10 marks).**

2. The following table gives a series of length at age data of a fish:

t (years)	L_t (cm)
0.64	17.3
1.16	27.9
1.65	35.3
2.10	40.2
2.64	43.3
3.21	45.5

Determine the von Bertalanffy growth equations for growth in length and weight using the Gulland and Holt method.
(N.B: The length-weight relationship is $W = 8{\cdot}10^{-3}L^3$; and the parameter t_0 to be used may be the average of the t_0 values to be obtained for different age-groups provided above) **(10 marks).**

Section B.

1. Study the map provided. The area is a degraded game management area in the Chisamba area, Kabwe District. However, recently the area was considered for restocking and for upgrading to a wildlife sanctuary. The area East of Chamapepe Hill is a proposed Soda Mine. The mine is to be an open pit with 150 workers, and the mine capacity is 300,000 tons per day of raw materials. This is to be processed in Kabwe. Initial investigations show that the area has several suitable habitat types for various wildlife species including Water buck, Kudu, Zebra, Wildebeest, Buffalo, Sable, Antelope, Eland, Bush buck, Warthog, Impala, Hippopotamus and Crocodile. As a qualified Wildlife Biologist, prepare a summary management plan of this sanctuary **(25 marks).**

2. Study specimens A and B, and answer the following questions:

(i)   Determine the age of each specimen and describe and list limitations of the technique used **(15 marks).**
(ii)   What is the practical application of aging of wildlife species **(10 marks).**

END OF EXAMINATION
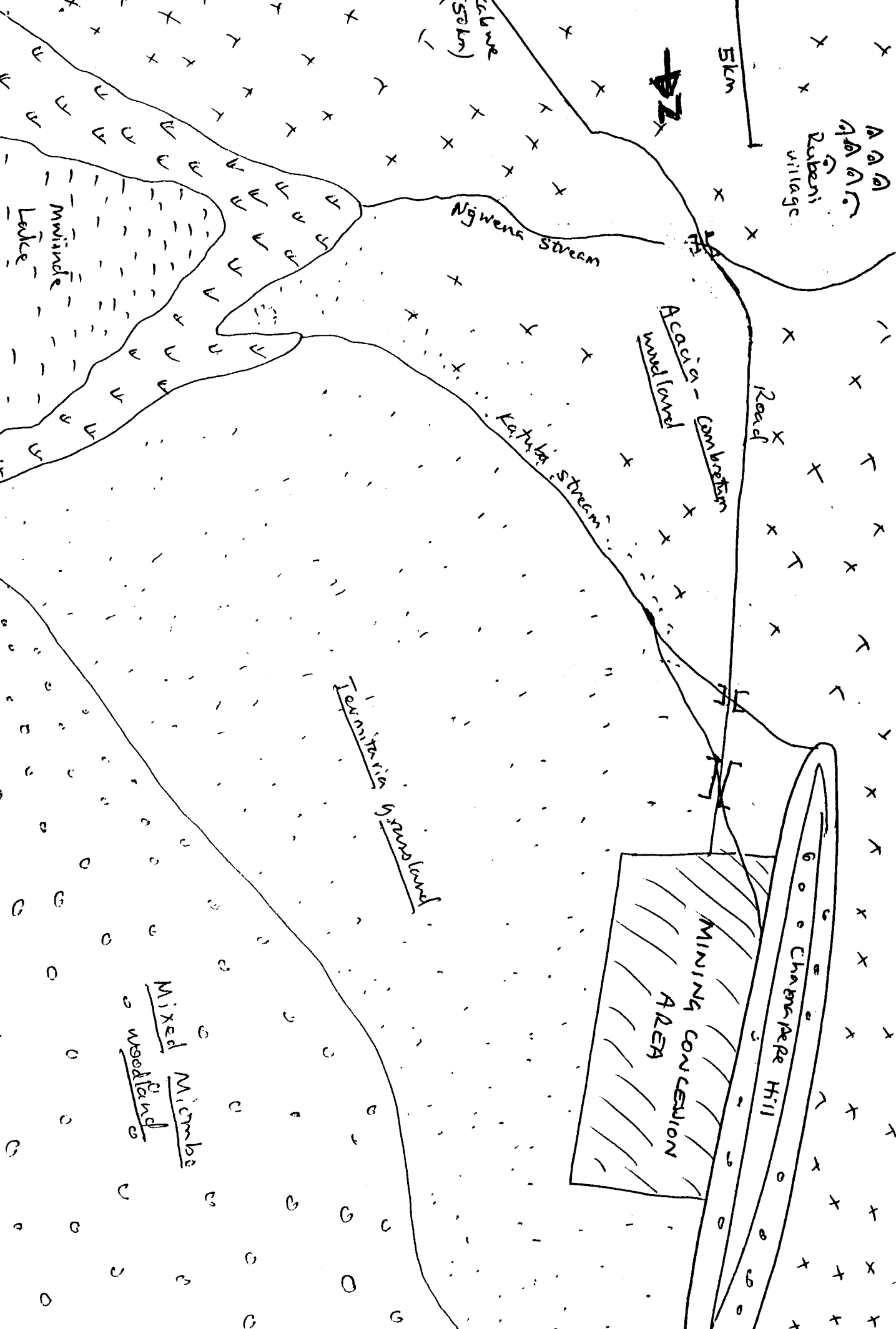
Good Luck

Mwinde
Lake

Ngwena Stream

Acacia - combretum
woodland

Katuba Stream

Road

Rubeni
village

5km

N

Termitaria
grassland

Mixed
woodland Miombo

MINING CONCESSION
AREA

Charenpere Hill

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER UNIVERSITY EXAMINATIONS - May 1999

BS 915

BIOLOGY OF SEED PLANTS

THEORY PAPER

THREE HOURS

INSTRUCTIONS:

Answer **FIVE** Questions, at least **One from Section A** and at least **Four from Section B**.

Write your answers clearly indicating the question numbers.

Write your *COMPUTER NUMBER* on all answer books.

Tie-up all the answer books in a single bundle.

SECTION A

1. Describe the botany and ecology of **rice** and **maize** and discuss their food value.

2. Define legumes and discuss their role in nutrition and agriculture. Identify six important legumes with their complete botanical names.

3. Distinguish between tissue and embryo culture and explain how the technique of embryo culture has been profitably used in horticulture.

SECTION B

4. Assuming that compound leaves could have evolved from a simple petiolate leaf, give an illustrated account of the evolutionary processes which could have culminated into the development of a 3-pinnately compound leaf.

5. Compare and contrast the anatomical features revealed in leaves of *Cycas revoluta* and *Pinus insularis*.

6. The latitundial line of 14°S, which runs just south of Kapiri Mposhi, roughly divides the Zambian territory into the high rainfall northern region that receives annual rainfall of about 1015-1520 mm and the southern region with an annual rainfall of 635-1015 mm. Explain how the miombo woodlands have responded to this climatic gradient along the transect running from Kitwe to Zimba.

7. Explain the manner in which plants express adaptations to xeric and hydric environments of the world.

8. Discuss the floristic composition and habitat preferences of some taxa that occur in Kalahari woodlands. Comment on the phytogeographical significance of this vegetation type to Angola, Botswana, Namibia and Zambia.

9. Distinguish between the "**weedy plant**" and "**alien plant**" and further describe the properties that determine the species ability to become a plant invader.

10. Define the term "**chorionomy**" and then discuss the features that characterise the Sudanian-Zambezian Region.

END OF EXAMINATIONS

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS, MAY 1999

BS935 - PLANT PATHOLOGY

THEORY PAPER

TIME: **THREE HOURS**

ANSWER: **ANY FIVE QUESTIONS**

1.   Discuss plant viruses and explain why they can be devastating agents of disease.

2.   Discuss the role of cell wall degrading enzymes in plant disease.

3.   Define patho- and microbial toxins and explain their importance in plant disease.

4.   Distinguish between structural and metabolic plant defence. Discuss how plants defend themselves chemically.

5.   What is disease management? Compare and contrast chemical control of plant disease and disease management through resistanct plant cultivars.

6.   What is biological control of plant disease? Discuss merits and demerits of biological control in disease management.

7.   Describe vascular wilt pathogens and explain how they cause disease in plants.

8.   Write short notes on any TWO of the following:

   i.   Disease forecasting
   ii.   Horizontal resistance
   iii. Anthracnose
   iv.   Plant rusts

END OF EXAMINATION

C 101   INTRODUCTORY CHEMISTRY I

Time: 3 hours

INSTRUCTIONS:

This examination paper has two (2) sections: section A and section B.

Section A: This section contains **25 multiple choice questions**.

You must answer **all questions** in this section.

Use the **answer grid** (the last page of this paper) for your answers.

Indicate your **computer number**, and **tutorial group number** on the answer grid.

Detach the answer grid from this paper and insert it in your answer booklet.

Section A carries **50 marks** in total.

Note that a correction for guessing will be applied.

Section B: This section contains **open-end questions**.

You must answer **any four (4)** of the five (5) questions given.

Use the **answer booklet** provided for your answers.

Indicate your **computer number**, and **tutorial group number** on the answer book.

Indicate on the answer book **which questions** you have answered.

Make sure your work is **clearly and neatly** presented.

Show your **working, calculations** and **reasoning**.

Each question carries 12½ marks, giving a total of **50 marks** for this section.

DATA ARE PROVIDED ON PAGES 2 AND 3 OF THIS QUESTION PAPER.

A COPY OF THE PERIODIC TABLE IS PROVIDED ON PAGE 3.

1. **Standard Reduction Potentials at 25 °C**

Half - reaction	E^o_{red} (in V)
$Cl_2(g) + 2e \longrightarrow 2Cl^-(aq)$	+ 1.36
$O_2(g) + 4H^+(aq) + 4e \longrightarrow 2H_2O(l)$	+ 1.23
$Fe^{3+}(aq) + e \longrightarrow Fe^{2+}(aq)$	+ 0.77
$I_2(s) + 2e \longrightarrow 2I^-(aq)$	+ 0.54
$Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$	+ 0.34
$2H^+(aq) + 2e \longrightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e \longrightarrow Pb(s)$	- 0.13
$Sn^{2+}(aq) + 2e \longrightarrow Sn(s)$	- 0.14
$Fe^{2+}(aq) + 2e \longrightarrow Fe(s)$	- 0.44
$Cr^{3+}(aq) + 3e \longrightarrow Cr(s)$	- 0.74
$Zn^{2+}(aq) + 2e \longrightarrow Zn(s)$	- 0.76
$2H_2O(l) + 2e \longrightarrow H_2(g) + 2OH^-(aq)$	- 0.83
$Al^{3+}(aq) + 3e \longrightarrow Al(s)$	- 1.66
$Mg^{2+}(aq) + 2e \longrightarrow Mg(s)$	- 2.36
$Na^+(aq) + e \longrightarrow Na(s)$	- 2.71
$Ca^{2+}(aq) + 2e \longrightarrow Ca(s)$	- 2.87
$Ba^{2+}(aq) + 2e \longrightarrow Ba(s)$	- 2.90

2. **Some useful constants**

Avogadro's Number, $N_A = 6.02 \times 10^{23}$ mol^{-1}

Universal Gas Constant, $R = 0.08206$ dm^3 atm mol^{-1} K^{-1} or 8.314 J mol^{-1} K^{-1}

Faraday's constant, $F = 9.65 \times 10^4$ C mol^{-1}

1.00 atm = 101.3 kPa = 760 mmHg = 760 Torr

Planck's constant, $h = 6.63 \times 10^{-34}$ J s

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

3. **Electronegativity values**

Be = 1.5   O = 3.5   S = 2.5   Cl = 3.0

4. **Standard enthalpies of formation** (in kJ mol^{-1})

$CaO(s) = - 635.1$ $Ca(OH)_2(s) = - 986.1$ $CaCO_3(s) = - 1207.0$

$CO_2(g) = - 393.5$ $H_2O(l) = - 285.8$

5. Some useful equations

Thermochemistry:

$$\Delta H = \Sigma n \Delta H_f(\text{products}) - \Sigma n \Delta H_f(\text{reactants})$$

$$\Delta H = \Sigma n \text{B.E.}(\text{reactants}) - \Sigma n \text{B.E.}(\text{products})$$

$$\Delta E = q - w \quad \text{and} \quad \Delta H = \Delta E + P\Delta V$$

Gases: van der Waals equation: $(P + n^2 a / V^2)(V - n b) = nRT$

Electrochemistry:

Nernst equation: $E_{cell} = E^o_{cell} - (2.303 \, RT / nF) \log([C]^c[D]^d/[A]^a[B]^b)$

6. Atomic masses (in a.m.u.)

H	=	1.01	C = 12.01	N	=	14.01
O	=	16.00	F = 19.00	Na	=	22.99
Mg	=	24.31	P = 30.97	S	=	32.06
Cl	=	35.45	K = 39.10	Ca	=	40.08
Ti	=	47.90	Fe = 55.85	Ni	=	58.71
Zn	=	65.43	Br = 79.90	Ag	=	107.87
Sn	=	118.71	I = 126.90	Ba	=	137.34
Au	=	196.97	Hg = 200.59	Pb	=	207.2

7. The Periodic Table of the Elements

SECTION A - MULTIPLE CHOICE QUESTIONS

Reminder: Use the answer grid (the last page of this paper) to answer the multiple choice questions.

Detach the answer grid from this paper and insert it in your answer booklet.

1. The true value for the concentration of a solution is 0.248 M. Which set of measured values would then represent a good accuracy but a poor precision?

    a. 0.248 M, 0.249 M, 0.250 M

    b. 0.242 M, 0.244 M, 0.246 M

    c. 0.244 M, 0.248 M, 0.252 M ✓

    d. 0.244 M, 0.244 M, 0.244 M

    e. 0.248 M, 0.248 M, 0.247 M ✗

2. Which one of the following units is NOT a SI base unit ?

    a. metre

    b. mole

    c. ampere

    d. gramme ✓

    e. second

3. The atoms $^{46}_{22}$Ti and $^{48}_{22}$Ti differ in

    a. atomic number.

    b. chemical properties.

    c. mass number. ✓

    d. number of electrons.

    e. valency.

4. A bottle labelled (i) contains 1 mol of liquid mercury; a bottle labelled (ii) contains 1 mol of zinc powder. Which bottle contains the larger number of metal atoms?

    a. Bottle (i).

    b. Bottle (ii).

    c. Both bottles contain the same number of atoms. ✓

    d. The question can only be answered if the densities of the metals are known.

    e. The substances cannot be compared since they are in a different physical state.

5. An experiment was performed to determine the formula of an oxide of lead. Some of the lead oxide was added to a tube. The tube was heated and the oxide reduced to lead by passing hydrogen gas over it.
The results were as follows:

mass of test tube:	15.647 g
mass of test tube and lead oxide:	15.875 g
mass of test tube and lead:	15.854 g

According to the experiment, the formula for the lead oxide is

a. PbO

b. PbO_2

c. Pb_2O_3

d. Pb_3O_2

e. Pb_3O_4

6. 1 dm^3 of 1 M aqueous oxalic acid reacts with 2 dm^3 of 1 M aqueous potassium hydroxide. Therefore

a. 0.5 dm^3 of 0.5 M oxalic acid reacts with 0.25 dm^3 of 1 M potassium hydroxide.

b. 1 dm^3 of 0.5 M oxalic acid reacts with 2 dm^3 of 1 M potassium hydroxide.

c. 2 dm^3 of 0.5 M oxalic acid reacts with 1 dm^3 of 2 M potassium hydroxide.

d. 0.5 dm^3 of 2 M oxalic acid reacts with 1 dm^3 of 1 M potassium hydroxide.

e. 1 dm^3 of 2 M oxalic acid reacts with 4 dm^3 of 0.5 M potassium hydroxide.

7. When aqueous barium hydroxide is added to dilute hydrochloric acid in a beaker, which one of the following is NOT happening in the solution in the beaker?

a. The hydrogen ion concentration decreases.

b. Water is produced.

c. A solution of a salt is formed.

d. The chloride ion concentration decreases.

e. A gas is given off.

8. Which one of the following acids is a strong acid ?

a. H_3PO_4

b. HF.

c. H_2SO_3

d. $HClO_4$

e. $HC_2H_3O_2$

Which one of the following reactions is an example of a redox reaction ?

a. $NaOH(s) + NH_4^+(aq) \longrightarrow Na^+(aq) + NH_3(g) + H_2O(l)$

b. $NaH(s) + H_2O(l) \longrightarrow Na^+(aq) + H_2(g) + OH^-(aq)$

c. $Na_2O(s) + 2H_3O^+(aq) \longrightarrow 2Na^+(aq) + 3H_2O(l)$

d. $Na_2CO_3(s) + 2H_3O^+(aq) \longrightarrow 2Na^+(aq) + CO_2(g) + 3H_2O(l)$

e. $NaOH(s) + H_3O^+(aq) \longrightarrow Na^+(aq) + 2H_2O(l)$

10. The thiosulphate ion, $S_2O_3^{2-}$, can be oxidised to the tetrathionate ion, $S_4O_6^{2-}$. The correct half-reaction would be

a. $2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2e$

b. $S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2e + 2H^+$

c. $2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 4e + 2H^+$

d. $S_2O_3^{2-} + 3H_2O \longrightarrow S_4O_6^{2-} + 6e + 6H^+$

e. $2S_2O_3^{2-} + 3H_2O \longrightarrow S_4O_6^{2-} + 4e + 2H^+$

11. Three students were asked to devise a galvanic cell using the following half-reactions:

$$Sn^{2+}(aq) + 2e \longrightarrow Sn(s) \qquad E^o_{red} = -0.14 \text{ V}$$
$$Cd^{2+}(aq) + 2e \longrightarrow Cd(s) \qquad E^o_{red} = -0.40 \text{ V}$$
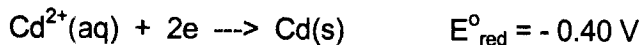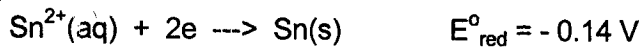
(i). Student (i) argued that a galvanic cell could not be constructed from these two half-reactions since both values for E^o_{red} were negative.

(ii). Student (ii) argued that a galvanic cell could only be made if the Cd^{2+} / Cd redox couple were the cathode.

(iii). Student (iii) reasoned that an inert platinum electrode would be needed for the anode and the cathode since Sn(s) and Cd(s) would be involved in the electrode half-reactions

Which student(s) argued correctly ?

a. None of the students.
b. Student (i) only.
c. Student (ii) only.
d. Student (iii) only.
e. Students (ii) and (iii).

12. Which one of the following species would, under standard conditions, NOT be able to oxidise iron ?

a. Iodine.
b. Lead.
c. Copper(II) ions.
d. Iron(III) ions.
e. Tin(II) ions.

13. An aqueous solution of aluminium chloride was electrolysed using inert electrodes. The most likely species produced at the cathode will be

a. aluminium

b. hydrogen gas.

c. oxygen gas.

d. chlorine gas.

e. aluminium(I) ions. .

14. A certain nickel salt was electrolysed: a current of 0.80 A produced 0.290 g of nickel after 10 min.
The amount of electricity needed to produce 1.0 mol of nickel atoms is therefore

a. 1.0 C

b. 2.4 C

c. 1.6×10^3 C

d. 9.7×10^4 C

e. 2.3×10^5 C

15. What is the value for the Universal Gas Constant R in dm^3 Torr K^{-1} mol^{-1} if experiment shows that the molar volume of a gas at STP equals 22.4 dm^3.

a. 62.4 dm^3 Torr mol^{-1} K^{-1}

b. 57.1 dm^3 Torr mol^{-1} K^{-1}

c. 8.31 dm^3 Torr mol^{-1} K^{-1}

d. 0.124 dm^3 Torr mol^{-1} K^{-1}

e. 0.0821 dm^3 Torr mol^{-1} K^{-1}

16. A student gave the following three reasons to explain that real gases do not behave exactly as ideal gases:

(i).   The volume of the molecules themselves cannot be neglected.

(ii).   Molecules in a gas experience attractions from each other.

(iii). Collisions between the molecules in a gas are not elastic collisions: molecules loose energy when they collide.

a. Only reason (ii) is correct.

b. Reasons (i) and (ii) are both correct.

c. Reasons (i) and (iii) are both correct.

d. Reasons (ii) and (iii) are both correct.

e. All three reasons are correct.

17. For which reaction equation is the standard reaction enthalpy the same as the standard enthalpy of formation for water.

    a. $H^+(aq)$ + $OH^-(aq)$ ---> $H_2O(l)$

    b. $2H_2(g)$ + $O_2(g)$ ---> $2H_2O(l)$

    c. $2H(g)$ + $O(g)$ ---> $H_2O(l)$

    d. $H_2(g)$ + $O_2(g)$ ---> $H_2O(l)$

    e. $H_2(g)$ + $\frac{1}{2}O_2(g)$ ---> $H_2O(l)$

18. The bond energy for the N N bond is 946 kJ/mol, for the H-H bond is 432 kJ/mol, and for the N-H bond is 392 kJ/mol.
What is the ΔH for the reaction: $N_2(g)$ + $3H_2(g)$ ---> $2NH_3(g)$?

    a. + 1458 kJ

    b. + 986 kJ

    c. + 110 kJ

    d. - 110 kJ

    e. - 1458 kJ

19. The following exothermic reaction occurs at constant pressure:

    $NH_3(g)$ + $HCl(g)$ ----> $NH_4Cl(s)$

Given three statements about this reaction:

(i) Work is done upon the system.

(ii) The reaction enthalpy (ΔH) equals the heat output (q) of this reaction.

(iii) The internal energy change (ΔE) for this reaction would be different from the enthalpy change (ΔH).

    a. Only statement (ii) is correct.

    b. Statements (i) and (ii) are both correct.

    c. Statements (i) and (iii) are both correct.

    d. Statements (ii) and (iii) are both correct.

    e. All three statements are correct.

20. A certain radiation emitted by magnesium has a wavelength of 285.2 nm.
Three statements concerning this radiation are given:

(i)   It has a higher frequency than radiation with a wavelength of 313 nm.

(ii)   It is in the visible region of the electromagnetic spectrum.

(iii) It has a greater speed than radiation with a wavelength of 700 nm.

Which of these statements are correct ?

a.   Only statement (i) is correct.

b.   Statements (i) and (ii) are both correct.

c.   Statements (i) and (iii) are both correct.

d.   Statements (ii) and (iii) are both correct.

e.   All three statements are correct.

21. Given the following orbital diagram: $(\uparrow\downarrow)$ $(\uparrow\downarrow)$ $(\uparrow\downarrow)(\uparrow\downarrow)(\uparrow\downarrow)$ $(\uparrow)$
$1s^2$ $2s^2$ $2p^6$ $3s^1$

What are the values for the quantum numbers for the electron in the 3s orbital ?

a. $n = 3$ $l = 0$ $m_l = 0$ $m_s = +\frac{1}{2}$ ✓

b. $n = 3$ $l = 0$ $m_l = 1$ $m_s = +\frac{1}{2}$

c. $n = 3$ $l = 1$ $m_l = 0$ $m_s = -\frac{1}{2}$

d. $n = 3$ $l = 1$ $m_l = 1$ $m_s = +\frac{1}{2}$

e. $n = 3$ $l = 1$ $m_l = -1$ $m_s = -\frac{1}{2}$

22. Which subshell is being filled up in the group of elements called the lanthanides ?

a.   4f subshell.

b.   5f subshell.

c.   5g subshell.

d.   6d subshell.

e.   6f subshell.

23. Arrange the following elements in terms of increasing first ionization energy: Si, Na, S, Rb, O.

a.   Si, Na, S, Rb, O.

b.   Rb, Na, Si, S, O.

c.   Na, Rb, O, S. Si.

d.   O, S, Si, Na, Rb.

e.   S, O, Rb, Na, Si.

24. The table below gives information about some properties for five substances:

substance	melting point (in K)	boiling point (in K)	electrical conductivity	
			if solid	if molten
A	1235	2485	good	good
B	1074	1686	nil	good
C	317	553	nil	nil
D	234	630	good	good

Which one of the substances would most likely be an ionic compound ?

a. Substance A.

b. Substance B.

c. Substance C.

d. Substance D.

e. None of the four substances.

25. In terms of its shape and polarity, the SO_2 molecule would be

a. linear and polar.

b. linear but non-polar.

c. bent and polar.

d. bent but non-polar.

e. trigonal planar and polar.

SECTION B - OPEN-END QUESTIONS

Reminder: You must answer any four (4) of the five (5) problems given.
Show your method, working and reasoning clearly.
Round the final answer to the correct number of significant figures.

---

1. Beryllium is the first element in group 2 of the Periodic Table, the alkaline earth metals. It is the least metallic of these elements, and several of its properties and that of its compounds are distinct from those of the other members of group 2.

(a). The standard reduction potential for the Be^{2+}(aq) / Be redox couple is - 1.85 V.

    (i). Explain that, based on its standard reduction potential, beryllium is expected to react with water. *(3 marks)*

    (ii). However, beryllium does not react with water. It is passivated like aluminium.
What is meant with the statement "it is passivated" ? *(1 marks)*

(b). Beryllium oxide shows amphoteric behaviour, it reacts with solutions of acids and strong bases.

    (i). Write the net ionic equation for the reaction of solid beryllium oxide with a strong acid. *(1 mark)*

    (ii) When beryllium oxide reacts with the solution of a strong base, the beryllate ion, $Be(OH)_4^{2-}$, is formed.
Give the Lewis structure for the beryllate ion (Be is the central atom).
What is the shape of the beryllate ion ? *(3 marks)*

(c). Beryllium chloride, $BeCl_2$, is a gaseous molecular compound at temperatures above 750 °C. It can be formed from the reaction of solid beryllium oxide with carbon and chlorine gas. Carbon monoxide is the other product of this reaction.

    (i). Write the reaction equation for the production of beryllium chloride. *(1 mark)*

    (ii) Give the Lewis structure of $BeCl_2$(g). *(1 mark)*

    (iii). What is special about the Lewis structure of $BeCl_2$(g) ? *(1 mark)*

    (iv). Do you expect $BeCl_2$(g) to be polar ? *(1.5 marks)*

2. Magnesium is the second element in group 2, and more typical of these metals than beryllium. It is the second most abundant metallic element in the sea, after sodium. The concentration of the magnesium ion in seawater is about 1.26 g dm^{-3}. Magnesium metal can be obtained from seawater in a three-step process:

> (i). It is precipitated as the hydroxide by treatment of seawater with lime (calcium hydroxide).

> (ii). After separation from the seawater by filtration, the magnesium hydroxide is treated with hydrochloric acid. Evaporation of the water gives solid magnesium chloride.

> (iii). The magnesium chloride is electrolysed in the molten state.

(a). Give the net ionic equation for each reaction mentioned in steps (i) and (ii).
(3 marks)

(b). Give the anode and the cathode reaction, and the overall reaction for the electrolysis mentioned in step (iii). *(2.5 marks)*

(c). What volume of seawater is required to produce 1.0 mol of magnesium metal, assuming a yield of 95% in each of steps (i) and (ii). *(4 marks)*

(d). Magnesium metal is often used as a sacrificial anode to protect large steel objects like a bridge or a pipe line. Explain briefly the use of magnesium as a sacrificial anode. *(3 marks)*

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3. Calcium, the third element in group 2, is the most abundant alkaline earth metal, and occurs as the carbonate in various types of mineral deposits like chalk, limestone and marble.

(a). A sample of impure calcium carbonate of mass 3.00 g is dissolved in 60.00 cm^3 of 1.00 M hydrochloric acid. The resulting solution is heated, and after cooling titrated with 26.89 cm^3 of 0.595 M aqueous sodium hydroxide.

> (i). Write the equation for the reaction of the sample with the hydrochloric acid solution. *(1 mark)*

> (ii). Write the equation for the titration reaction. *(1 mark)*

> (iii). Calculate the mass percentage of calcium carbonate in the sample. *(4.5 marks)*

(b). Calcium carbonate decomposes to give calcium oxide (called quicklime) when heated.
Controlled addition of water to quicklime produces slaked lime, solid calcium hydroxide, with a considerable release of heat.

> (i) Using both reactions mentioned, write the reaction equation for the overall reaction of converting calcium carbonate to slaked lime. *(2 marks)*

> (ii) Calculate the heat effect for the conversion of 1.0 kg of calcium carbonate to slaked lime, using the thermochemical data in the data section of this paper. *(4 marks)*

4. Strontium is the element following calcium in group 2 of the Periodic Table.

(a). Write the full electron configuration for the strontium atom.   (2 marks)

(b). Compare the size of a strontium atom with that of a rubidium atom (Rb), the element preceding it in the Periodic Table, and with that of a barium atom.
                                                                                (2 marks)

(c). Using the following data, calculate the lattice enthalpy for strontium chloride.

$$Sr(g) \longrightarrow Sr^{2+}(g) + 2e \qquad \Delta H^\circ = + 1613 \text{ kJ mol}^{-1}$$

Electron affinity for $Cl(g) = - 349 \text{ kJ mol}^{-1}$

Standard enthalpy of formation for $SrCl_2(s) = - 828 \text{ kJ mol}^{-1}$

Enthalpy of sublimation for $Sr(s) = + 163 \text{ kJ mol}^{-1}$

Bond enthalpy Cl-Cl bond $= + 244 \text{ kJ mol}^{-1}$ (5.5 marks)

(d). Given its position between calcium and barium in the Periodic Table, would you expect that electrolysis of an aqueous solution of strontium chloride would yield the metal strontium ?   (3 marks)

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5. Barium, like the two elements above it in group 2 of the Periodic Table, emits a characteristic colour when heated in a flame.

(a). Barium atoms give a green colour when heated in a flame due to an electronic transition that gives off light at 554 nm.

(i). Explain why barium atoms could give off light when heated in a flame.
                                                                                (2 marks)

(ii). What is the energy difference for this electronic transition ?   (2 marks)

(b). The first ionization energy of barium is 503 kJ mol^{-1}.

(i). Write the reaction equation representing the first ionization energy of barium.   (1 mark)

(ii). What is the first ionization energy per barium atom ?   (2 marks)

(c). Barium can form a peroxide. At 700 °C, solid barium peroxide decomposes to solid barium oxide and oxygen.

(i). Write the reaction equation for the decomposition of barium peroxide.
                                                                                (1 mark)

(ii). What is the volume of oxygen collected if a sample of 10.5 g of barium peroxide is heated strongly at 25 °C and 695 mm Hg ?   (3.5 marks)

(ii). Explain briefly if the volume of gas collected would have been the same as in (i) above if the oxygen would have been collected over water.
                                                                                (1 mark)

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
MAY 1999

C205
ANALYTICAL-INORGANIC CHEMISTRY

TIME: **Three (3) Hours**
Instructions:

> 1. **Answer Question 1 and any other THREE Questions.**

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1. (a) What is the most important requirement for a sample? Explain one method used to reduced a solid sample to a manageable size.
        Define: (i) Normality (ii) Molality (iii) ppm and (iv) mg%

    (b) What are determinate errors? Name three sources of these errors.

        Define the standard deviation of a set of data.

    (c) What is the F-test and what is it used for?

        Compare and contrast the student's paired t-test and the t-test for multiple samples.

    (d) Define any two acid-base theories. What is a buffer and what is it used for?

    (e) Compare and contrast the equivalence point and end-point of a reaction. Name three types of volumetric analyses and briefly mention what happens in each case.

    (f) Name three major types of bonds between atoms indicating the type of atoms involved.

    (g) What are the assumptions on which the Bohr theory of the structure of the hydrogen atom is based?

    (h) Solutions to Schrödinger's equation that are physically possible must have four properties. Name the properties.

(i) Explain (i) the exclusion principle
(ii) Hund's rule; and
(iii) Heinsenberg uncertainity principle

(28 Marks)

2. (a) Give an explanation as to why d-orbitals only hybridize if highly electronegative atoms are bonded to the central atom of a molecule.

Determine the hybridisation on the central atom in:

(i) PF_3
(ii) SF_4

Indicate whether the bond angles are likely to be distorted from the theoretical values.

$$P = 15, \ S = 16, \ F = 19$$

(b) The work function of a metal is defined as $E_o = h\nu_o$ where ν_o is the threshold or cut-off frequency. If the work function for a metal is 1.8 eV, calculate the kinetic energy and velocity of the ejected photoelectron when a photon of wavelength equal to 4000Å strikes the metal.

Me $= 9.11 \times 10^{-31}$ Kg
h $= 6.63 \times 10^{-34}$ J.Sec
1 eV $= 1.602 \times 10^{-19}$ J

(24 Marks)

3. (a) (i) Ionization energy increases across a period from left to right and decreases as you descend a group. Explain these observed trends.

(ii) Calculate the energy emitted when an electron drops from infinity to a Lyman line of the hydrogen atom. Use your answer to calculate the ionization energy of one mole of hydrogen atoms.

Rydeberg constant $(R_H) = 1.10 \times 10^7 \, m^{-1}$

Avogadro's number $(N_A) = 6.02 \times 10^{23}$

(24 Marks)

(b) (i) Draw molecular energy diagrams for the molecules O_2^+ and O_2^{2-}. Determine the bond order and magnetism of the ions.
(ii) Use molecular orbital theory to predict whether Be_2 can exist.
Be $= 4$, O $= 8$

(24 Marks)

4. A solution is 0.200M in potassium acid oxalate ($KHC_2O_4.H_2C_2O_4$). How many grams of sodium oxalate ($Na_2C_2O_4$) must be added to 200 mL of the solution so that the normality of the resulting solution as a reductant ($C_2O_4^{2-} \rightarrow CO_2$). is 3 times the normality as an acid (all 3 protons ionize). Assume no volume change.

Molecular mass:-

$$KHC_2O_4.H_2C_2O_4 = 218.16$$
$$Na_2C_2O_4 = 58.44$$
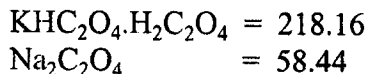
(24 Marks)

5. A 100 mL solution of 0.100M sodium acetate is titrated against 0.100M hydrochloric acid. Calculate the pH of the solution, and hence plot the tiration curve, at the following points of the titration:

0%, 25%, 50% 75%, 100% and 125%.

$$Ka(CH_3COOH) = 1.75 \times 10^{-5}$$

(24 Marks)

6. (i) If the concentration of a solution of A is given as X% w/w and density $= \rho$ g/cm^3 show that its molarity (M) is given by:

$$M = \frac{X\% \times \rho gcm^3 \times 10}{MolecularMassofA}$$

(ii) What volume of concentrated sulphuric acid (93.0% w/w, $\rho = 1.83$ g/cm^3) should be diluted with water to 1.00 litre to make a 25.0% w/w solution of the acid. What is the molality of the dilute solution?

$$\rho(H_2O) = 1.00 \text{ g/cm}^3$$

(24 Marks)

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C205 DEFERRED / SUPPLEMENTARY EXAM

SEMESTER 1 1999

TIME ALLOWED　:　THREE (3) HOURS

ANSWER　　　　:　ANY TWO QUESTIONS FROM EACH SECTION

ALL QUESTIONS CARRY EQUAL MARKS

SECTION A
(ANALYTICAL CHEMISTRY)

1) a) Define the following terms
   i) Accuracy and precision.
   ii) Relative error and absolute error
   iii) Standard deviation of the mean (s_x) and coefficient of variation (s_r)
   iv) Confidence limit and confidence level
   v) Arrhenius theory and Bronsted Lowry theory.

   b) The following data was obtained for phosphorous in urine. Determine the linear least-squases line and make the plot. Calculate the concentration of phosphorous in the urine if its absorbance reading is 0.625.

Standards (ppm P)	Absorbance reading
1.00	0.205
2.00	0.410
3.00	0.615
4.00	0.820

2. a) Derive the α_o expression for H_2S hence calculate the concentration of all the species in a 0.100M solution of H_2S at pH = 6.00 $Ka_1 = 9.1 \times 10^{-8}$, $Ka_2 = 1.2 \times 10^{-15}$

   b) Calculate the concentration of all the species in a 0.100M solution of H_2SO_4. Assume the first ionization step proceeds to completion and the second ionization step has $Ka_2 = 0.012$.

3. a) Calculate the pH of 1.00×10^{-7} M HCl.

   b) How many moles of potassium hydroxide must be added to a 250ml solution containing 0.100M each of C_6H_5COOH and C_6H_5COOK in order to give a solution whose pH is 4.60? Assume no volume change. $Ka (C_6H_5COOH) = 6.3 \times 10^{-5}$

c)   Calculate the pH of 0.200M NaH_2PO_4

For H_3PO_4:
$Ka_1 = 1.1x10^{-2}$
$Ka_2 = 7.5 \times 10^{-8}$
$Ka_3 = 4.8 \times 10^{-13}$

SECTION B
(INORGANIC CHEMISTRY)

1.   a)   One of the rules governing hybridisation is that the resultant hybrid orbital assume the direction (in shape) characteristic of the dominating atomic orbital (in terms of energy). Name the other four rules.

      b)   Predict the hybridization on the central atom of the following molecules and hence determine the shape of each molecule.
            $Cl F_3$, I_3^- and SO_2

      c)   The trend in ionization energy is generally an increase across a period. Explain why the opposite is true when you move from Be ----> B or Mg --->Al and when you move from N --->O or P --->S.

2.   a)   Use molecular orbital theory to determine which molecule has the stronger bond in the following pairs.
            O_2^+ and O_2^-
            N_2^+ and N_2^-

            Which molecules are paramagnetic and which are diamagnetic?

      b)   Name four factors that affect ionization energy and briefly explain any two.

3.   a)   Name three properties of photoelectric emissions.

      b)   Calculate the wavelength of an electron that drops from infinite to
            i)   Lyman series
            ii)   Balmer series
            iii) Brackett series

            Which wavelength would correspond to the ionization energy of a hydrogen atom?

            $R = 1.10 \times 10^7 \, m^{-1}$

      c)   i)   Define all the four quantum numbers that describe an electron and state how they are related to each other.

ii)   Give the electronic configuration for:

As (Atomic No. 33)
Cu^+ (Atomic No. 30)

d)   What is eletronegativity? What is its observed trend with regard to the periodic table. Explain briefly why this trend is observed.

END OF EXAM.

TIME ALLOWED   :   THREE (3) HOURS

ANSWER   :   ALL QUESTIONS
                :   ALL QUESTIONS CARRY EQUAL MARKS

---

1. a) Define the following terms:

    i)   Accuracy and precision
    ii)   Relative error and absolute error
    iii) Confidence limit and confidence level.
    iv)   Relative standard deviation and standard deviation of the mean.
    v)   Gravimetric factor and gravimetric analysis.

    b) The following data was obtained for phosphorus in urine. Determine
        the linear least-squares line and make the plot. Calculate the
        concentration of Phosphorus in the urine sample if its absorbance
        reading is 0.625.

Conc. of phosphorus standards (ppm)	Absorbance reading (Arbitrary units)
1.00	0.205
2.00	0.410
3.00	0.615
4.00	0.820

2. a) Calculate the pH of a 1.00×10^{-7} MHCl solution.

    b) Calculate the concentration of the following species in a 0.020M
        H_2SO_4 solution:
        H^+, OH^-, HSO_4^- and SO_4^{2-}
        $Ka_1 (H_2SO_4) = 1.00 \times 10^2$ and $Ka_2 (H_2SO_4) = 1.20 \times 10^{-2}$

3. a) Calculate the pH of a 0.100 M solution of $Na_3 PO_4$.

    b) The carbon dioxide content (HCO_3^- plus CO_2) in a blood sample was
        determined by acidifying the sample and measuring the volume of
        CO_2 evolved with a Van Slyke manometric apparatus. The total
        concentration was determined to be 28.5 mmol/L. The blood pH at
        $37^\circ c$ was determined to be 7.48. What are the concentrations of
        HCO_3^- and CO_2 in the blood sample.

4. a) A sample known to contain only AgCl (143.32) and AgI (234.77) weighs 1.50g. It is reduced quantitatively to metallic silver (107.87), which amounted to 0.8500g. What is the weight of AgCl and AgI in the sample?

    b) The mineral dolomite is a mixture of $CaCO_3$ (100.07) and $MgCO_3$ (84.32) only. A 1.0g sample of dolomite is ignited, volatilizing CO_2 and leaving a residue of CaO (56.08) and MgO (40.31), which is found to weigh 0.52g. What is the % $CaCO_3$ and % $MgCO_3$ in the dolomite?

5. a) Calculate the molar solubility of $Ag_2 CrO_4$ when its solubility product has the value of 2.0×10^{-12}.

    b) Solid $Ag_2 CrO_4$ ($K_{sp} = 2.0 \times 10^{-12}$) is equilibrated with a 1.0×10^{-3}M $AgNO_3$ solution. What is the equilibrium concentration of chromate ion in the solution?

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
MAY 1999

C245
INORGANIC CHEMISTRY

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1.   (a)   Briefly write short notes on each of the following:

        (i)   Photoelectric effect

        (ii)   Bohr's postulates

    (b)   (i)   The critical wavelength for producing the photoelectric effect in tugsten is 2600Å. What will be the kinetic energy of electrons produced when photons of wavelength 2200Å strike the tungsten metal?

        (ii)   Calculate the wavelength of photon emitted when an electron drops from the third to the second orbit.

2.   (a)   Discuss the variation of the following atomic properties across second period.

        (i)   Covalent radius

        (ii)   Electronegativity

        (iii)   First ionization energy

    (b)   Sketch the shapes of atomic orbitals associated with the principal quantum number, $n = 3$.

3.   (a)   Using molecular orbital theory concepts explain why the bond length of N_2^+ is 0.02Å greater than that of N_2 whereas that of NO^+ is 0.09Å less than that of NO.

    (b)   Deduce the geometry and the type of hybridization around the central atom in;

        (i) XeO_3 (ii) XeF_4 (iii) BrF_5 (iv) XeF_6

4. (a) Consider the elements sodium, magnesium and aluminium. Briefly discuss their reactions, if any, with hydrogen, chlorine, oxygen and water. Give balanced equations where possible. What do you expect to happen when samples of products from reactions with hydrogen, chlorine and oxygen are added to water?

(b) Given the following thermodynamic data, sketch a Born-Haber cycle. Hence calculate the lattice energy of MgS.

$Mg(s) \rightarrow Mg(g)$ +152.6

$Mg(g) \rightarrow Mg^{2+}(g)$ +2176.1

$1/8 S \rightarrow S(g)$ +556.1

$S(g) \rightarrow S^{2-}(g)$ -302.6

$Mg(s) + {}^{1}/_{8} S(s) \rightarrow MgS(s)$ -343.6 Units are in KJ Mol^{-1}
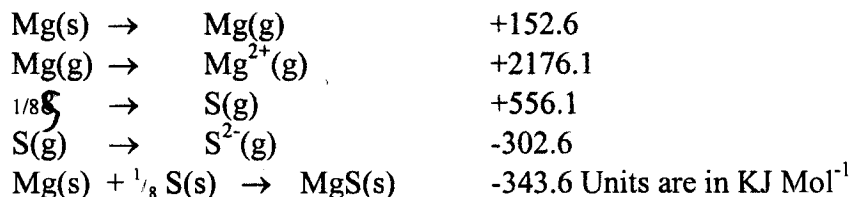
5. (a) Determine the number of unpaired electrons and the magnetic moments in:-

(i) Fe(II)   (ii) Pt(IV)

(b) $[Cu(CN)_4]^{2-}$ is a square planar complex. Deduce the type of hybridization around the central metal atom and show the arrangement of metal d-electrons in the complex.

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2

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER I DEFERRED/SUPPLEMENTARY EXAMINATIONS, NOVEMBER 1999

C251

ORGANIC CHEMISTRY I

INSTRUCTIONS:

1. THIS PAPER CONSISTS OF SECTION A AND SECTION B
2. TIME ALLOWED FOR THIS PAPER IS THREE (03) HOURS
3. ANSWER TWO QUESTIONS FROM SECTION A AND TWO QUESTIONS FROM SECTION B
4. ALL QUESTIONS CARRY EQUAL MARKS. MARKS FOR EACH PART OF THE QUESTION ARE INDICATED

SECTION A

Answer two (02) questions in this section

QUESTION ONE

(a) (i) When 3,3-dimethyl-1-butene was treated with $CBrCl_3$ in presence of light a single product was obtained. Write a mechanism for this reaction to account for the formation of this product.

(ii) Account for the fact that the addition of aqueous hydrogen bromide in presence of hydrogen peroxide takes place faster to 2-ethyl-1-hexene than to 1-octene. Would you expect the same rate of reaction in absence of hydrogen peroxide?

06 Marks

(b) A chemist prepared a compound A by reacting 2-methylpropene with an aqueous solution of bromine. Compound A was then treated with an aqueous solution of sodium hydroxide and a compound B was obtained. When compound B was reacted with methylbromide that had been previously refluxed with magnesium turnings in ether, yielded a compound which after acidic hydrolysis gave a compound C. Compound C was subsequently treated with Jone's reagent and it

1

quantitatively yielded a compound D. Provide a plausible reaction mechanism to account for these transformations showing in detail all steps and intermediates involved and name compounds A, B, C and D.

13 Marks

(c)   Show how you would accomplish the following transformations.

i) $\longrightarrow$ -Br + CH_3Br + H_2O

ii) $CH_3CH_2OH \longrightarrow$
$$\underset{CH_3\overset{\overset{\displaystyle OH}{|}}{C}HCH_3}{}$$
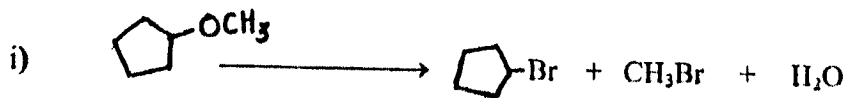
06 Marks

QUESTION TWO

a)   Assign E or Z configurational label to the following alkenes.

(i)

(ii)

(iii)
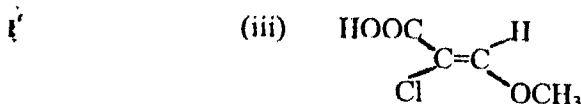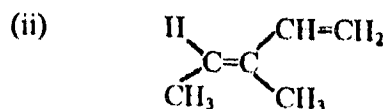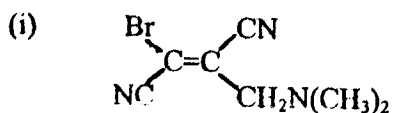
(ii)   With the help of a mechanism show what type of stereospecific reaction you would expect if cyclopropene were chlorinated

04 Marks

b)   (i)   Hydration of alkynes is usually catalysed by mercury II salts. Write a mechanism for the hydration of cyclooctyne and comment briefly on its regiochemistry.

(ii)   Using a sawhorse structure representation show the product(s) of the reaction of (1S, 2S)–1,2–dibromo–1,2–diphenylethane with potassium hydroxide in ethanol.

10 Marks

c) (i) On treatment with sulfuric acid, ethylidenecyclohexane yields a compound A, C_8H_{14}. Propose a mechanism for this transformation and name compound A. Which compound is more stable, ethylidenecyclohexane or compound A?

(ii) Reaction of compound A in c(i) above with mercuric acetate in water, followed by treatment with sodium borohydride, gives a compound B in a high yield. Provide a mechanism, showing all intermediates involved in this reaction and name compound B. If the water in this reaction were replaced by methanol, what product would you expect to obtain?

11 Marks

QUESTION THREE

a) The molecular structure of organic compounds, can be revealed by their respective cleavage products. Using this knowledge predict the molecular structure of compounds whose respective cleavage products are given in the following reactions.

(i) ? $\xrightarrow[\text{2. Zinc, H}_3\text{O}^\oplus]{\text{1. Ozonolysis}}$ $C_6H_{10}O + CH_3COCH_3$

(ii) ? $\xrightarrow[\text{H}_2\text{O}]{\text{HIO}_4}$ $2CH_3CHO$

(iii) ? $\xrightarrow{\text{KMnO}_4}$ $CH_3COCH_3 + C_6H_5COOH$

(iv) ? $\xrightarrow{\text{NaOI}}$ $CH_3COO^- Na^\oplus + CHI_3$
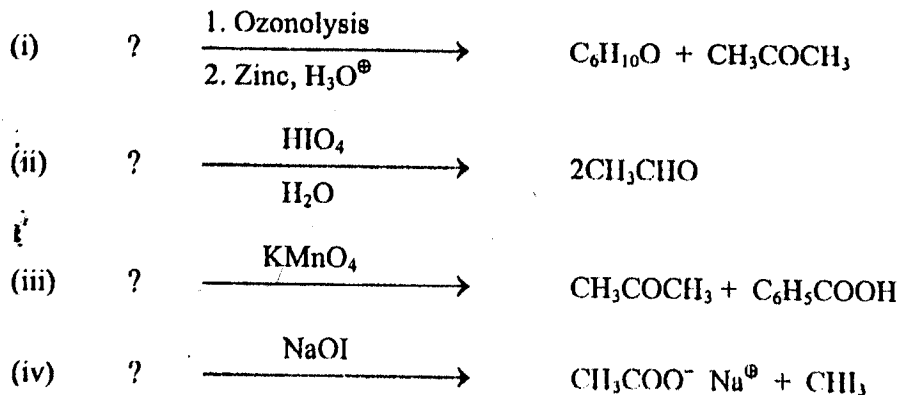
02 Marks

b) (i) Using an appropriate route of synthesis, write a mechanism for the reaction of cyclopropyne with bis(1,2-dimethylpropyl)borane, R_2BH, showing the stereochemistry and regiochemistry of the reaction and name the final product.

(ii) The reaction of 2-butyne with a solution of lithium in liquid ammonia proceeds with the maintenance of a particular configuration. Using a reaction mechanism show the geometrical structure and configurational stability of the intermediate radical and the intermediate anion.

13 Marks

(c) Given triethylamine, $[(CH_3CH_2)_3N]$, acetaldehyde, (CH_3CHO), chlorotrimethylsilane $\{(CH_3)_3SiCl\}$, magnesium turnings and ether, show clearly how you would prepare 1,4-pentanediol from 3-bromopropanol in the laboratory.

10 Marks

SECTION B

Answer two (02) questions in this section

QUESTION FOUR

(a) Draw all structural formulae that fit the following descriptions:

i) Esters with the formula $C_4H_8O_2$

ii) Alcohols with the formula $C_4H_{10}O$

[04 marks]

(b) State whether the formulae for each pair of structural formulae given below represent the same compound, or different compounds that are constitutional isomers of each other, or different compounds that are not isomers.

i) $CH_3CO\ CH_3$ and $CH_3CH=CHOH$

ii) $CH_2=CHCH_2CH_3$ and
$$\begin{array}{c} CH_2\text{---}CH_2 \\ | \qquad\quad | \\ CH_2\text{---}CH_2 \end{array}$$

iii) $CH_3-\overset{\overset{\displaystyle CH_3}{|}}{CH}-Br$ and $CH_3CH_2CH_2Br$

iv) $\begin{array}{c} CH_2-CH-CH_3 \\ | \\ CH_2-O \end{array}$ and

[02 marks]

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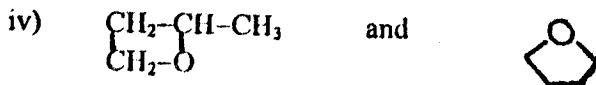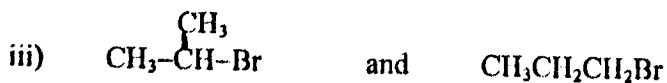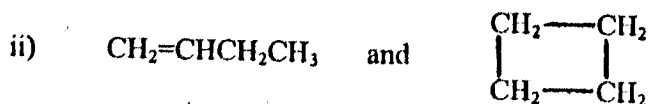
(c)　i)　Assign Cahn-Ingold-Prelog priorities to these sets of substituents.

　　i)　$-C(CH_3)_3$,　　$-C \equiv CH$,　　⟨benzene ring⟩　　$-CH=CH_2$

　　ii)　$-CH_2Br$,　　$-C \equiv N$,　　$-Br$,　　$-CH_2CH_2Br$

　　iii)　$-CH_2OCH_3$,　　$-COCH_3$,　　$-COOCH_3$,　　$-CH_2OH$

　　iv)　$-CH_2NH_2$,　　$-C \equiv N$,　　$-NH_2$,　　$-CH_2NHCH_3$

[04 marks]

ii)　What is the stereochemical relationship between the following pairs of compounds?

a)

and

b)

and

c)

and

d)

and

[06 marks]

5
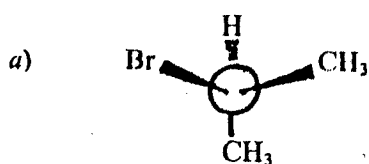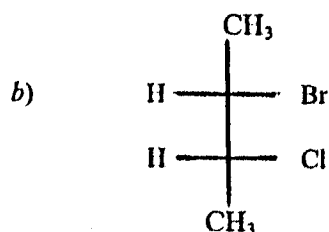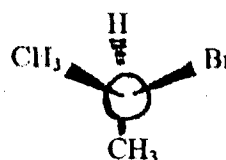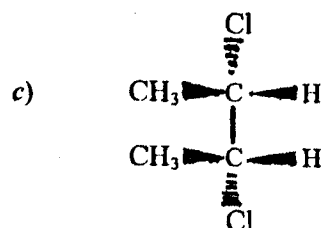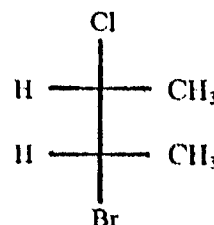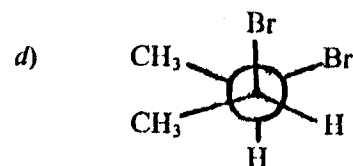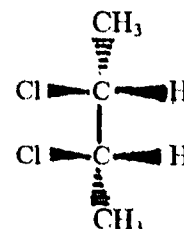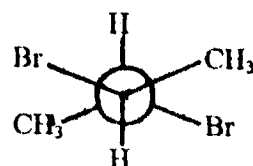
iii) Draw all possible stereoisomers for the following compounds and indicate which isomers are optically active.

    (*a*)   1,2,3-Tribromocyclopropane

    (*b*)   1,3-Cyclobutane dicarboxylic acid

[04 marks]

(d)   i)   Construct a qualitative potential-energy diagram for rotation about the carbon-carbon bond of 1,2-dibromoethane and indicate which conformation you would expect to be more stable.

      ii) Explain why 1,3-cis disubstituted cyclohexane is always more stable than its trans isomer?

[05 marks]

QUESTION FIVE

(a)   Arrange the following solvents in order of increasing solvent ionizing power and provide an explanation for the order you have chosen.

$$H_2O, \quad CH_3CON(CH_3)_2, \quad \overset{O}{\overset{\|}{H}CNH_2}, \quad CH_3OH, \quad \overset{O}{\overset{\|}{H}CNHCH_3}$$

[05 marks]

(b)   Give a brief explanation to account for the following facts.

    i)   In hydrolysis of 3-iodopropene in 50% aqueous acetone, a mixed first and second order rate equation is observed.

    ii) Iodide ion (I^-) does not react with $CH_3CH_2CH_2OH$ in an uncatalysed S_N2 reaction.

    iii) Cyanate ion [$O=C=N:^-$ $\longleftrightarrow$ $^-O-C\equiv N$] reacts with R–I to give R–N=C=O rather than R–O–C≡N in an S_N2 reaction.

    iv) Nitrate ion (NO_3^-) and acetate ion (CH_3COO^-) react at the same rate with tert-butylbromide under identical reaction conditions.

    v) $CH_3CH=CHCH_2Br$ may yield a mixture of isomers with alcoholic potassium cyanide.

[10 marks]

(c)   Provide an explanation for each of the following observations.

   i)   (R)-3-Chloro-3-methylhexane reacts in aqueous acetone to give racemic 3-methyl-3-hexanol.

   ii) (S)-2-Bromo-2,4-dimethyl hexane reacts in aqueous acetone to give optically active 2,4-dimethyl-2-hexanol.

[06 marks]

(d)   Comment on the effects of the indicated solvents on the reaction rates of each of the following reactions.

   i) $R–X \xrightarrow{\text{Water}} R^+ + :X^-$

   ii) $Nu^- + R–X^+ \xrightarrow{\text{Ethanol}} R–Nu^+ + X\cdot$

   iii) $Nu: + R–X^+ \xrightarrow{\text{Propanone}} R–Nu^+ + X:$

   iv) $R–X^+ \xrightarrow{\text{Methanamide}} R^+ + X:$
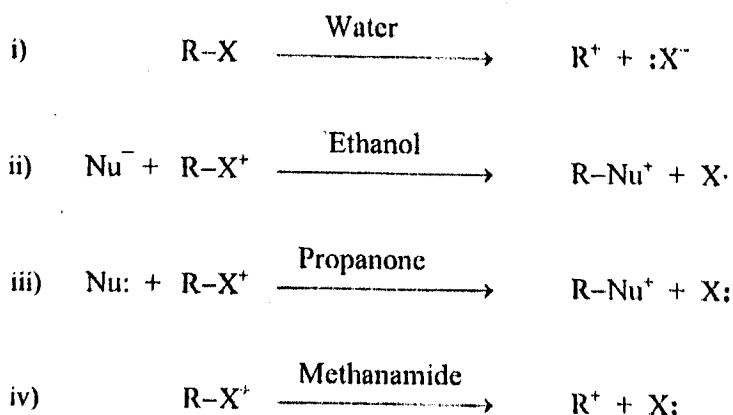
[04 marks]

QUESTION SIX

(a)   Provide the IUPAC names for each of the following compounds.

   i) $CH_3OCH_2CH_2OH$ ii) $(CH_3)_2NCH_2CH_2COOH$

   iii) $CH_3CH_2O\overset{\overset{\textstyle O}{\|}}{C}CH_2CH_2OH$ iv) $CH_3 -$

   v) $CH_3CH_2CONHBr$
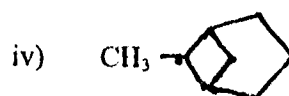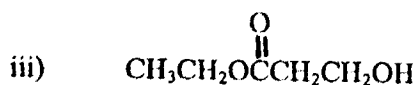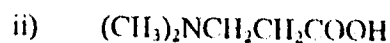
[05 marks]

(b) Draw the structural formulae for each of the following compounds.

i) 4-Oxo-2-cyclohexene carboxylic acid

ii) Ethanoic-2-methylpropanoic anhydride

iii) 2-Cyclopropylpropanol

iv) Butanedioyl bromide

v) 3-Hepten-5-yn-2-one

[05 marks]

(c) i) Describe how the following types of bonds are formed.

(a) π-bond.

(b) Non-bonding molecular orbital.

ii) What effect does hybridisation has on the stability of bonds?

[04 marks]

(d) i) Draw the resonance structures of each of the following and point out the most **unlikely** resonance form:

(a) SO_2 (b) O_3 (c) $CH_2=CHNO_2$ (d) NO_3^-

[04 marks]

ii) State which of the following molecules are polar and which are non-polar. Account for your answers. (You may ignore the small polarity of C–H bond in working the polarity).

(a) SO_2 (b) $SOCl_2$ (c) CCl_4 (d) CH_3OCH_3

[04 marks]

iii) The dipole moment of NH_3 (1.49 Debys) is greater than that of NF_3 (0.24 Debys). On the other hand, the dipole moment of PH_3 (0.55 Debys) is less than that of PF_3 (1.03 Debys). Explain these results.

[03 marks]

END OF EXAM

The University of Zambia
University Examinations

Deferred/Supplementary Examinations

Biochemistry   *C311*

Time: Three hours

Section A:

Answer **ALL** questions

Section B:
All Questions in this section carry **EQUAL** marks
Answer **ANY FOUR** Questions

SECTION A

For questions 1-3 state true or false, if false explain why

1.   When oxygenated the 3-D structure of Hb *in vivo* losses much of its α-helical conformation.
[2 marks]

2.   The Michaelis-Menten constant, Km:
      a) Represents the substrate concentration at which the reaction rate is half Vmax.
      b) Of some enzymes may be altered by the presence of metabolites structurally unrelated to the substrate.
[2 marks]

3.   Substrate strain necessarily results in formation of an enzyme-substrate intermediate.

[2 marks]

4.   How much iron is in the haemoglobin of a 70kg adult? Assume that the blood is 70ml/kg-body weight and that the haemoglobin content of blood is 16g/100ml.
      [Fe: 56g/mol, Hb; 67 000g/mol]

[2 marks]

5. Neglecting secondary factors that might affect partitioning, which of the following peptides (all ionisable groups are protonated) would display the fastest migration through a column packed with a strongly cation-exchange resin? Assume operating pH is distinctly acidic.
   (a) met-gln
   (b) glu-asp-phe

[2 marks]

6. Eubacteria and archaebacteria are both prokaryotes. Which one of the two groups lacks the peptidoglycan layer in the cell wall?

[2 marks]

7. Which step in tricarboxylic acid cycle is catalysed the α-ketoglutarate dehydrogenase enzyme complex?

[2 marks]

8. Both plant cells and certain eukaryotic micro-organisms contain one or more large fluid - filled organelles that store many nutrient and waste molecules and also participate in the degradation of cellular proteins and other macromolecules. What is the name of these organelles?

[2 marks]

9. The energy released by the hydrolysis of phosphohydride bonds in ATP powers many otherwise energetically unfavourable events. Give two examples that are power by such energy.

[2 marks]

10. Give any two phosphoryl-transfer reactions in the Embden-Meyerhof pathway.

[2 marks]

SECTION B

Important

a)   Answer **ANY FOUR** Questions

b)   All questions in this section carry **equal** marks

11.   (a) A polypeptide that binds strongly to a column packed with a strong cation exchange resin at pH 3.5 can be washed off the column by passing a buffer of pH8 through the column. Explain why.

[5 marks]

        (b) The absorbance of a protein solution containing 1 mg/ml albumin was measured using a 1 cm light path and was found to be 0.550 and 0.199 absorbance units at 279 nm and 290 nm respectively. Assuming that tyrosine and tryptophan are the only amino acids which absorb appreciably at these wave lengths, calculate the number of these two amino acids in a molecule of the protein given that:

(a) MW of albumin is 65 kD.
(b) The molar extinction coefficient of tyrosine is 1.1×10^3 l/mol.cm at 279 nm and 0.28×10^3 l/mol.cm at 290 nm.
(c) The molar extinction coefficient of tryptophan is 5.2×10^3 l/mol.cm at 279 nm and 4.3×10^3 l/mol.cm at 290 nm.

(d) $N_A = 6.023 \times 10^{23}$ mol^{-1}

[15 marks]

12.   (a) In an experiment the activity of a sample of 10microgram of enzyme (MW = 10 000g/mol) each in 1 cm of solution was tested at various substrate concebtrations and ij the presence of two substances, **A** and **B**. the results are shown below:

[S] mM	1	2	5	10	20
Product with **A** present micomole/min	0.77	1.25	2.00	2.50	2.86
Product with **B** present micromole/min	1.17	2.10	4.00	5.70	7.70
Product with neither A nor **B** present micromole/min	1.5	4.0	6.3	7.6	9.0

3

(i) On the same pair of axes, graph these results in an appropriate way.
(ii) Calculate Vmax and Km for the enzyme, in the presence of substrate alone.
(iii) Calculate the turnover number for the enzyme

What conclusions can you draw about **A** and **B**? Explain their effects.

[15 marks]

(b) Distinguish between regulation by means of covalent modification and that by allosteric interaction(s).

[5 marks]

13. (a) In enzyme catalysis, how does the equation below explain the catalytic process?

$$\Delta G^* = \Delta H^* - T\Delta S^*$$

[15 marks]

(b) After a preincubation with ρ-chloromercuribenzoate, the binding of an enzyme with its substrate was no different from that of untreated enzyme, but the catalytic activity of the treated enzyme was found to be 40% less. What conclusion can be drawn from this type of observation?

[5 marks]

14. Discuss the energetic of carbohydrate breakdown to CO_2 and H_2O.

[20 marks]

15. (a) Describe the re-oxidation of reduced co-enzyme in the respiratory chain.

[10 marks]

(b) Briefly discuss substrate level phosphorylation.

[5 marks]

(c) Outline the similarities between mitochondria and chloroplast

[5 marks]

TIME: **THREE HOURS**

ANSWER: **ALL QUESTIONS**

---

1. a)   Calculate the frequency in hertz of
          i) an X-ray beam with a wavelength of 2.45 Å
          ii) an infra-red absorption peak of $18.5\mu m$

    b)   Calculate the wave length in centimeters of
          i) an airport tower transmitting at 118.4 MHz
          ii) an NMR signal at 106 MHz

    c)   Express the following absorbances in terms of percent transmitance
          i) 0.055   ii) 0.475

    d)   Covert the accompanying transmitance data to absorbances
          i) 24.8%   ii) 0.785%

    e)   Calculate the percent transmitance of solutions that have twice the
          absorbance of the solutions in 1c.

    f)   Calculate the absorbance of solutions with half the transmitance of
          those of 1d.

    g)   Calculate the energy in KJ/mol for the transition of a mol at 780nm
          $(h=6.62 \times 10^{-34} J$ sec, $N_A = 6.02 \times 10^{23}$ mol^{-1},c$=3.10^{10}$cm).

    h)   Calculate the molar absorptivity of $K_2Cr_2O_7$ (M.M=294.19) at 455nm,
          given that 36.5 mg dissolved in 500 ml exhibits 15% transmitance
          at 455 nm in a 2cm cell.

    i)   Predict the titration curves in following spectrophotometric titrations
          i) $E_s = E_p = O$ and $E_t > O$
          ii) $E_p > O$ and $E_s = E_t = O$

2. a)   What type of sources, monochromators, cells and detectors are used in
          the UV, VIS and IR region?

    b)   Explain the quantum treatment of vibrations.

c) Explain the different sample handling techniques in IR - Spectroscopy.

d) Calculate the thickness of the two cells from their interference fringes between 1000 - 1200cm^{-1}.
i) cell one has 34 peaks
ii) Cell two has 18 peaks

e) Explain the principle of Raman spectroscopy.

f) Calculate the approximate wavenumber and wavelength of the fundamental absorption peak due to the stretching vibration of a carbonyl group $C = O$.
($C = 12, 0 = 16, k = 1 \times 10^3 N/m$, $N_A = 6.02 \times 10^{23}$ mol$^-$,
$C = 3 \times 10^{10}$ cm).

g) What type of vibrations do you know in IR - spectroscopy; sketch them.

3. a) Explain the principle of NMR spectroscopy and Larmor equation.

b) What are the differences between ^1H NMR and ^{13}C NMR.

c) Explain chemical shift in NMR spectroscopy.

d) Explain spin - spin coupling in NMR spectroscopy.

e) i) Many modern proton NMR instruments employ a magnet that provides a field strength of 4.69 T. At what frequency would the hydrogen nucleus absorb in such a field?
(^1H $\gamma = 2.68 \times 10^8$ T^{-1}s^{-1}).

   ii) How many tesla must a magnet have for a 600 MHz NMR spectroscope.

f) Predict the ^1H NMR spectrum for:
i) ethanol   ii) acetone   iii) methyl - propylketone

g) Explain proton decoupling for ^{13}C NMR.

4. a) Describe the differences between AAS and conventional absorption spectrophotometry. Include a comparison of source, sample container, and monochromator for the two techniques.

b) Explain the principle of a fluorometric method.

c) Explain briefly the emission spectroscopy method.

d. A well water sample is analyzed by FES for potassium. The emission signal is 4.8 units. Standards give the data shown below. Prepare a calibration curve, and determine the K^+ level in the water sample.

K$^+$ Standard (ppm)	Signal (units)
0.2	0.32
0.5	0.80
1	1.4
2	2.7
5	5.7

e)   Magnessium in blood serum can be determined by AAS. A 2 ml serum sample is diluted to 100 ml, and its absorbance is 0.250. A standard containing 2.0×10^{-5}M Mg^{2+} gives an absorbance of 0.187. Calculate Mg concentration in the blood as milligram percent (milligrams per 100 ml).

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
MAY 1999

C321
SPECTRAL ANALYTICAL METHOD

TIME: **Three (3) Hours**

Instructions:

    1.   **Answer any FOUR Questions.**

    2.   **Each Question carries 25 Marks.**

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1.   (a)   Convert the following frequencies to wavelengths in nanometers. Indicate the spectral region within which the wavelengths falls.

        (i) $4.283 \times 10^{14} s^{-1}$ (ii) $1.333 \times 10^{15} s^{-1}$ **(1 Mark)**

   (b)   Convert the following wavelengths to frequencies in hertz(waves/s).

        (i)   510nm   (ii)   25.4 cm   **(1 Mark)**

   (c)   Calculate the energy in kJ at 180 nm, 400 nm and 780 nm, per mole respectively.

        $[h = 6.62 \times 10^{-34} J.s;\ N_A = 6.02 \times 10^{23};\ c = 3.0 \times 10^{8}\ m/s]$

                                          (2 Marks)

   (d)   Convert the following percent transmitance to absorbances.

        (i)   7.85%   (ii)   84.6%   (iii)   26.2%

                                          (1½ Marks)

   (e)   Convert the following absorbances to percent transmitance

        (i)   0.56   (ii)   1.25   (iii)   0.84   **(1½ Marks)**

   (f)   Calculate the percent transmitance of solutions having twice the absorbance of the solution in question 1(e).

                                          (1½ Marks)

   (g)   Calculate the absorbances of solutions having half the percent transmitance of those in question 1(d).

                                          (1½ Marks)

(h)   Complete the following table:

	A	T%	b(cm)	ε(l/mol.cm)	x[M]
(1)		86		3,500	4.0×10^{-5}
(2)	0.235		2.0		2.5×10^{-3}

(2 Marks)

(I)   A 1.25×10^{-4} M solution of potassium permanganate has a transmitance 60% at 525 nm in 2.0 cm cell.
[M.M. $KMnO_4 = 158.04$].

(i)   What is the absorbance and molar absorptivity of this solution?

(ii)   If the concentration were doubled, what would be transmitance and absorbance respectively?

(iii)   What concentration would have a transmitance of 50% in this cell?

(3 Marks)

(j)   A 2.0 g steel sample is dissolved and Mn in the sample is oxidized to permanganate by periodate using Ag^+ as a catalyst. After the sample is diluted to 500 ml, the absorbance is found to be 0.395 at 540 nm in a 2.00 cm cell. The molar absorptivity for permanganate at 540 nm is 2025. Calculate the percentage of Mn in the steel sample.
[Mn =54.938].

(4 Marks)

(k)   Titanium and Vanadium form colored complexes with hydrogen peroxide. Separate solutions containing 15.0 mg of these metals were treated with perchloric acid and hydrogen peroxide, and diluted to 100 ml. A third solution was prepared by dissolving 3.00 g of alloy (containing Ti and V but not other interfering metals) and treating in the same manner as the standard solutions. The absorbances of the solutions were measured at 410 and 460 nm in 2.0 cm cell.
[Ti = 47.90, V= 50.9415].

Calculate % V and % Ti in the alloy.

Solution	A_{410}	A_{460}
Ti	0.760	0.513
V	0.185	0.250 •
Alloy	0.715	0.657

(6 Marks)

2. (a) Describe blue and red shift in absorption spectroscopy. **(2½ Marks)**

(b) What method do you know for determination of number of ligand by spectrophotometric method? Explain them and sketch them.
(2½ Marks)

(c) Explain determination of pK_a of weak acid in absorption spectroscopy.
(2½ Marks)

(d) Describe photometric titration and sketch 6 different curve as an example. **(2½ Marks)**

(e) Bilirubin in blood serum absorbs strongly at 461 nm but not at all at 551 nm. On the other hand, the absorbance due to hemoglobin and solution turbidity is about the same at both wavelengths. Thus a simple method for determining bilirubin is based on the difference in absorbance at the two wavelengths. A 20.0 µl sample of blood serum, diluted to 1.00 ml with sodium citrate buffer of pH8.8, had absorbances of 0.871 and 0.637 at 461 and 551 nm respectively. When 20.0 µl of a bilirubin standard (50.0 µl/ml) was treated similarly, the absorbances were 0.337 and 0.014 at 461 and 551 nm. Calculate the concentration of bilirubin in units (50.0 µl/ml) in the serum. **(7 Marks)**

(f) Ammonia can be determined spectrophotometrically by reaction with phenol in the presence of hypochlorite (OCl⁻):
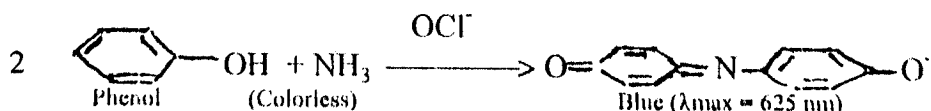
A 4.37 mg sample of protein was chemically digested to convert all of its nitrogen to ammonia. After this treatment, the volume of the sample was 100.0 ml. Then 10.0 ml of the solution was placed in a 50 ml volumetric flask and treated with 5 ml of phenol solution plus 2 ml of sodium hypochlorite solution. The sample was diluted to 50.0 ml, and the absorbance at 625 nm was measured in a 1.00 cm cell after 30 minutes. For reference, a standard solution was prepared from 1.00×10^{-2} g of NH_4Cl dissolved in 1.00 liter of water. Then 10.0 ml of this standard was placed in 50 ml volumetric flask and analysed in the same manner as the unknown. A reagent blank was prepared using distilled water in place of unknown. [$NH_4Cl = 53.49$; $N = 14.0067$]

Sample	A at 625 nm
Blank	0.140
Reference	0.308
Unknown	0.592

(i) Calculate the molar absorptivity of the blue product.
(ii) Calculate the weight percent of nitrogen in the protein.
(8 Marks)

3. (a) Explain the principle of IR - spectroscopy.   **(4 Marks)**

    (b) Explain the principle of Raman spectroscopy.   **(3 Marks)**

    (c) Describe Quantum treatment of Vibrations.   **(5 Marks)**

    (d) What are the differences between sources, monochromators, cells and detectors in UV + VIS and IR spectroscopy ?   **(3 Marks)**

    (e) Explain sample handling techniques in IR spectroscopy.   **(2 Marks)**

    (f) What type of bending and stretching vibrations do you know? Sketch them.   **(1 Mark)**

    (g) Calculate the thickness in mm of the IR cell with 20 peaks between 1000 and 1400 cm^{-1}.   **(2 Marks)**

    (h) Calculate the wavenumber and wavelength (in μm) of the fundamental absorption peak due to stretching vibration of $C \equiv N$ group.
    $[C = 12, N = 14, k = 1.5 \times 10^3$ N/m, $c = 3.0 \times 10^8$ m/s, $N_A = 6.02 \times 10^{23}]$ **(5 Marks)**

4. (a) Explain the principle of ^{1}H NMR spectroscopy.   **(4 Marks)**

    (b) What are basic differences between NMR and ESR spectroscopy respectively?   **(3 Marks)**

    (c) Explain ^{13}C NMR spectroscopy and their advantages comparing to ^{1}H NMR.   **(2 Marks)**

    (d) Explain chemical shift and spin-spin splitting for ^{1}H NMR.   **(3 Marks)**

    (e) Describe the advantages for using Fourier Transformation technique in NMR spectroscopy. What is meant by the term decoupling in ^{13}C NMR.   **(3 Marks)**

    (f) Write a ^{1}H NMR spectrum integrating and derivative of the compounds.

    $HO-CH_2-CO-CH-CH_3$

    $\langle O \rangle - CH_2-CH-CH = CH_2$

    $|$

    NH_2

    (i)   (ii)

$$CH_3\text{-}CO\text{-}CH = CH\text{-}CH = CH_2 \quad Cl\text{-}CH_2\text{-}CH = CH_2 \quad Cl\text{-}CH = CH\text{-}CH_3$$
(iii)   (iv)   (v)
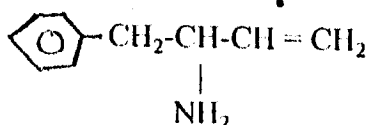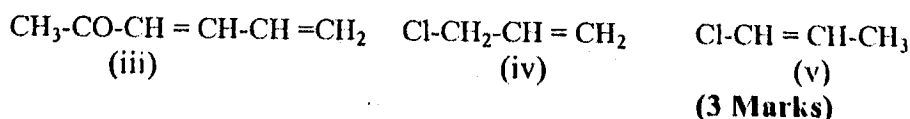
(3 Marks)

(g)   Predict the appearance of the high-resolution proton NMR spectrum of:

(i) acetone   (ii) acetic acid   (iii) methylpropylketone

(iv) toluene   (v) ethylbenzene   (vi) *i*-butane   **(3 Marks)**

(h)   The proton spectrum for a compound of empirical formula C_4H_8O has a singlet, triplet and quartet. Identify the compound.

(4 Marks)

5.   (a)   Explain the principle of emission spectroscopy.   **(5 Marks)**

(b)   What are the basic differences between emission spectroscopy and atomic absorption spectroscopy respectively?   **(3 Marks)**

(c)   Explain Inductively Coupled Plasma (ICP) source. Sketch a diagram.

(3 Marks)

(d)   Explain:
(i)   Plasma source,   (ii)   DC arc,
(iii)   AC spark,   (iv)   Resonance line,
(v)   Internal standard   (vi)   Matrix effects. **(3 Marks)**

(e)   The internal standard method was used for the analysis of strontium by FES. A stock solution of strontium nitrate (M.M. = 211.63) was prepared by dissolving 0.2415 g of strontium nitrate in sufficient water in a volumetric flask to prepare 1 liter of solution. Varying volumes of the strontium stock solution and 10.0 ml of a 160.0 µg/ml $VOSO_4$ solution were added to 100 ml volumetric flasks with pippets. The resulting solutions were diluted to the mark with distilled water. A 10.0 ml portion of the vanadium solution and 50.0 ml of the analyte solution were added to the 100 ml volumetric flask that was labelled "sample" and the solution was diluted to the mark with distilled water. The intensities of the strontium line at 460.7 nm and the vanadium line at 437.9 nm were measured. Determine the concentration of strontium in the analyte solution.
(Sr = 87.62)   **(6 Marks)** ·

Sr stock volume, ml	Relative intensities	
	Sr 460,7 nm	V 437.9 nm
2.00	16.9	35.7
4.00	29.9	33.1
6.00	54.7	38.5
8.00	74.7	39.3
10.00	81.2	34.1
Sample	36.1	35.4

(f) For the analysis of cement samples, a series of standards was prepared and the emission intensity for sodium and potassium was measured at 590 and 768 nm, respectively. Each standard solution contained 6300 $\mu g/ml$ of calcium as CaO to compensate for the influence of calcium on the alkali readings. The results are shown in the table. For each cement sample 0.5 g was dissolved in acid and diluted to exactly 100.0ml.. Calculate the percent of Na_2O and K_2O. (Na = 22.98977, K = 39.0983, 0 = 15.9994).

Concentration (µg/ml)	Emission Reading	
	Na₂O	K₂O
100	100	100
75	87	80
50	69	58
25	46	33
10	22	15
0	3	0
Cement A	28	69
Cement B	42	63

(5 Marks)

6. (a) Briefly describe or define:
    (i) fluorescence; (ii) vibrational relaxation;
    (iii) internal conversion **(3 Marks)**

(b) Briefly explain why fluorescent emission ordinarily occurs at wavelengths that are longer than that of excitation radiation.
(3 Marks)

(c) The quinine in an antimalarial tablet was dissolved in sufficient 0.1M HCl to give 500 ml of solution. A 15.0 ml aliquot was then diluted to 100.0 ml with the acid. The fluorescent intensity for the diluted sample at 347.5 nm provided a reading of 288 on an arbitrary scale. A standard 100 ppm quinine solution registered 180 when measured under conditions identical to those for the diluted sample. Calculate the milligrams of quinine in the tablet. (quinine = 324.41).
(4 Marks)

(d) 3,4-benzopyrene is a potent carcinogen often found in polluted air. A sensitive method for its determination is to measure its fluorescence in sulfuric acid solution. The excitation wavelength is 520 nm and the emission wavelength is 548 nm. Ten liters of air were drawn through 10.0 ml of dilute sulfuric acid solution. One milliliter of this sulfuric acid solution gave a reading of 33.3 in a fluorometer. Two different standard solutions of 3,4-benzopyrene containing 0.750 µg per 10.0 ml of sulfuric acid gave readings of 24.5 and 38.6 when 1.00 ml was placed in the same cell used for the unknown. A blank sample with no 3,4-benzopyrene gave a reading of 3.5. Calculate the weight of 3,4-benzopyrene in 1 liter of air. (3,4-benzopyrene = 146.14).
(5 Marks)

(e)   Explain the principle of mass spectrometry. Sketch the apparatus.
$$\text{(4 Marks)}$$

(f)   For a field strength of 0.24T in $180°$ magnetic deflection spectrometer, what electrostatic voltage range suffices for scanning from 18 to 200 mass? The radius of curvature of the $180°$ analyzer tube is 12.7 cm.
$$\text{(3 Marks)}$$

(g)   Describe how the following compounds will degrade; write their m/z:

$R - CH_2 - CH_2 - CH_2 - CH_3$ $-0-CH_3$
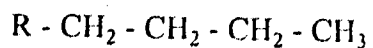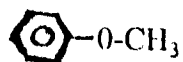
(i)   (ii)   (iii)

$$\text{(3 Marks)}$$

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THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
MAY 1999

C341
INORGANIC CHEMISTRY

TIME: Three (3) Hours

Instructions:

1. The Examination paper has six(6) Questions.
2. Answer any **FOUR** Questions.
3. A tidy and orderly presentation is a must.
4. Each question carries 25 Marks.

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1. (a) Write the formula of the following co-ordination compounds.

    (i) Tetrapyridine platinum(II) tetrachloro platinum (II)
    (ii) Potassium pentacyanonitrosylferrate (II)
    (iii) Bromotrichlorodinitro cobalt (II))anion

    (b) Derive ground state spectroscopic R-S term and determine the number of microstates for d^6 ion.

    (c) Draw all possible isomers of the following co-ordination compounds.

    (i) Tetrahedral $[CoCl_3(OH_2)]^-$
    (ii) $[IrCl_3(PMe_3)_3]$

    (d) Account for the following:

    (i) $[Ni(NH_3)_4] SO_4$ is a square Planar complex.

    (ii) $K_4Fe(CN)_6$ is diamagnetic, while $K_3Fe(CN)_6$ is paramagnetic.
    [Atomic No: Ni = 28; Fe = 26.]

2. (a) Discuss the various steps involved in the extraction of chromium metal from its ore Chromite.

    (b) The compound Na_2IrCl_6 reacts with triphenylphosphane in diethylene glycol under an atmosphere of CO to give trans-$(IrCl(CO)(PPh_3)_2]$, known as Vaska's compound. Excess CO produces a five co-ordinate species and on treatment with $NaBH_4$ in ethanol gives $[IrH(CO)_2(PPh_3)_2]$. Draw and name the three complexes.

    (c) Write a short account on the factors affecting the magnitude of 10Dq.

(d) The electron configuration of chromium is $[Ar]3d^5 4s^1$. If the CFSE of the Octahedral $[Cr(en)_3]^{3+}$ complex (strong ligand field) is -24000 cm^{-1}. Calculate Δ_T and Δ_{OCT} values for the complex, if the pairing energy P is 5000 cm^{-1}.

3. The aqueous solution of Cobalt(II) complexes are pink with the following absorptions:

v/cm^{-1}	ε/M^{-1}	f
8,000	1.3	1.4×10^{-5}
19,600	4.8	5.4×10^{-5}
21,600	2.1	1.8×10^{-5}

(i) What is **f** and what does it measure?

(ii) The spectrum shows other weak Laporte forbidden, spin forbidden absorptions in the region 16000-22000 cm^{-1}. Sketch the spectrum and indicate what transitions are asssociated with each spin allowed bands.

(iii) Using the TS diagram below determine the Racah Parameter **B** for the complex.

(iv) Given that free Co^{2+} has **B$_o$** = 1,120 cm^{-1}. Comment on the influence of complexation.

(v) Calculate the crystal field splitting energy, Δ_{oct}, for $[Co(H_2O)_6]^{2+}$
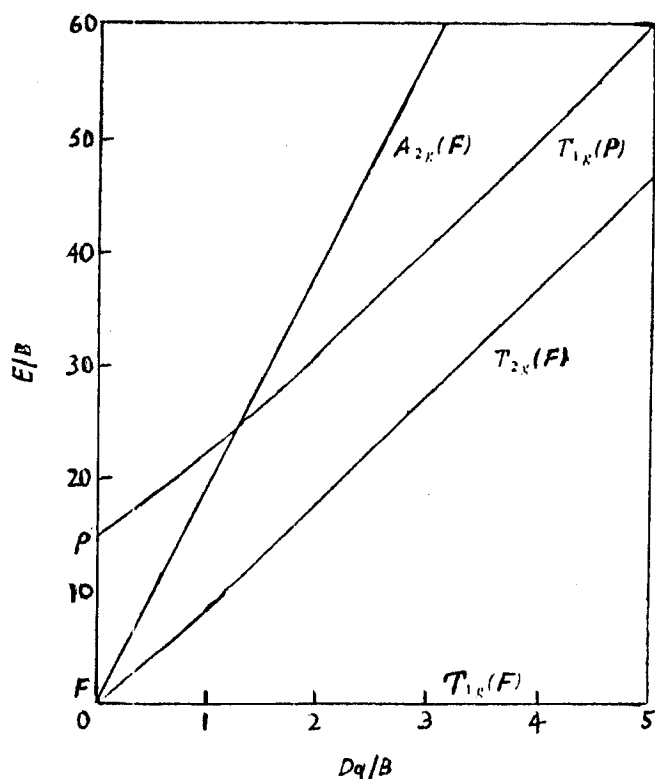
Tanabe-Sugano diagram for a d^7 ion in an octahedral crystal field.

4. (a) What are the characteristics of soft bases?

   (b) The stepwise formation constants (k_n) for the addition of ammonia (NH_3) and ethylenediammine ($NH_2CH_2CH_2NH_2$ = en) to Ni^{2+} ion in solution are given below:

n	1	2	3	4	5	6
log $k_{(NH3)}$	2.70	2.11	1.60	1.08	0.60	-0.10

n	1	2	3
log $k_{(en)}$	7.51	6.3	4.3

   (i) Explain, why log k_6 is very small and that it is almost impossible to add this ligand?.

   (ii) By considering the occupation of four positions about Ni^{2+} show that chelation results in the overall stabilization of the metal complex.

   (c) Other than chelation, what factors contribute to the stabilization of metal complexes?

5. (a) Describe the preparation of hydrazine by two steps reaction using ammonia and sodium hypochlorite. Write balanced chemical reactions when ~~hydrazine~~ reacts with.
   silicoethane

   (i) Aq. KOH   (ii) chloroform   (iii) water

   (b) Write the structures of the following species.

   $(P_2O_7)^{4-}$, $H_2S_2O_3$, XeO_2F_2, IF_5

   (c) Write balanced chemical reactions when,

   (i) Vapours of carbon disulphide are passed over calcium hydroxide.
   (ii) Conc. nitric acid reacts with glycol in presence of conc. sulphuric acid.
   (iii) Potassium nitrate is warmed with ferrous sulphate in presence of dilute sulphuric acid.
   (iv) Arsenic pentasulphide reacts with potassium hydroxide.
   (v) Xenon tetrafluoride reacts with sulphur tetrafluoride.

   (d) Write three commercial uses of each of the following.

   (i) Nitric acid   (ii) Hydrogen peroxide

6.   (a)   Write a short account on'PSEUDOHALOGENS'

(b)   How would you obtain;

hydro chloride

(i)   Hydrazoic acid from hydrazine ~~hypochlirite~~.
(ii)   Arsenic oxide from arsenopyrite.
(iii)   Sodium thioantimonate from antimony trisulphide.
(iv)   Dichloroheptaoxide from perchloric acid.
(v)   Hydrogen peroxide from propane-2-ol.

(c)   Write balanced chemical reactions between sodium hydroxide and

(i) Cl_2O_6 (ii) ClO_2 (iii) XeF_2 (iv) XeO_3

(d)   Complete and balance the following reactions:

(i) $LiALH_4 + SiCl_4 \rightarrow$
(ii) $KMnO_4 + H_2SO_4 + 10NO \rightarrow$
(iii) $PCl_5 + SO_2 \rightarrow$
(iv) $XeO_3 + XeF_6 \rightarrow$
(v) $AgClO_3 + Cl_2 \quad \xrightarrow{\quad 90°C \quad}$

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THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER I DEFERRED EXAMINATION, NOVEMBER 1999

C341

INORGANIC CHEMISTRY II

TIME: THREE (3) HOURS

INSTRUCTIONS:

1.   The Examination Paper has six (6) questions.

2.   Answer only FOUR (4) questions.

3.   Each question carries 25 marks.

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1.   (a)   Write the structure of the following coordination compounds.

(i)   Tetrathiocyanato - N-Zinc (II) ion

(ii)   Cis - diaquadichloroplatinum (II)

(iii)   Tris - (ethylenediamminetetra acetic acid) chromium (III) chloride.

(iv)   Potassium aminedicyanodioxo peroxo chromate (VI) *Chloride*

(b)   Describe three methods with suitable examples for the preparation of transition metal complexes.

(c)   Using valence bond approach, explain the following:

(i) $[Ni (NH_3)_6]^{2+}$ is an octahedral complex ion.

(ii) $[Fe F_6]^{3-}$ is an outer orbital complex. Also discuss its magnetic property.

2.   (a)   Draw and name all possible isomers of the following compounds.

(i)   Octahedral $[RuCl_2 (NH_3)_4]$

(ii) $[CO(NH_3)_3 Cl_3]$

(b)   Discuss various steps involved in the extraction of titanium metal from its ore Ilimenite.

(c)   Draw molecular energy level diagram for the complex $[CO(NH_3)_6]^{3+}$ and determine its bond order.

3.   (a)   Write concise notes on "INTERHALOGEN" compounds.

(b)   What happens when,
   (i)   Carborn dioxide is passed through calcium hydroxide solution for a long time.
   (ii)   Hydrazine reacts with acidic solution of potassium permanganate solution.
   (iii)   Antimony pentaoxide reacts with potassium iodide solution in presence of dilute hydrochloric acid.
   (iv)   Hydrogen peroxide is passed through chromic hydroxide in presence of caustic soda.
   (v)   Sodium hydroxide reacts with bromine dioxide.

3.   (c)   Write balanced chemical reactions between phosphorous trichloride and
   (i) Water   (ii) Acetic acid   (iii) SO_2Cl_2

(d)   Write possible structures of the following species.
   $(PO_3)^{3-}$, N_2O_5, Cl_2O_6, XeO_4

4.   (a)   Carbon and silicon are the members of the carbon group. Explain clearly, by giving suitable examples, why carbon does not form complex compounds whereas silicon is able to form such complex compounds whereas silicon is able to form such compounds?

(b)   Discuss three methods for the preparation of phosphine. Write balanced reactions when phosphine reacts with

(i) Chlorine   (ii) Water   (iii) aq. silver chloride

(c)   Write balanced reactions when water reacts with

(I) $XeOF_4$ (ii) XeO_2F_2 (iii) XeF_4

(d)   Complete and balance the following reactions.

(i) $K_2Cr_2O_7 + H_2SO_4$

(ii) $SbCl_3 + Zn + H_2SO_4$

(iii) $CO + I_2O_5$

(iv) $SiO_2 + Xe\ F_6$

(v) $(SCN)_2 + KOH$

5.   (a)   What does the Irving - William series represent?

(b)   Given that log K values for Co^{2+}, Ni^{2+}, Cu^{2+} Zn^{2+} are 2.1, 2.8, 4.2 and 2.4, respectively. Plot an Irving - William series and account for the shape of the plot.

6.   (a) $Mn\ O_4^-$ is deep purple in colour and during titration reactions it is self - indicating and does not require an indicator.

(i)   What type of transitions are associated with the $Mn\ O_4^-$ complex?

(ii)   Discuss the nature of these bands in terms of molar extinction coefficient, spin type, oscillator frequency, f, and Larporte selection rule.

(b)   For the tetrahedral complexes, discuss why aqueous $[Cu\ (NH_3)_4]^+$ complex is colourless while its sister complex $[Cu(NH_3)_4]^{2+}$ is intensely blue

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER I DEFERRED/SUPPLEMENTARY EXAMINATIONS, NOVEMBER 1999

C351

ORGANIC CHEMISTRY III

INSTRUCTIONS:

1. THIS PAPER CONSISTS OF SECTION A AND SECTION B

2. TIME ALLOWED FOR THIS PAPER IS THREE (03) HOURS

3. ANSWER TWO QUESTIONS FROM SECTION A AND TWO QUESTIONS FROM SECTION B

4. ALL QUESTIONS CARRY EQUAL MARKS. MARKS FOR EACH PART OF THE QUESTION ARE INDICATED

SECTION A

Answer two (02) questions in this section

QUESTION ONE

a) i) The mass spectra of compounds 1 and 2 show peaks at the following m/z values.

      Compound 1:   100,   85,   71,   57,   43,   41 (base peak)

      Compound 2:   85,   57,   43,   41 (base peak)

One of the two spectra corresponds to 2,2-dimethylpentane, while the other corresponds to 2,3-dimethylpentane. Determine which spectrum corresponds to 2,2-dimethylpentane and which one corresponds to 2,3-dimethylpentane and give reasons for your answer.

  ii) Suggest a reason for the base peaks in (a)(i) above having the mass they have.

07 Marks

1

b) i) Predict the UV-maximum values for compounds 3 and 4 shown below.
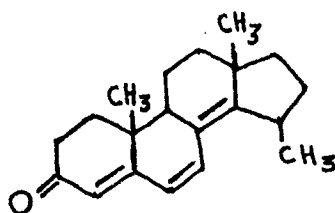
$$\underline{\underline{3}}$$
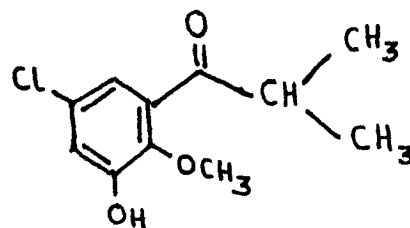
$$\underline{\underline{4}}$$

ii) Compound 5 ($C_9H_{14}O$) gives positive tests with 2,4-dinitrophenyl- hydrazine, with sodium hydroxide/iodine and with bromine in CCl_4. The UV-spectrum of 5 shows a λ_{max} at 248nm. Deduce the structure for this compound

12 Marks

c) The ^{1}HNMR spectrum of compound 6, ($C_8H_{14}O$), a tertiary alcohol, is shown below. Deduce the structure for this compound.

06 Marks

2
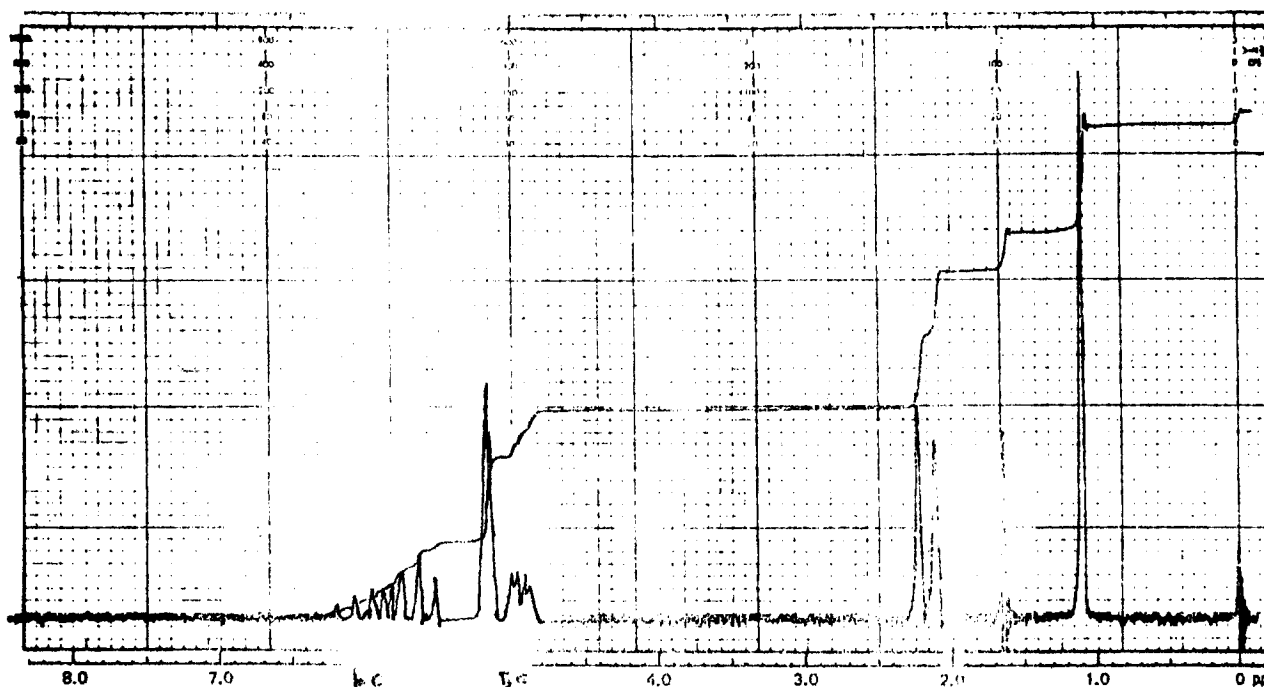
QUESTION TWO

a) Deduce the structure of compound 7 from the following MS, IR and ^{1}HNMR spectra.

MASS SPECTRUM OF COMPOUND 7

MS: 162.068
IR: KBr
HMR: CDCl$_3$
CMR: CDCl$_3$
Analysis: 74.1% C; 6.2% H

IR-SPECTRUM OF COMPOUND 7

3

¹HNMR SPECTRUM OF COMPOUND 7

δ (ppm)

13 Marks
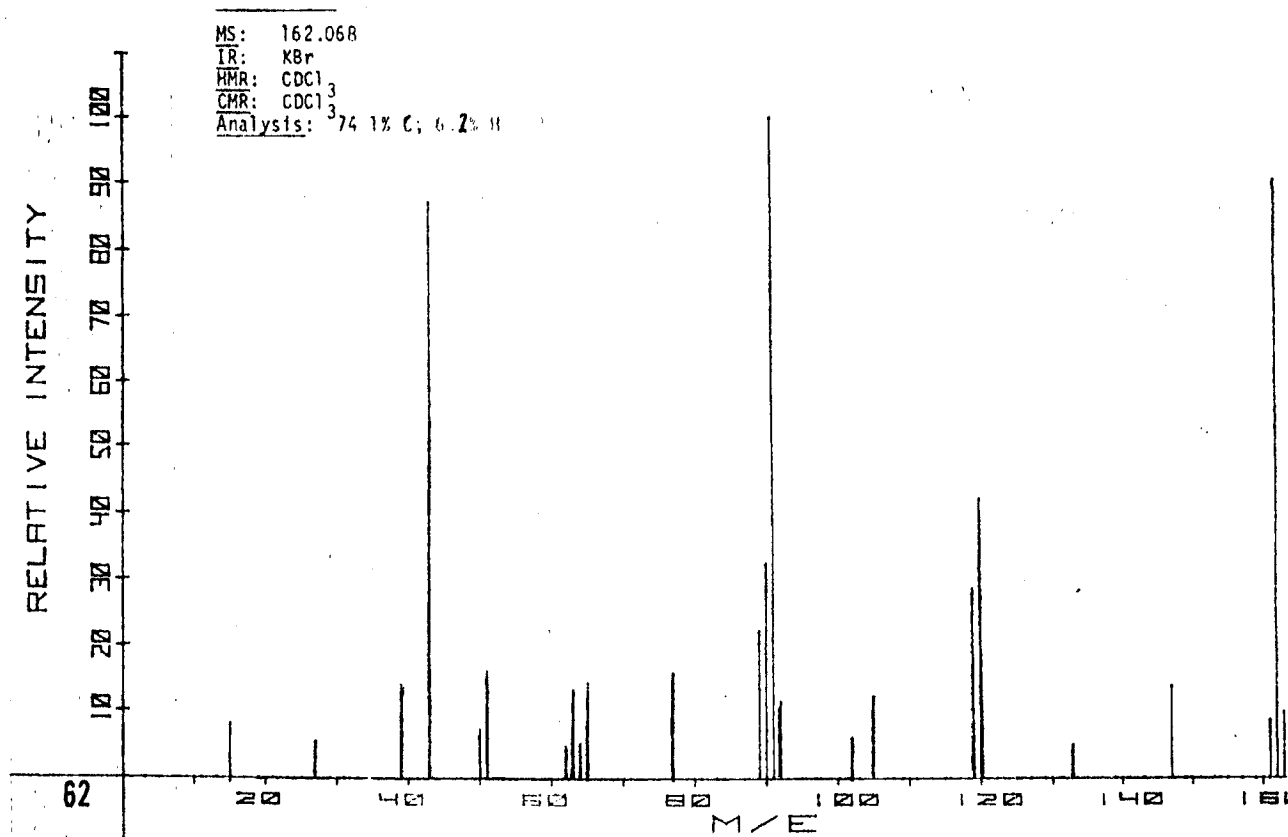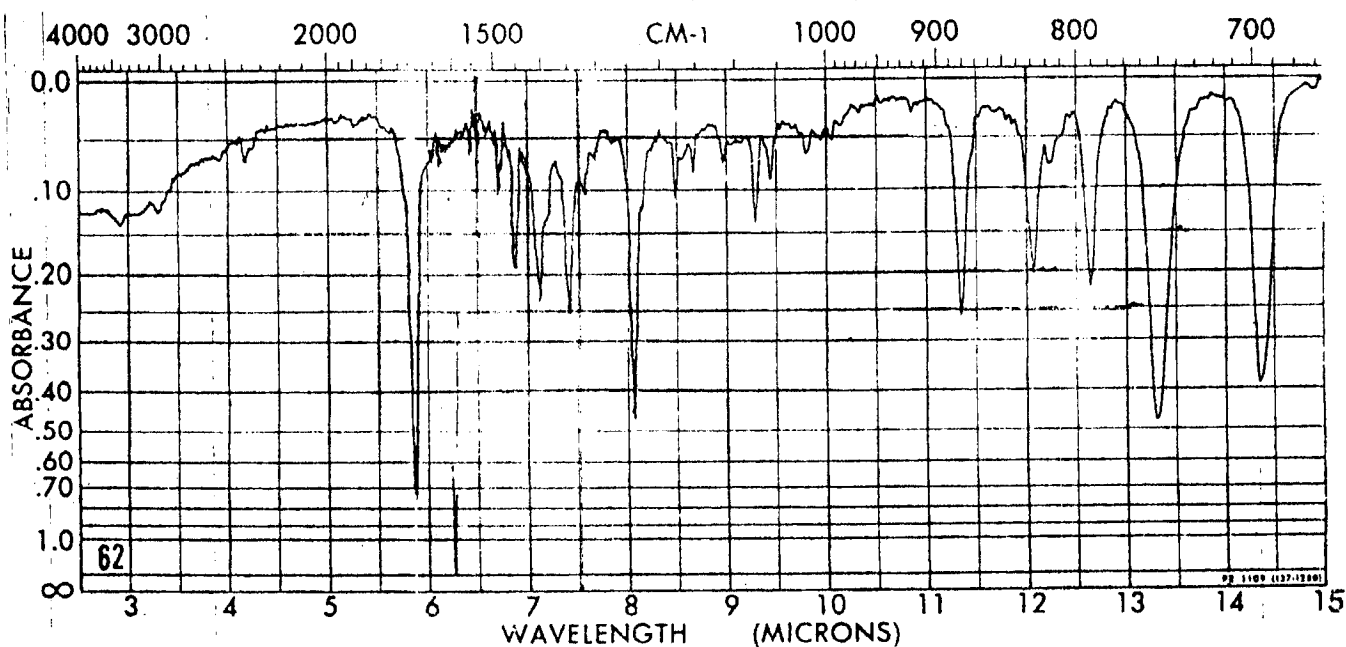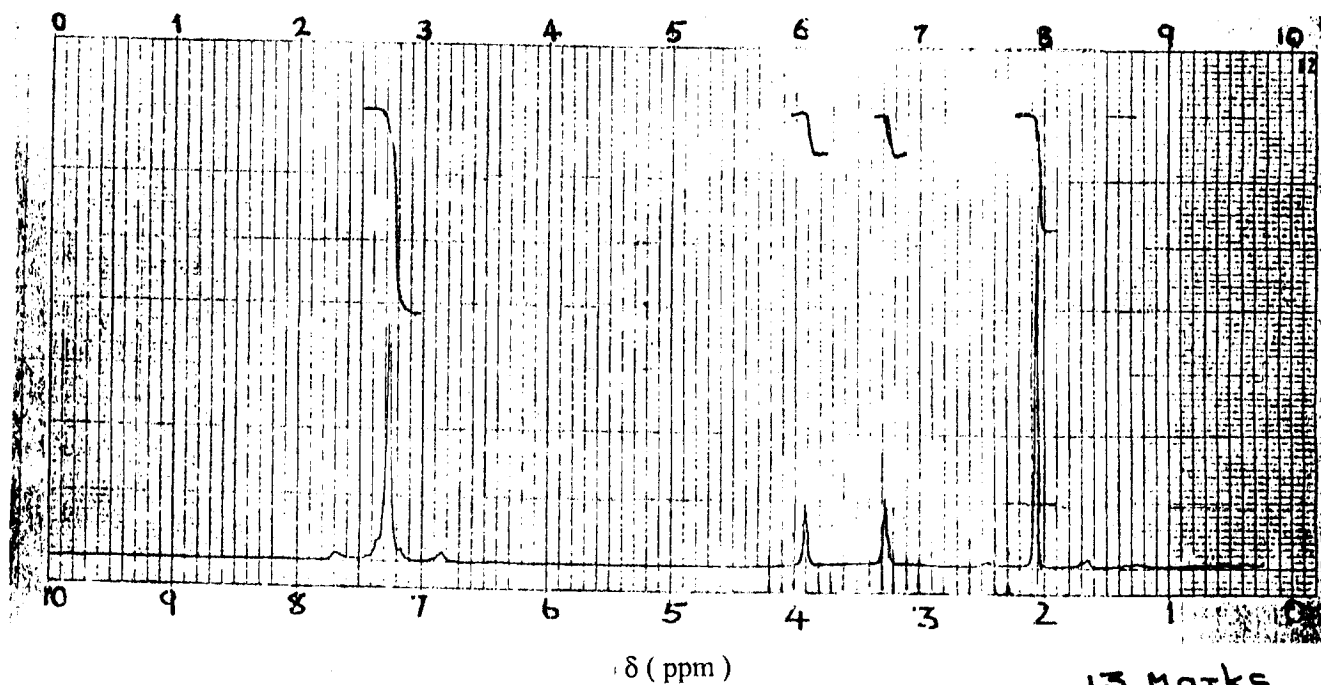
b) Deduce the structure of compound 8 from the following MS, IR and ¹HNMR spectra.

MASS SPECTRUM OF COMPOUND 8

MS: 132.057
IR: $CHCl_3$
HMR: $CDCl_3$
CMR: $CDCl_3$
Analysis: 81.7% C; 5.1% H

MOLECULAR FORMULA C_9H_8O

M/E
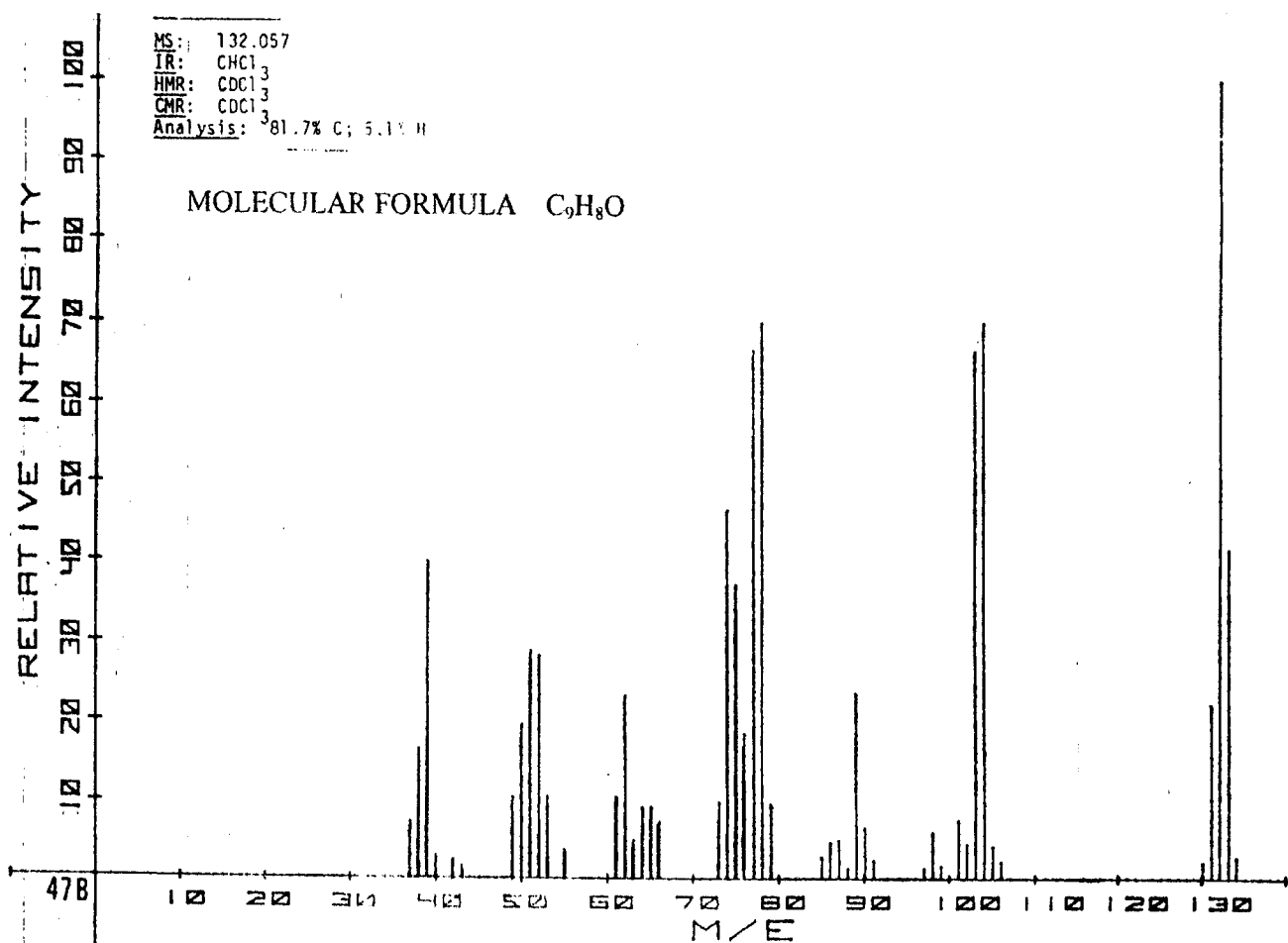
IR SPECTRUM OF COMPOUND 8

^{1}HNMR SPECTRUM OF COMPOUND 8

δ (ppm)

12 Marks

5
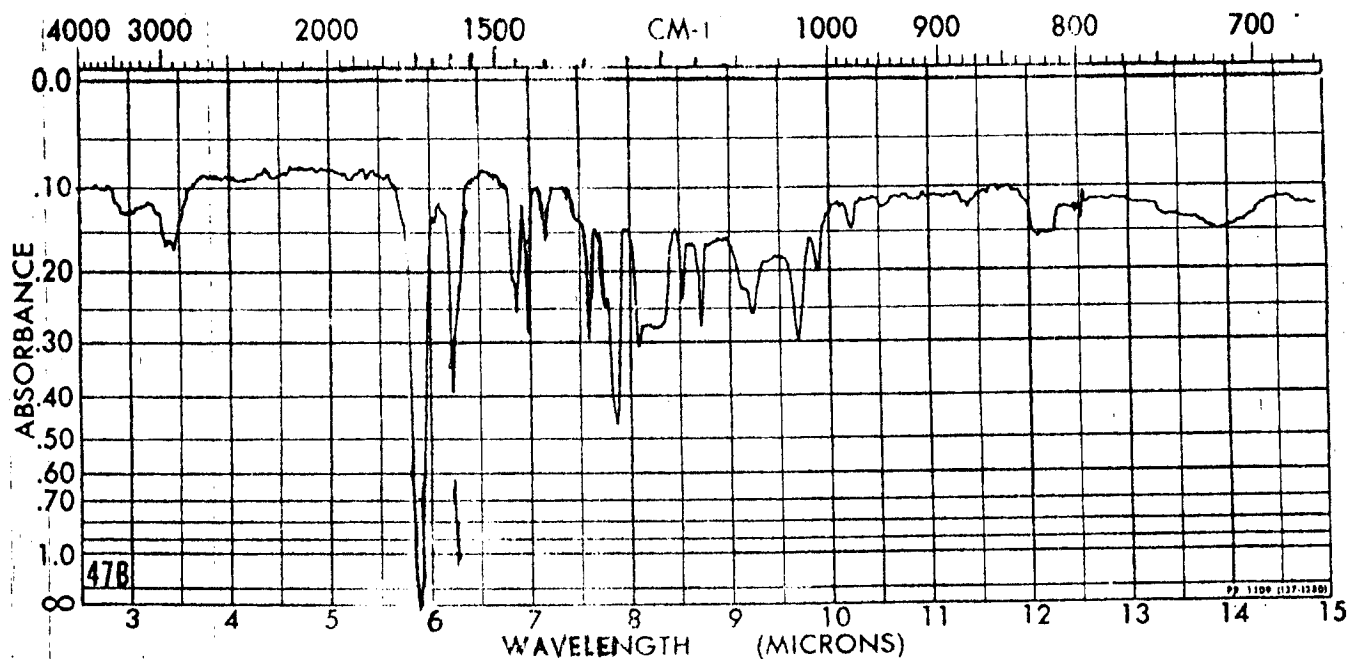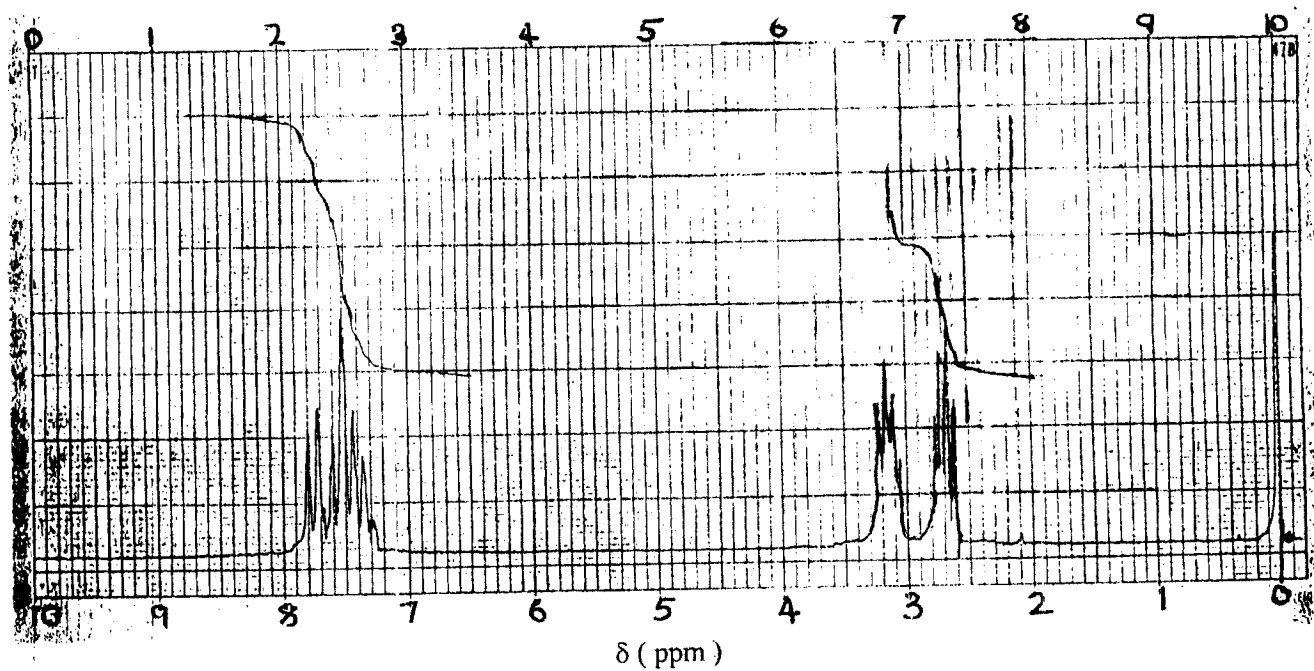
QUESTION THREE

a) Deduce the structure of compound 9 from the following MS, IR and ^{1}HNMR spectra.

MASS SPECTRUM OF COMPOUND 9

MS: 121.089
IR: neat
HMR: CDCl$_3$
CMR: CDCl$_3$
Analysis: 79.3% C; 9.1% H
11.6% N

^{1}HNMR SPECTRUM OF COMPOUND 9

δ (ppm)

13 Marks
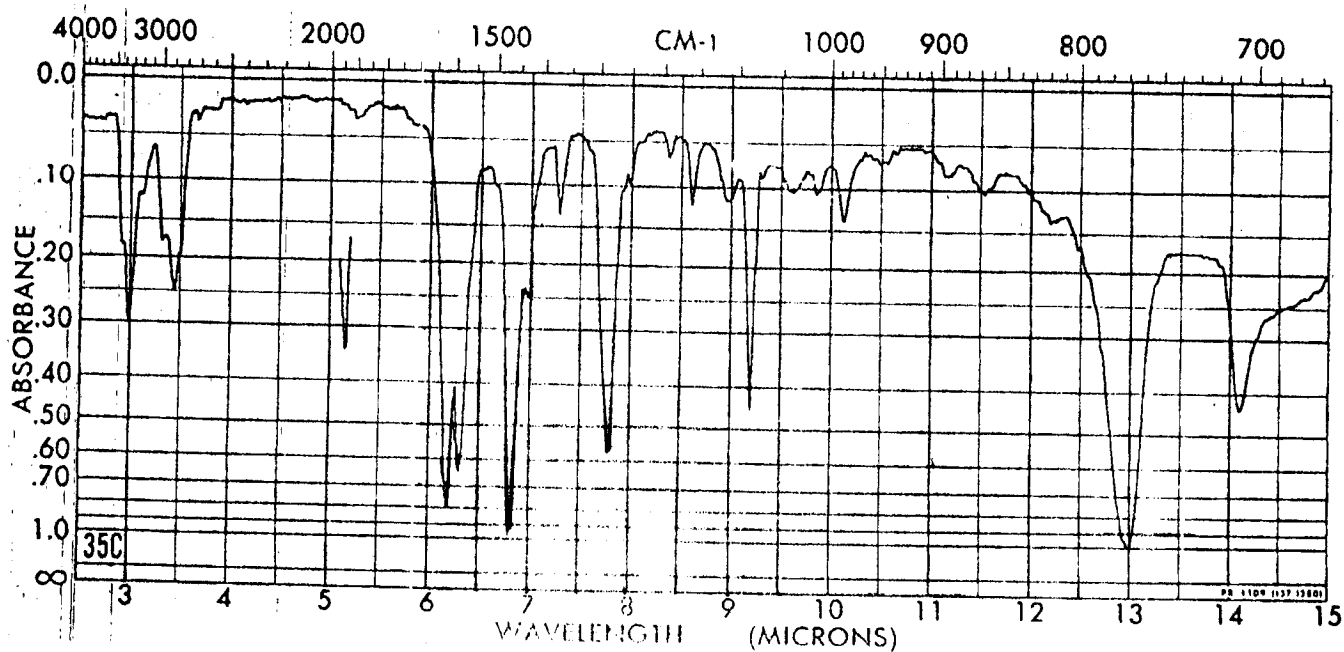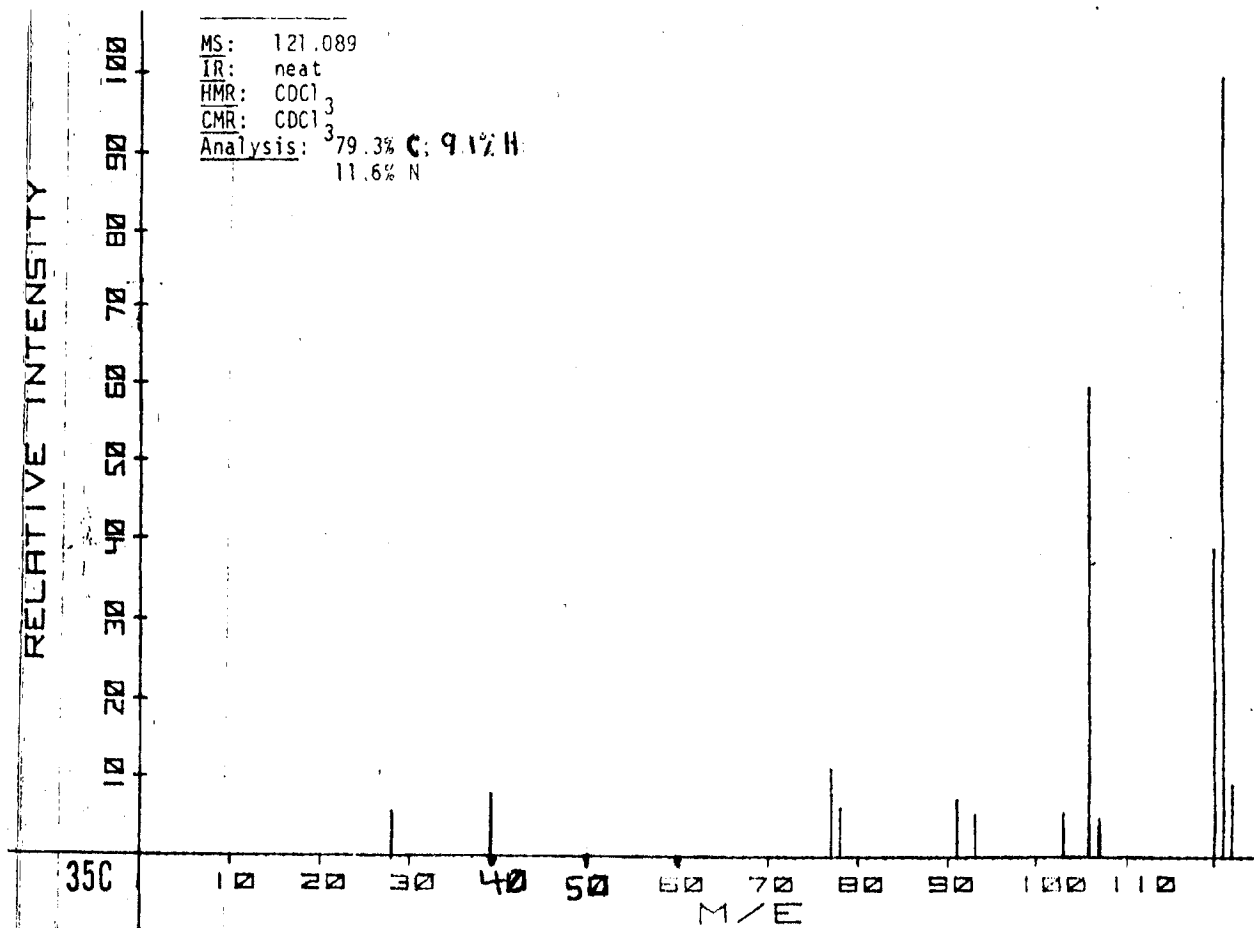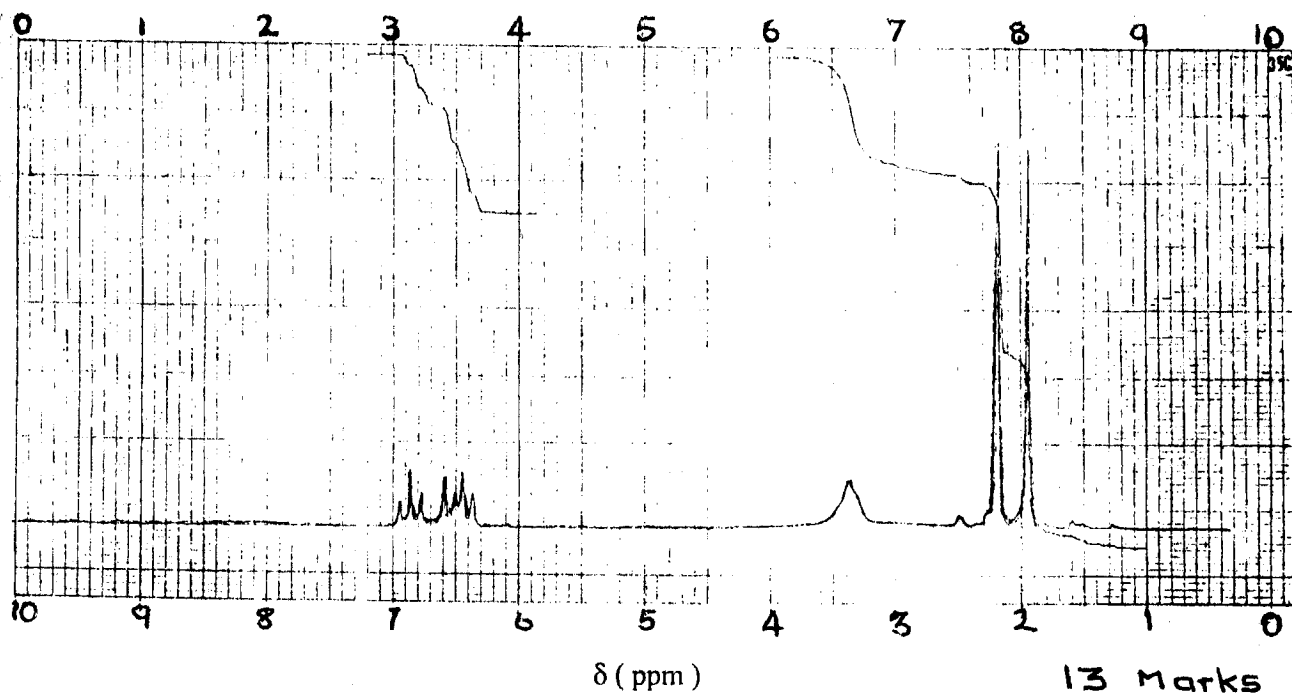
b)   Deduce the structure of compound 10 from the following MS, IR and ^{1}HNMR spectra.

MASS SPECTRUM OF COMPOUND 10

MS: 114.C68
IR: neat
HMR: CDCl
CMR: CDCl
Analysis: 63.1% C; 8.8% H

MOLECULAR FORMULA $C_6H_{10}O_2$

RELATIVE INTENSITY

13A
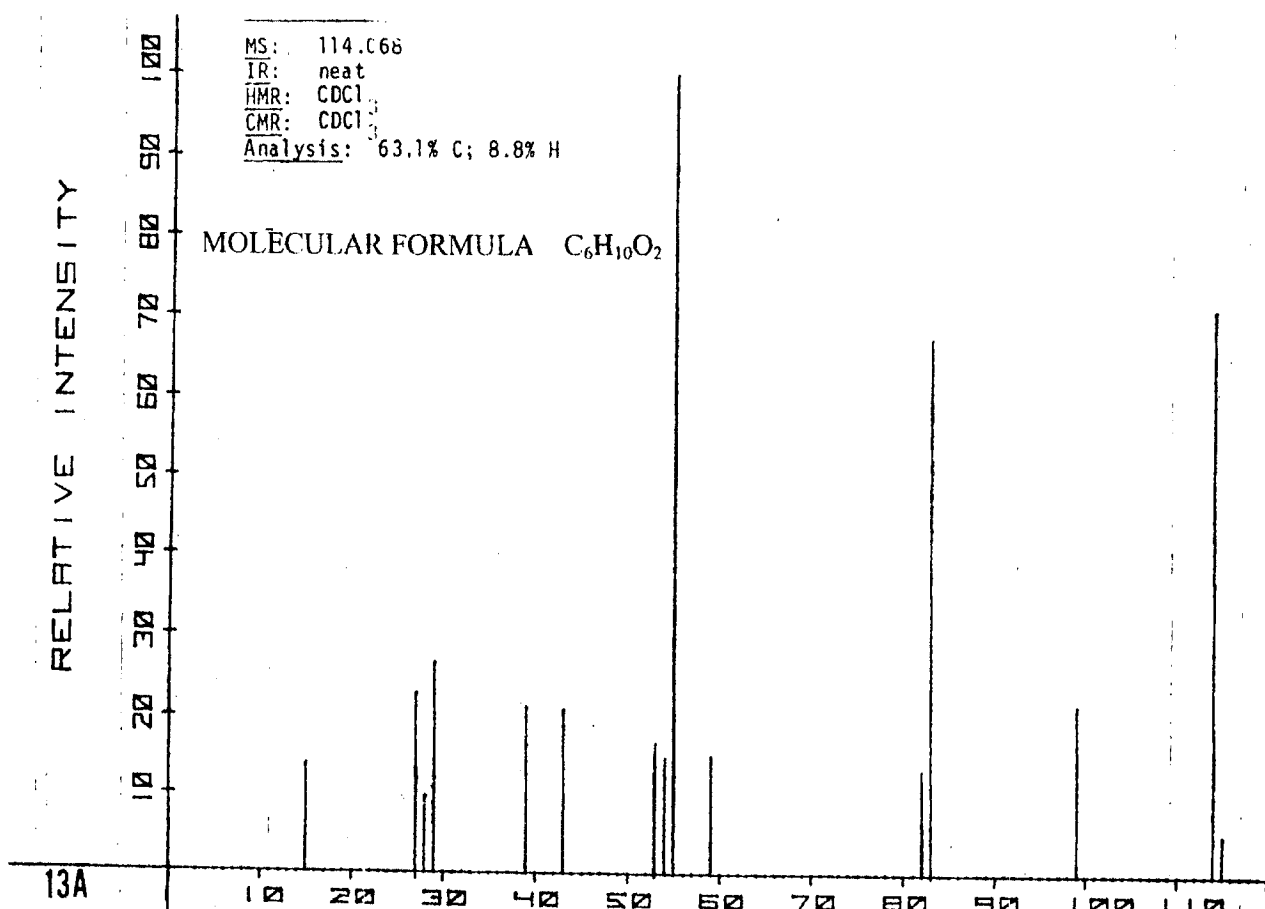
IR SPECTRUM OF COMPOUND 10

¹HNMR SPECTRUM OF COMPOUND 10

δ (ppm)

12 Marks

8
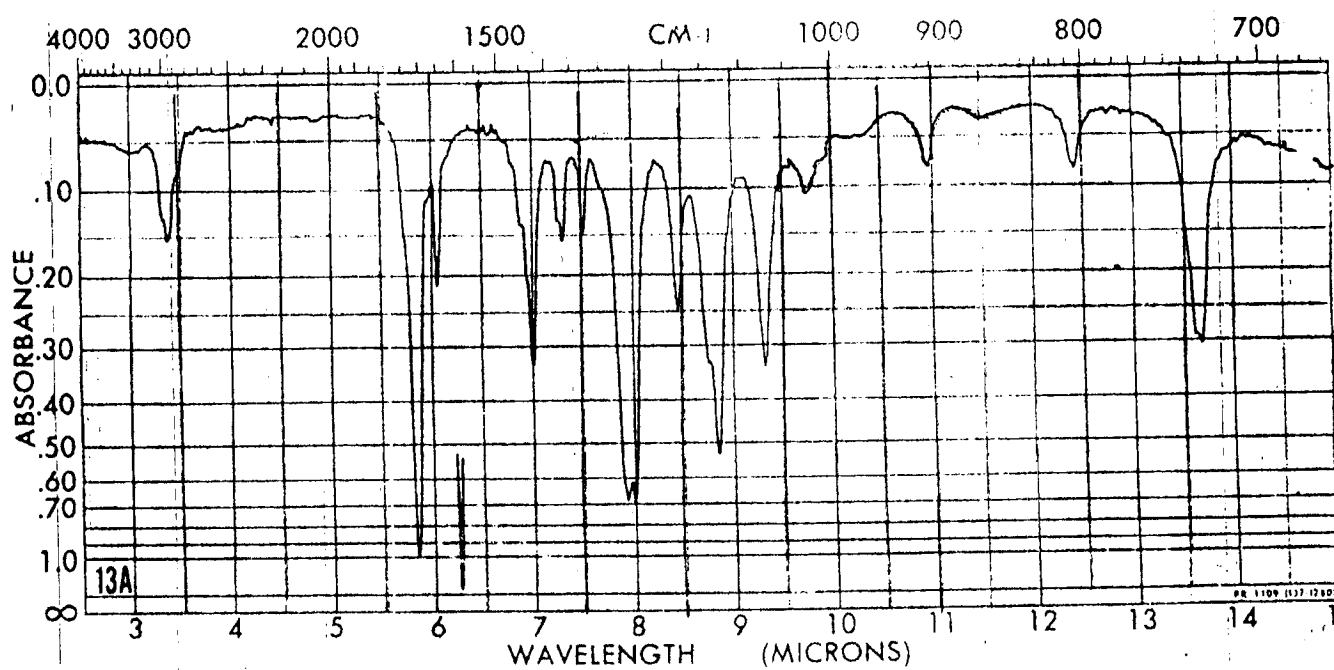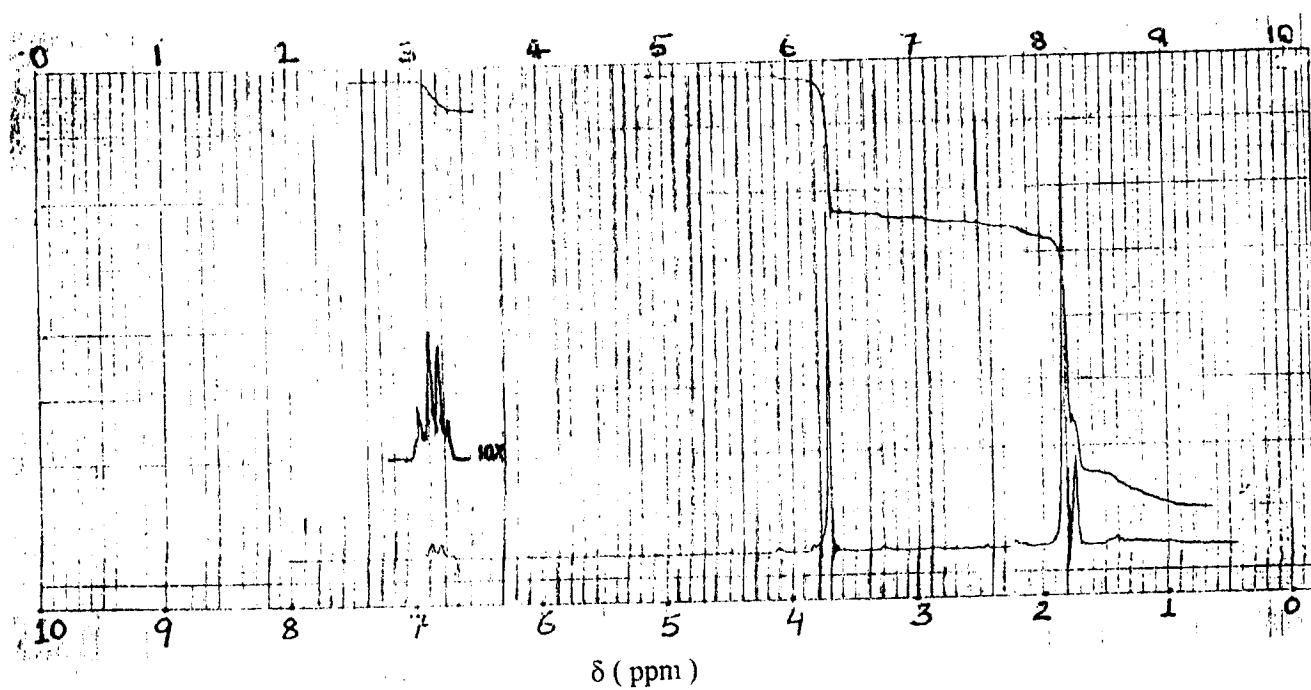
SECTION B:

Answer two (02) questions in this section

QUESTION FOUR

(a)   Using Williamson's procedure for ether synthesis, a mixture of allyl halide and 2-naphthol was refluxed in aqueous sodium hydroxide to yield a single product, 1-allyl-2-naphthol. Give a reasonable explanation for the exclusive formation of 1-allyl-2-naphthol rather than the alternative 3-allyl-2-naphthol, and provide a plausible mechanism for this reaction showing succinctly all the intermediates involved in the reaction.

12 Marks

(b)   Predict the product(s) of each of the following reactions and account for their formation.

(i) $CH_3-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}-\overset{O}{\underset{Cl}{C}}$ $\xrightarrow[AlCl_3]{C_6H_5OCH_3}$?

(ii) $CH_3-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}-\overset{O}{\underset{Cl}{C}}$ $\xrightarrow[AlCl_3]{C_6H_6}$?

(iii) $CH_3-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}-\overset{O}{\underset{Cl}{C}}$ $\xrightarrow[NaOH]{C_6H_5OH}$?
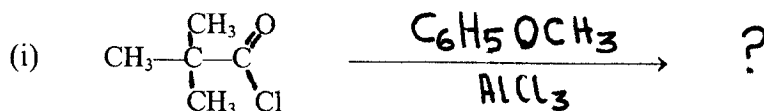
03 Marks

(c)   Outline all steps involved in the synthesis of 1,7-dimethylnaphthalene from benzene and any other needed readily available reagents.

10 Marks

QUESTION FIVE

a)   An organic chemistry student carried out two experiments in a laboratory. In the first experiment he refluxed methylacetate in ether in presence of sodium metal and obtained a compound A. In the second exeperiment he reacted compound A with $LiAlH_4$ and obtained a compound B. He further reacted compound B with aqueous solution of lead tetraacetate, $Pb(OCOCH_3)_4$, and obtained a compound C. Provide the mechanisms for the reactions and give the structures and names for compounds A, B and C.

12 Marks

9

b) Provide a reaction mechanism for dimethoxylation of p-benzoquinone with methanol in presence of zinc chloride, showing clearly all intermediates involved and name the final product.

08 Marks

c) What compound would you expect to obtain if resorcinol (1,3-dihydroxy benzene) were reacted with chloroform in presence of sodium hydroxide? Write a mechanism for this reaction.

05 Marks

QUESTION SIX

a) Benzaldehyde reacts smoothly with acetophenone and aqueous sodium hydroxide to yield benzalacetophenone, $C_6H_5CH=CHCOC_6H_5$, in high yield. Write the mechanism of this reaction. When benzalacetophenone is nitrated, a single compound is obtained. Which ring is nitrated and what is the orientation of the nitration?

06 Marks

b) Complete the following reactions.

(i)

i) C_6H_5Li/THF
ii) CO_2
iii) H_2O
→ ?

(ii)

H^+
→ ?

(iii)

 + $CH_2=CHCCH_3$ (with O above C)

$\dfrac{KOH}{EtOH}$ → ?

(iv)

CH_3COCl
$AlCl_3$
→ ?

(v)

Conc. HNO_3
→ ?

05 Marks

10
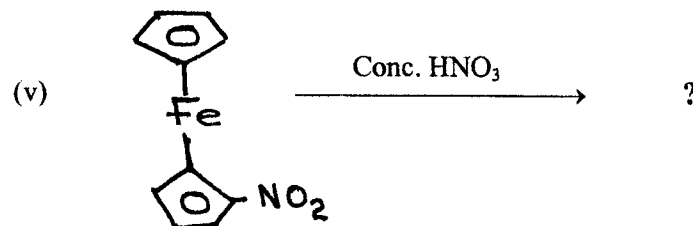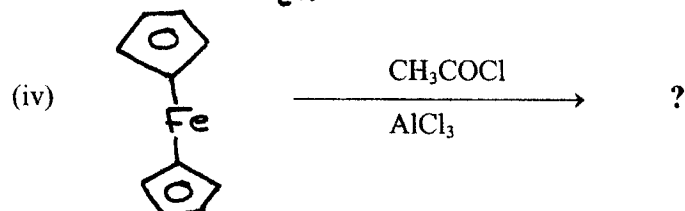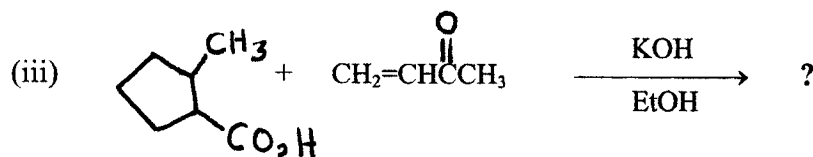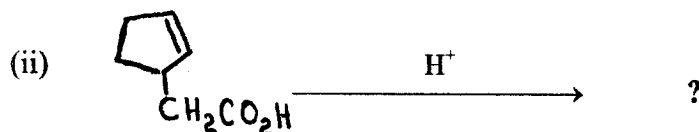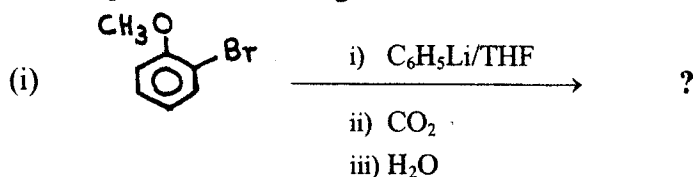
c) The reactivity of ferrocene towards Friedel-Crafts acetylation is approximately 10^5 times that of benzene. Explain why?

02 Marks

d) Write the mechanism for the following reaction.

$$\bigcirc + CHCl_3 \xrightarrow[2. \ H^{\oplus}]{1. \ AlCl_3} 9 - Phenylfluorene$$
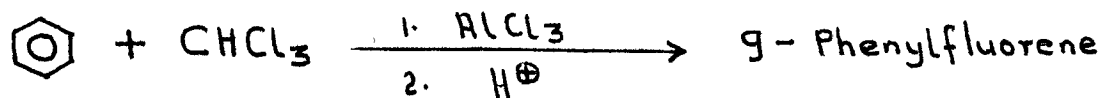
12 Marks

END OF EXAM

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
MAY 1999

C361
PHYSICAL CHEMISTRY

TIME: **Three Hours**

Instructions:

    1.   **Answer ANY FIVE (5) Questions**

CONSTANTS: $\pi = 3.143$, $R = 8.314$ J mol^{-1}

                  $h = 0.76$ m of mercury, density of mercury $= 13600$ kg m^{-3}

                  $g = 9.8$ m s^{-2}, $F = 96500$ coul mol^{-1}

                  Debye-Huckel constant, $A = 0.509$

---

1.   (a)   Define the term, specific heat capacity. What are its units?

     (b)   What is the practical importance of the Debye third power law?

     (c)   The atoms of a monoatomic crystalline solid undergoing a simple harmonic motion vibrate with a single frequency, v. The heat capacity of such solid is,

$$C_v = 3R\left(\frac{hv}{kT}\right)^2 \frac{e^{-hv/kT}}{\left(1 - e^{-hv/kT}\right)^2}$$

     (i)   What is the limiting value of C_v as $T \to O$ and $T \to \infty$?

     (ii)   What are the implications of the limits vis-a'-vis the existing laws on the thermodynamic properties of crystalline solids?

     (d)   The molar heat capacity at constant volume, $C_v = \dfrac{12\pi^4 R}{5}(T/\theta)^3$. If θ for lead is 98.5 K, calculate the entropy change for heating 51.75 g of lead at constant volume from 15 K to 150 K (Molar mass of lead = 207).

2. (a) What is the full meaning of the abbreviation, PMV. Define it.

   (b) Give the equation for the total volume of a binary solution in terms of the PMV of its components, A and B.

   (c) The inequality, $P_i > X_i P_i^{\theta}$ describes the behaviour of a solution and its components. Give the names of the components of a solution that conform with the inequality and hence sketch an anotated vapour pressure- composition diagram for the behaviour of the solution.

   (d) Give a qualitative rationalisation for the shape of your diagram in (c).

   (e) A sample of oxygen at 1 atm expands adiabatically and reversibly from $0.52 \ dm^3$ to $1.25 \ dm^3$. The temperature of the gas is 298 K and C_v is $12.60 \ J \ mol^{-1} \ K^{-1}$. If the gas behaves ideally, calculate,
   (i) the final pressure of the gas
   (ii) the enthalpy change
   (iii) the maximum obtainable work

3. · (a) Define (i) excluded volume (ii) free volume.
   (b) show how the α-function is related to the Z-factor.
   (c) A graph of fugacity coefficient versus reduced pressure at some reduced temperature is supplied. Calculate the fugacity of carbon (IV) Oxide at 298 K and $2.58 \times 10^5 \ N \ m^{-2}$ from the chart given the critical temperature and pressure for carbon (IV) Oxide to be 304.3 K and $7.39 \times 10^6 \ N \ m^{-2}$ respectively.
   (d) The critical temperature and pressure of ethane are $32.1°C$ and $4.94 \times 10^6 \ N \ m^{-2}$ respectively. What are the van der Waals constants for the gas? What pressure is exerted by 15 g of ethane in a cubic decimeter flask at $27°C$?

4. (a) State the Claussius - Clapeyron equation.
   (b) Each of the following liquids, $CH_3(CH_2)_6CH_3$, C_2H_5OH, $C_2H_5OC_2H_5$, CH_3COCH_3, CCl_4 and H_2O can be used as a working substance in a Carnot Engine. Assuming that the vapour pressure of each liquid is obtained as a function of temperature, sketch the relative graphs (many diagrams on the same sheet) for the liquids in conformity with Claussius-Clapeyron equation. On what principle is the relative position of your plots based?
   (c) Show briefly but quantitatively why the adiabatic processes do not contribute to the work output of a reversible Carnot Engine.

2

Tr = 0.99

Tr = 0.98

Tr = 0.97

Tr = 0.96

Tr = 0.95

Coeficient

Reduced pressure

0.00   0.01   0.02   0.03   0.04
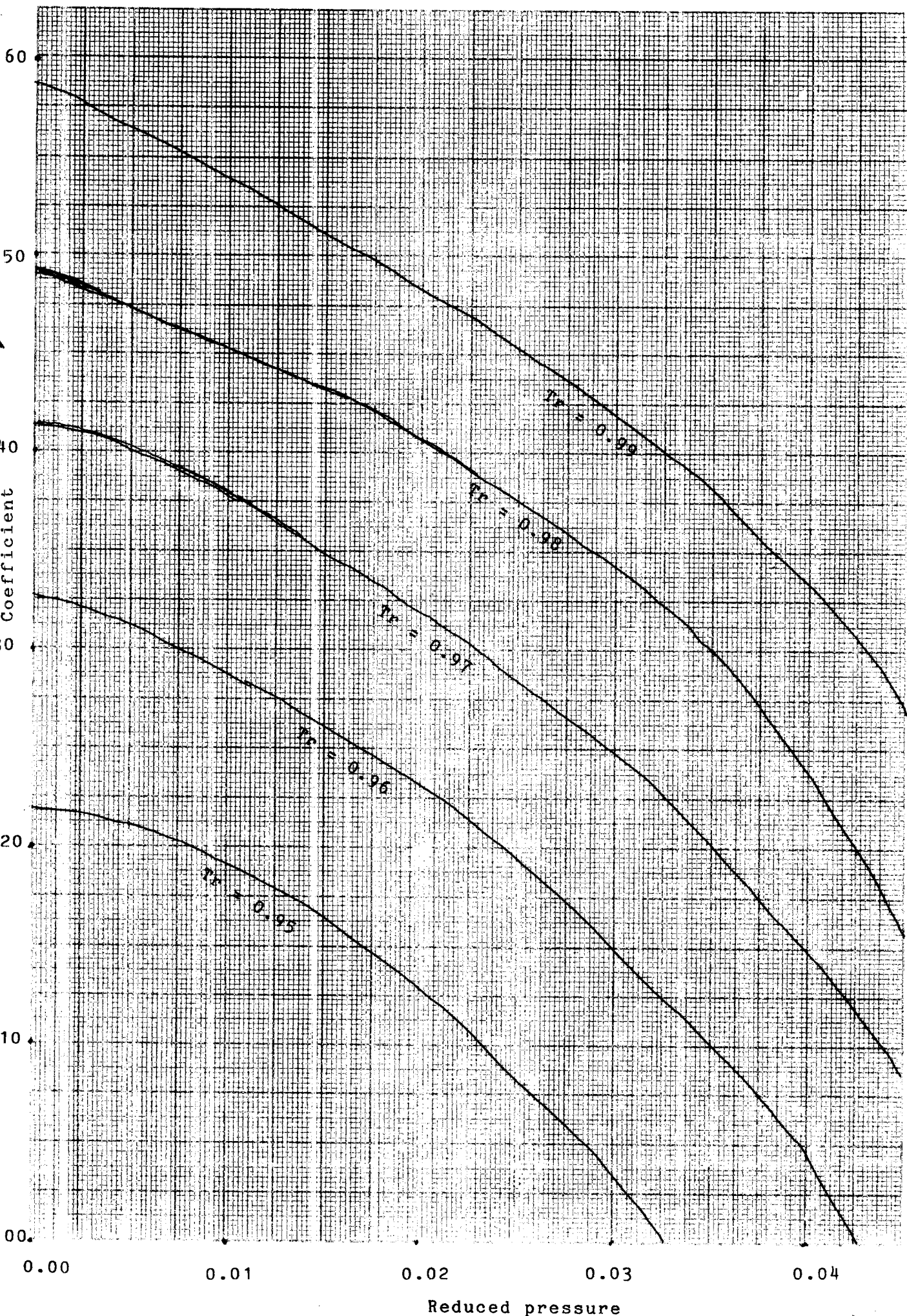
(d)   The diagram below shows a Carnot Engine driving a Carnot Refridgerator.

Heat Reservoir at 500 K

$q_h = 100J$

q'_h

w

Carnot Engine

Carnot Refrigerator

q_c

q'_c

Heat Reservoir at 100 K
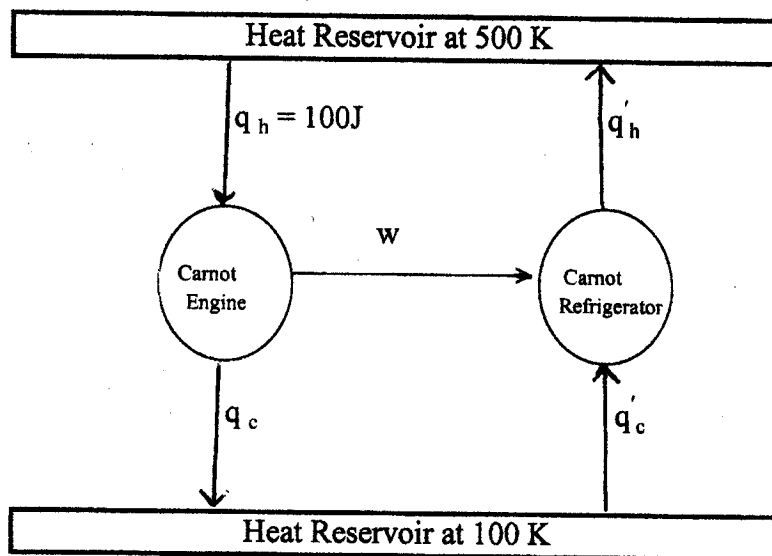
Determine w, q'_c and q'_h

5   (a)   Why does the conductance of a piece of copper wire falls with increase in temperature whereas that of an electrolyte increases as temperature rises?

(b)   Name the retarding forces that tend to impede the mobility of the ions of an electrolyte in an applied electric field.

(c)   What is a reference electrode?

(d)   (i)   Write the equilibrium between hydroquinone and quinone in a quinehydrone electrode.

(ii)   Write the Nernst equation for the function of the electrode.

(iii)   Why is the quantity of quinehydrone in the electrode insensitive to its potential?

(e)   The resistance of a cell filled with 0.01 mol dm^{-3} KCl was found to be 145 ohms. The cell was then filled with ammonia solution of 0.01 mol dm^{-3} and the resistance was 2054 ohms. Calculate the degree of dissociation of ammonia solution given that the molar conductances at infinite dilution of OH$^-$, Cl$^-$, NH$^+_4$ and K$^+$ are 19.86 x 10^{-3}, 7.35 x 10^{-3}, 7.34 x10^{-3} and 7.64 x 10^{-3} ohm^{-1} mol^{-1} respectively.

6.   (a)   On what principle is the moving boundary method of estimating the transport number of an ion based? How does this differ from that of Hittorf method? [Confine your answer to 7 lines or less and be warned not to describe the methods].

(b)   A salt solution and an electrolyte of interest are used in a moving boundary cell. What conditions must be fulfilled for the choice of the liquids?

(c) Consider the ions Sr^{2+}, Be^{2+} and $H_9O_4^+$ in solution. Arrange the ions in the decreasing order by which they carry current in an applied field. Justify your order.

(d) The cell reaction, $MnO_4^- + SO_3^{2-} \rightarrow MnO_2 + SO_4^{2-}$ occurs in alkaline medium. Obtain the cathodic and anodic balanced reaction equations and hence the full cell balanced equation. What is the free energy change for the cell reaction given the following standard reduction potentials? $MnO_4^-/MnO_2 = 0.60V$ and $SO_4^{2-}/SO_3^{2-} = -0.93V$.

(e) Calculate, according to the Debye-Huckel limiting law, the activity coefficient of Cl^- and SO_4^{2-} ions in an aqueous solution at 298K which is 0.001 mol kg^{-1} with respect to potassium chloride and 0.001 mol kg^{-1} with respect to potassium sulphate.

** *You ared warned to number your answers as numbered in the questions. Any floating answer without proper anotation will not be graded.*

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
MAY 1999

C411
ADVANCED BIOCHEMISTRY

TIME: **Three (3) Hours**

Instructions:

     SECTION A:

         1.   **SHORT ANSWER QUESTIONS**

         2.   **ANSWER ALL QUESTIONS**

     SECTION B:

         1.   **ESSAY QUESTIONS**

         2.   **ANSWER ANY FIVE(5) QUESTIONS**

         3.   **ALL QUESTIONS CARRY EQUAL MARKS**

SECTION A:

1.   (a)   Giving at least **TWO** reasons explain why electrophoresis is carried out on gel or paper.

           (2 Marks)

     (b)   (i)   Why is polyacrylamide a choice for gels?
Provide **THREE** reasons.

           (3 Marks)

         (ii)   Describe at least one serious drawback associated with polycrylamide gel electrophoresis.

           (1 Marks)

2.   (a)   Calculate

         (i)   The number of radioactive atoms, and

         (ii)   The weight in grams of Potassium in 1Ci of pure ^{40}K.

         [1 curie $= 3.7 \times 10^{10}$ dps]

           (4 Marks)

3. Briefly describe the functions of the following eukaryotic cell organelles.

    (a)   Peroxisomes

    (b)   lysosomes

    (c)   Golgi apparatus

                                                              (5 Marks)

4. Briefly discuss the

    (a)   The use of cell fractionation in biochemical investigations.
    (b)   Different cells of central nervous system.
    (c)   **THREE** major functions of the liver.

                                                              (5 Marks)

5. Write brief notes on the following:

    (a)   "The metabolic steady State"

    (b)   Glutamine Synthase as a regulatory enzyme of amino acids
           biosynthesis.

    (c)   Regulatory mechanisms of the activity of glycogen phosphorylase

                                                              (5 Marks)

SECTION B

1. Discuss the validity of the expression: "Differential centrifugation is another name for density gradient centrifugation".

   (15 Marks)

2. Briefly describe hormone induced cAMP production. Explain the relevance of the latter in Cholera.

   (15 Marks)

3. Describe the molecular mechanism of muscle contraction.

   (15 Marks)

4. What are synapses? Explain the different synapses in mammals.

   (15 Marks)

5. Describe the transcriptional control mechanism of the tryptophan operon as the case is in bacteria

   (15 Marks)

6. Discuss, with examples, the different modifications that an enzyme protein structure can undergo leading to change in the rate of a metabolic process.

   (15 Marks)

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF CHEMISTRY
C421
APPLIED ANALYTICAL CHEMISTRY

PAPER 1
TIME: 3 HOURS

ANSWER ANY 4 FROM THE 6 QUESTIONS IN THIS PAPER

QUESTION 1

(a) A farmer would like to know the fertility of his soil, describe 2 important characteristics that determine this and how they are evaluated in soils.(3)

(b) Most soils contain some exchangeable cations, what are they and explain in detail how any 2 of them can be determined.(3)

(c) Physical ways can be used in trying to identify the type of soils in any field, describe how soils can be differentiated.(2)

(d) What do you understand by the following terms (I) available P (ii) alkalinity of ash and (iii) exchangeable acidity.(3)

(e) Ca in a sample solution is analyzed by FAAS. A stock solution is prepared from 1.84g $CaCl_2.2H_2O$ in water and diluted to 1L. This is diluted 1:20; 1:10; 1:5. Sample is diluted 1:25. When the solutions are aspirated into air-acetylene flame, the following absorbances are recorded. Blank 1.5cm, standards 10.6, 20.1, 38.5 cm; sample 29.6 cm. What is the concentration of Ca in the sample in ppm.(4)
    (Use Ca = 40.08; Cl = 35.45)

Question 2

(a) Compare the determination of gold and that of zinc from their ores.(3)

(b) Describe in detail how silicon can be determined and glass in limestone.(3)

(c) It is desirable in metal analysis to separate various components before colorimetric assay when dealing with rocks. Discuss this statement and give examples to explain the statement.(2)

(d) Some alloys tend to have common elements, name any 2 of such alloys and describe how to determine one of the common elements.(3)

(e) An iron ore analyzed for Fe content by dissolving in acid, converting Fe to Fe^{2+} then titrating with standard 0.02 N potassium dichromate solution. If 34.5 ml is required to titrate Fe in a 1.54g ore sample. How much Fe is in the sample expressed as $\%Fe_2O_3$?
    (Use Fe = 55.85) (4)

Question 3

a) Describe how to determine Mn and Mo in steel.(3)

b) How would you determine Mg in limestone and Ti in bauxite.(3)

c) B can be determined in fertilizers in 2 ways, describe them. (3)

d) Discuss how to determine K in the presence of sulfates and phosphates in a fertilizer.(3)

e) A piece of solder was analyzed as follows: the solder was dissolved in nitric acid and then treated with sulfuric acid to precipitate lead as lead sulfate. The solution was neutralized to precipitate tin as stannic acid. Stannic acid was ignited to yield stannic oxide. A 3.5g sample yielded 3.76g lead sulfate and 1.02g stannic oxide. What is % Pb and Sn in the solder? (Use Pb = 207.2; Sn =118.7) (4)

Question 4

(a) In monitoring sulfur dioxide in the environment absorption train using hydrogen peroxide as an absorbent is used rather than West and Gaeke reagent. Discuss the advantages and disadvantages of this for large scale monitoring.(3)

(b) What instrumental methods would be used for the analysis of the following in soil extracts? K, Ca, Mg, available P and traces of metals.(3)

(c) How do the following situations contribute to pollution problems (I) production of methane by animals as part of their digestion (ii) large quantities of nitrate fertilizers used in farming (iii) increased population in the developed world.(3)

(d) What do you understand by the terms (I) pollution (ii) bioconcentration factor (iii) TWA and (iv) eutrophication.(2)

(e) As accepted limit in water as given by WHO:

WHO limit / ppm   FAAS working range / ppm
0.05   0.1

with the aid of sketches, describe a method aimed at improving the sensitivity, hence detection limit for the determination of As by FAAS (tip: the method is hydride generation) (4)

Question 5

(a) Discuss the advantages and disadvantages of each of the following methods (I) ICP-AES (ii) AFS (iii) GFAAS and (iv) FAAS. (3)

(b) Discuss the advantages and disadvantages of determining BOD, COD and TOC.(2)

(c) If Pb is deposited on soil close to a busy highway is to be monitored, how would you select sampling positions and how would you determine Pb in such samples.(3)

(d) Which approaches would you use for the following analyses (1) nitrous oxide in the atmosphere at several sites and (2) an organic solvent in a lab atmosphere.(3)

(e) Al can be analyzed by titration with EDTA
$$Al^{3+} + H_2Y^{2-} \longrightarrow AlY^- + 2H^+$$
A 1.0g sample requires 20.5ml EDTA for titration. EDTA is standardized by titrating 25ml of a 0.1M $CaCl_2$ solution, requiring 30 ml. Calculate %Al_2O_3 in the sample. (4)
(Use Al = 26.9 and O = 16)

Question 6

(a) Compare the routes by which high molecular mass organic compounds and toxic metals may disperse and re-concentrate in the environment and in organisms.(2)

(b) In your lab., you are to analyze water that is known to have been contaminated with Hg and Cd, what instruments and approaches would you apply to determine the levels of these 2 toxic elements?(3)

(c) Discuss the significance and analysis of the following (I) water hardness (ii) chlorides and (iii) nitrites in a water sample.(3)

(d) Sulfate in a water sample was analyzed by a turbidimetric method as follows:
Standards were treated with 5ml of conditioning reagent. 0.5g of barium chloride were added and made up to 100ml with water.

Sulfate (mg/L)	turbidity (NTU)
Blank	02
5×10^{-3}	20
1×10^{-2}	40
2×10^{-2}	79
3×10^{-2}	105

A 5ml water sample from Goma lakes was treated similarly and gave a value of 75. Calculate % (w/v) of sulfate in the water sample.

(e) A 0.3g sample containing copper is dissolved and a colored complex is formed in the presence EDTA. The solution is then diluted to 50ml and absorbance measured as 0.260. A 0.5g sample containing 0.24% copper is treated similarly and the resulting solution has an absorbance of 0.60. Calculate % copper in the sample.(4)

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER 1 EXAMINATIONS

DEFERRED/SUPPLEMENTARY EXAMINATIONS

NOVEMBER 1999

C 445

BIO-INORGANIC CHEMISTRY

TIME ALLOWED   :   THREE (3) HOURS

INSTRUCTIONS   :   ANSWER 4 QUESTIONS
             :   EACH QUESTION CARRIES 15 MARKS

---

1.   a)   Define hydrogen transfer enzymes. Explain the mechanism of the reactions in general catalysed by such enzymes. Discuss the conversion of 1,2 diols to aldehyde catalysed vitamine B_{12} Coenzyme.

    b)   Write a short account on the following

        i)   Ferritin

        ii)   Comparison of non - heme iron proteins with hematoproteins.

2.   a)   i)   List the functional differences between hemoglobin and myglobin.

        ii)   Write the structures of the following unsubstituted porphyrin ring:

            isoleucine, aquacobalamine, methionine.

2 (b) In the [H Ni(OPR$_3$)$_4$]$^+$ five co-ordinate complex, the nickel atom is bonded to the hydrogen and the oxygen atoms of the O=PR$_3$ ligands. The sketch of the ^{1}HNMR spectrum of the complex is shown below.
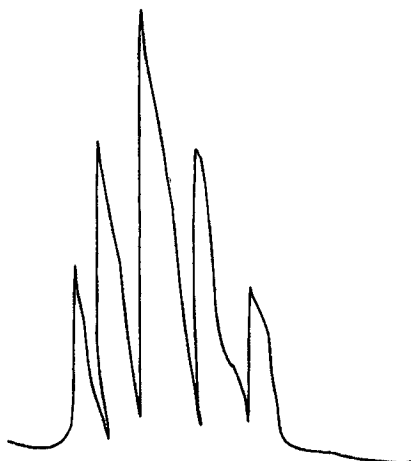
Propose the geometry of the complex given ^{1}H (I = ½), ^{31}P (I= ½) and that R group has a negligible effect on the spectrum.

3 (a) The dinitrogen ligand in a molybdenum moiety moiety (Mo-N≡N) is readily reduced in an acidified medium to produce ammonia molecules. Give a plausible mechanism for the conversion.

(b) The ESR spectra and the corresponding radicals are given below. Interpret the spectra including the intensity ratios of the peaks.
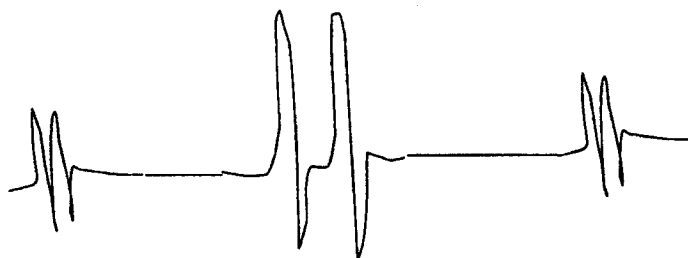
$^•$CH$_2$OH

C$_5$H$_5$$^•$

(c) Sketch the ESR spectrum of $^•$NH$_2$ radical. ^{14}N(I = 1), and ^{1}H(I=1/2).

4. a) Discuss the steps taken in determining the usefulness of the application of preformed metal complexes for chelation therapy.

    b) Illustrate with equations the action of Lewisite on a functioning enzyme. Show how BAL reverses this condition.

5. a) Distinguish between siderophores that are catecholates and hydroxamates. Give example of each. Of what use is deferrioxamine B?

    b) Discuss dioxygen uptake in heamocyanin.

6. a) What consequences arise from excess copper in living systems?

    b) Bulky metal ions in the body include Mg^{2+} and Ca^{2+}. What roles do these metal ions play in the body.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
MAY 1999

C445
INORGANIC CHEMISTRY

TIME: **Three (3) Hours**

Instructions:

1.   **Answer All Questions.**

2.   **Each Question carries 15 Marks.**

---

1.   (a)   The conversion of methane to methanol in methanotropic bacteria is catalysed by methane monooxygenase (MMO) enzyme. Propose a full sequence of mechanism of the reaction for this conversion.

(b)   Discuss the properties of $Vit.B_{12(a)}$, $Vit.B_{12(r)}$ and $VitB_{12(s)}$ forms of Vitamine B_{12} coenzyme.

2.   (a)   (i)   Give one example of each of the following type of amino acid, which can be used as bio-inorganic ligands. Write their structures and discuss their coordinating sites suited for the metal coordination.

Amino acid containing aliphatic hydroxyl side chain.

Amino acid containing amide side chain.

(ii)   Differentiate between a metalloenzyme and a metal activated enzyme.

(b)   (i)   The sketch of ^1HNMR spectrum of $[C_2H_5)Tl]^+$ is given below. Interpret the spectrum

What do the two J-values represent?

(ii)   Deduce the expected $^{11}BNMR$ spectrum of B_2H_6 molecule.

$^{75}As(I=3/2)$, $^{31}P(I=1/2)$, $^{14}N(I=1/2)$, $^{203}Tl(I=1/2)$, and $^{11}B(I=3/2)$.

3.   (a)   Give a concise account of how ammonia is produced by catalytic reduction of atmospheric dinitrogen by nitrogenase enzyme in biological systems.

     (b)   The EPR spectra and the corresponding radicals are given below. Interpret the spectra including the intensity ratios of the peaks.

     (i) $\bullet$As(CH(SiMe$_2$)$_2$]$_2$

     (ii) $C\!\!/\tilde{P}\!=\!NR_2$

     (iii)

4.   (a)   Distinguish the types, functions and characteristics of Copper containing proteins.

     (b)   State and explain two disorders associated with each of the following:-

            (i)   Copper deficiency
            (ii)   Copper overload

     (c)   What are the characteristics of an "ideal ligand" for use in Chelation Therapy"?

5.   (a)   What are siderophores? Discuss the nature of the donor atom(s) in siderophores and explain why they are suitable for their functions.

(b)   Classify the siderophores below and state their binding groups.

(i) enterobactin

(ii) aerobactin

(c)   In the reaction

$$Fe^{3+} + (enterobactin)^{6-} \rightleftharpoons [Fe(enterobactin)]^{3-}$$

the stability constant is $K = 10^{49}$. Despite the large K value enterobactin has not been used as a chelating ligand for removal of Fe overload in β-Thalassaemia blood disorder. Why is this the case?

6.   (a)   Vibrational frequencies associated with dioxygen, superoxide and peroxide are 1560 cm^{-1}, 1150-1100 cm^{-1} and 850-740 cm^{-1}, respectively. With the aid of simple MO diagrams discuss the terms: dioxygen, superoxide and peroxide.

       (b)   Binding of dioxygen to Fe^{2+} in haemoglobin (Hb) and myoglobin(Mb) can be discussed using the Pauling formulation or the Weiss formulation. Distingush between the two formulations as regards the nature of bonding in oxy-Hb or oxy-Mb.

       (c)   Discuss dioxygen uptake in haemerythrin(Hr).

****

3

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
MAY 1999

C451
ADVANCED ORGANIC CHEMISTRY

TIME: **Three (3) Hours**
Instructions:

1. Answer any **FOUR** Questions.
2. All Questions carry equal Marks.
3. Marks Allocation for each question is shown.

Max-Marks = 100

---

1. (a)   Attempted synthesis of compound **B** by acetoxylation of compound **A** with lead tetraacetate in refluxing acetic acid unexpectedly gave a compound **C**, structure shown below.

A   **B**   **C**

(i)   Suggest a reason why compound **B** was not obtained.

(ii) Propose a plausible reaction mechanism to account for the formation of the unanticipated product **C** from **A**.

(9 Marks)

(b)   Beta-keto sulfoxides react with aqueous acids and other acidic reagents to yield α-hydroxysulfides. The reaction is called Pummerer rearrangement.

Suggest a mechanism for this transformation.

(8 Marks)

(c)   Acylsilanes react with electrophiles in the presence of fluoride ion to
       give ketones. The reaction is thought to be initiated by fluoride attack
       on the carbonyl carbon.

       On this basis propose a mechanism for this reaction.

       (8 Marks)

2.   (a)   Solvolysis of 2-cyclopent-3enylethyl tosylate, **D**, in dilute ethanoic
             acid at 25°C gives a compound **E**.

        D   **E**

       Provide a plausible explanation of the molecular events involved in
       this transformation.

       (12 Marks)

(b)   Suggest mechanisms of the following reactions.

       (i)

       (7 Marks)

(ii)

(i) NaH, Et₂O

(ii) $H_2C=CH\overset{+}{P}Ph_3\,\overset{-}{Br}$

(6 Marks)

3.   (a)   Identify the principal pharmacophore in, and state the pharmacological action(s) of the biologically active compounds **F, G** and **H** , structures shown below.

F   **G**   **H**

(6 Marks)

(b)   Briefly explain the mode of pharmacological action of compound **G**, structure shown in 3(a) above.

(6 Marks)

(c)   Explain the mechanisms of the reactions involved in the following synthesis of compound **H**, structure shown in 3(a) above.

NaOEt

$\rightarrow$ (1), $C_{11}H_{11}NO$

CH_2N_2, THF

(2), $C_{12}H_{13}NO$ (8 Marks)

H $\leftarrow$

(d)   Suggest a synthesis of compound **F**, structure shown in 3(a) above.

(5 Marks)

3

4. Give the structures of the major organic products, including pertinent stereochemistry, of the reactions (a)-(j) shown below.

(a)

(i) thexylborane
————————————>
(ii) CO/H$_2$O
(iii) H$_2$O$_2$/CH$_3$COONa

(b)

OMe

O

(i) Me$_3$SiCl,Et$_3$N
————————————>
(ii)

COOMe
⊕
(iii) H$_3$O

(c)

SMe

CN

(i) H$_2$O$_2$
————————————>
(ii) Δ

(d)

Et O$_3$P

(i) BrCH$_2$COOEt,THF
————————————>
(ii) n-BuLi, THF
(iii) Cyclopentanone

(e)

COOH

(i) Pb(OAc)$_4$
————————————>
(ii) I$_2$, CCl$_4$, hv

(f)

CHO

(i) HS(CH$_2$)$_3$SH, BF$_3$
————————————>
(ii) n-BuLi,then Me$_3$SiCl
(iii) HgCl$_2$,H$_2$O,MeCN

(g)

O

SPh

(i) i-Pr$_2$N Et
————————————>
(ii) 9-BBNOTf,
(iii)

Me   Me

MeO-C   CHO

O

4

(h)

(i) Sia$_2$BH
———————————>
(ii) BrCH$_2$COOEt,

+OK, +OH

(i)   Et$_2$S

(i) MeI
———————————>
(ii) PhLi,THF
(iii) Cycloheptanone

(j)

(i) HC≡CCH$_2$CH$_2$CH$_3$
———————————>
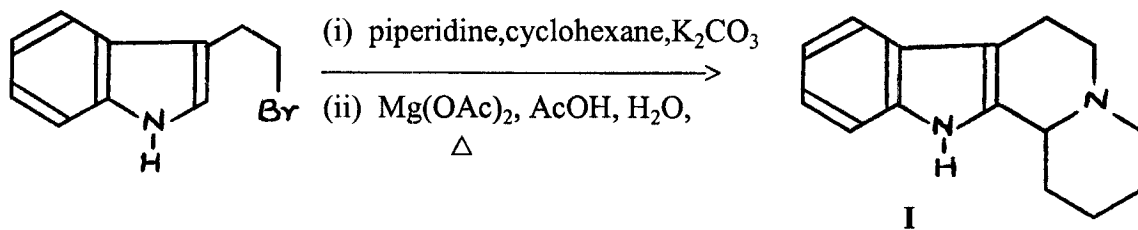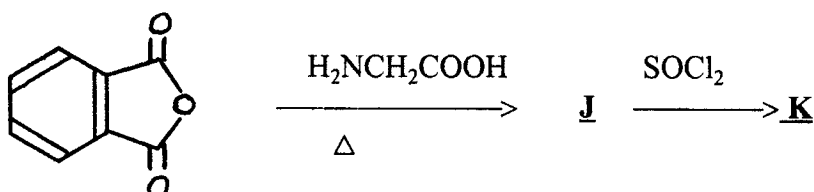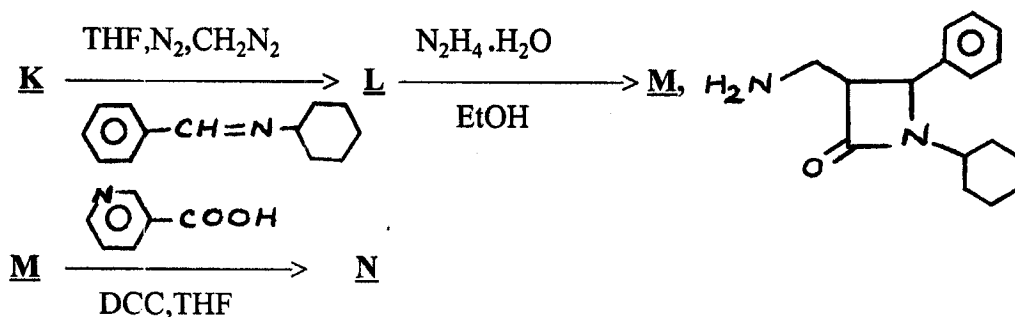(ii) NaOMe
(iii) >—COOH

(25 Marks)

5.   (a)   Explain the mechanisms of the reactions involved in the following
synthesis of a biologically active compound **I**, structure shown below.

(i) piperidine,cyclohexane,K$_2$CO$_3$
———————————————>
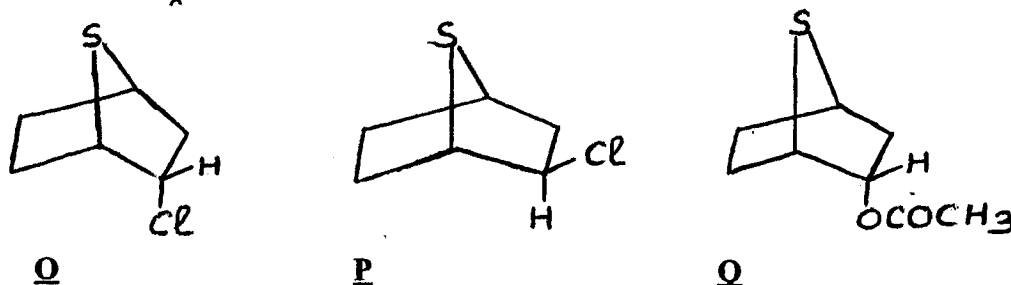(ii) Mg(OAc)$_2$, AcOH, H$_2$O,
Δ

I

(7 Marks)

(b)   Deduce the structure of a potent anti-microbial agent **N** from the
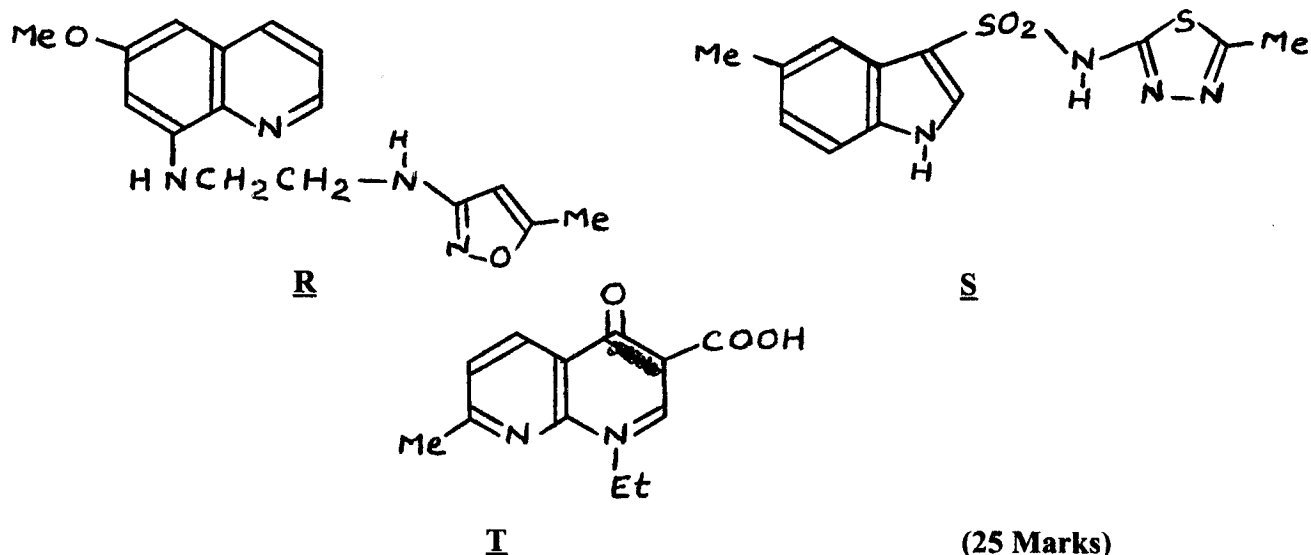following synthesis. Show the structures of the intermediates **J – L**.

H$_2$NCH$_2$COOH
———————————>
Δ

J

SOCl$_2$
———————>**K**

THF,N$_2$,CH$_2$N$_2$

K ⟶ **L** ⟶ **M, H$_2$N**

phenyl–CH=N–cyclohexyl

N$_2$H$_4$·H$_2$O / EtOH

pyridyl–COOH

M ⟶ **N**

DCC,THF

(8 Marks)

(c) Solvolysis of endo 2-chloro-7-thiabicyclo [2.2.2] heptane, **Q**, occurs 4.7 x 10^9 times faster than that of the exo isomer, **P**. The product of acetolysis of both **Q** and **P** in the presence of sodium acetate is the endo acetat **Q**, structure shown below.

Q   **P**   **Q**

Offer a mechanistic interpretation of these results.

(10 Marks)

6. Propose a stepwise synthesis of **TWO** of the following antimicrobial/anti-malarial compounds from readily available non-heterocyclic starting materials and any other needed reagents. Show the logic of your proposal.

R   **S**

T   **(25 Marks)**

6

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I DEFERRED/SUPPLEMENTARY EXAMINATIONS

NOVEMBER 1999

C 461
QUANTUM CHEMISTRY

TIME: **THREE HOURS**
Instructions:

Answer ALL FOUR questions.

CONSTANTS/DATA: $c = 3.00 \times 10^8$ m. s^{-1}
$N_A = 6.02 \times 10^{23}$ mol^{-1}
$h = 6.63 \times 10^{-34}$ J. s
$k = 1.38 \times 10^{-23}$ J. K^{-1}
1 eV $= 1.60 \times 10^{-19}$ J
Newton $\equiv$ m. kg^2. s^{-2} = J. m^{-1}

$\int \sin ax \cos ax \, dx = 1/2a \sin^2 ax$

---

1.   a)   In cartesian co-ordinates, a point **O** is defined by the three co-ordinates x, y, z whose ranges are not limited, e.g. $-\infty \leq x \leq +\infty$. The point **O** can also be defined by the spherical polar co-ordinates r, θ, and ϕ.

(i)   Express the cartesian co-ordinates of the point **O** in terms of its spherical polar co-ordinates

(ii)   What are the limits of each of the co-ordinates r, θ and ϕ ?

(iii)   Express the cartesian volume element dxdydz as a spherical polar co-ordinate volume element dτ.

    b)   The wave functions of the hydrogen atom for the energy level n = 2, l =1, commonly known as p orbitals are:

$$\Psi_{210} = 2p_o = 1/4\sqrt{(2\pi)} \, [Z/a_o]^{3/2} \, \varrho e^{-\varrho/2} \cos\theta$$

$$\Psi_{211} = 2p_1 = 1/4\sqrt{(2\pi)} \, [Z/a_o]^{3/2} \, \varrho e^{-\varrho/2} \sin\theta \cos\phi$$

$$\Psi_{21-1} = 2p_{-1} = 1/4\sqrt{(2\pi)} \, [Z/a_o]^{3/2} \, \varrho e^{-\varrho/2} \sin\theta \sin\phi$$

where $\varrho = Zr/a_o$ and Z is the charge.

(i) What is the degeneracy g_n of the n = 2 energy level of the hydrogen atom ?

(ii) Calculate the magnetic strength H_z at the centre of the hydrogen atom due to the orbital motion of the electron in the 2p state. The magnetic field vector will be aligned along the z-axis. The field strength can be calculated from the expectation value:

$$< H_z > = - e/(\mu c) \int \psi_{2p} J_z/r^3 \, \psi_{2p} \, d\tau$$

The angular momentum operator J_z along the z-axis, $J = h/2\pi i \nabla_\phi$, so that $J_z \psi_{2p} = mh/2\pi \psi_{2p}$ and μ is the reduced mass of the atom and c is the speed of light.

2. a) (i) What is a Hermitian operator ?

(ii) Express the kinetic energy of a particle moving with a constant potential V(-x) = 0 as a quantum mechanical operator.

(iii) Show that the quantum mechanical operator you expressed in part a)(ii) is Hermitian.

b) Is the function $\Psi = 3\cos^2\theta - 1$ an eigenfunction of the operator
$$J = -h^2/4\pi^2 [\partial^2/\partial\theta^2 + \cot\theta \partial/\partial\theta]$$
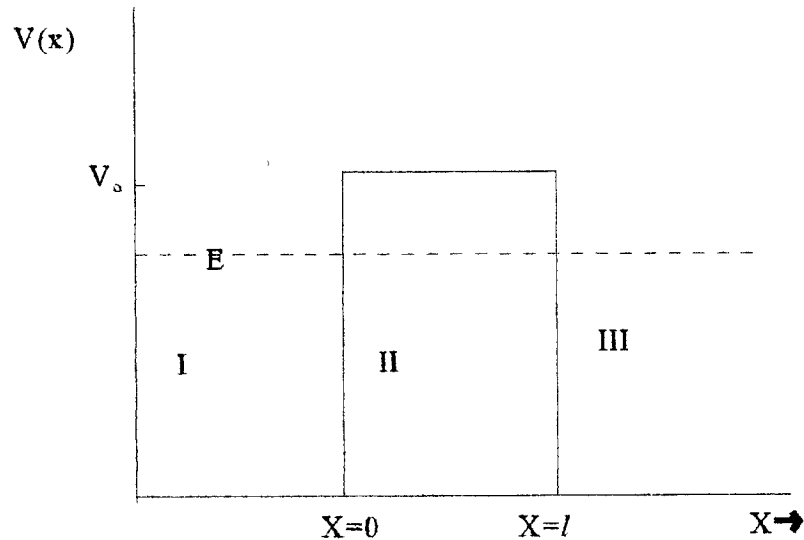If yes, what is the eigenvalue ?

c) The angular momentum of a particle about a point **O** is defined as **L = r x p** where **r** is the position vector and **p** is its linear momentum. It can be shown that:

$$L_x = yp_z - zp_y \; ; \; L_y = zp_x - xp_z \; ; \; L_z = xp_y - yp_x \; ; \text{ and } L^2 = L^2_x + L^2_y + L^2_z .$$

(i) Calculate the commutator of L_x and L_y.

(ii) Calculate the commutator of L_y and L_z

(iii) What is the commutator of L_z and L_x ?

(iv) Evaluate the commutator of L^2 and L_x , of L^2 and L_y ; and of L^2 and L_z . Comment on your result.

3. a) Discuss, briefly, the vibration of carbon monoxide $C^{12}O^{16}$:
(i) as a harmonic oscillator obeying Hooke's law ; and
(ii) as anharmonic oscillator (real molecule) with a Morse potential.

b) On the same diagram, sketch the eigenfunction Ψ_n and the probability density $\Psi^*_n \Psi_n$ for carbon monoxide in the vibrational state n = 2.

c) The difference in the energy between the n = 0 and n = 4 vibrational states of carbon monoxide is 1.72×10^{-19} J molecule^{-1} . Calculate
(i) the vibrational force constant;
(ii) the zero point energy; and
(iii) the fraction of molecules in the n = 4 vibrational state to those in the ground state at room temperature, T = 300 K .

4.

This diagram relates to a particle moving in the +x -direction. $V(x)$, V_o and E have the usual meanings.

a)   (i)   What is the overall Schrödinger equation for the particle ?

         (ii)   Write the Schrödinger equation and its solution in each of the regions I, II and III. Comment on the constants in the solution for each region.

         (iii)   What is the general solution of the overall Schrödinger equation of part a)(i)

b)   (i)   Find an expression for the transmission coefficient of the probability that the particle can be found in region III.

         (ii)   Calculate the classical probability of finding the particle in region III. Explain your result.

c)   Given your results in part b), give an example for which your result in part b) (i) is valid.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY

C 461 : QUANTUM CHEMISTRY

SEMESTER I FINAL EXAMINATION, MAY 1999.

Time Allowed: Three (3) Hours

Instructions: Answer Question 1 and Any Four (4) Questions.

1. a) What is the zero - point energy for a linear harmonic oscillator.

    b) Write down the time dependent wave function ψ (q, t) in terms of the time independent function ψ (q).

    c) The electrons in metals move about freely and may be treated approximately like particles in a three dimensional container of size equal to that of a piece of metal. What is the degeneracy g_n of the energy level in a cube of solid copper whose energy is $E = 14h^2/8ml^2$.

    d) Calculate the wave number shift for the second line in the Lyman series on changing from atomic hydrogen to deuterium.
    $$R_H = 1.097373177 \times 10^7 \, m^{-1}$$

    e) What is the Compton effect?

    f) What is the Tunnel effect?

    g) What is the commutator of the operators : $\alpha = x$; and $\beta = p_x$. What is the physical meaning of your result?

    h) Give the magnitude and units of the following natural constants:
    - (i)   Avogadro constant
    - (ii) Ratio of proton rest mass to electron rest mass m_p/m_e
    - (iii) The Bohr radius a_0
    - (iv) The Boltzmann constant k
    - (v)   Molar gas constant R.

    i) Calculate the de Broglie wave length for an electron with a kinetic energy of 200 eV.
    $$1 \, eV = 1.60 \times 10^{-19} \, J \; ; \; m_e = 9.11 \times 10^{-31} \, kg \; ; \; h = 6.63 \times 10^{-34} \, J.s$$

    j) Calculate the number of independent degrees of freedom each for sulfur dioxide and for nitrous oxide. For each molecule sketch each of the normal vibrational modes.

Which mode is expected to have the highest frequency (in wave number). In what part of the electromagnetic spectrum would you expect these frequencies to occur?

2.   a)   What is the photo-electric effect?

   b)   Describe the photo-electric effect experiment, its result(s) and its importance in the development of quantum theory. Avoid trivial details.

   c)   An experiment was done on the emission of photo-electrons from a sodium surface by light of different wave lengths. The following values for the potentials at which the photo-electric current was reduced to zero were obtained:

λ (nm)	E (volts)
312.5	2.128
365.0	1.595
404.7	1.215
433.9	1.025
546.1	0.467

Plot the voltage against the frequency and calculate:

   (i)   the threshold frequency;
   (ii)   Planck's constant.
(From R. A. Millikan; Physical Reviews; 7, 355 (1916).)

   $e = 1.602 \times 10^{-19}$ C ; $c = 3.0 \times 10^{8}$ m s^{-1}

3.   a)   Give the formula for the energy of a harmonic oscillator.

   b)   The selection rule for the emission or absorption of radiation by the oscillator is $\Delta n = \pm 1$. What will the frequency observed in the spectrum of the harmonic oscillator be for the transition n = 5 to n = 4?

   c)   The harmonic oscillator wave functions for the energy levels n = 0 and n = 1 are:

   $\psi_o = [\alpha/\pi]^{1/4} \exp (-\alpha r^2/2)$ and $\psi_1 = [4\alpha^3/\pi]^{1/4}$ r exp $(-\alpha r^2/2)$

   where $\alpha = 4\pi^2 \nu m/h$, and exp means " e to the power ( )"

   (i)   Show that the two wave functions are normalized.

   (ii)   What is the value of the integral $\int_{-\infty}^{\infty} \psi_o \psi_1 d\tau$?

   (iii)   Calculate the average value of $1/r^2$ for the state n =1

$(\int_0^\infty \exp(-ax^2) \, dx = \sqrt{(\pi/a)}; \quad \int_0^\infty x \exp(-ax^2) \, dx = 1/2a; \quad \int_0^\infty x^2 \exp(-ax^2) dx = 1/2\sqrt{(\pi/a^3)})$

4. a)   It is experimentally possible to observe the spectra of ionized atoms. Apart from a scale factor for the frequencies, the spectrum of an ion A^{3+} should resemble most closely those of :
    (i)   the neutral atom A;
    (ii)   the neutral atom three rows above A in the Periodic Table;
    (iii) the neutral atom three rows below A in the Periodic Table;
    (iv)   the neutral atom of atomic number three less than that of A;
    (v)   the neutral atom of atomic number three more than that of A.
    Which of the above statements is correct? Explain.

    b)   Calculate the energy change ΔE in kilojoules for the following chemical reaction on the assumption that the atoms of both reactants and products are in their ground states:
    $$Mg \ (g) + Ca^+ \ (g) \quad = \quad Mg^+ \ (g) + Ca \ (g)$$
    The ionization potentials of magnesium and calcium are 7.646 eV and 6.113 eV respectively. 1 eV = 96.50 kJ mol^{-1}

    c)   An electrical discharge through a mixture of hydrogen and helium gases at low pressure causes the emission of spectral lines due to the H-atoms and He$^+$ ions. Among others, two spectral lines of nearly the same frequency are observed at approximately 20570 cm^{-1}, one due to H -atoms and the other to He$^+$ ions.

    (i)   In what spectral region do the two lines appear?
    (ii)   Find the values of the quantum numbers n_1 and n_2 for the stationary states in the H-atom between which the transition producing one of the lines takes place.
    (iii) Find the values of the quantum numbers n_1 and n_2 for the other line, which is produced by a transition of He$^+$.
    (iv)   Calculate the separation in cm^{-1} of the two lines.

5. A simple approach that has been used to study the electronic spectra of unsaturated hydrocarbons is the Free Electron Theory. It is assumed that in a linear unsaturated system of 2k carbon atoms, the electrons are free to move anywhere within a length $l = (2k -1)R$ along the chain, where R is the average C-C bond length. Outside this region the electrons are forbidden.
    a)   Set up the quantum mechanical Hamiltonian for this system and solve the Schrödinger equation for the wave functions and energy.

    b)   If the system undergoes a transition from the state $\psi_n \rightarrow \psi_{n+1}$, derive an expression for the wave length of the light absorbed.
    c)   Determine the ground state electronic configuration and calculate the ground state energy of the π electrons in butadiene $H_2C = CH - CH = CH_2$ if R = 0.14 nm.
    $$h = 6.63 \times 10^{-34} \, J.s; \quad m_e = 9.11 \times 10^{-31} \, kg \ ; \quad c = 3.0 \times 10^8 \, m.s^{-1}$$

6. In the one variable system known as the plane rotator, a particle of mass m moves in a circular path with constant radius r_o. The only variable is the angle ϕ, which locates the position of the particle in its fixed circular path. The angular momentum of the rotating particle P_ϕ is mvr_o. Since $v = r_o(d\phi/dt)$, $P_\phi = mr_o^2 (d\phi/dt)$.

a) Express the kinetic energy of the plane rotator in terms of P_ϕ.

b) Write the Hamiltonian of the system with a constant value V_o for the potential energy.

c) Set up the Schrödinger equation in one variable for the plane rotator.

d) Find the energy levels E_m of the plane rotator, making use of the requirement that $\psi(\phi)$ have a single value at each point, that is, that $\psi(\phi) = \psi(\phi + 2\pi) = \psi(\phi + 4\pi)$, etc., since the angles ϕ, $\phi + 2\pi$, $\phi + 4\pi$, etc., correspond to the same point on the circular path.

e) The normalized wave functions for the stationary state of energy E_m can be written as:

$$\psi_{+m}(\phi) = \sqrt{(1/2\pi)}\, e^{im\phi}$$

$$\psi_{-m}(\phi) = \sqrt{(1/2\pi)}\, e^{-im\phi}$$

where m = an integer

What is the degeneracy g_m of the energy state E_m. What is the physical interpretation of this degeneracy?

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
MAY 1999

C481
INDUSTRIAL CHEMISTRY

TIME: Three (3) Hours

Instructions:

      1.   **Answer Questions FIVE Questions.**

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1.   Discuss crushing and grinding processes and equipment in terms of particle size and nature of equipment.

2.   Explain the transportation of fluids. What type of apparatus are used for moving the fluids?

3.   Discuss evaporation and distillation equipment. How do these processes differ?

4.   Describe the production of lampblack, carbon black and activated carbon and state when each one is used.

5.   Explain how can be produced CO, H_2 and CO_2 (Flowsheet is attached).

6.   Describe the production of Portland cement (Flowsheet is attached).

7.   Explain air-and-hydrolic-setting binding materials.

8.   Discuss the industrial production of sodium and ammonium sulfates (Flowsheet is attached).

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER I EXAMINATIONS, MAY 1999

Department of Chemistry

C491 – Organic Technology

Time	: 3 hours
Instructions	: Answer any five questions.
	Detach and submit relevant flow charts.

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1. (i) Chemical processing can be carried by either batch, semi-continuous or continuous processes.

    (a) Distinguish between the 3 types of processes.
    (b) Outline the advantages/disadvantages associated with the continuous process.

    (ii) Corrosion is a common problem in chemical plants. Suggest one method used to minimize corrosion.

    (iii) Automated systems adjust operations in response to changing conditions in three main steps. Outline briefly the sequence of events resulting in intervention by the system.

2. (i) Crude petroleum contains several impurities. Explain the effect of the following impurities on plant machinery and processing.

    (a) Sulfur
    (b) Inorganic salts such as $CaCl_2$ and $MgCl_2$
    (c) Fe, Na, Ni, Mo and V

    (ii) Outline the major steps involved in the pretreatment of crude petroleum.

    (iii) Simple distillation is often not sufficient to separate petroleum fractions. Fractional distillation techniques are therefore used in order to achieve optimum separation. Explain by means of diagrams how efficiency of separation is increased in a rectification column.

3. Write brief notes on the following refinery processes.

    (a) moving catalyst bed unit
                        or
    (b) fluid-bed catalytic-cracking unit

    Fully label the accompanying flow chart for the process you describe.

4. (a) Outline the physical processes occurring during washing resulting in cleansing.

What problem is associated with the use of soap in hard water?

(b) Discuss the various additives used in the manufacture of soaps and detergents indicating their function.

5. (a) What is the octane rating of a gasoline and how can this be increased?

(b) What are sizing agents as used in pulp and paper industries?

Distinguish between stock sizing and tub sizing.

(c) Glycerine can be prepared as a by-product of the manufacture of soap. A large market demand, however, requires a means of producing it as an independent product. By means of equations show its preparation from propylene clearly indicating process conditions such as temperature and pressure.

6. (a) Show all the main reactions associated with the gasification of coal.

(b) Using information from (a) and the plots shown below what conclusions are you able to draw about the process conditions for the gasification of coal?
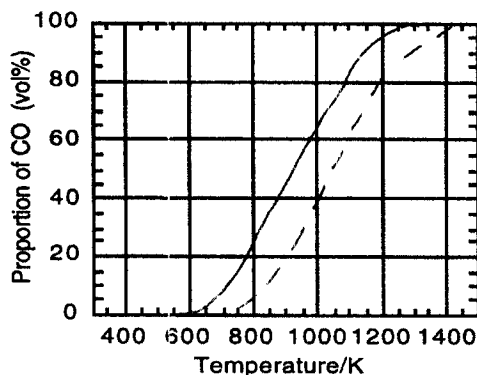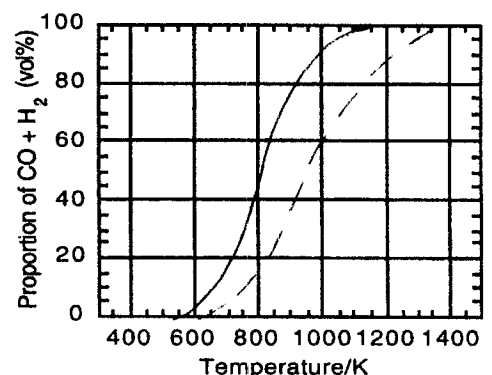

Figure 1 CO/CO_2 equilibrium
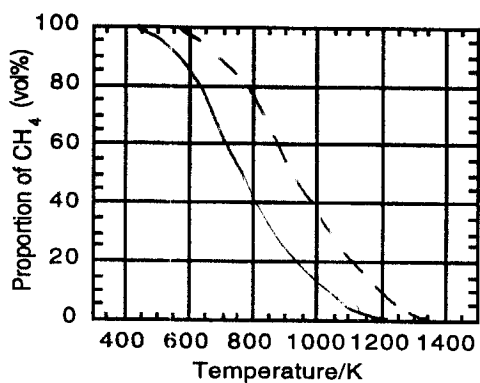

Figure 2 $H_2O/CO/H_2$ equilibrium

Figure 3 CH_4/H_2 equilibrium

Figure 4 $CO/H_2O/CO_2/H_2$ equilibrium

Figure 5 $CO/H_2/CH_4/H_2O$ equilibrium

Key: ——————▶ 1 bar
     - - - - - 20 bar

FLOW CHARTS

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
MAY 1999

CAV 251

ANALYTICAL /ORGANIC CHEMISTRY

TIME: THREE (3) HOURS

Instructions:

1.   There are **THREE** sections in this examination paper:
      Section A, B and C.

2.   Answer **ALL** the questions in Section A. Section A carries 40 marks. You
      will need to spend fifty minutes in this section.

3.   Answer only **ONE** question in Section B. Each question carries 20 marks.

4.   Answer any **THREE** questions in Section C. Each question carries 20 marks.

5.   Show all your working for those questions involving calculation.

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

ν	CONFIDENCE LEVEL			
	90%	95%	99%	99.5%
1	6.314	12.706	63.657	127.32
2	2.920	4.303	9.925	14.089
3	2.353	3.182	5.841	7.453
4	2.132	2.776	4.604	5.598
5	2.015	2.571	4.032	4.773
6	1.943	2.447	3.707	4.317
7	1.895	2.365	3.500	4.029
8	1.860	2.306	3.355	3.832
9	1.833	2.262	3.250	3.690
10	1.812	2.228	3.169	3.581
15	1.753	2.131	2.947	3.252
20	1.725	2.086	2.845	3.153
25	1.708	1.060	2.787	3.078
∞	1.645	1.960	2.576	2.807

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

Rejection Quotient, Q at Different Confidence Limits

Number of Observation	CONFIDENCE LEVEL		
	Q_{90}	Q_{95}	Q_{99}
3	0.94	0.970	0.994
4	0.76	0.829	0.926
5	0.64	0.710	0.821
6	0.56	0.625	0.740
7	0.51	0.568	0.680
8	0.47	0.526	0.634
9	0.44	0.493	0.598
10	0.41	0.466	0.568
15	0.338	0.384	0.475
20	0.300	0.342	0.425
25	0.277	0.317	0.393
30	0.260	0.298	0.372

Values of F at the 95% Confidence Level

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

Other Important Information

^1_1H ; $^{12}_6C$; $^{16}_8O$; $^{79.9}_{35}Br$

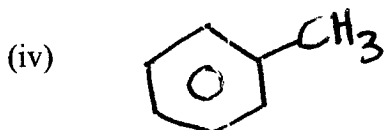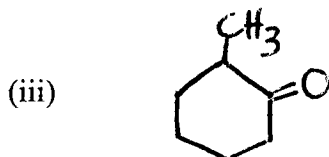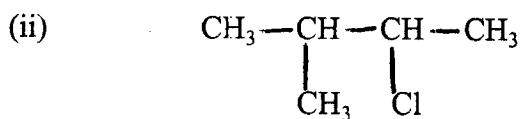## SECTION A

Answer ALL the questions in this section.

1.(a)   Explain the difference between a gross sample and an analysis sample.

(2 marks)

(b)   How would you obtain an analysis sample of soil from a one-hectare farm plot?

(2 marks)

(c)   State the possible problems you are likely to encounter in getting the analysis sample from this plot. How would you overcome these problems?

(4 marks)

2.(a)   To check the accuracy of a new method for copper analysis, a standard copper alloy containing 23.24% Cu was analysed and found to contain 23.17%. Calculate the relative error of the method in parts per thousand.

(3 marks)

(b)   The following results were obtained during the testing of the validity of a method by analysing a standard sample that contains 21.20% Ca. Mean $\bar{x} = 21.24\%$, s = 0.12 and n = 10. Is there a significant difference between $\bar{x}$ and μ at the 95% and 99% confidence levels?

(5 marks)

3(a)   Name each of the following by IUPAC system.

(4 marks)

(i)

5

(ii)
$$CH_3-CH-CH-CH_3$$
with CH_3 and Cl substituents

(iii)

(iv)

(b)(i) Explain the meaning of the designations D- and L- as used to specify the stereochemistry of monosaccharides

(5 marks)

(ii) Draw the four stereoisomers of 2, 3, 4 - trihydroxybutanal. Label them A, B, C and D. Which of these are pairs of enantiomers?

(3 marks)

4.(a) Write an equation for the synthesis of 2 - pentanone by

(i) oxidation of an alcohol.

(2 marks)

(ii) hydration of a terminal alkyne.

(1 mark)

(b) Write the possible dipeptide structures that can be obtained by joining alanine and glycine by a peptide bond.

(3 marks)

(c) Glucose exists in α- and β- forms, with specific rotations of $+112°$ and $+19°$, respectively.

(i) Draw the structures of both anomers.

6

(ii)   Aqueous solution of each isomer mutarotates to an equilibrium value of +52°. What is the percentage composition of each isomer in solution at equilibrium?

(3 marks)

SECTION B

Answer only ONE question in this section.

1.   The following data were obtained in the spectrophotometric determination of iron.

STANDARD SAMPLE	CONCENTRATION OF IRON, Fe (ppm)	ABSORBANCE
1	1.0	0.240
2	2.0	0.460
3	3.0	0.660
4	4.0	0.876

(a)   Determine the linear least squares line.

(15 marks)

(b)   Compute the concentration of iron in a solution if is absorbance is 0.452.

(5 marks)

2.(a)   Chromate, CrO_4^{2-}, ions are added to an aqueous solution containing 0.030 M Ba^{2+}, 0.00030M Sr^{2+} and 0.010M Ca^{2+}. What is the order of precipitation of chromates?

(8 marks)

        Ksp for $BaCrO_4$ is 1.2 x 10^{-10}
        Ksp for $SrCrO_4$ is 3.6 x 10^{-5}
        Ksp for $CaCrO_4$ is 7.1 x 10^{-4}

(b)   Two CAV251 students analysed the same sample. Mr. J. Chongo made six determinations and obtained a standard deviation of 0.14 whereas Ms. S. Chilufya made five determinations and obtained a standard deviation of 0.05. Are the two standard deviations significantly different at 95% confidence level? Show your reasoning clearly.

(12 marks)

SECTION C

Answer THREE questions in this section.

1.(a) Compound **A** ($C_5H_{10}O$) is optically active, decolourizes a solution of bromine in carbon tetrachloride, and also decolourizes dilute potassium permanganate. Treatment of **A** with hydrogen gas over a platinum catalyst yields a compound **B** ($C_5H_{10}O$). Treatment of **B** with phosphoric acid forms a compound **C** (C_5H_{10}). Ozonolysis of **C** yields two compounds, CH_3CHO and CH_3CH_2CHO, in equal amounts. Only compound **A** is optically active. Propose structural formulas for compounds **A, B** and **C** consistent with these observations.
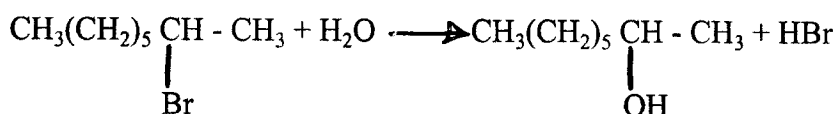
(10 marks)

(b) Draw the structure of the product formed when benzene is reacted exhaustively with chlorine gas in the presence of UV light and name the product.

(2 marks)

(c) Show that the hydroxyl group in phenol favours para over meta bromination.

(8 marks)

2.(a) Hyrolysis of 2-bromo octane yields 2-octanol.

$$CH_3(CH_2)_5 \underset{Br}{CH} - CH_3 + H_2O \longrightarrow CH_3(CH_2)_5 \underset{OH}{CH} - CH_3 + HBr$$

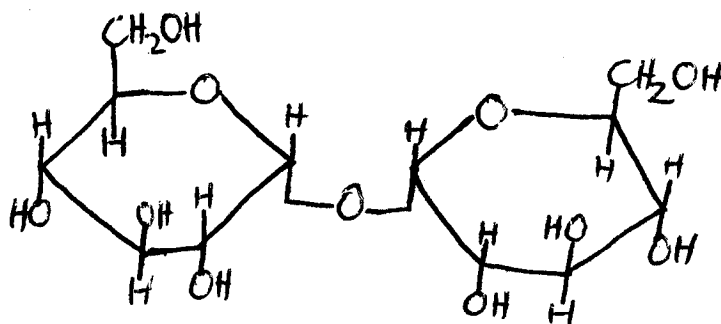2-bromo octane   2-octanol

Assume that the starting material is R-2-bromo octane. Use suitable stereo representations to show the course of this reaction and the stereochemistry of the product if the reaction takes place by:

(i) SN_1 mechanism

and (ii) SN_2 mechanism

(12 marks)

(b) A structure of disaccharide X consisting of two glucose units joined by an α -1, -1 glycoside bond is shown below:

8

Disaccharide X.

On the basis of its structural formula, would you expect disaccharide X to:

(i) be a reducing sugar?

(ii) undergo mutarotation?

State your reasoning.

(8 marks)

3.(a)(i) Briefly describe a chemical test for the detection of the presence of carbonyl group in an organic compound.

(2 marks)

(ii) What is the difference in structure between an aldehyde and a ketone? Which is more reactive between an aldehyde and a ketone?
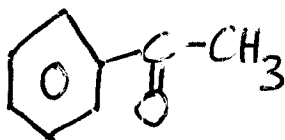
(4 marks)

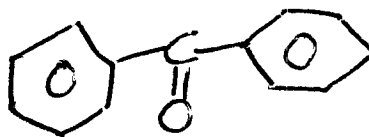(b)(i) How would you distinguish propanal from propanone?

(4 marks)

(ii) How would you distinguish compound K form compound L?
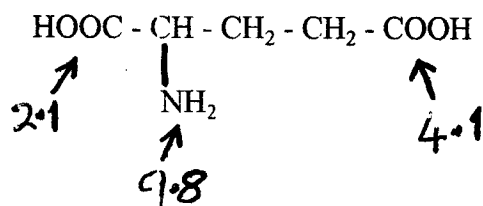
(4 marks)

Compound K

Compound L

(c)   The pKa values for glutamic acid are given on the structure below:

HOOC - CH - CH$_2$ - CH$_2$ - COOH

2.1   NH$_2$ 4.1

9.8

(i)   Deduce the isoelectric point of the amino acids and briefly outline the rationale underlying the deduction.

(4 marks)

(ii)   Draw the structure of glutamic acid at pH 2.0

(2 marks)

4.(a)   The benzene ring is a common structural feature in drug molecules. Explain briefly why benzene undergoes substitution reactions but open chain alkenes undergo addition reactions.

(6 marks)

(b)   Identify the products of the following reactions:

(14 marks)

(i)   CH$_3$ - CH - CH - CH$_2$ - CH$_3$ + Zn $\xrightarrow{\text{heat}}$

        Br   Br

(ii)   CH$_3$ - CH = CH$_2$ + cold KMnO$_4$(aq) $\xrightarrow{\text{NaOH}}$

(iii)   + H$_2$O $\xrightarrow{\text{H+}}$

(iv)   + $\xrightarrow{\text{(CH}_3\text{CH}_2)_3\text{N}}$

10

(v) $CH_3 - CH_2 - CH_2 - OH + KMnO_4(aq)$ $\xrightarrow{\text{heat}}$

(vi) $\xrightarrow{\text{LiAlH}_4}$ $\xrightarrow{\text{H}_2\text{O, H+}}$

END OF EXAMINATION

TIME: THREE HOURS
ANSWER: QUESTION ONE (40%) AND ANY OTHER THREE (60%)
NOTE: ILLUSTRATE YOUR ANSWERS WHERE EVER POSSIBLE.
USE OF A CALCULATOR AND AN APPROVED ATLAS IS
ALLOWED

Q1. Figure 1 shows an assumed spatial distribution of towns.

(a) Use nearest-neighbour analysis to determine what the pattern of distribution of the towns is.

(b) Use the table of critical values of the nearest-neighbour Index, R to test the significance of your result at 0.05 level of significance.

Q2. (a) Name and define the four (4) basic culture processes.

(b) Describe and diagram how the four (4) basic culture processes are interlocked in actual occurrences.

Q3. What is the significance of the 'invention' of culture as the means for mankind to transcend the biological limits of evolution?

Q4. "Resolution of the [population] problem is less a matter of industrial technology and energy resources than a matter of human population control" (Spencer and Thomas,1978). Discuss.

Q5. Write short explanatory notes on <u>each</u> of the following.

(a) The Nile Valley as a cultural hearth
(b) Push and pull factors in urbanisation
(c) von Thunen's crop theory
(d) Critical isodapane
(e) Contact field

Q6. Discuss the difficulties of applying the Central place theory in Zambia.

END OF EXAMINATION

Fig. 1. Assumed Spatial Distribution of Towns

SCALE

0   1   2   3   4 km

Area = 210 km^2

n	Clustered pattern					Dispersed pattern				
	0.1	0.05	0.01	0.005	0.001	0.1	0.05	0.01	0.005	0.001
2	0.527	0.392	0.140	0.048		1.473	1.608	1.860	1.952	2.139
3	0.614	0.504	0.298	0.223	0.071	1.386	1.497	1.702	1.777	1.930
4	0.666	0.570	0.392	0.327	0.195	1.335	1.430	1.608	1.673	1.805
5	0.701	0.616	0.456	0.398	0.280	1.299	1.385	1.544	1.602	1.720
6	0.727	0.649	0.504	0.451	0.343	1.273	1.351	1.497	1.550	1.657
7	0.747	0.675	0.540	0.491	0.392	1.253	1.325	1.460	1.509	1.609
8	0.764	0.696	0.570	0.524	0.431	1.237	1.304	1.430	1.476	1.569
9	0.777	0.713	0.595	0.551	0.463	1.223	1.287	1.406	1.449	1.537
10	0.789	0.728	0.615	0.574	0.491	1.212	1.272	1.385	1.426	1.509
11	0.798	0.741	0.633	0.594	0.515	1.202	1.259	1.367	1.406	1.486
12	0.807	0.752	0.649	0.612	0.535	1.193	1.248	1.351	1.389	1.465
13	0.815	0.762	0.663	0.627	0.554	1.186	1.239	1.337	1.373	1.447
14	0.821	0.770	0.675	0.640	0.570	1.179	1.230	1.325	1.360	1.430
15	0.827	0.778	0.686	0.653	0.584	1.173	1.222	1.314	1.348	1.416
16	0.833	0.785	0.696	0.664	0.598	1.167	1.215	1.304	1.337	1.403
17	0.838	0.792	0.705	0.674	0.610	1.162	1.209	1.295	1.327	1.391
18	0.842	0.797	0.713	0.683	0.621	1.158	1.203	1.287	1.317	1.380
19	0.847	0.803	0.721	0.691	0.631	1.154	1.197	1.279	1.309	1.369
20	0.850	0.808	0.728	0.699	0.640	1.150	1.192	1.272	1.301	1.360
21	0.854	0.812	0.735	0.706	0.649	1.146	1.188	1.266	1.294	1.351
22	0.857	0.817	0.741	0.713	0.657	1.143	1.183	1.259	1.287	1.343
23	0.861	0.821	0.746	0.719	0.664	1.140	1.179	1.254	1.281	1.336
24	0.864	0.825	0.752	0.725	0.671	1.137	1.176	1.248	1.275	1.329
25	0.866	0.828	0.757	0.731	0.678	1.134	1.172	1.243	1.269	1.322
26	0.869	0.831	0.762	0.736	0.684	1.131	1.169	1.239	1.264	1.316
27	0.871	0.835	0.766	0.741	0.690	1.129	1.166	1.234	1.259	1.310
28	0.874	0.838	0.770	0.746	0.696	1.127	1.163	1.230	1.254	1.304
29	0.876	0.840	0.774	0.750	0.701	1.124	1.160	1.226	1.250	1.299
30	0.878	0.843	0.778	0.754	0.706	1.122	1.157	1.222	1.246	1.294
31	0.880	0.846	0.782	0.758	0.711	1.120	1.155	1.219	1.242	1.289
32	0.882	0.848	0.785	0.762	0.715	1.118	1.152	1.215	1.238	1.285
33	0.884	0.850	0.788	0.766	0.720	1.117	1.150	1.212	1.234	1.280
34	0.885	0.853	0.791	0.769	0.724	1.115	1.148	1.209	1.231	1.276
35	0.887	0.855	0.794	0.773	0.728	1.113	1.145	1.206	1.228	1.272
36	0.889	0.857	0.797	0.776	0.732	1.112	1.143	1.203	1.224	1.268
37	0.890	0.859	0.800	0.779	0.735	1.110	1.141	1.200	1.221	1.265
38	0.892	0.861	0.803	0.782	0.739	1.109	1.140	1.197	1.218	1.261
39	0.893	0.862	0.805	0.785	0.742	1.107	1.138	1.195	1.216	1.258
40	0.894	0.864	0.808	0.787	0.746	1.106	1.136	1.192	1.213	1.255
41	0.896	0.866	0.810	0.790	0.749	1.105	1.134	1.190	1.210	1.252
42	0.897	0.867	0.812	0.792	0.752	1.103	1.133	1.188	1.208	1.249
43	0.898	0.869	0.815	0.795	0.755	1.102	1.131	1.186	1.205	1.246
44	0.899	0.870	0.817	0.797	0.757	1.101	1.130	1.183	1.203	1.243
45	0.900	0.872	0.819	0.799	0.760	1.100	1.128	1.181	1.201	1.240
46	0.901	0.873	0.821	0.802	0.763	1.099	1.127	1.179	1.199	1.237
47	0.903	0.875	0.823	0.804	0.765	1.098	1.126	1.178	1.196	1.235
48	0.904	0.876	0.825	0.806	0.768	1.097	1.124	1.176	1.194	1.232
49	0.905	0.877	0.826	0.808	0.770	1.096	1.123	1.174	1.192	1.230
50	0.905	0.878	0.828	0.810	0.772	1.095	1.122	1.172	1.190	1.228
55	0.910	0.884	0.836	0.819	0.783	1.090	1.116	1.164	1.182	1.217
60	0.914	0.889	0.843	0.826	0.792	1.086	1.111	1.157	1.174	1.208
65	0.917	0.893	0.849	0.833	0.800	1.083	1.107	1.151	1.167	1.200
70	0.920	0.897	0.855	0.839	0.808	1.080	1.103	1.145	1.161	1.193
75	0.923	0.901	0.860	0.845	0.814	1.077	1.099	1.141	1.156	1.186
80	0.925	0.904	0.864	0.850	0.820	1.075	1.096	1.136	1.151	1.180
85	0.928	0.907	0.868	0.854	0.825	1.073	1.093	1.132	1.146	1.175
90	0.930	0.909	0.872	0.858	0.830	1.071	1.091	1.128	1.142	1.170
95	0.931	0.912	0.875	0.862	0.835	1.069	1.088	1.125	1.138	1.165
100	0.933	0.914	0.878	0.865	0.839	1.067	1.086	1.122	1.135	1.161
200	0.953	0.939	0.914	0.905	0.886	1.047	1.061	1.086	1.095	1.114
300	0.961	0.950	0.930	0.922	0.907	1.039	1.050	1.070	1.078	1.093
400	0.967	0.957	0.939	0.933	0.920	1.034	1.043	1.061	1.067	1.081
500	0.970	0.962	0.946	0.940	0.928	1.030	1.039	1.054	1.060	1.072

To test for clustering: reject H_0 if calculated value of R is **less than** critical value at chosen significance level

To test for dispersion: reject H_0 if calculated value of R is **greater than** critical value at chosen significance level

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - OCT. 1999

GEO 175

INTRODUCTION TO MAPPING TECHNIQUES IN GEOGRAPHY

PAPER II

STATISTICAL MAPPING AND DIAGRAMS

TIME: Three Hours
ANSWER: Any four Questions
NOTE: The use of an approved Atlas and Calculators is allowed

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Q1. Write short explanatory notes on all of the following:

(a) Scatter diagrams
(b) Simple Line Graphs
(c) Quantitative Mapping Techniques
(d) Nature of tables
(e) Dot Maps

Q2. Table 1 below shows a frequency distribution of the hypothetical monthly wages in Zambian Kwacha of 65 employees at M & C Company.

Table 1: Monthly Wages at M and C Company

Wages (K)	Number of Employees
50,000 - 59,999	8
60,000 - 69,999	10
70,000 - 79,999	16
80,000 - 89,999	14
90,000 - 99,999	10
100,000 - 109,999	5
110,000 - 119,999	2

Source: Imaginary Data

Using data in Table 1 above, determine:

(a)   the lower limit of the sixth class.
(b)   the upper limit of the fourth class.
(c)   the class mark of the third class.
(d)   the class boundaries of the fifth class.
(e)   the size of the fifth class interval.
(f)   the frequency of the third class.
(g)   the relative frequency of the third class.
(h)   the class interval having the largest frequency.
(i)   the percentage of employees earning less than K80,000 per month.
(j)   the percentage of employees earning less than K100,000 but at least K60,000 per month.
(k)   the total number of open classes.

Q3.   (a)   Using the most appropriate statistical mapping technique show the data given in Table 2 below on the outline map of Zambia (Fig. 1) provided.

Table 2:   Zambia's Population by Province in 1990

Province	Population ('000)	Area Km^2 ('000)
Central	726	94
Copperbelt	1580	31
Eastern	974	69
Luapula	527	51
Lusaka	1208	22
Northern	868	148
North-western	383·	126
Southern	946	85
Western	607	126
Zambia	7819	752

Source: GRZ (1992: 6)

(b)   Discuss the merits and limitations of the method you have used.

Q4. Examine the data given in Table 3 below and then answer the questions that follow:-

Table 3: Fish Production from Major Fisheries 1975-1990
(Tones, Fresh weight Equivalent)

Year	Rivers	Lakes	Swamps	Total
1975	5,000	33,200	2,600	40,800
1980	9,700	37,800	900	48,400
1984	14,500	67,200	1,000	82,700
1990	19,271	30,324	2,613	52,208

Source: GRZ (1992:18)

a) Using the most appropriate statistical technique, compare the production of fish from the major fisheries from 1975 to 1990.

b) Discuss the advantages and disadvantages of the method you have used.

Q5. Imagine that the Department of Geography at the University of Zambia has just produced the 1998 annual report which gives information on the recently completed sample survey of George Compound residents on the journey to the Central Business District (CBD) of Lusaka each day. The results were as follows:-

Table 4: Journey to the Central Business District
(Sample of George Compound Population)

Mode of Transport	Number
Foot	68
Cycle	52
Car	09
Bus	321
Train	350

Source: Field Survey (1998)

You have been requested by the Head of Department to present the data in Table 4 above in a suitable diagramatic form for display on the Departmental Notice Board in order to illustrate the Cartographic skills acquired in GEO 175. He wants the data not only to be attractive but also easy to understand. In order to provide the maximum flexibility for display on the notice board, he wants two diagramatic versions for the data in Table 4.

(a) Draw the two versions and in each case highlight the role of the cycle mode of transport.

(b) Briefly discuss the limitations of the two versions you have selected.

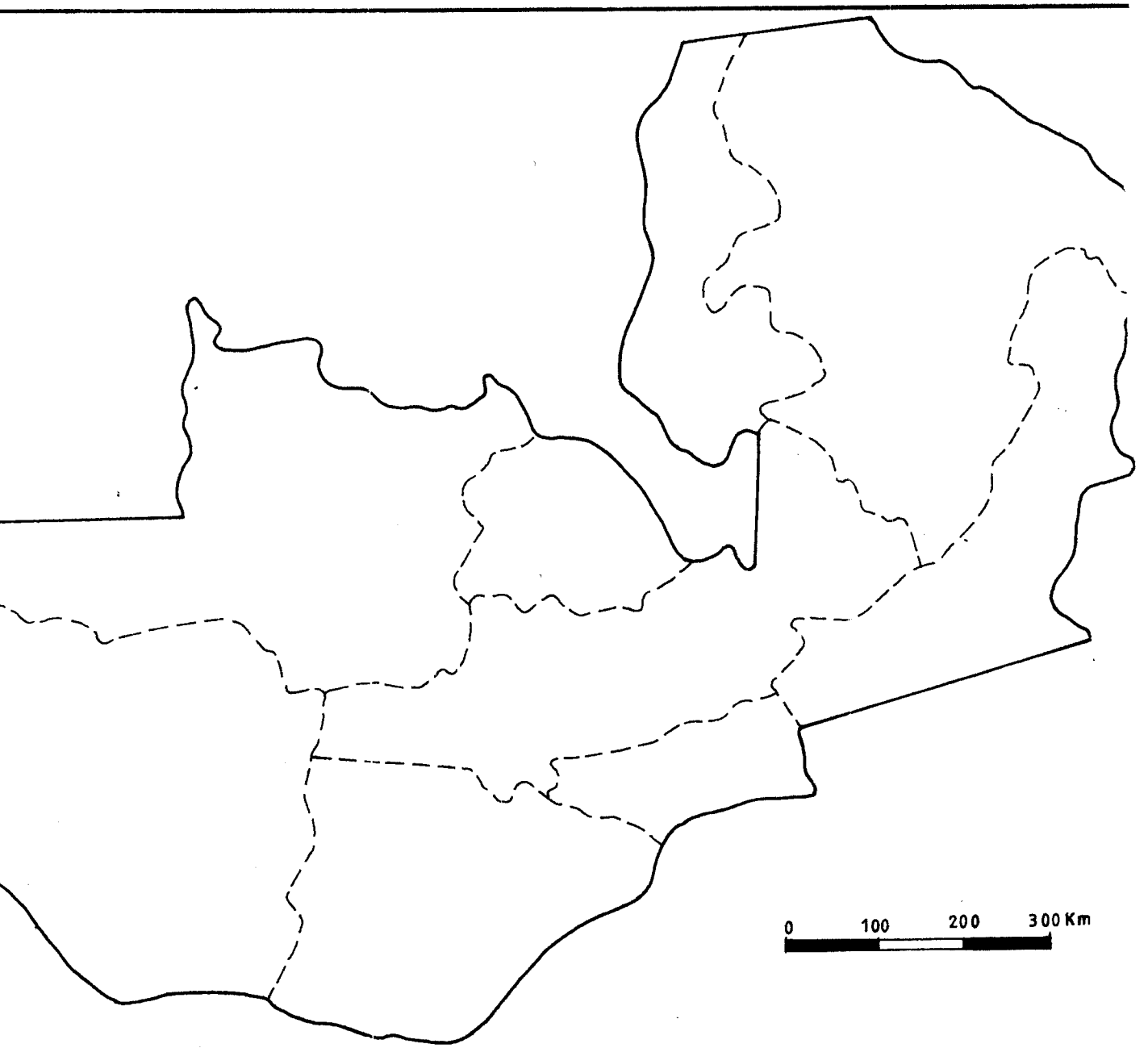Q6. Study the data given in Table 5 below and then answer the questions that follow:-

Table 5: Passenger Traffic From London Airport

Destination	Number
Athens	15,500
Dublin	105,250
Gibraltar	44,500
Moscow	3,000
Oslo	12,500
Rome	22,850
Tel Aviv	3,750

Source: World Air Traffic Survey (1993)

(a) On the outline map of the world (Fig2) provided, construct a map to show the number of airline passengers flying between London airport and the listed cities.

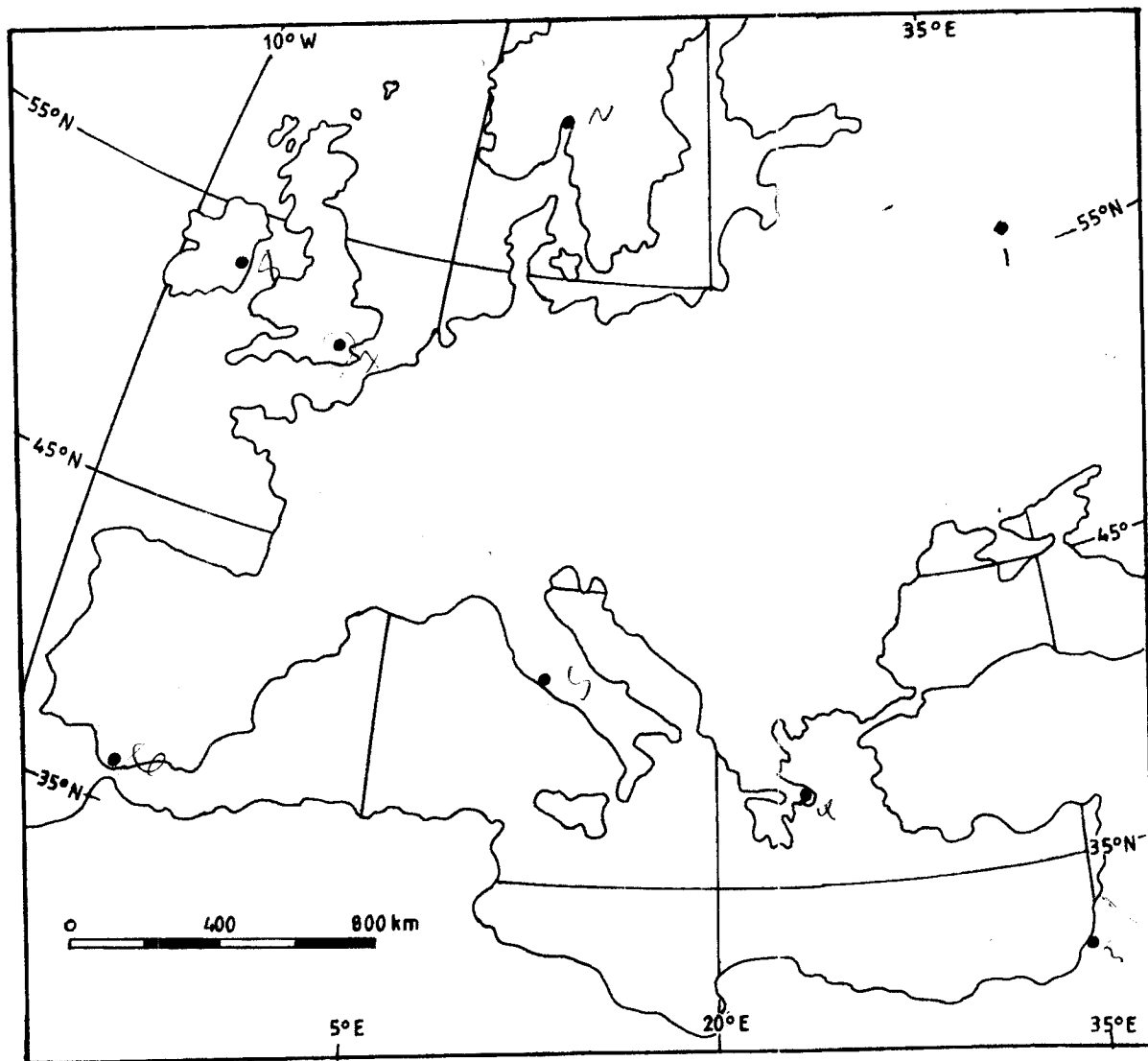(b) Briefly, discuss the merits and limitations of the method you have used.

END OF EXAMINATION

1

0   100   200   300 Km

Fig. 2

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - OCT. 1999

GEO 175
INTRODUCTION TO MAPPING TECHNIQUES IN GEOGRAPHY

PAPER I

MAP READING, ANALYSIS AND INTERPRETATION

TIME: Three hours
ANSWER: All questions
NOTE: The use of Calculators and an approved Atlas is allowed

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SECTION A

Q1. Write short explanatory notes on all of the following:-

a) Advantages of maps over aerial photographs
b) The four categories of map symbols on the 1:50,000 topographical maps.
c) Marginal information on a topographical map
d) Quantitative methods of showing relief on maps
e) Vertical aerial photographs

Q2. If a given map does not carry its scale expressed in both figures and words, it may be necessary to convert scale from one form to the other using the fundamental formula.

$$GD = MD \times SF$$

where

GD = Ground Distance
MD = Map Distance
SF = Scale Factor

a) Convert two centimetres to one mile to a scale in figures in metric units (show all steps of your work).
b) Convert 1:5000 to a scale in words (show all steps of your work).
c) Convert 1:250,000 to a scale in words (show all steps of your work).
d) Briefly explain how the conversion of scale in (b) differs from that in (c)
e) Draw a linear scale in metric units for a map drawn at the scale of 1:10,000 given that the maximum space available is 13 centimetres.

Q3. 'The scale of an aerial photograph is not constant and hence the position of certain objects is slightly incorrect. The degree of distortion may present problems when exact measurements are required'.

(a) Outline and discuss any two sources of distortion on the vertical aerial photograph.

(b)   With the help of examples, explain how you would calculate the scale of an aerial photograph in

(i)   a flat area
(ii)   on area where the ground is not flat

SECTION B

With reference to Map sheet 1628B1 provided, answer all the questions that follow:-

Q4   (a)   When was this map sheet first published and by whom?
       (b)   How can one read grid references on this map sheet
       (c)   Using map evidence only, state any three methods used to show relief on this map sheet.
       (d)   State the height of the highest point on this map sheet.
       (e)   Name the historical feature found in grid square 8127.

Q5.   (a)   Calculate the distance along the Main Tarred road between the road junctions in grid squares 8127 and 8219 in kilometres.
       (b)   Using the square method, calculate the approximate area occupied by Mutulanganga Local Forest Reserve No.183 in square kilometres.
       (c)   Calculate the average gradient along a straight line in degrees from the village at 846181 to the summit of Njami Hill in grid square 8419.
       (d)   What is the grid bearing of Chipangula village at grid reference point 786125 from the summit of Njami Hill in grid square 8419?

Q6.   Study topographic map sheet 1628B1 very closely and then

       (a)   Divide the map into a number of relief regions
       (b)   Give each region a distinct name
       (c)   Describe any <u>one</u> relief region you have named in (b) in detail.

Q7.   (a)   Draw a map to show the area extending from Easting 78-87 and northing 10-21 on a scale 2cm to 1km and on it show:-
               (i)   the Lusitu River
               (ii)   the road from Njami to Chikankata
               (iii)   the road to Kariba
               (iv)   the rock outcrop in the North west
               (v)   Njami store
               (vi)   the power line

       (b)   What is the relationship between drainage and settlement in this part of the map.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - OCT. 1999

GEO 211
THE GEOGRAPHY OF AFRICA

TIME: Three hours

ANSWER: Any four questions:

NOTE: The use of approved atlas is allowed.

Q1. To what extent are racial and linguistic diversity positive factors rather than impediments to African unity?

Q2. 'The reduction of numerous wild animals through poaching would eventually affect Kenya's economy.' Discuss this statement giving possible solutions to the problem.

Q3. With reference to the theory of plate tectonics, describe the extent of the African rift valley and discuss the theories regarding its origin.

Q4. Discuss the distribution and character of manufacturing industries in East Africa explaining why industrialization appears to be the key to economic development in the region.

Q5. In what ways can the natural resource base of Africa be a basis for renewed economic development in the new millennium?

Q6. Account for the regional imbalance in socio-economic development in Ghana and Cote d'Ivoire (Ivory Coast).

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - OCT. 1999

GEO 271

QUANTITATIVE TECHNIQUES IN GEOGRAPHY 1

TIME: THREE HOURS.

ANSWER: Question 1 and three others.

NOTE: Tables of random numbers are provided. Use of a calculator is allowed.

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1. Suppose you wanted to establish whether or not motor vehicles in Zambia meet environmental standards in terms of levels of harmful exhaust gases. You have been informed that the Roads and Road Traffic Department gives registration numbers of vehicles starting from 1 and ending at 9999 per letter code (e.g. AAK), and that the same department keeps addresses of where to find these vehicles. Proceed with the following tasks:

   a) State a hypothesis which you would test in the study.

   b) From vehicles registered in Lusaka as AAK 1 to AAK 9999, take a sample of 30 using:

      i. simple random sampling,
      ii. interval (systematic) sampling.

   c) If you were to take 30 AAK registered vehicles from the population AAK 1 - AAK 9999 by availability sampling, how would you do so? Comment on the reliability of such a sample as a representation of the population

   d) Suppose you wanted to take a sample of 30 newly registered vehicles from Lusaka and Kitwe combined. You have been told that for Kitwe the newly registered vehicles range from ACE 1 to ACE 4137 and that for Lusaka they range from AAT 1 to AAT 6173. Obtain a combined sample of 30 vehicles which represents these differences in population between Lusaka and Kitwe.

2. Design a questionnaire for use in a study which seeks to establish whether socio-economic factors are more influential than environmental considerations when Lusaka's residents choose a housing unit to live in.

3. Write short explanatory notes on <u>ALL</u> of the following:

    a) The role of literature during research problem formulation
       and during research data collection.
    b) Pre-requisites of research design.
    c) Methods of administering questionnaires.
    d) Non-scheduled, structured interviews.
    e) The necessity of sampling.

4. Using examples, compare and contrast descriptive, correlational and explanatory research in Geography.

5. If you wanted to undertake research on the causes of the urban to rural migration in Zambia, describe what the contents of your research proposal would be.

6. Suppose you wanted to establish the relationship between amounts of uncollected waste in residential areas and the incidence of cholera in Lusaka, explain how you would conduct your study using <u>each</u> of the following research designs. Comment on the reliability of conclusions from each of the designs.

    a) One-shot case study.
    b) Pre-test/post-test control group design.
    c) Contrasted group design.

END OF EXAMINATION

Table A-1
Random Numbers

```
08210 32973 54512 64863 78634 73293 77660 90199
56822 81546 04735 15228 37475 79057 95554 39734
89182 97110 11688 69132 97318 82573 72506 55631
72674 35938 08612 23129 95675 47142 74290 17531
90431 35286 05594 75288 52097 07687 36274 59709

26899 07988 97601 03588 46466 55558 25847 59878
18345 22317 08035 39380 80045 80231 50908 15304
59231 50655 21753 70621 91045 11318 73098 32794
25446 92080 34212 76028 20044 78244 53847 04736
64825 37691 90465 51579 83918 22217 55262 47065

12938 37575 74532 60769 26928 29666 84318 21283 17537 31834
84984 54147 59332 70137 24535 17957 51279 67206 53847 31834
46002 37283 88126 63220 09217 89809 41827 63143 94194 69001
60389 69818 90903 25258 02601 40884 18925 19143 69001 00382
80520 76260 83873 30245 69153 36222 71188 50184 00382

62903 81216 82151 05623 29557 17355 75959 26697 92112 50471
94504 39905 37479 59621 90903 25258
53130 21244 18794 69981 42182 90286
74368 66450 66013 32765 05637 59267
49684 94165 26723 59644 97156 95754
56879 44941 45205 84341 92222 50193

86956 16358 66811 24846 57071 40649 92444 63235 69761 57118
22071 81837 14952 50079 76769 83059 23254 73901 36254 73901
92592 82165 90227 88560 86908 32283 83958 92590 97910 40983
43016 56171 27506 72769 60939 50508 37332 77234
27455 43144 85543 85639 91044 58951 85251 69761

90057 12880 89522 81453 41294 14603 39279 54730
97431 01310 04978 25833 48959 12864
03346 61125 91434 84200 45914 90551 58889
04812 76028 20044 78244 58015 05867 53847 04736
74532 60769 26928 29666 90414 80832 17065 65350
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Table A-1 (continued)

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91225 47297 05208 09509 83287 98993 04792 82551 59606 88054
48832 04241 71986 08556 40419 69537 86871 54707 41149 16991
83516 35332 54964 28304 46934 61746 09772 20208 36456 51403
55814 15346 17425 41510 13329 09591 71725 31094 34654 45090
85716 12864 61976 24101 23601 62813 47996 57362 30232 35867

77799 89902 53499 34027 44773 91246 93487 85827 35988 31423
89346 94359 64580 88245 21215 78937 18180 62989 17247 98211
22821 26700 43247 48748 35591 77935 97016 92278 91298 23556
19651 46588 74048 25245 88242 89392 74849 23163 74727 89559
21738 10422 44197 57245 23564 05076 18267 27692 18681 71298

14439 16349 58690 24767 66401 63240 44038 15142 81338 70308
25482 05354 72238 75754 75234 88446 87496 92774 28165 06299
14606 94425 14315 64213 35591 29901 94156 13008 34784 34997
47291 66501 04111 98604 76249 16047 95252 69177 23764 57974
00097 39513 26145 50286 37804 95165 97489 83770 80511 71298

44474 18685 83439 63916 76277 87092 43999 65474 45455 17684
80188 55310 74084 41674 80282 46222 74965 69025 10428 30224
99909 70398 88267 96784 22232 74548 18681 71053 49820 54954
58968 12199 67836 95022 67725 67527 86541 97150 74569 90047
19893 22171 37003 03270 40464 39309 71950 31827 28303 62957

31180 66582 07814 48192 79581 82781 59678 20881 03922 96690
55358 46206 28790 27657 47210 39684 69566 95109 17541 67975
45265 25613 50103 93017 22232 54548 46824 55305 68436
23713 29543 20617 02525 49301 62333 84918 38377 45095 89424
70125 93654 46311 61173 48844 38937 03812 05838 34285 08267

74948 69730 38268 45877 74220 17727 68357 92038 16486 72612
01975 51053 74679 33939 04308 29308 00031 52498 46210 21401
19636 08802 55859 83454 29762 95675 80618 46154 81250 49413
37063 11564 68775 32383 78364 35447 70729 31821 41957 96650
06570 48472 76950 25543 37661 13124 05752 28250 06892 32216

67187 70029 32276 51020 16715 26725 00374 24518 85007 95592
74318 70268 14616 51147 63823 63506 67422 63950 21521 62018
84658 32328 48257 69420 57437 18892 88152 43925 07585 13485
43578 54413 29390 82628 06420 48451 80697 68097 22577 12231
65336 91369 07765 92143 34215 96303 03353 71515 55424 58205

39954 51272 93372 19705 20047 81087 62993 40227 95610 75971
61131 59612 43759 27369 68613 88117 88168 62985 01794 51874
01608 31737 72572 47112 73266 45496 54882 51293 52863 62018
72348 55701 98604 75531 73355 05236 88152 43925 20682 13485
59312 10832 96672 32093 71354 71923 25833 55831 35692 71534
90697 91454 99243 74995 80926 93834 49471 55910 09853 12529
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THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - OCT.1999

GEO 451

LAND RESOURCES SURVEY

TIME: Three Hours
ANSWER: Any four questions.
NOTE: All questions carry equal marks
          The use of calculators and approved atlas is allowed

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1. Write short any notes on all of the following:

    a) Land Use System
    b) Land Quality
    c) Productive Available Moisture
    d) Adaptation and land improvements
    e) Moisture Range for working the soil

2. Explain how the two-stage and Parallel Approaches to land evaluation
    are carried out. In which situations are the two approaches appropriate?

3. Explain how you would go about carrying out a gross margin analysis after a
    physcial land evaluation.

4. Discuss the principles of land evaluation.

5. Discuss the structure of the land suitability classification.

6. Imagine you are a Land Use Planner for one of the districts of Zambia. One of
    the villages in your district is facing severe forest, range and soil problems as a
    result of increasing population and poor land management. You have been
    asked to provide advice on how you should go about planning land
    redistribution and conservation of resources such as water, forests and soil. It
    has been emphasized that since this exercise is very sensitive, you must make
    sure that the community is involved at all stages. Explain the procedure you
    would follow to implement this programme.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - OCT. 1999

GEO 481

ENVIRONMENT AND DEVELOPMENT II

TIME: Three Hours
ANSWER: Any Four Questions
NOTE: All Questions carry equal marks
          Illustrations and examples should be used wherever appropriate.

Q1.   'The pricing of natural resources is an important factor in sustainable natural resource management.' Discuss.

Q2.   Write short explanatory notes on all of the following:.

   (a)   An environmental profile
   (b)   Opportunity cost of water
   (c)   Jurisdictional Complexity
   (d)   Agricultural intensification
   (e)   Indoor pollution

Q3.   What are the different methods of setting concession fees in forestry? Which one would you recommend for Zambia and why?

Q4.   What are the environmental and socio-economic consequences of the use of woodfuel as a principal source of household fuel in Zambia?

Q5.   You have been asked to develop a comprehensive analytical framework to deal with problems of water management in Zambia. What issues would you address in such a framework and why?

Q6.   What are the key factors aggrevating urban environmental degradation in the city of Lusaka and how can they be resolved.

END OF EXAMINATION

TIME: Three Hours

ANSWER: Question 1 and Three others

Q1. Write short explanatory notes on all of the following:

   a) Diseconomies of agglomeration
   b) Kondratief cycles
   c) Relationship between plant age and plant closure
   d) Actual route location
   e) Relationship between quota system and trade.

Q2. "Economic Geography is a hybrid science between Economics and Geography" (Hope, 1965). Discuss.

Q3. To what extent are Norcliffe's (1975) criticisms of the Weberian Framework valid in the Zambian situation?

Q4. With the aid of examples, explain P.A. Wood's (1969) typology about industrial linkages.

Q5. 'The increasing globalisation over the last four decades has favoured economic growth in the world'. To what extent is this assertion valid for the Zambian economy?

Q6. 'Trade can take place between countries with identical production possibilities'. Discuss.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER SUPPLEMENTARY/DEFERRED EXAMINATIONS DECEMBER 1999

GEO 931

RURAL GEOGRAPHY

TIME: THREE HOURS
ANSWER: ANY FOUR (4) QUESTIONS
NOTE: ALL QUESTIONS CARRY EQUAL MARKS.
            CANDIDATES ARE ADVISED TO MAKE USE OF
            ILLUSTRATIONS AND EXAMPLES WHEREVER
            APPROPRIATE. USE OF AN APPROVED ATLAS IS
            ALLOWED.

Q1.   Write short explanatory notes on <u>Five</u> of the following:-

   (a)   The 'Top-Down' versus the 'Bottom-up' approaches in development
         theory.
   (b)   Marginal land.
   (c)   Economic man.
   (d)   Comparative advantage in agriculture.
   (e)   Common Property Resources
   (f)   The farmer's goals
   (g)   Supply, demand and prices

Q2.   What efforts are being made to effectively integrate women in Rural
      Development in Africa?

Q3.   Define Rural Geography and show how the sub-discipline is linked to
      Agricultural Geography.

Q4.   Discuss ways and means of utilizing some rural water resources for tourism in
      Zambia.

Q5.   'Investment in rural roads in Zambia may not be justifiable because of low
      traffic on them'. Discuss.

Q6.   What have been the problems and prospects of rural industrialization in
      Zambia, since 1991?

END OF EXAMINATION

TIME: Three Hours

ANSWER: Question One and three others

NOTE: All questions carry equal marks. Illustrations and examples should be used
            wherever appropriate. Use of a calculator is allowed.

Q1.   Write short explanatory notes on FIVE of the following:

      (a)   Insolatiom
      (b)   Radiation balance
      (c)   Agrometeorology
      (d)   Temperature inversion
      (e)   Ana-front
      (f)   Tornado
      (g)   Monsoon trough

Q2.   Discuss the heat exchange processes taking place between the atmospheric and
       hydrospheric components of the climate system.

Q3.   Discuss the roles of the radiation and energy balances in the maintenance of world
       climate.

Q4.   Give a detailed account of the origin and characteristics of thunderstorms.

Q5.   Discuss the origin of Monsoon and its effect on rainfall distribution in the south of
       the Tropic of Cancer.

Q6.   Write an essay on the Polar Front theory.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - OCT. 1999

GEO 961

SOILS GEOGRAPHY

TIME: Three Hours
ANSWER: Any four questions.
NOTE: All questions carry equal marks
              The use of calculators and approved atlas is allowed

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1. Write short explanatory notes on all of the following

    a) Measurement of plant available water
    b) The difference between compaction and hardsetting in soil
    c) Genesis of an argillic horizon
    d) Why some 2:1 clay minerals do not expand and contract when wet or dry
    e) Plant nutrition

2. Outline the soil farming factors and explain their influence on soil formation.

3. a) Explain how you would go about classifying a soil up to suborder level.

    b) Define the criteria used for the identification of umbric, histic, mollic and albic horizons.

4. a) Explain how charge develops on clay minerals
    b) In which situation can a soil with a high base status be less fertile?

5. Discuss the contribution of autotrophic bacteria and fungi to soil fertility.

6. Discuss the factors which can be controlled to prevent soil erosion by water.

END OF EXAMINATION

TIME:	THREE HOURS.
ANSWER:	ANY FOUR QUESTIONS, ALL QUESTIONS CARRY EQUAL MARKS.
NOTE:	USE OF A CALCULATOR IS ALLOWED.

1. Write short explanatory notes on all of the following:

   a) Camouflage detection
   b) Absolute and relative orientation
   c) Parallactic angle
   d) Spectral reflectance
   e) Central Projection

2. Using a dynamic environmental process, outline and explain at least five advantages and disadvantages of using each of the following:

   a) Field observation
   b) Conventional aerial photography

3. Discuss the major constraints affect the full utilization of aerial photography in Zambia.

4. Explain various innovations that have contributed to the current status of aerial photography.

5(a) Explain the relationship between relief displacement and:

   (i) height of an object in an aerial photograph
   (ii) distance between the displaced object and the photo centre.

(b) Two overlapping vertical aerial photographs covering a copper mining plant on the Copperbelt, have been aligned in the flight direction and fastened after obtaining a stereomodel.

Using a parallax bar, the parallax of the base of the tallest chimney is found to be 60.4mm and that of the top is 59.7mm.

The distance between the principal point in the left photo and the principal point in the right photo is 90.4mm.

Calculate the height of the chimney if the scale of the 230mm x 230mm photographs taken with a 152mm focal length camera is 1:5000.

(c)   (i)   The interpreter, using a mirror stereoscope, views the stereomodel with the (be/h) ratio of 0.15. Calculate the vertical exaggeration in the stereomodel, if the forward overlap is 60% and the scale of the photographs is 1:30000.

       (ii)   What is the importance of vertical exaggeration in aerial photography?

6(a)   Explain the relevance of particle theory in aerial photography.

(b)   The following table shows three (3) cover types reflecting electromagnetic radiation in varying frequencies:

Cover Type	Frequency(cycles/Sec)	Absolute Temperature
A	7.5×10^{13}	400 K
B	3.3×10^{13}	300 K
C	6.0×10^{12}	200 K

NOTE: Planck's Constant $= 6.626 \times 10^{-34}$ Sec.
       Stefan-Boltzman Constant $= 5.6 \times 10^{-8}$ w.m^2 ($^{\circ}$K)$^{-4}$

       (i)   Establish the radiation type being reflected by each cover type.

       (ii)   Comment on whether the land cover types would be recognised on the photograph taken using black and white infraved film and a yellow filter.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER DEFERRED/SUPPLEMENTARY
EXAMINATIONS DECEMBER 1999

GEO 971

AERIAL PHOTOGRAPHY AND PHOTO INTERPRETATION

PAPER II

TIME: THREE HOURS
ANSWER: ALL QUESTIONS
NOTE: USE OF A CALCULATOR IS ALLOWED

Q1. Compare and contrast between aerial photo reading and aerial photo interpretation.

Q2. In what respect are aerial photographs different from topographic maps?

Q3. The distance on a map between two road intersections in flat terrain measured 65.4mm. The distance between the same two points is 74.6mm on a vertical photograph. If scale of map is 1:50000 what is the scale of the photograph?

Q4. Using the photograph that has been provided, undertake the following tasks:

  (a)   provide a table showing main cover types and the image elements used for their identification.

  (b)   On the tracing paper provided, delineate the cover classes.

  (c)   Explain and justify interpretation procedure used.

END OF EXAMINATION

The University of Zambia
Physics Department
University Examinations. October 1999.
P-191 : Introductory Physics- I

All questions carry equal marks. The marks are shown in brackets.
Question 1 is compulsory. Attempt <u>four</u> <u>more</u> questions.
Clearly indicate which questions you have attempted.
Time : Three hours.   **Maximum marks = 100.**

Don't forget to write your computer number on the answer book.

==

Wherever necessary, use : $g = 9.8$ m/s^2. $P_A = 1.01 \times 10^5$ N/m^2;   1 cal. = 4.18 J
$\rho_{water} = 1000$ kg/m^3 ; specific heat of water = 4180 J/kg.$^{\circ}$C ; speed of light in vacuum =
3.00×10^8 m/s ; velocity of sound at room temp. = 343 m/s

Some equations you may find useful :

$v_f = v_0 + at$ $v_f^2 = v_0^2 + 2ax$ $x = v_0 t + (1/2)at^2$ $f = \mu F_N$ $W = mg$

$Ft = m(v_f - v_0)$ kin.energy = $(1/2)mv^2$ grav. pot.energy = mgh   work = F.s.cosθ

$\Delta PE + \Delta KE + \Delta TE = 0$ power = work/time $v_{avg.} = (1/2)(v_0 + v_f)$ $x = v_{avg.} t$

$v_T = \omega r$ $\omega_f = \omega_0 + \alpha t$ $\omega_f^2 = \omega_0^2 + 2\alpha\theta$ $\theta = \omega_0 t + (1/2)\alpha t^2$ $Ft = \Delta p$

$p = mv$ $a_T = \alpha r$ $L = I\omega$ $\tau = I\alpha = Fr$ Kin. energy = $(1/2)mv^2 + (1/2)I\omega^2$

1 rev = 360° = 2π radians $F_c = (mv^2)/r$ $I = \Sigma mr^2$ $F = (Gm_1 m_2)/r^2$

$Y = (F/A)/(\Delta L/L_0)$ $B = -\Delta P/(\Delta V/V_0)$ $W_{app.} = mg - B.F.$ $P = \rho gh$

$W_{app.} = W [1 - (\rho_f /\rho)]$ $F = -kx$ $[(1/2)mv^2]_{avg.} = (3/2)kT$ $\Delta Q = cm\Delta T = nC\Delta T$

$\Delta L = \alpha L\Delta T$ $\Delta V = \gamma V\Delta T$ $\Delta W = P\Delta V$ $P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$ $(\Delta Q/\Delta t) = (kA\Delta T)/\Delta L$

$\Delta Q = \Delta U + \Delta W$ $a_{max.} = kx_0/m$ $a_c = \omega^2 x_0$ P.E. = $(1/2)kx^2$ $\Delta W = nRT.\ln(V_f/ V_i)$

$(1/2)kx^2 + (1/2)mv^2 = (1/2)kx_0^2$ $a = -kx/m$ $\omega = \sqrt{(k/m)}$ $v = \pm \sqrt{[(k/m)(x_0^2 - x^2)]}$

$v = \sqrt{(Y/\rho)}$ $f = (1/2\pi)\sqrt{(k/m)}$ $f = (1/2\pi)\sqrt{(g/L)}$ $v = \sqrt{[T/(m/L)]}$ $v = \sqrt{(B/\rho)}$

$PV = nRT$ $v = \sqrt{(\gamma RT/M)}$ $f = 1/\tau$ $\omega = 2\pi f$ $I_1 \omega_1 = I_2 \omega_2$ $\Delta T.E. = f.s$

area of a sphere = $4\pi r^2$ area of a right cylinder = $2\pi rl$ $0K = 273^{\circ}C$

$x = x_0 \cos(\omega t)$ 1 metric ton = 1000kg

Question 1 : Sample answers : L (a)   M (b)....   [Marks : 10 × 2 = 20]
NOTE: DO NOT GUESS : A guessed (but wrong) answer will receive negative marks.

A. The force needed to punch a hole 8.0mm square in a steel sheet 3.0mm thick
whose shear strength is 2.5×10^8 Pa. is :

    (a) 6kN
    (b) 24kN
    (c) 48kN
    (d) 2.7 kN.

B. The stress on a wire supporting a load does not depend on :

    (a) the mass of the load
    (b) the acceleration of gravity
    (c) diameter of the wire
    (d) length of the wire.

C. Which of the following statements is not correct ?

    (a) Matter is composed of tiny particles called molecules
    (b) All molecules have the same size and mass
    (c) The molecules are in constant motion
    (d) The relative motion of the molecules is not the same in solids,
        liquids, and gases.

D. A frictionless heat engine can be 100% efficient only if its exhaust
temperature is :

    (a) 0^0C
    (b) 0K
    (c) equal to its input temperature
    (d) less than its input temperature.

E. A spring whose force constant is k is cut in half. Each of the new springs
has a force constant of

    (a) 2k   (b) (1/2)k   (c) 4k   (d) k

F. To keep a vehicle moving at the speed v requires a force F. The power
needed is :

    (a) F/v   (b) Fv
    (c) F/v^2 (d) $(1/2)Fv^2$

G. If a shell fired from a cannon explodes in mid-air :

    (a) its total kinetic energy decreases
    (b) its total momentum increases
    (c) its total momentum decreases
    (d) its total kinetic energy increases.

H. An object in equilibrium may not have :

    (a) velocity   (b) acceleration
    (c) any forces acting on it   (d) any torques acting on it.

I. A quantity not directly involved in the rotational motion of an object is :

    (a) angular speed   (b) torque
    (c) mass   (d) moment of inertia.

J. The centripetal force needed to keep the earth in orbit around the sun is provided by :

    (a) its rotation on its axis
    (b) the gravitational pull of the moon
    (c) inertia
    (d) the gravitational pull of the sun.

Attempt any four questions from below :

**Q2.(a)** (i) Give a statement of the second law of thermodynamics. [2]
       (ii) State in a few sentences the difference between a heat engine
           and a refrigerator. [2]

(b) A sample of air ($\gamma = 1.4$) is slowly compressed from 2 atmosphere pressure to 5 atmos. pressure. The original volume and temperature are 20 litres and 17°C respectively. The process is isothermal. Next the air is adiabatically expanded back to its original pressure of 2 atmosphere.

    Find   (i) The final volume (in litres) and temperature.
   (ii) Sketch the P-V diagram of the processes. [10]

(c) In a downhill race, a skier slides down a 40° slope. Starting from rest, how far must she slide down in order to reach the speed of 130km/h ? How many seconds does it take to reach this speed ? The friction coefficient between her skis and the snow is $\mu_k = 1$. Ignore the resistance offered by the air. [6]
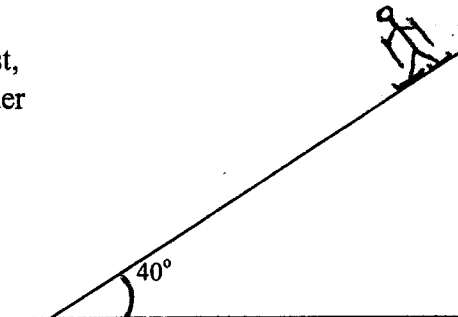
Q3.(a) Write a short note on "radius of gyration" of a rotating object. [2]
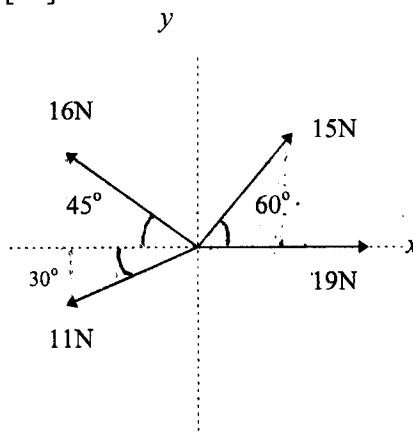
(b) A hollow sphere of radius R starts rolling from rest at the top of an inclined plane 15m long, and making an angle of 4° with the horizontal.
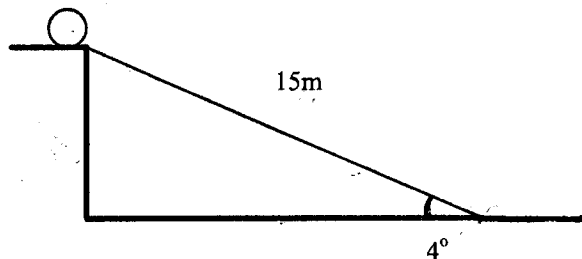
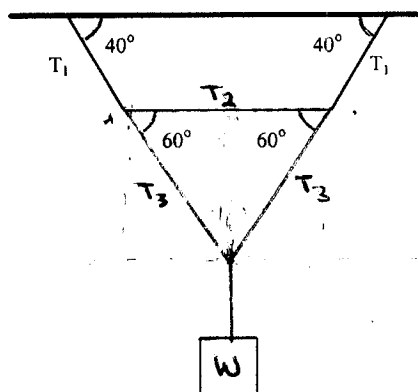How long does it take for the sphere to reach the bottom ?
(Hint : You may use the energy conservation method. $I = (2/3)MR^2$). [9]

(c) Find the resultant force *F* due to the four coplanar forces in the figure which act on the object. [9]

Q4.(a) State the conditions for an object to be in equilibrium. [4]

(b) If T_1 is given to be 65N, find the values of T_2, T_3, and W (figure). Assume the ropes to be massless. [6]

(c) A 5kg mass is hung from a vertical steel wire (Young's modulus = 2 × 10^{11}N/m^2) 2m long and 0.004cm^2 in cross section. The wire is securely fastened to the ceiling. Calculate :

(i)   the amount the wire is stretched by the hanging mass
(ii)   the external force P needed to pull the mass downward 0.05cm from its equilibrium position
(iii)   the work done by gravity when the mass moves downward 0.05cm
(iv)   the work done by the force P
(v)   the change in the elastic potential energy when the mass moves downward 0.05cm.   [10]

Q5.(a) State the work-energy theorem for net force. [2]

(b) A block of mass 300g is released from rest (figure) and slides down a frictionless track of height 1.5m above the horizontal. At the bottom of the track the surface is horizontal and the block strikes and sticks to a light spring. If the maximum distance the spring is compressed is 0.50m, what is the value of the spring constant ? [10]
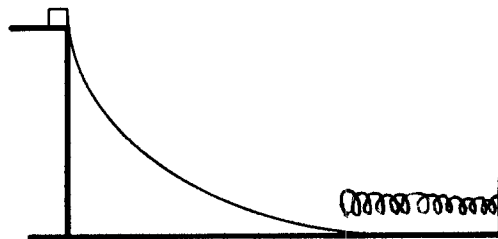
(c) In some canals, barges are lifted from a low level of the canal to a higher level by means of wheeled carriages. In a certain canal, barges of 70 metric tons are placed on a carriage of 35 metric tons which is pulled by a wire rope to a height of 12m along an inclined track 500m long.

    (i)   What is the tension in the wire rope ?
    (ii)   How much work is done to lift the barge and the carriage ?
    (iii)   If the cable breaks just as the carriage reaches the top, what would be the final speed of the carriage when it would crash at the bottom ? Ignore friction. [8]

Q6.(a) State which quantities are conserved in a perfectly elastic collision. [2]

(b) An antiaircraft shell is fired vertically upward with an initial velocity of 500m/s. Find :

    (i)   the maximum height it can reach
    (ii)   the time taken to reach that height
    (iii)   the instantaneous velocity at the end of 60 seconds
    (iv)   the time(s) at which it will be at the height of 10km. [8]

(c) Two automobiles of 540kg and 1400kg collide head-on while moving at 80km/h in opposite directions. After the collision, the automobiles remain locked together :

    (i)   Find the velocity of the wreck immediately after the collision.
    (ii)   Find the kinetic energy of the two-automobile system before and after the collision. [6]

(d) When braking (without skidding) on a dry road, the stopping distance of a sports car with a high initial speed is 38m. What would be the stopping distance of the same car with the same initial speed on an icy road ?

    Assume that $\mu_s = 0.95$ for the dry road, and
                 $\mu_s = 0.20$ for the icy road. [4]

Q7.(a) State the principle of superposition of waves.   [2]

(b) A body of mass 4kg is moving along the x-axis under the influence of the force of a spring with k = 3.5 × 10^2 N/m. There are no other forces acting on the body. The equilibrium point is at x = 0. Suppose that at t = 0, the body is (instantaneously) at rest at x = 0.20m.

   (i)   Where will the body be at t = 0.05 sec ?
   (ii)   What will be the speed of the body when it passes through the equilibrium point ? [10]

(c) A locomotive of mass 90,000kg is one-third of the way across a bridge 90m long. The bridge consists of a uniform iron beam of mass 90,000kg, which rests on two pillars.
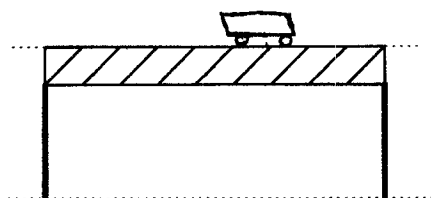
What is the load on each pillar ?   [8]

Q8.(a) Write a short note on centripetal force. Also write the equation for the magnitude of this force, explaining the meaning of the symbols used. [4]

(b) A 1kg grindstone 24cm in diameter is turning at 100rad/sec. The motor is switched off, and a chisel is pressed against the grindstone. If it takes 5 seconds for the grindstone to come to a halt, what is the tangential component of the force with which the grindstone is pressed ? [I =(1/2)MR^2]   [6]

(c) A 70g can (c = 0.20cal/g.°C) contains 400g of water and 200g of ice at equilibrium. To this is added a 300g piece of hot metal (c = 0.10cal/g.°C). The final temperature is 10°C. What was the original temperature of the metal ?   (Water has c = 4180 J/kg.°C; heat of fusion of ice = 335 kJ/kg). [10]

– End of Examination –

Have you written your <u>Computer Number</u> on the answer book ?

<u>If not, do it NOW</u> !!

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT

FIRST SEMESTER UNIVERSITY EXAMINATION MAY, 1999

P231 (PROPERTIES OF MATTER AND THERMAL PHYSICS)

TIME: THREE HOURS MAX.   MARKS 100

NOTE: ANSWER IN ALL FIVE QUESTIONS, AT LEAST TWO FROM EACH
SECTION A AND B

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SECTION A: ANSWER AT LEAST TWO QUESTION FROM THIS SECTION

QUESTION 1.

(1a)   Define coefficient of viscosity for a liquid, find its dimensions and derive an
expression for the rate of flow of viscous fluid through a narrow tube.

(10 Marks)

(1b)   In a horizontal narrow pipe line of uniform cross-sectional area with a radius of
9×10^{-4} m, pressure falls by $5N/m^2$ between two points separated by a distance
of 2 m. If 1 m^3 of water issues from the pipe in 10 min, calculate
the coefficient of viscosity for water.   (5 Marks)

(1c)   Water is escaping from a cistern by way of a horizontal capillary tube 0.10 m
long and 4.0×10^{-4} m in diameter, at a distance of 0.5 m below the free
surface of water in the cistern. Calculate the rate at which the water is escaping.

(5 Marks)

QUESTION 2.

(2a)   The figure below shows three concentric soap bubbles A, B, and C of radii
        6×10^{-3} m, 4×10^{-3} m and 2×10^{-3} m respectively. If surface tension for the soap
        solution is T, calculate the excess pressure in C.   (5 Marks)
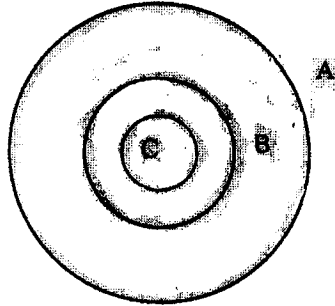
(2b)   Water rises to a height of 5×10^{-2} m in a capillary tube. In the same tube the level
        of the mercury surface is depressed by 1.54×10^{-2} m. Compare the surface
        tensions of water and mercury, if the specific gravity of mercury is 13.6, the angle
        of contact for water is $0°$, and that of mercury is $130°$.   (5 Marks)

(2c)   A U tube is made up of two capillaries of bore 0.1×10^{-2} m and 0.2×10^{-2} m
        respectively. The tube is held vertically and partially filled with a liquid of surface
        tension 49×10^{-3} N/m and zero contact angle. Calculate the density of
        the liquid, if the difference in the levels is 1.25×10^{-2} m.   (5 Marks)

QUESTION 3.

(3a)   Show that the bending moment of a beam under deforming forces is given by
        YI_g/R where I_g is the geometrical moment of inertia of the beam, Y is Young's
        modulus of the material of the beam and R is the radius of curvature. (5 Marks)

(3b)   A horizontal steel wire of length 1 m and area of cross-section 10^{-6} m^2 is
        stretched between two fixed supports. When a load of 0.04 kg is applied to the
        mid point, a sag of 5×10^{-3} m is produced; for a load of 0.6 kg the sag is
        15×10^{-3} m. Calculate Young's modulus for the wire.   (5 Marks)

(3c)   Find the work done in stretching a wire of 1×10^{-6} m^2 cross-section and 2 m length
        through 0.1×10^{-3} m if Young's modulus for the material of the wire is equal to
        2×10^{11} N/m^2.   (5 Marks)

QUESTION 4.

(4a)   Show that the depression of a beam supported at the ends, and loaded at the centre is given by:

$$y = \frac{WL^3}{48YI_g}$$ (8 Marks)

  where W is the weight loaded in the middle of the beam,
         L is the length of the beam
         Y is Young's modulus for the material of the beam
         I_g is the geometrical moment of inertia of the beam.

(4b)   A brass bar $1 \times 10^{-4}\,m^2$ cross-section is supported on two knife edges 1 m apart. A load of 1 kg at the centre of the bar depresses that point by 2.51×10^{-3} m. What is Young's modulus for brass?   (5 Marks)

(4c) (i) Show that a small and uniform strain v is equivalent to three linear strains v/3 in any three perpendicular directions   (7 Marks)

    (ii) Show that the bulk modulus for a gas at constant temperature is equal to its pressure

SECTION B: ANSWER AT LEAST TWO QUESTIONS FROM THIS SECTION

QUESTION 5.

(5a)   Define an adiabatic change and derive an equation relating pressure and volume of an ideal gas for this type of change.   (5 Marks)

(5b)   A mass of an ideal gas of volume $4 \times 10^{-3}\,m^3$ at 288 K expands adiabatically and its temperature falls to 273 K. What is the new volume if $\dfrac{C_p}{C_v} = 1.40$? If the same gas is then compressed isothermally until the pressure returns to its original value, calculate the final volume of the gas.   (10 Marks)

(5c)   Calculate entropy change of the gas mentioned in (5b) due to the isothermal process.   (5 Marks)

QUESTION 6.

(6a)   Derive Charles' law and Dalton's law on the basis of the kinetic theory of gases, and write a brief note on Absolute Zero from the standpoint of the theory.

(15 Marks)

(6b)   Given that the molar gas constant has a value of $8.31 \text{ mol}^{-1} \text{ K}^{-1}$ and the atomic weight of chlorine is 35.5, find the root mean square velocity of its molecule.

(5 Marks)

(6c)   If the density of nitrogen is 1.25 Kg per m^3 at normal temperature and pressure, calculate the root mean square velocity of its molecules.   (5 Marks)

QUESTION 7.

(7a)   One end of a copper rod is in thermal contact with a reservoir at 500 K and the other end is in thermal contact with a reservoir at temperature 300 K. If 8 kJ are conducted from one end to the other, with no change in temperature gradient along the rod, find   (6 Marks)

   (i)   the entropy change of each reservoir
   (ii)   the entropy change of the rod and
   (iii) the entropy change of the universe.

(7b)   A hot stone of mass m_2, specific heat c_2, and temperature T_2 is dropped into the container of cool water of mass m_1, specific heat c_1, and temperature T_1 (where T_1 is greater than T_2). The final temperature of the combination is T_f (ignore the effects of the container). What entropy change occurs in this process?

(7 Marks)

(7c)   A dish of hot food is placed in a refrigerator maintained at $5^\circ C$. To cool to this temperature, the food must lose 220,000J. How much electric energy is needed to operate the compressor ($1\text{kWh} = 3.60 \times 10^6 \text{ J}$)?   (7 Marks)

4

UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS
FIRST SEMESTER 1999
SUPPLEMENTARY AND DEFERRED EXAMINATIONS
P251
CLASSICAL MECHANICS

TIME: THREE HOURS
ANSWER ANY FIVE QUESTIONS
ALL QUESTIONS CARRY EQUAL MARKS
TOTAL MARKS: 100

Q 1 (a). Show that the force

$$\mathbf{F}(x, y, z) = ax\widehat{\mathbf{i}} + by\widehat{\mathbf{j}} + cz\widehat{\mathbf{k}},$$

where a, b and c are constants, is conservative. [4]

(b) A particle of mass m moving in one dimension is acted upon by the force

$$F(x) = ax(3x - 2b)$$

where a and b are positive constants. Determine

(i) the equilibrium position of the particle, [2]

(ii) the potential energy of the particle, assuming that $V(x = 0) = 0$. [2]

(iii) the period of small oscillations about the position of stable equilibrium. [4]

(iv) Plot both $F(x)$ and $V(x)$. [6]

(c) The moon travels around the earth once every 27.3 days in an almost circular orbit of radius 3.84×10^8m. Use this information to estimate the mass of the earth. [2]

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

Q 2 (a) What is a central force? [2]

(b) Prove that for a central force

(i) the angular momentum **L** is conserved, [2]

(ii) the magnitude of angular momentum is $mr^2\,\dot\theta$, [2]

(iii) the total energy E is conserved. [4]

(c) By use of Newton's second law and for an attractive inverse square force $-\lambda/r^2$,

(i) show that the Lenz-Runge vector $\mathbf{k}$ is a constant of the motion and is given by

$$\mathbf{k} = \dot{\mathbf{r}} \times \mathbf{L} - \lambda\hat{\mathbf{r}}, \qquad [4]$$

(ii) show that $\mathbf{k}$ is orthogonal to the angular momentum $\mathbf{L}$ and hence $\mathbf{L}$ is orthogonal to $\mathbf{k} \times \mathbf{L}$ [2]

(iii) show that $|\mathbf{k}|^2$ is related to the total energy E by

$$|\mathbf{k}|^2 = \frac{2L^2 E}{m} + \lambda^2. \quad [4]$$

Q 3 (a) Show that for a system of N particles moving under the influence of internal as well as external forces, $\mathbf{F} = \dfrac{d\mathbf{P}}{dt}$, where $\mathbf{F}$ is the total external force acting on the system and $\mathbf{P}$ is the total linear momentum of the system. [6]

(b) Four particles of masses 2kg, 4kg, 6kg, and 8 kg are rigidly joined by massless rods so as to lie on the corners of a 2m long square with position coordinates $(1,1,0)$, $(1,-1,0)$, $(-1,-1,0)$ and $(-1,1,0)$ respectively.

(i) Find the position of the centre of mass of the system. [2]

(ii) The system is initially at rest. If an external force $(2,2,0)$ starts acting on the system (which is free to move in the $x-y$ plane) find the position of the centre of mass of the system after 2s. [3]

(iii) Find the velocity of the centre of mass after 2s. [3]

(c) The energy of a simple harmonic oscillaor is defined by

$$E = \frac{1}{2}m\,\dot{x}^2 + \frac{1}{2}m\omega^2 x^2.$$

Show that if the oscillator is damped, then E decreases at a rate proportional to the square of the speed of the oscillator. [6]

Q 4 (a) State the parallel-axes theorem for moments of inertia and prove the theorem for a two-dimensional object. [4]

2

(b) A uniform disk of density r_0 has mass m.

(i) Calculate its moment of inertia about an axis perpendicular to its plane passing through its centre.   [3]

(ii) Hence or otherwise, obtain its moment of inertia about an axis perpendicular to its plane and through a point on its rim.   [3]

(c) A wheel of moment of inertia I and radius r is free to rotate frictionlessly about a horizontal axis. A weightless string wound round the wheel carries a particle of mass m hanging vertically. The system is released from the rest and the mass m starts to descend.

(i) Sketch the system and write down the equations of motion of the mass m and the wheel. [2]

(ii) Hence show that in time t, the wheel rotates through an angle

$$\theta = \frac{mgrt^2}{2\left(I + mr^2\right)}. \quad [8]$$

Q 5 (a) A stationary particle of mass $3m$ explodes into three equal pieces. Two of the pieces fly off at right angles to each other, one with a speed $2v$ and the other with a speed $3v$. What is the magnitude and direction of the momentum of the third fragment? [10}

(b) The orbit of a particle moving about a centre of gravitational force is the conic

$$\frac{1}{r} = \frac{1}{l}\left(1 + e\cos\theta\right).$$

(i) State the conditions on e for this orbit to be a circle, an ellipse, a parabola and a hyperbola. [4]

(ii) Show that the eccentricity of this orbit is

$$e = \frac{r_a - r_p}{r_a + r_p},$$

where r_a and r_p are the aphelion and perihelion distances respectively.   [6]

Q 6(a) A particle of mass m is suspended from fixed point 0 by a spring of natural length a. The particle is in equilibrium when the height of the spring is b. The particle is then pulled down a distance μb and released from rest. Find the

3

frequency of the resulting oscillation and obtain an expression for the displacement $y(t)$ of the particle from its equilibrium position. [8]

(b) A particle undergoing simple harmonic motion has a velocity v_1 when the displacement is x_1 and a velocity v_2 when the displacement is x_2. Find the angular frequency and the amplitude of the motion in terms of the given quantities. [4]

(c) A liquid in a U shaped tube is in equilibrium . When the liquid is slightly displaced, it executes simple harmonic motion. Calculate the frequency of such oscillations. [8]

Q 7 (a) State Newton's law of universal gravitation (descriptive and mathematical statements both required). [2]

(b) A particle of mass m moves along the axis of a fixed uniform ring of mass M and radius r. Assume that the only force acting on the particle is the gravitational attraction of the ring. The position of the particle at any time is specified by its distance y from the centre of the ring.

(i) Draw a diagram of this arrangement. [2]

(ii) Show, using symmetry considerations, that the force on the particle is along the axis through the centre of the ring. [2]

(iii) Determine the potential energy of the particle as a function of y. [4]

(iv) Obtain the magnitude of the force acting on the particle as a function of y. [4]

(v) If the particle is "projected" from the centre of the ring, show that is escape velocity is

$$v_e = \sqrt{\frac{2GM}{r}}. \quad [6]$$

4

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT

FIRST SEMESTER FINAL EXAMINATIONS - APRIL 1999

P261 - ELECTRICITY AND MAGNETISM

TIME: 3 HOURS   MAXIMUM MARKS: 100

NOTE: ANSWER ANY **FIVE** QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS. SHOW YOUR WORKING CLEARLY. EACH IMPORTANT STEP WILL CARRY SOME MARKS.

*THIS QUESTION PAPER CONTAINS **FOUR** PRINTED PAGES.*

QUESTION 1.

1a).   Find the electric field intensity at a point P on the perpendicular bisector of a uniformly charged rod. The length of the rod is L, the charge on it is Q, and the distance of P from the centre of the rod is d.

(10 Marks)

1b).   Find the force between a long thin rod and a point charge q. The thin rod is uniformly charged with a total charge Q on it and the length of the rod is L. The point charge q is situated at a distance d from its one end along the axis of the rod.

(10 Marks)

QUESTION 2.

2a).   Find an expression for the capacity of two coaxial conducting cylinders of length L placed in air. The inner cylinder of radius R_1 has a charge q per unit length and the outer cylinder of radius R_2 is earth connected.

(10 Marks)

2b). Three capacitors having the capacitances C_1, C_2, and C_3 respectively are connected as shown in figure. Find the equivalent capacitance between the point a and b.

(10 Marks)
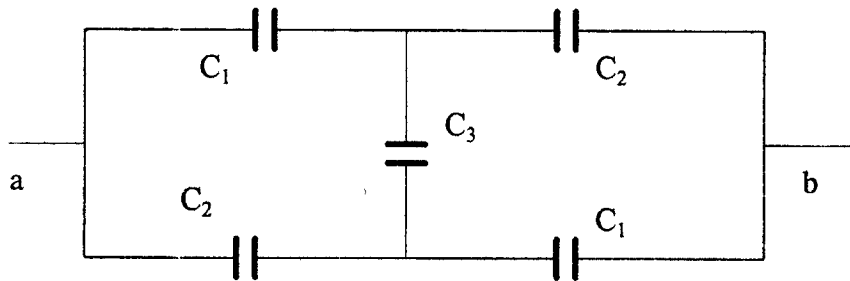
QUESTION 3.

3a). A magnetic dipole of length 2d and magnetic pole strength m is placed along the x-axis. The line joining the centre of the dipole from the point P makes an angle θ with the dipole axis. Assume $r >> d$.

(i). Find the potential at the point P distant r from the centre of the dipole on the broad side position.

(ii). Find the resultant magnetic field at point P and its direction.

(10 Marks)

3b). Using Maxwell's equations, show that the x-component of the magnetic vector potential is given by

$$\nabla^2 A_x = - \mu_o J_x$$

if this potential satisfies the condition $\nabla.\mathbf{A} = 0$

(10 Marks)

QUESTION 4.

4a). The magnetic field due to a current element idl at a point P distant r from the element is given by

$$d\mathbf{B} = (\mu_o/4\pi) (idl \times \mathbf{r})/r^3.$$

The direction of dB is the same as that of the vector dl x r.

(i). Use this information to find the magnetic field at P due to a long straight current. The perpendicular distance of the current from P is d.

2

(ii). If this long current is bent into a circular loop of radius d, show that the field is increased by a factor of π.

(10 Marks)

4b). Two long wires carrying currents I_1 and I_2 are placed perpendicular to each other in such a way that they just avoid contact. Find the magnetic force on a small length dl of the second wire situated at a distance x from the first wire. What is the direction of this force?

(10 Marks)

QUESTION 5.

5a). A series circuit consists of a resistance, an inductance, and a capacitance. The applied voltage and the current at any instant are given by $V = 141.4 \cos (3000t - 10^0)$ and $I = 5 \cos(3000t - 55^0)$. The inductance is 0.01 henry. Calculate the value of the resistance and capacitance.

(10 Marks)

5b). A variable inductance is made by winding a coil on an iron core of 30 cm long, which has an adjustable air gap. With no air gap, the self inductance is 2 henrys. For what air gap is the inductance reduced to 1 henry? The permeability of the iron core is 1000 μ_0.

(10 Marks)

QUESTION 6.

6a). A solenoid of inductance L and resistance 10 Ω is connected to a battery of 6 V. The time elapsed before the current acquires half of its steady-state value becomes 3.5 millisecond. Find L.

(10 Marks)

6b). Two parallel wires are carrying equal currents I in opposite directions. The radius of each wire is r and the distance between the centres of the wires is d. Find the self inductance of a 1 meter length of the two parallel wires.

(10 Marks)

QUESTION 7.

7a). An inductance L and a resistance R are connected in series with a battery of emf E. Show that the maximum rate at which the energy is stored in the magnetic field is $E^2/4R$.

(10 Marks)

7b). State and prove the reciprocity theorem of mutual inductance between two coils.

(10 Marks)

You may use the following if required

$\mu_0 = 4\pi \times 10^{-7}$ w/A-m; $\qquad \epsilon_0 = 8.85 \times 10^{-12}$ C^2/N-m^2; $\quad$ V$_e$ = q/4$\pi\epsilon_0$r;

ϕ = B A n; $\qquad$ q = (ϕ_1 - ϕ_2)/R; $\qquad$ q = 1.6 x 10^{-19} C; $\qquad \nabla^2$V = - ρ/ϵ_0;

B = (μ_0 I a^2)/ 2(a^2 + x^2)$^{3/2}$; $\quad$ B = μ_0 n I /2a; $\quad \phi$ = L I; $\quad \phi$ = M I;

V$_m$ = μ_0m/4πr; $\qquad$ **F** = q$_1$q$_2$**r**/4$\pi\epsilon_0$r^3; $\qquad$ E = qr/2$\pi\epsilon_0$r^2; $\qquad$ q = CV;

d**B** = (μ_0 / 4π) id**l** x **r**/r^3; $\qquad$ F = $\int$ I dl B; $\quad$ **F** = q (**v** x **B**); $\;$ L = μ_0 n^2 A;

R = 1/μA; $\qquad$ W = L I^2/2; $\quad$ C = 2$\pi\epsilon_0\epsilon_r$ 1/ln(R$_2$/R$_1$); $\qquad$ X$_c$ = 1/ωC – ωL;

∇.**E** = ρ/ϵ_0; $\quad \nabla$.**B** = 0; $\qquad \nabla$ x **B** = μ_0**J**; $\;\; \nabla$ x **E** = 0; $\qquad$ **B** = ∇ x **A**;

$\int$ **E**.d**l** = 0; $\qquad \int$ **E**.d**S** = q/ϵ_0; $\int$ **B**.d**l** = μ_0 I ; $\;\int$ **B**.d**S** = 0; $\quad$ I = I$_0$ (1 - e$^{-t/\tau}$).

END OF THE EXAMINATION - GOOD LUCK

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS
FIRST SEMESTER - 1999
P361 - ELECTROMAGNETISM

TIME: 3 HOURS   MAX MARKS: 100

ATTEMPT ANY **FOUR** QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

You may use the following information:

$$\varepsilon_0 = 8.85 \times 10^{-12} \ farad \,/\, meter$$
$$\mu_0 = 4\pi \times 10^{-7} \ N \,/\, A^2$$

$$\int \sec\theta \, d\theta = \ln(\sec\theta + \tan\theta)$$

The vector identities

$$\vec{\nabla} \times (\vec{\nabla} \times \vec{A}) = -\vec{\nabla}^2 A + \vec{\nabla}(\vec{\nabla}.\vec{A})$$
$$\vec{\nabla}.(f\vec{A}) = f\vec{\nabla}.\vec{A} + A.\vec{\nabla}f$$
$$\vec{\nabla} \times (f\vec{A}) = \vec{\nabla}f \times \vec{A} + f(\vec{\nabla} \times \vec{A})$$
$$\vec{\nabla}(V.\vec{\nabla}V) = (\vec{\nabla}V)^2 + V\vec{\nabla}^2 V$$

The vector $\vec{r}$ is directed from $P'(x', y', z')$ to $P(x, y, z)$. If P' is fixed and P is allowed to move, then the gradient under this condition is given by

$$\vec{\nabla}\left(\frac{1}{r}\right) = -\frac{\hat{r}}{r^2}$$

If P is fixed and P' is allowed to move, then the gradient is

$$\vec{\nabla}'\left(\frac{1}{r}\right) = \frac{\hat{r}}{r^2}$$

In spherical coordinates (r, θ, ϕ)

$$\vec{\nabla} f = \frac{\partial f}{\partial r} \hat{r} + \frac{1}{r} \frac{\partial f}{\partial \theta} \hat{\theta} + \frac{1}{r \sin \theta} \frac{\partial f}{\partial \phi} \hat{\phi}$$

$$\vec{\nabla}^2 \equiv \frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial}{\partial r} \right) + \frac{1}{r^2 \sin \theta} \frac{\partial}{\partial \theta} \left(\sin \theta \frac{\partial}{\partial \theta} \right) + \frac{1}{r^2 \sin^2 \theta} \frac{\partial^2}{\partial \phi^2}$$

$$\vec{\nabla} . \vec{A} \equiv \frac{2}{r} A_r + \frac{\partial A_r}{\partial r} + \frac{A_\theta}{r} \cot \theta + \frac{1}{r} \frac{\partial A_\theta}{\partial \theta} + \frac{1}{r \sin \theta} \frac{\partial A_\phi}{\partial \phi}$$

$$\vec{\nabla} \times \vec{A} = \frac{\hat{r}}{r \sin \theta} \left[\frac{\partial}{\partial \theta} (\sin \theta \, A_\phi) - \frac{\partial A_\theta}{\partial \phi} \right] + \frac{\hat{\theta}}{r} \left[\frac{1}{\sin \theta} \frac{\partial A_r}{\partial \phi} - \frac{\partial}{\partial r} (r A_\phi) \right] + \frac{\hat{\phi}}{r} \left[\frac{\partial}{\partial r} (r A_\phi) - \frac{\partial A_r}{\partial \theta} \right]$$

In cylindrical coordinates (ρ, ϕ, z)

$$\vec{\nabla} f = \hat{\rho} \frac{\partial f}{\partial \rho} + \hat{\phi} \frac{1}{\rho} \frac{\partial f}{\partial \phi} + \hat{z} \frac{\partial f}{\partial z}$$

$$\vec{\nabla} \vec{A} = \frac{1}{\rho} \frac{\partial}{\partial \rho} (\rho A_\rho) + \frac{1}{\rho} \frac{\partial A_\phi}{\partial \phi} + \frac{\partial A_z}{\partial z}$$

$$\vec{\nabla} \times \vec{A} = \hat{\rho} \left(\frac{1}{\rho} \frac{\partial A_z}{\partial \phi} - \frac{\partial A_\phi}{\partial z} \right) + \hat{\phi} \left(\frac{\partial A_\rho}{\partial z} - \frac{\partial A_z}{\partial \rho} \right) + \hat{z} \left[\frac{1}{\rho} \frac{\partial}{\partial \rho} (\rho A_\phi) - \frac{1}{\rho} \frac{\partial A_\rho}{\partial \phi} \right]$$

$$\nabla^2 f = \frac{1}{\rho} \frac{\partial}{\partial \rho} \left(\rho \frac{\partial f}{\partial \rho} \right) + \frac{1}{\rho^2} \frac{\partial^2 f}{\partial \phi^2} + \frac{\partial^2 f}{\partial z^2}$$

For any arbitrary vector $\vec{A}$

$$\int_\tau \left(\vec{\nabla} \times \vec{A} \right) d\tau = -\int_s \vec{A} \times d\vec{a}$$

2

Poisson's Equation

$$\vec{\nabla}^2 V = -\frac{\rho}{\varepsilon_0}$$

For a long solenoid of length L, the magnetic induction $B = \dfrac{\mu_0 NI}{L}$ inside
$$= 0 \quad \text{outside}$$

The vector potential

$$\vec{A} = \frac{\mu_0 I}{4\pi} \int \frac{d\vec{l}}{r}$$

The magnetic induction

$$\vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{d\vec{l} \times \hat{r}}{r^2}$$

$$\vec{B} = \vec{\nabla} \times \vec{A}$$

Vector potential due to a magnetic dipole

$$\vec{A} = \frac{\mu_0}{4\pi} \frac{\vec{m} \times \hat{r}}{r^2}$$

The magnetic induction at a point on the axis of a circular current carrying loop is

$$B = \frac{\mu_0 I a^2}{2\left(a^2 + z^2\right)^{3/2}}$$

The Maxwell's Equations are

$$\vec{\nabla}.\vec{D} = \rho_f$$
$$\vec{\nabla}.\vec{B} = 0$$
$$\vec{\nabla} \times \vec{E} + \frac{\partial \vec{B}}{\partial t} = 0$$
$$\vec{\nabla} \times \vec{H} = J_f + \frac{\partial \vec{D}}{\partial t}$$

3

A long cylinder of dielectric material has a radius R and a linear charge density λ coulomb/meter along its axis. Assuming the dielectric material to be linear and isotropic with relative permittivity ε_r,

(a) calculate $\vec{D}$ and $\vec{E}$ (i) inside, and (ii) outside the cylinder,   (8 marks)
(b) calculate the induced surface charge density everywhere on the cylinder,   (8 marks)
(c) calculate the induced volume charge density,   (5 marks)
(d) show that the total induced charge on the cylinder is zero.   (4 marks)

2 (a) Show that the components of the electric field intensity due to a dipole of moment $\vec{p}$ at a point (r,θ) are given by the following expressions:

$$E_r = \frac{1}{4\pi\,\varepsilon_0}\frac{2p}{r^3}\cos\theta$$

$$E_\theta = \frac{1}{4\pi\,\varepsilon_0}\frac{p}{r^3}\sin\theta$$

What is the essential difference between the electric field intensity due to a point charge and that due to a dipole?   (10 marks)

(b) A spherical shell of radius R has a surface charge density $\sigma = \sigma_0 \cos\theta$, where θ is the polar angle.

(i)   Compute the dipole moment of the spherical shell.   (10 marks)

(ii) What will be the dipole moment of the above spherical shell if it has a uniform surface charge density σ_0?   (5 marks)

3 (a) Starting with the general expression of $\vec{B}$ due to a volume current density, obtain an expression for the vector potential. What is the significance of the vector potential? What will be the expression for the vector potential in the case of current in a conducting wire?   (10 marks)

(b) (i)   Using the result in (a) above, obtain an expression for the vector potential at a distance ρ from a straight conductor of length $2L$ carrying a current I. What will be the vector potential in the case of a long wire?   (9 marks)

(ii) Use the expression for the vector potential obtained in (i) above to calculate $\vec{B}$ due to a long wire.   (6 marks)

4

Q.4 (a) Define mutual inductance. Obtain an expression for the mutual inductance between two long coaxial solenoids of nearly the same radii R, the lengths L_a and L_b $(L_a > L_b)$ and the total number of turns N_a and N_b, respectively.

(10 marks)

(b) Two long rectangular loops have lengths L_1 and L_2 $(L_2 < L_1)$ and widths W_1 and W_2, respectively. The loops are lying in the same plane such that their lengths are parallel and the distance between the near sides is S. Assuming that end effects are negligible and the loops have a single turn, show that the mutual inductance between the loops is given by

$$M = \frac{\mu_0 L_2}{2\pi} \ln\left\{\frac{(S+W_1)(S+W_2)}{S(S+W_1+W_2)}\right\}.$$

(15 marks)

Q.5 (a) Show that the vector potential due to a magnetized body at a point outside the body can be expressed as the sum of the vector potentials due to a surface current density and a volume current density. (10 marks)

(b) A thin disk of iron of radius a and thickness t is magnetized in the direction parallel to its axis. Calculate $\vec{H}$ and $\vec{B}$ on the axis, both inside and outside the iron.

(15 marks)

Q.6 (a) Rewrite Maxwell's equations in vacuum and charge free region. Show that the $\vec{E}$ and $\vec{H}$ vectors satisfy unattenuated wave equations in three dimensions. Calculate the velocity of these waves. (8 marks)

(b) Show that a plane electromagnetic wave in vacuum is transverse in nature.

(4 marks)

(c) Establish the relative orientation of the $\vec{E}$ and $\vec{H}$ vectors and their relative phases. (8 marks)

(d) Compare the energy density associated with the electric and magnetic fields.

(5 marks)

.... END OF THE EXAMINATION ....

5

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS-1999
P-401
(Computational Physics-II)

Time: Three Hours.   **Max.Marks:** 100

Answer: (i) Question One is compulsory.

        (ii) Any Three questions from 2,3,4,5,and 6.

All Questions carry equal marks.

(Marks are shown in the square brackets).

Q.1. (a) Make necessary corrections or state the errors in the following   [6]

      (i) I=5
         J=6
         A=B*LOG(I / J)

      (ii) NAME=' PHY '
         DEPT=21
         IF(DEPT.NE.21)THEN
         PRINT * , 'NOT PHYSICS'
         ENDIF

      (iii) OPEN(2,FILE='EXAM.DAT ')
         CLOSE 2
         READ(2,*) A , B

      (iv) CHARACTER*10, PR*14 , Q*5

      (v)   DO 10 J= 1, -36, -1
            A=A+1
         10   CONTINUE

      (vi)   INTEGER A,B
           REAL X,Y
           WRITE(2,10)A,B,X,Y
      10   FORMAT(2X,F6.3,2X,I3,2X,2E10.7)

(b) Explain the difference between   [2]
   (i) A function subroutine and a subroutine,
   (ii) Stop and End statements,

(c) (i) Explain what you understand by non-linear least squares fit of given data.   [2]

   (ii) Explain the difference between an interpolation and fitting the data   [2]
      by the least squares method.

(d) The normal probability function ϕ is defined as   [5]

$$\phi(x) = \frac{1}{\sqrt{2\pi}} \, e^{-x^2/2}$$

Write a program to evaluate $\phi(x)$ for values of x from -3.0 to +3.0 in steps of 0.2

(e) An input file named 'atom.dat' the contains atomic number and the corresponding [8] chemical symbol in each line in the following form as shown by a typical example,

> 1 , H
> 2 , He
> ....etc.

The file covers all the atomic numbers of the standard periodic table. Write a program such that the user enters the atomic number of one of the chemical elements of the periodic table and the program produces the appropriate chemical symbol.

Q:2: An electrical circuit consists of an inductance $L=0.98$ henries and [25] a resistance $R=0.142$ ohms in series. A voltage $E(t)$ is applied at time $t=0$. Kirchhoff's first law gives the relationship

$$E = L\frac{di}{dt} + Ri \qquad , \qquad \text{where } i \text{ is the current.}$$

A measurement of current i for several values of t in seconds is tabulated as given below.

t	1.0	1.01	1.02	1.03	1.04
i	3.10	3.12	3.14	3.18	3.24

Write a program
(i) to write the data in tabular form on an input file,
(ii) to calculate the voltage E at the values $t=1.01,1.02,1.03$.

Use the formula $\dfrac{df}{dt} = \dfrac{f(t+h) - f(t-h)}{2h}$ for approximating $\dfrac{di}{dt}$

(iii) to write the output on an output file with titles
Time t, Current i and Voltage E

Q:3: An estimate of the escape velocity from the surface of a [25] planet is given by the expression

$$V_{esc} = \sqrt{\frac{2GM}{R}}$$

where G = gravitational constant = 6.67×10^{-11} Nm^{2}kg^{-2}
M = mass of the planet
R = radius of the planet.
The following data is available in an input file 'planet.dat' in free format in the following order in each row.
Planet name, mass of the planet kg and radius of the planet in m.

> ' Earth ' , 5.98E+24 , 6.38 E+6
> ' Saturn ' , 5.69E+26 , 6.04E+7
> ' Jupiter ', 1.90E+27 , 7.14E+7

Write a program
   (i) to read the data from the input file,
   (ii) to calculate the escape velocity, and
   (iii) to write the output on an output file in the following form with titles
         as given below :

Name of the planet , Mass of the planet (kg), Radius of the Planet(m), Escape Velocity (m/s)

Q:4: Consider the diffusion of an aromatic molecule in air, having velocity [25]
500m/s and a mean free path λ of *0.5m*. Assume that the molecule moves only
in the (x,y) plane and in any of the following directions after each collision.
                    East or **West** or **North** or **South**

Assume that the molecule starts at time *t=0* from the centre of a square hall of dimension
5mx5m with an opening at one side as shown below:
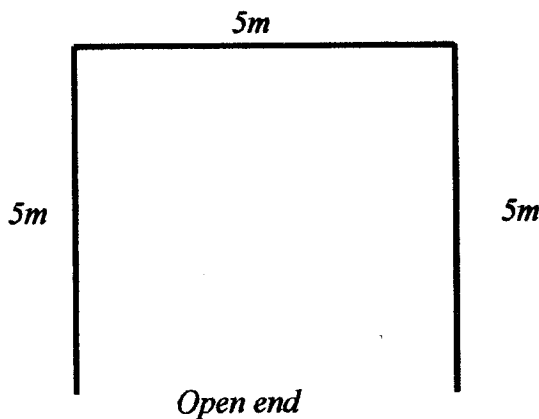
Write a pseudo code to find the average number collisions a molecule will undergo to reach
the opening . Assume that if a molecule hits the wall it recoils back without loss of energy.
Consider the following number of trials in finding the average number of collisions.
        100,200,500,1000 and *2000*
What do you expect of the behaviour of the average as the number trials increase?

Hint: Assume that the subroutine for random number generation is given.

Q:5: Assume that a central potential with r-dependence as given below binds the [25]
neutron and proton together to form a deuteron
        $V(r) = \infty$ $0 < r < c$
             $= -V_0$ $c < r < b$

with c=0.4 x 10^{-15} m , b = 1.34 x 10^{-15} m and E=-2.225 Mev.
The radial equation is given by

$$\frac{d^2 u_l}{dr^2} + \frac{2m}{\hbar^2}\left[E - V(r) - \frac{l(l+1)\hbar^2}{2mr^2}\right] u_l = 0$$

Write an algorithm in pseudo-code
(i) to calculate well depth V_0 needed to bind the two particles for l=0,
(ii) to calculate E for l=1 using the V_0 determined in (i).

The boundary conditions for u_l are,

$u_l = 0$ at $r = 0$ and at $r = \infty$. For convenience take $u_l = 0$ beyond $r = 20$ b.

Hint: Use the Numerov method given below

Numerov Method: Second order equation with boundary conditions given below:

$$\frac{d^2 y}{dx^2} + k^2 y = S(x) \ , \quad y \text{ and } y' = \frac{dy}{dx} \text{ are known at starting point.}$$

can be solved using the algorithm,

$$(1 + \frac{h^2}{12} k_{n+1}^2) y_{n+1} - (1 - \frac{5h^2}{12} k_n^2) y_n + (1 + \frac{h^2}{12} k_{n-1}^2) y_{n-1} = \frac{h^2}{12} (s_{n+1} + 10 s_n + s_{n-1})$$

Q:6: (a) A is a square matrix of order N x N . The upper bound, on the eigenvalues   [10]
of this matrix is given by

$$P = \max\left[\sum_{k=1}^{N} |a_{ik}| \right]$$

where a_{ik} = matrix element of the i-th row and k-th column.
Given A and N, write a subroutine subprogram to compute P. Note that *max* corresponds to
maximum value.

(b) Giving examples, write short notes on,   [15]
    (i) Fast Fourier transform,
    (ii) Chaos and,
    (iii) Auto correlation .

@@@END OF EXAMINATIONS@@@

THE UNIVERSITY OF ZAMBIA

Physics Department

UNIVERSITY EXAMINATIONS 1997/98

P421

Solid State Physics I

Time: Three (3) hours
Attempt **ANY FOUR (4)** questions.
(All Questions carry Equal Marks)
The marks for each question are shown in square brackets.   Maximum Marks 100

Use the following wherever necessary:

Magnitude of electronic charge, $e = 1.60 \times 10^{-19}$ C
Electron rest mass, $m = 9.11 \times 10^{-31}$ kg
Reduced Planck's constant, $\hbar = 1.05 \times 10^{-34}$ J s
Boltzmann's constant, $k_B = 1.38 \times 10^{-23}$ J K^{-1}
Avogadro's number, $N_A = 6.02 \times 10^{26}$ per Kg mole
Permittivity of free space, $\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
                               $1\,\text{eV} = 1.60 \times 10^{-19}$ J

The sums: $\displaystyle\sum_{n=0}^{\infty} x^n = \frac{1}{1-x}$, $\displaystyle\sum_{n=0}^{\infty} nx^n = x\frac{d}{dx}\left(\frac{1}{1-x}\right) = \frac{x}{(1-x)^2}$

The integrals: $\displaystyle\int_0^{\infty} \frac{x^3}{e^x - 1}dx = \frac{\pi^4}{15}$

Q. 1 (a) Explain why an infinite point lattice is only capable [3]
of showing 2,3,4 or 6-fold type rotational symmetry.

(b) Prove that in the cubic system

(i.) the direction *(hkl)* is parallel to the face normal *(hkl)* [4]

(ii.) the angle ϕ between the surface normal (h_1, k_1, l_1) [4]
and (h_2, k_2, l_2) is given by

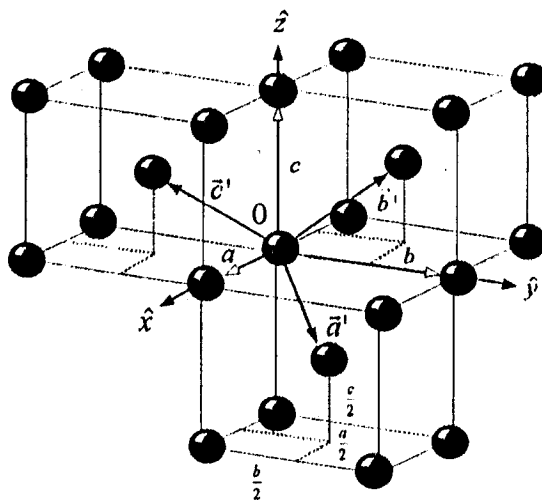$$\cos\phi = \frac{h_1 h_2 + k_1 k_2 + l_1 l_2}{(h_1^2 + k_1^2 + l_1^2)(h_2^2 + k_2^2 + l_2^2)^{\frac{1}{2}}}$$

Figure 1

(c) Figure 1 shows a body-centred cubic lattice with a simple
cell of length of side a, b, c.

(i) Derive the translational vectors of the primitive [3]
lattice, $\vec{a}', \vec{b}'$ and $\vec{c}'$ in terms of a, b, c and the unit
vectors $\hat{x}, \hat{y}, \hat{z}$.

(ii) Determine the volume of the primitive cell. [4]

(iii) Determine the translational vectors $\vec{A}, \vec{B}, \vec{C}$ of the [7]
primitive reciprocal lattice.

Q. 2 (a) Explain why crystal diffraction is not possible with photons [3]
at optical wavelengths, i.e. $\lambda \approx 5000\text{Å}$

(b) Explain what crystal diffraction is evidence of? [3]

(c) Derive the Bragg equation which defines the minimum condition forthe diffraction of incident radiation of wavelength λ at an angle θ from the (hkl) planes in a crystal. [4]

(d) In an x-ray powder diffraction experiment performed on analuminium powdersample the Bragg diffractionangles were found to be

19.23,22.4,32.54,39.10,49.52,56.00,58.30 and 68.80 degrees.

If the incident radiation has a wavelength 1.54Å
(i.) Find the indices of the lines [5]
(ii.) Identify the lattice type, giving reasons for your choice [2]
(iii.) Find the unit cell size in Å. [2]
(iv.) Given that aluminium has atomic mass of 27.0, find the density of aluminium. [6]

Q. 3 (a) (i) State the type of interactions found in ionic crystals. [4]

(ii) Then show how you would arrive at the total lattice energy of an ionic crystal of KCl, composed of N molecules. [10]

(iii) What is the total energy at equilibrium separation R_0? [7]

(b) Draw a simple diagram showing the energy of a molecule of an ionic crystal in dependence on ion separation. [4]

Q. 4 (a) Briefly describe the phonon contribution to heat transport. [2]

(b) Given Planck's distribution

$$n(\omega) = \frac{1}{e^{\hbar\omega/k_uT} - 1}$$

(i.) Explain why this distribution is suitable for phonons [3]
(ii.) Show that in thermal equilibrium at temperature T, the average energy of a sufficiently long wavelength mode is k_BT, where k_B is Boltzmann's constant. [5]

(c) At temperatures much less than the Debye temperature θ_D [10]

(Q. 4 continued)

approximately how many modes will be excited?

(d) Use your answer from part (c) above to show that for $T << \theta_D$, the specific heat due to atomic vibrations is of the order of [5]

$$Nk_B(\theta_D / T)^3,$$

where N is the number of atoms in the solid specimen.

Q. 5 (a) For a Fermi electron gas define

(i.) the density of electron states [2]
(ii.) the Fermi energy and explain its physical significance [3]

(b) The density of electron states in a crystal of volume V is

$$D(E) = \frac{V}{2\pi^2}\left(\frac{2m}{\hbar^2}\right)^{\frac{3}{2}} E^{\frac{1}{2}}$$

where m is the electron mass and E is the energy.
Show that

(i.) the concentration of free electrons is [4]

$$\frac{N}{V} = \left(2mE_F / \hbar^2\right)^{3/2} / \left(3\pi^2\right)$$

(ii.) the kinetic energy density U_0 at 0 K is [7]

$$U_0 = \frac{3}{5} E_F \frac{N}{V}$$

where N is the total number of electrons and E_F is the Fermi energy.

(c) Determine the free electron concentration for the monovalent sodium (Na) metal, which has a body-centred cubic (bcc) structure with lattice constant $a = 4.28\text{Å}$. [7]

(d) Hence estimate U_0 and E_F for sodium using the above relations. [2]

Q. 6 (a) Explain what is

(i.) an intrinsic semiconductor and explain why it is a [3]
perfect insulator at $T = 0K$

(ii.) what is the effective mass of charge carriers and [3]
explain its importance in the description of solid
state properties.

(iii.) energy band gap and describe its importance in [3]
determining the electrical properties of dielectric
crystals.

(b) In a semiconductor the concentrations n and p of
conduction band electrons and valence band holes
are given by

$$n = Cm_n^{3/2} e^{(E_F - E_g)/K_B T}$$

$$p = Cm_p^{3/2} e^{-E_F/k_B T}$$

where $C = 2(k_B T / 2\pi\hbar^2)^{3/2}$, m_n and m_p are electron and hole
effective masses, respectively, E_F and E_g are the Fermi
energy and the energy band gap respectively.

(i.) Show that the expression for E_F in terms of E_g, [8]
m_n and m_p for an intrinsic semiconductor is

$$E_F = \frac{E_g}{2} + \frac{3}{4} k_B T \ln\left(\frac{m_p}{m_n}\right)$$

(ii.) What is the position of E_F relative to the [3]
conduction and valence band edges for
$m_n > m_p$ at finite temperatures T?

(c) Show that in the intrinsic region the electrical conductivity [5]
σ is proportional to
$$e^{-E_g/2k_B T}$$

**END OF EXAMINATION**

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATION
MAY 1999
P441
ANALOG ELECTRONICS

TIME 3 HOURS   MAXIMUM MARKS 100

ANSWER 4 QUESTIONS
ALL QUESTIONS CARRY EQUAL MARKS

Q.1.   a) What is the difference between negative feedback and positive feedback with regards to the golden rule? Golden rule is given by $\dfrac{V_o}{V_i} = \dfrac{A}{1 - \beta A}$.   [2]

b) Derive the output of a non-inverting amplifier using the simple equivalent circuit of an op-amp. The result should include the op-amp gain A.   [1

c) From the result in part b) find the expression for the feedback factor β.   [?

d) Derive the transfer function for the inverting adder with n inputs.   [$

Q.2.   a) For the circuit below find the voltage transfer function. $v_3 = k_1 v_1 + k_2 v_2$.   [8
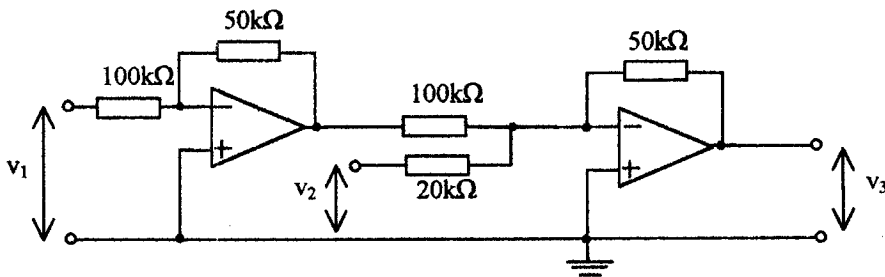
b) Calculate the power delivered to the 10kΩ resistor in the voltage follower below using the improved model of the Op-amp (includes input and output resistance). $R_i = 1M\Omega$, $R_o = 30\Omega$.   [11]
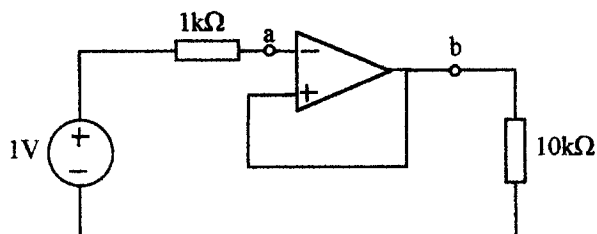
c) Calculate the power delivered to the same resistor if the points a and b are shorted.   [4]

d) Comment on the advantage of using the voltage follower at the output of voltage supplies.   [2]

Q.3.   a) What is the advantage of using Laplace transforms in circuit analysis to other   [2]
methods.

b) For the circuit below find $v_o(t)$. given that $v_i(t) = 10u(t)$, $v_1(0-) = 1$, $v_2(0-) = 0$.   [13]
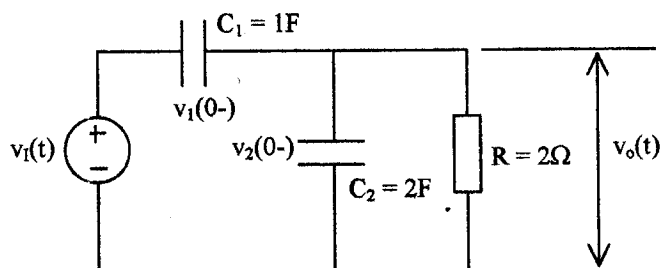
c) For the same circuit if $v_i(t)$ is a sinusoidal voltage determine the frequency   [10]
response $H(j\omega)$. Hence find the magnitude $|H(j\omega)|$.

Q.4.   a) What is the advantage of using a second order butterworth low-pass filter
instead of a first order filter.   [2]

b) Design a second order Butterworth low pass filter with cutoff frequency f_c =
100Hz and a pass band gain of 6dB.   [12]

c) Draw the bode plot indicating the cutoff frequency and roll off rate.   [6]

d) Show that the phase at cutoff is -90°.   [5]

Q.5.   a) The equation for a simple harmonic oscillator can be given by

$$m\frac{d^2x(t)}{dt^2} = -kx(t).$$ Where $x(t)$ is position as a function of time,

k is a constant,
m is the mass.

Make an analog circuit using Op-amp circuit elements to simulate simple
harmonic motion. How is the initial position and velocity set?   [12]

b) Draw the circuit of the wien bridge oscillator circuit and show that the
oscillation frequency $\omega_r = 1/RC$.   [13]