THE UNIVERITY OF ZAMBIA
UNIVERSITY EXAMINATIONS
FIRST SEMESTER AUGUST 2003

1. BS 111	:	CELL BIOLOGY AND GENETICS (THEORY PAPER)
2. BS 211	:	CELL MOLECULAR BIOLOGY AND GENETICS
3. BS 221	:	FORM, FUNCTION & DIVERSITY OF PLANTS (THEORY PAPER)
4. BS 321	:	ETHOLOGY AND EVOLUTION (PAPER II: PRACTICAL)
5. BS 341	:	MICROBIOLOGY (PAPER I THEORY)
6. BS 341	:	MICROBILOGY (PAPER II PRACTICAL)
7. BS 351	:	ENTOMOLOGY (THEORY PAPER)
8. BS 361	:	MOLECULAR BIOLOGY)
9. BS 375	:	INVERTEBRATE ZOOLOGY
10. BS 411	:	INSECT BEHAVIOUR AND ECOLOGY
11. BS 425	:	IMMUNOLOGY (THEORY)
12. BS 431	:	ADVANCED PARASITOLOGY I (THEORY)
13. BS 431	:	ADVANCED PARASITOLOGY I (PRACTICAL)
14. BS 475	:	POPULATION ECOLOGY (PAPER I)
15. BS 491	:	FRESHWATER BIOLOGY
16. BS 915	:	BIOLOGY OF SEED PLANTS (THEORY PAPER)
17. C 101	:	INTRODUCTORY CHEMISTRY I
18. C 225	:	ANALYTICAL CHEMISTRY
19. C 245	:	INORGANIC CHEMISTRY
20. C 251	:	ORGANIC CHEMISTRY I
21. C 321	:	FOOD CHEMISTRY THEORY
22. C 321	:	ANALYTICAL CHEMISTRY II (SPECTRAL ANALYTICAL METHODS)
23. C 321	:	CHEMISTRY PRACTIAL
24. C 341	:	INORGANIC CHEMISTRY II
25. C 351	:	ORGANIC CHEMISTRY III
26. C 411	:	ADVANCED BIOCHEMISTRY I
27. C 421	:	APPLIED ANALYTICAL CHEMISTRY
28. C 451	:	ADVANCED ORGANIC CHEMISTRY
29. C 481	:	INORGANIC INDUSTRIAL CHEMISTRY
30. CAV 251	:	ANALYTICAL/PHYSICAL/ORGANIC CHEMISTRY
31. GEO 111	:	INTRODUCTION TO HUMAN GEOGRAPHY
32. GEO 175	:	INTRODUCTION TO HUMAN GEOPGRAPHY
33. GEO 175	:	INTRODUCTION TO MAPPING TECHNIQUES
34. GEO 211	:	THE GEOGRAPHY OF AFRICA
35. GEO 271	:	INTRODUCTION TO QUANTITATIVE TECHNIQUES IN GEOGRAPHY I
36. GEO 381	:	ENVIRONMENT AND DEVELOPMENT
37. GEO 451	:	LAND RESOURCE SURVEY

38. GEO 911	:	POPULATION GEOGRAPHY
39. GEO 921	:	ECONOMIC GEOGRAPHY
40. GEO 931	:	RURAL GEOGRAPHY
41. M111	:	MATHEMATICAL METHODS I
42. M 161	:	INTRODUCTION TO MATHEMATICS PROBABILITY AND STATISTICS I
43. M 211	:	MATHEMATICAL METHODS III
44. M 221	:	LINEAR ALGEBRA I
45. M 231	:	REAL ANALYSIS I
46. M 261	:	INTORDUCTION TO STATISTICS
47. M 325	:	GROUP AND RING THEORY
48. M331	:	REAL ANALYSIS III
49. M 361	:	MATHEMATICAL STATISTICS
50. M 411	:	THEORY OF FUNCTIONS OF A COMPLEX VARIABLES I
51. M 421	:	STRUCTURE AND REPRESENTATIONS OF GROUPS
52. M 431	:	REAL ANALYSIS
53. M 461	:	MULTIVARIANT ANALYSIS
54. M 911	:	MATHEMATICAL METHODS V
55. P 191	:	INTRODUCTION PHYSICS I
56. P 351	:	INTRODUCTION TO QUANTUM MECHANICS
57. P 411	:	NUCLEAR EXPERIMENTAL TECHQUES
58. P 421	:	SOLID STATE PHYSICS I
59. P 441	:	ANALOG ELECTRONICS

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47. M 325 : GROUP AND RING THEORY
48. M331 : REAL ANALYSIS III
49. M 361 : MATHEMATICAL STATISTICS
50. M 411 : THEORY OF FUNCTIONS OF A COMPLEX VARIABLE
51. M 421 : STRUCTURE AND REPRESENTATIONS OF GROUPS
52. M 431 : REAL ANALYSIS
53. M 461 : MULTIVARIATE ANALYSIS
54. M 911 : MATHEMATICAL METHODS V
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THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS
FIRST SEMESTER EXAMINATIONS – AUGUST 2003

BS 111
CELL BILOGY AND GENETICS
THEORY PAPER

TIME:	THREE HOURS	
ANSWER:	ALL QUESTIONS	
MARKS	CORRECT ANSWER	+4
	INCORRECT ANSWER	- 1
	BLANK SPACE	- 1
	DO NOT KNOW	0

NOTE:

1. The paper has two sections.
   Section A: Cell Biology and Biochemistry (1 – 50)
   Section B: Genetics (50 – 100)

2. Ensure that your question paper is complete.
   Report any anomalies to the invigilator now.

3. Return the question paper to the invigilator at the end of the examination period.

SECTION A:
CELL BIOLOGY AND BIOCHEMISTRY

1. Guanine always pairs up with …

   1. adenine
   2. uracil
   3. thymine
   4. cytosine
   5. guanine
   6. I do not know

2. What is the main difference between DNA and RNA?

   1. absence of a phosphoric group in both of them
   2. the number of oxygen atoms in the pentose sugar
   3. the presence of a glycosidic bond in DNA
   4. DNA is acidic and RNA is basic
   5. DNA is found in eukaryotes whereas RNA is found in prokaryotes
   6. I do not know

3. Which molecule carries genetic information out of the nucleus?

   1. tRNA
   2. proteins
   3. mRNA
   4. enzymes
   5. amino acids
   6. I do not know

4. There are … essential amino acids which the human body is …to synthesise itself but which it … obtain from the diet.

   1. 9; not able; can
   2. 20; able; can
   3. 9; able; can
   4. 20; not able; can
   5. 9; able; can not
   6. I do not know

5. A large protein molecule, when dissolved in water with a pH of 4.0 has a +2 charge. At pH 7.0 the molecule has no charge (neutral). What would you expect the charge on the molecule to be in water that has a pH of 10.0?

1. a positive charge of unknown value
2. +2
3. between +2 and neutral
4. neutral
5. a negative charge of unknown value
6. I do not know

6. Cholestrerol …

1. holds membrane bound proteins within the lipid bilayer
2. helps to control the fluidity of cell membranes
3. has a role as a hormone receptor on the surface of membranes
4. is a water soluble molecule found in both prokaryotes and eukaryotes
5. is a toxic molecule not found in the body of healthy humans
6. I do not know

7. Homologous pairs of chromosomes line up at the equatorial zone of a cell during …

1. mitosis
2. meiosis
3. metaphase
4. meiosis I
5. meiosis II
6. I do not know

8. What happens when oxygen is not available during respiration?

1. the process of glycolysis stops
2. the production of ATP stops
3. reduction of NAD to NADH in the Krebs cycle stops.
4. there is increased production of ATP in the electron transport chain system
5. less ATP is produced during glycolysis
6. I do not know

9. A plant cell with a thick cell wall and an animal cell were placed in distilled water. What would you expect to happen if the solute concentration of the animal cell cytoplasm was the same as the fluid in the vacuole.

1. both cells would decrease in size and collapse
2. the animal cell would decrease in size but the plant cell would remain the same
3. both cells would remain the same size
4. the plant cell would increase in size and burst but the animal cell would remain about the same size
5. the animal cell would increase in size and burst but the plant cell would remain around the same size
6. I do not know

10. Which of the following characteristics are found in both chloroplasts and mitochondria

I. DNA
II. membranes
III. reproduce by binary fission

1. I, II and III
2. II and III only
3. I and II only
4. III only
5. I only
6. I do not know

11. Some biological material was collected. To which of the following would a positive test indicate the material was from a plant?

1. fat
2. cellulose
3. sugar
4. simple carbohydrate
5. protein
6. I do not know

12. In which of the following is the surface area to volume ratio of the cell most important to its function?

1. bone marrow cell
2. red blood cell
3. tooth enamel cell
4. white blood cell
5. plant fibre cell
6. I do not know

13. Which of the following would be best viewed using a transmission electron microscope?

1. surface of a pollen grain
2. the body of an insect
3. the internal structure of a mitochondrion
4. live microorganisms in a sample of water
5. the bonding of hydrogen to oxygen in the water molecule
6. I do not know

14. Prokaryotes are different from eukaryotes because prokaryotes …

1. have membrane bound organelles
2. are all autotrophic
3. posses a cell wall and a nucleus with a double membrane
4. lack ribosomes
5. reproduce by asexual reproduction only
6. I do not know

15. Natural fibres such as cotton and wool are widely used in clothing. Cotton is primarily composed of … and wool is primarily composed of …

1. protein; protein
2. protein; carbohydrate
3. protein; waxes
4. carbohydrate; protein
5. carbohydrate; carbohydrate
6. I do not know

16. An animal was discovered which had DNA that contained an additional two nucleotide bases. These two nucleotide bases form a base pair, so that the DNA contains six different bases which form base pairs. What would be the maximum number of amino acids that its DNA could code for, assuming that there are three stop codons that do not code for an amino acid and that there are the normal three bases per codon.

1. 213
2. 141
3. 125
4. 65
5. 61
6. I do not know

17. Large bodies of water like seas and oceans provide constant environmental conditions for life in them because …

1. water is transparent
2. the volume of water does not change drastically over a short period of time
3. water flows slowly
4. water is a useful nutrient for aquatic life.
5. some aquatic organisms drink water
6. I do not know

18. Define gel as in protoplasm.

1. non ionic substances in a large volume of water
2. proteins in a solution in which water is in higher proportion
3. a restricted loose network of polar substances in a small volume of water
4. ions in solution in protoplasm
5. water is the suspending medium of the non-ionic substance
6. I do not know

19. A functional group of a biological chemical compound

I. is soluble in water
II. determines the reactivity of the chemical compound
III. takes part in a chemical reaction.

1. I only
2. II and III only
3. I and II only
4. I, II and III
5. I and II only
6. I do not know

20. Which carbohydrates are important as an intermediate stage in the glycolysis pathway?

1. trioses
2. tetroses
3. pentoses
4. hexoses
5. disaccharides
6. I do not know

21. The following features are some of those found in a prokaryotic cell.

I. cell surface membrane
II. plasmids
III. mitochondria

1. I only
2. I and II only
3. I and III only
4. II and III only
5. I, II and III
6. I do not know

22. The following features are some of those found in a eukaryotic cell.

I. RNA
II. Ribosomes
III. Mitochondria

1. I only
2. I and II only
3. I and III only
4. II and III only
5. I, II and III
6. I do not know

23. Proteins are composed of long chains of monomers called … which are linked together by … bonds. These bonds are formed by …

1. monosaccharides; glycosidic; condensation
2. nucleotides, glycosidic; condensation
3. glycerol; hydrogen; dehydration
4. amino acids; peptide; dehydration
5. amino acids; peptide; condensation
6. I do not know

24. What are the waste products of glycolysis in yeast cells?

1. oxygen and water
2. carbon dioxide and lactic acid
3. alcohol and carbon dioxide
4. oxygen, water and carbon dioxide
5. carbon dioxide, lactic acid and alcohol
6. I do not know

25. Which of the following features are present in DNA?

I. uracil
II. pentose sugar
III. cytosine

1. I only
2. II only
3. I and III only
4. I, II and III
5. II and III only
6. I do not know

26. The two peptide chains in insulin are held together by ... bonds which form between ... amino acids.

1. hydrogen; three atoms of
2. disulphide; two chains of
3. peptide; adjacent
4. covalent; similar
5. ionic; residual
6. I do not know

27. Which of the following sets of words would construct a lipid?

I. Glycerol; fatty acids
II. Fatty acids; triglycerides
III. Triglycerides; glycerol

1. I, II and III
2. II only
3. I only
4. I and III only
5. III only
6. I do not know

28. The lipid used for cooking is … which is classified as …lipid.

1. an oil; an unsaturated
2. a fat; a saturated
3. a fat; an unsaturated
4. an oil; a saturated
5. a triglyceride; a saturated
6. I do not know

29. What is the function of acetyl co-enzyme A in the process of respiration?

1. accelerates the break down of pyruvic acid to provide raw materials for the Krebs cycle
2. it is a kind of enzyme which helps with the formation of ATP
3. forms a temporal intermediate complex with pyruvic acid to enter the mitochondrion
4. it provides the necessary energy for the production of ATP
5. the electron transport chain is less efficient in its presence
6. I do not know

30. The secondary structure of a protein may be a coil, known as … which is held in shape by … bonds between different monomers in the chain.

1. a pleated sheet; disulphide
2. an alpha helix; hydrogen
3. a double helix; ionic
4. a quarternary structure; polar
5. a tertiary structure; hydrogen
6. I do not know

31. Where in the cell are glycoproteins found?

1. in the cytosol as temperature stabilisers
2. in mitochondria as sources of energy
3. in bacteria as a carbohydrate storage substance
4. in the plasma membrane as sensory structures
5. in the plasma memrane as passage gates for non polar substances
6. I do not know

32. If the magnification of a specimen is 10u and the actual size of the specimen is 2u, what is the size of the image?

1. 0.2u
2. 5.0u
3. 20u ✓
4. 0.5u
5. 50.0u
6. I do not know

33. Water is an important … in living organisms because most biochemical reactions take place in aqueous solution. Water also has a high … that means that its temperature remains relatively stable despite large changes in the temperature of the surrounding environment.

1. solvent; viscosity
2. substance; force of cohesion
3. solvent;specific heat capacity ✓
4. organic substance; boiling point
5. inorganic substance; melting point
6. I do not know

34. Which of the following sets of information is/are true for sucrose?

I. fructose is part of the molecule
II. it is a reducing sugar
III. a glycosidic bond is part of the molecule

1. I and II only
2. II only
3. II and III only
4. I, II and III
5. I and III only
6. I do not know

35. Which carbon donates its hydroxyl group during the condensation of two glucose molecules?

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

36. Which of the following statements is **correct**?

1. alpha glucose has its hydroxyl group on carbon 1 below the plane of the benzene ring
2. beta glucose has its hydroxyl group on carbon 1 below the plane of the benzene ring
3. galactose is an isomer of glucose
4. adenine and guanine are pyrimidines
5. cytosine always pairs up with thymine
6. I do not know

37. Which of the following statements is **true**?

1. alpha glucose joined to another glucose molecule forms cellobiose
2. beta glucose joined to another glucose molecule forms cellobiose
3. the pentose sugar in nucleic acids is always a hexose sugar
4. deoxyribose sugar and ribose sugar are the same depending on the molecule in which they are found
5. fructose has only five carbons in its molecular structure
6. I do not know

38. The true starches which occur naturally are … and …whereas … is a starch produced by animals

1. amylose; glucose; glycogen
2. cellulose; glucose; glycogen
3. amylose; amylopectin; glycogen.
4. wax; sphingolipid; glucose
5. amyopectin; amylose; glucose
6. I do not know

39. When the alkyl group in an amino acid is replaced by the methyl group, the amino acid is called …

1. cysteine
2. leucine
3. valine
4. alanine
5. glycine
6. I do not know

40. Identify parts of a nucleotide.

I. hexose sugar
II. methyl group
III. pentose sugar
IV. glycosidic bond
V. ester bond
VI. carboxyl group
VII. base
VIII. amino group

1. I, II and VI
2. I, VI and VIII
3. II, IV and VI
4. III, VII and V
5. III, IV, and VII
6. I do not know

41. Milk becomes sour when ...

1. the milk solution is above the isoelectric point of its protein
2. the milk protein in solution becomes negatively charged
3. the pH of the milk solution is about the same as that of its protein
4. the solution of milk makes its protein develop a positive charge
5. the milk protein goes into a colloidal solution and therefore the protein precipitates out
6. I do not know

42. Which of the following pairs of terms are matched correctly?

I. Protein – peptide bond
II. DNA – hydrogen bond
III. Lipids – ionic bond

1. I and II only
2. I and III only
3. II and III only
4. I, II and III
5. III only
6. I do not know

43. In DNA a triple bond is found between …

1. A and C
2. G and T
3. C and T
4. A and G
5. C and G
6. I do not know

44. When a eukaryotic cell is examined under the light microscope at high magnification, the most prominent structure is likely to be the …

1. nucleus
2. ER
3. SER
4. golgi body
5. ribosome
6. I do not know

45. Enzymes are synthesized by/in the …

1. lysosomes
2. rough endoplasmic reticulum
3. smooth endoplasmic reticulum
4. nucleus
5. mRNA
6. I do not know

46. Chiasma formation takes place in … of …

1. prophase; meiosis II
2. metaphase; meiosis
3. prophase; meiosis I
4. prophase; mitosis
5. metaphase; mitosis
6. I do not know

47. Mitosis is a useful cell division because it …

1. brings about variation in genetic material
2. sets the stage for sexual reproduction
3. restores the haploid number of chromosomes in a cell
4. only takes place when an organism is ready for reproduction
5. replaces damaged cells in an organism
6. I do not know

48. What is the end product of glycolysis?

1. acetyl co-enzyme A
2. ATP
3. pyruvic acid
4. phosphoglyceraldehyde
5. adolase
6. I do not know

49. Which of the following statements is **false**?

1. the most useful product of the Krebs cycle is ATP
2. in the formation of lactic acid NADH is oxidized while pyruvic acid is reduced
3. glycolysis is not the main pathway for ATP production
4. in the Krebs cycle, reactions can not proceed in the absence of oxygen
5. glucose finally yields two 3 – carbon compounds during glycolysis
6. I do not know

50. The electron transport chain of respiration takes place in the…

1. nucleoplasm of the nucleus
2. cytosol of the cell
3. stroma of the mitochondria
4. outer membrane of the mitochondria
5. inner membrane of mitochondria
6. I do not know

SECTION B: GENETICS

51. Which of the following is **not** a function of mitosis in humans?

1. repair of wounds
2. production of gametes
3. growth
4. multiplication of somatic cells
5. None of the above
6. I do not know

52. Which of the following traits is determined by one or few genes and is not amenable to environmental influences?

1. Sickle cell anemia
2. Crop yield
3. Skin pigmentation
4. Height
5. Two of the above
6. I do not know

53. Which of the following statements is **not** true about the ABO blood system?

1. Blood group is according to the proteins or antigens found on the surfaces of red blood cells.
2. The synthesis of proteins called, antigen A and B, is determined genetically, and is an example of the interaction of multiple alleles
3. If only antigen A is present, then anti-B antibodies will be in the plasma.
4. Group O people have neither of the antigens so may donate their blood to all other groups.
5. None of the above
6. I do not know

54. The condition in which one pair of alleles code for contrasting phenotypic characteristics; one allele is dominant and one recessive is termed as…

1. genotype
2. gene interaction
3. heterozygote
4. phenotype
5. Polydactyl
6. I do not know

55. One of the coincident factors for erythroblastosis fetalis to occur in certain pregnancies in humans is:

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. Non of the above
6. I do not know

56. Genetic screening involves certain tests to assess whether an individual possess an abnormal gene or a chromosome mutation. The presence of a triple X Syndrome in a fetus can be determined by amniocentesis. A small amount of amniotic fluid is removed for cell culture, and the nuclei stained with a special dye. How many barr bodies do you expect to see in the cell nuclei of a triple X syndrome patient?

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

57. Phenylketonuria means ketone bodies appearing in the urine in abnormally excessive amounts. It is a symptom of a group of genetic diseases affecting the metabolism of amino acids phenyalanine and tyrosine. In this disease a single mutant gene is involved. This is an example of ....

1. pleiotropy
2. modifiers
3. variable expressivity
4. epistasis
5. dominance
6. I do not know

58. A photograph of a dividing cell from *Drosophila melanogaster* showed 4 chromosome pairs each consisting of homologous chromosomes. During which of the following stages of cell division could this picture have been taken?

1. Prophase II of meiosis
2. Telophase of meiosis
3. Prophase I of meiosis
4. Anaphase of meiosiss
5. Prophase of mitosis
6. I do not know

59. Which of the following statements is **false**?

1. sister chromatids separate from each other in anaphase of mitosis
2. in humans the males are the homogametic sex
3. the diploid phase of the human life cycle begins with fertilization
4. homologous chromosomes carry the same information for the same trait.
5. Genes carried on the X chromosome are called sex-linked genes.
6. I do not know

60. In the short horn breed of cattle, all the offspring of a white cow and a red bull were spotted with red and white colours. The simplest explanation for this pattern of inheritance is…

1. Autosomal inheritance
2. Independent assortment
3. Co-dominance
4. Hypostatic alleles
5. Incomplete dominance
6. I do not know

61. In question 60 above what would be the phenotypic ratio of the of the progeny from a cross among the red- and white-spotted animals?

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

62. In some of his experiments, Mendel studied the inheritance of patterns of two traits at once – flower colour and pod shape, for example. He did this to find out…

1. how sex linked genes behave
2. whether factors for different traits are inherited together or separately
3. how many genes are responsible for determining a particular trait
4. whether genes are on chromosomes
5. how many different genes are on chromosomes
7. I do not know

63. A man who has type O blood and a woman who has type A blood could have children of the following phenotypes?

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

64. Hemophilia is a recessive sex linked trait which leads to the lack of a blood clotting factor in affected individuals. If a normal woman with a history of the condition in the family marries a normal man. What would you tell the couple about the chances that they would have a hemophilic child?

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

65. One of the explanations for the high frequency of sex linked traits in males as compared to females is that.....

1. males are a weaker sex
2. males have the male hormone called progesterone
3. females have the female hormone called Oestrogen
4. the sex chromosomes in males are of unequal size
5. males have Y- linked genes
6. I do not know

66. What would be the phenotypic ratio of the cross AaBb x aabb?

1. 1AB : 1Ab:1 aB:1 ab
2. 3AB :3Ab:1 aB :1ab
3. 9AB: 3AB: 4ab
4. 3AB: 1Ab:3aB:ab1
5. 9AB:3Ab:3 aB :1ab
6. I do not know

67. The cross in Question 66 above is called:

1. A back cross
2. A dihybrid cross
3. A double heterozygote cross
4. A test cross
5. Two of the above
6. I do not know

68. Variable expressivity can be defined as…

1. the percentage of individuals with a particular gene combination which exhibit the corresponding character
2. the degree of the effect produced by a penetrant genotype
3. the modification of the effect of a particular allele by the environment
4. masking of the effect produced by one pair of alleles by another pair of alleles
5. the combined effect of sub-lethal genes
6. I do not know

69. The tall aggressive syndrome is associated with what type of chromosome change?

1. Chromosome deletion
2. Change in a single DNA base (point mutation)
3. Primary non-disjunction
4. Non –disjunction in one of the autosome chromosomes
5. X –ray damage to the germplasm
6. I do not know

70. Individuals of genotype BB will have a bald head whether they are females or males. On the other hand heterozygotes (Bb) will only show baldness if they are males. Homozygous (bb) males and females have no pattern baldness. Patten badness is therefore an example of …

1. Sex limited trait
2. Sex influenced trait
3. Autosomal recessive trait
4. Autosomal dominant trait
5. Holandric trait
6. I do not know

71. In peas , the gene for smooth seeds is dominant to the gene for wrinkled seeds. Pea plants from homozygous smooth seeds were crossed with pea plants from wrinkled seeds. What were the ratios of the progeny phenotypes in the F2?

1. 1 smooth : 1 wrinkled
2. 3 smooth :1 wrinkled
3. all smooth
4. 1 smooth:2 oval:1 wrinkled
5. all wrinkled
6. I do not know

72. A sex linked dominant allele causes hypophosphatemia in humans. A man with hypophosphatemia marries a normal woman. What proportion of their daughters will be affected?

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

73. In *Drosophila*, the recessive white eye gene (w) is sex linked. The phenotypic ratio of the F2 progeny of the cross WW x wy would be

	red females	white females	red males	white males
1.	2	1	2	1
2.	1	1	1	1
3.	1	-	-	1
4.	2	-	1	1
5.	1	-	1	-
6.	I do not know			

74. In rabbits, the coat colour is determined by the following series of multiple alleles: Agouti (C^+)> Chinchila(C^{ch})>Himalayan (C^h)>Albino (c). What is the phenotypic ratio of the progeny of the cross : $C^h C^h$ x C^+c

	albino	himalayan	chinchilla	agouti
1.		1	1	
2.	1	1		
3.	2	1	1	1
4.	1	1	1	1
5.		1		1
6.	I do not know			

75. Which of the following is **not** a feature of meiosis?

1. crossing over
2. gamete formation
3. source of variation
4. maintenance of a species ✓
5. none of the above
6. I do not know

76. Which of the following is not a sex linked trait

1. red-colour blindness
2. absence of central incisors
3. muscular dystrophy
4. rhesus factor
5. 2 and 4 together
6. I do not know

77. Which of the following theories forms the core of the modern genetic theory?

1. acquired characteristics
2. vapour and liquids
3. preformation
4. particulate ✓
5. 2 and 3 together
6. I do not know

78. Several black guinea pigs of he same genotype were crossed and produced 65 black and 22 white offspring. What would you predict the genotypes of the parents to be?

1. Bb x Bb
2. BB x Bb
3. BB x BB
4. Bb x bb
5. None of the above
6. I do not know

79. 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?

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

80. 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. 100%
2. 33%
3. 50%
4. 75%
5. 25%
6. I do not know

81. 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

82. 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

83. If an organism with a diploid number of chromosomes of 20 produced four cells by meiosis, how many chromosomes would each cell have?

1. 40
2. 4
3. 5
4. 12
5. None of the above
6. 6. I do not know

84. 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

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

1. Monosomy
2. abnormal mitosis
3. Primary non-disjunction
4. abnormal meiosis
5. Trisomy
6. I do not know

86. 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

87. In a particular variety of corn, the kernels turn 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

88. 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

89. 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

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

91. 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. 3:1:6:2:4
2. 9:3:3:1
3. 3:1:6:2
4. 3:1:6:2:1
5. none of the above
6. I do not know

92. 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

93. 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. 1 and 2 together
6. I do not know

94. Which of the following statements is **false** about continuous characters
1. they are influenced by both genotype and environment
2. they are determined by polygenes
3. phenotypic measurements form a spectrum
4. also called quantitative characters
5. single gene effects can easily be detected
6. I do not know

95. 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

96. A gene such as the one responsible for the Tay-sachs disease (ganglioside lipidosis) which kills individuals before reproductive age is referred to as

1. a recessive lethal gene
2. a sublethal gene
3. a complete lethal gene
4. a dominant lethal gene
5. a super lethal gene
6. I do not know

97. A brown-eyed man marries a blue-eyed woman, and they have eight children all brown-eyed. What are the genotypes of all the children in the family?

1. Both the dominant and recessive alleles are expressed equally in all the eight children
2. Homozygous for the dominant allele for brown eyes
3. Some children are homozygous for the dominant brown eye allele while others are hererozygous
4. Homozygous for the recessive allele for blue eyes
5. Heterozygous for the dominant allele for brown eyes
6. I do not know

98. A blood test for Mr. Hantobolo gave the reactions indicated below.

Antisera-A	Antisera-B	Anti-Rh sera	Antisera-M	Antisera-N
-	+	-	+	-

What are the probable genotypes of Mr. Hantobolo in relation to the above blood tests?

1. $I^{B}irrMM$
2. $I^{A}iRRNN$
3. $I^{B}I^{B}RRMM$
4. $I^{A}I^{A}RRNN$
5. $I^{B}I^{B}rrNN$
6. I do not know

99. What are the probable genotypes of Mr. Hantobolo's parents

	Mother	Father
1.	I^{A}iRRMN	$I^{A}I^{B}$ rrMM
2.	I^{A}iRrMN	$I^{A}I^{B}$ rrMM
3.	I^{A}irrNN	$I^{B}I^{A}$ RrMN
4.	$I^{A}I^{A}$rrMN	$I^{B}I^{B}$ rrMM
5.	iirrMN	$I^{A}I^{B}$ rrNN
6.	I do not know	

100. Given that Turner's syndrome patients have a genotype 45 AAXO. Turner's syndrome individuals are phenotypically

1. Bisexual (have both male and female features)
2. moon faced sterile males with a cat cry
3. sterile males with breasts and long legs
4. sterile females with underdeveloped sex organs
5. are females with cancer of the bone marrow
6. I do not know

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER UNIVERSITY EXAMINATIONS

AUGUST 2003

BS 211

CELL MOLECULAR BIOLOGY AND GENETICS

PRACTICAL PAPER

TIME: TWO HOURS THIRTY MINUTES

INSTRUCTIONS: Answer **Question 1** and any other two questions.

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1. You Have been provided with three lots of homogenized germinating seeds, germinating for 1, 2 and 3 days.

   Follow the metabolism of the reserve substances in the seeds during germination by carrying out qualitative tests for proteins and carbohydrates in each of the samples.

   Note the results in each case and record.

   Report you experiment in the following format:

   Title of Experiment
   Aim
   Procedure
   Results.

   (i) What is the main reserve substance in the seeds?
   (ii) What do your results indicate regarding the metabolic events that might accompany germination in the particular seeds?

2. Suppose that you have a homozygous stock carrying the autosomal recessive genes a, b and c linked in that order. You cross females of this stock with males of the homozygous wild-type. You then cross the F1 heterozygous males with their heterozygous sisters and obtain the following F2 phenotypes:

Genotype	Number
+++	1,364
a++	47
a+c	5
++c	84
+bc	44
+b+	4
ab+	87
abc	365

WHAT IS THE COEFFICIENT OF COINCIDENCE?

3. In a diploid plant, the three loci A/a, B/b, and C/c are linked as follows:

A/a 20m.u B/b 30m.u C/c

One plant is available to you (call it the parent plant) of the following constitution:-

$$\frac{A \quad b \quad c}{a \quad B \quad C}$$

(a) Assuming no interference, if the plant is selfed (allowed to self pollinate), what proportion of the progeny will be of the genotype abc/abc?

(b) Again assuming no interference, if the parental plant is crossed with the abc/abc plant, what genotypic classes will be found in the progeny and what will their frequencies be if there are 1000 progeny?

4a. The following M-N blood types were obtained from the entire populations of an isolated American Indian village and an isolated village of Central American Indians.

Group	Population size	M	MN	N
Central American Indian	86	53	29	4
American Indian	278	78	61	139

(a) Calculate the frequencies of the M and N alleles in the two populations.
(b) Discuss the possible reasons for the differences in allele frequencies between the two populations.

4b. What is the frequency of heterozygotes Aa in a randomly mating population if the frequency of recessive phenotypes (aa) is 0.09.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATIONS

AUGUST 2003

BS 221

FORM, FUNCTION AND DIVERSITY OF PLANTS

Theory Paper

TIME:	***Three Hours***
ANSWER:	**Five** questions, **One** from **Section A, Two** from **Section B** and **Another Two** from **Section C.** Use a **separate** Answer Book for **each** of the three Sections.

SECTION A

1. Outline the steps involved in the development of a moss from a spore into a sporophyte plant. Indicate which parts of the development cycle are haploid or diploid.

2. Describe the two main modes of reproduction in bryophytes.

SECTION B

3. What are the distinguishing features of Chaetophorales? Describe modifications of the thallus and reproduction shown by its members.

4. Describe the vegetative and reproductive structure of *Oedogonium* in detail and explain why this alga is considered as a special type.

5. Describe the ecology, structure, reproduction and economic importance of diatoms.

6. Write short notes on any FOUR of the following:

   i. Heterocyst
   ii. Conjugation in bacteria
   iii. Cell wall structure in blue-green algae
   iv. Plurilocular sporangia
   v. Chloroplast types of *Chlamydomonas*
   vi. Oogamy in *Fucus*

SECTION C

7. Compare and contrast the reproductive structures exhibited in the life cycles of species of the genera ***Isoetes*** and ***Psilotum***.

8. Give an illustrated account of some vegetative and reproductive features that are characteristic of the genus ***Equisetum***.

9. Make brief comments on any FOUR of the following concepts:

   a) Heterospory
   b) Dioecious plants
   c) Sori patterns in true ferns
   d) Synangia in *Psilotum*
   e) A 2-pinnatifid leaf structure

10. Describe some morphological and anatomical structures of the genus ***Pinus*** that could be correlated to plant adaptation to temperate climates.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS- AUGUST 2003

BS 319

BIOSTATISTICS

TIME: **THREE (3) HOURS**

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS. **TWO** FROM SECTION A, **TWO** FROM SECTION B AND **ONE** FROM EITHER SECTION A OR B. **SECTION A** AND **SECTION B** SHOULD BE ANSWERED IN **SEPARATE ANSWER BOOKS**. ALL QUESTIONS CARRY EQUAL MARKS.

SECTION A

1. In a certain locality where two species of Acacia trees are common, the probability that a randomly chosen Acacia tree is *Acacia tortilis* is 0.7 and that it is *A. xanthophloea* is 0.3. An entomologist believes that the probability of infestation by a particular species of insect are 0.05 and 0.20 respectively for the two Acacia species. Find :

(i) The probability of infestation for a randomly chosen Acacia tree irrespective of species.

(ii) The probability that an Acacia tree randomly chosen among all those infected is *A. xanthophloea.*

(iii) The probability that an Acacia tree randomly chosen among all those not infected is *A. tortilis*

(iv) The expected frequency of infestation if the sample size is 120 trees.

2. The mark distribution of boys and girls in a school examination were as follows:

Mark range (%)	**0-20**	**21-30**	**31-40**	**41-50**	**51-60**	**61-70**	**71-80**	**81-100**
Boys	6	8	9	13	10	8	6	4
Girls	5	4	7	10	14	10	5	5

Test whether the difference between the sexes is significant at 0.05 significance level.

3. The distance travelled (cm) by two constituents of a dye in 13 paper chromatographs were as follows:

Chromatograph	Constituent 1	Constituent 2
1	5.8	4.0
2	6.6	6.1
3	7.3	4.5
4	6.3	4.9
5	5.9	5.2
6	6.5	5.1
7	5.0	5.2
8	4.9	5.2
9	5.6	5.4
10	5.7	5.6
11	5.1	3.8
12	5.6	4.3
13	6.2	5.7

Is there any difference in the distance traveled by the two constituents when you assume that the variance is unequal? (significance level =0.05)

4. The concentration of fructose (mg%) before and after incubation was measured in 12 samples of bull semen; the values obtained were as follows:

Sample	Concentration before	Concentration after
1	116	30
2	190	58
3	570	100
4	375	48
5	236	58
6	505	153
7	120	54
8	322	66
9	429	67
10	102	34
11	167	69
12	299	82

Calculate

(i) The mean concentration of fructose before and after incubation

(ii) The log transformed mean concentration of fructose before and after incubation

(iii) The back transformed mean concentration of fructose before and after incubation

SECTION B

TAKE NOTE: ALL CALCULATIONS SHOULD BE DONE TO TWO DECIMAL PLACES FOR QUESTION 1 AND TO FOUR DECIMAL PLACES FOR OTHER QUESTIONS.

1. The function Y, natural log of fish number, versus X, natural log of mid-length, is often used to represent the size spectrum of fish communities. The following table provides the 1992 length-frequency distribution of the Sinazongwe area fish community in Lake Kariba, Zambia, as obtained from records of gill net surveys.

Mid-length (cm)	Number of fish
15	1865
25	1129
35	301
45	68
55	52
65	26
75	9
85	10
95	4
105	3

(i) Plot the scatter diagram of Y against X and draw the preliminary conclusions.
(ii) Calculate the regression coefficients and give the equation (i.e. the size spectrum function) of the regression line (if any).
(iii) Superimpose the fitted regression line on the scatter diagram plotted in (i) above.
(iv) Conduct an analysis of variance to test the strength of the size spectrum function established in (ii) (significance level = 0.05).
(v) Calculate and interpret the coefficient of determination of the regression.

2. In an experiment on maize grown as fodder crop, five plant densities were tested in a randomized block design with five blocks. The yield (Kg of dry matter per plot) were as follows:

Blocks	Plant density (plant per unit area)				
	20	**25**	**30**	**35**	**40**
I	21.1	26.8	30.4	28.4	27.6
II	16.7	23.8	25.5	28.2	24.5
III	14.9	21.4	27.1	25.3	26.5
IV	15.5	22.6	26.3	26.5	27.0
V	19.7	23.6	26.6	32.6	30.1

(i) Using an appropriate parametric approach, analyze the results of this experiment and write a summary of your conclusions (significance level = 0.05).

(ii) Assuming that the plant density and the block add their contributions for a certain yield without influencing each other, calculate the plant density effects and the block effects as well as the expected yields.

3. Nineteen pigs were divided into four groups, and each group was given a different feed. Their weights in kilograms are summarized below.

Feed 1	**Feed 2**	**Feed 3**	**Feed 4**
60.8	68.7	102.6	87.9
57.0	67.7	102.1	84.2
65.0	74.0	100.2	83.1
58.6	66.3	96.5	85.7
61.7	69.8		90.3

(i) Check the homogeneity of weight variances for pigs on all four feeds (significance level = 0.05).

(ii) Upon the conclusions drawn from (i) above, perform an appropriate test for the equality of weight of pigs fed with the four feeds (significance level = 0.001).

4. Concentrations of nitrogen oxides and of hydrocarbons (in $\mu g.m^{-3}$) were determined in a certain urban area.

Nitrogen oxides	Hydrocarbons
104	108
116	118
84	89
77	71
61	66
84	83
81	88
72	76
61	68
97	96
84	81

Test the appropriate hypotheses with Wilcoxon' s paired sample test (significance level = 0.05).

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS
AUGUST 2003

BS 321
ETHOLOGY AND EVOLUTION

PAPER II: PRACTICAL

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS IN SECTION **A**, AND **TWO** FROM SECTION **B**. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY.

SECTION A

1. Suppose in a court case being contested in a Ndola Resident Magistrate Court, the Ndola City Council was being sued for having allowed a chemical manufacturing plant to be located within the residential area. It is alleged that since the plant started operating, the incidences of child violence in schools had increased during the same period; and that this behavioral disorder was attributed to the gas produced from the chemical plant.

   In a court order, the following data were collected in two schools (near and far from the plant) for a period of five months.

	Period and Number of cases of violence				
Location (School)	June	August	October	January	March
Near the plant	11	8	24	21	35
Far location	3	12	17	17	29

   (a) From the data given above, do you think it was justifiable for the community to have taken the City Council to court?
   (b) List five possible causes of abnormal behaviour.

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

The most conspicuous feature in the social system of the Kob population studied is the selection of mating areas, consisting of a tight cluster of small territories, each occupied by one adult male. Beuchner in 1963 first described these arenas, leks, or territorial breeding grounds, hereafter abbreviated "TGs". They contain 10 – 20 central territories, each 15 – 34m in diameter, with contiguous boundaries, and a similar number of slightly larger and more widely spaced peripheral territories; a whole TG is ordinarily 200 – 400m 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.

(b) How could this behaviour affect (a) species dispersion and (b) population growth?

3. A survey of a breeding population of the Red Billed Quelea *(Quelea quelea)* in four habitat types in Lukanga swamp provided the following data on the average percent hatching success between 1970 and 1980.

Habitat Type	**Habitat Structure**	**Percent Nests with Young**	
		1970	**1980**
Echinochloa colunum	Medium tall grass	80	60
Aeschynomene sp.	Dense shrub thicket	65	15
Acacia tortolis	Young tree stand	73	40
Andropogon sp.	Very tall grass	15	10

On the basis of the data given, discuss the fate and success of the species in its decision of habitat selection for breeding.

SECTION B

4. Briefly describe the possible dysfunction (behavioral disorders) that might be caused by damage to the following structures (a) Hypothalamus (b) Limbic system (c) Pituitary gland (d) Occipital lobe.

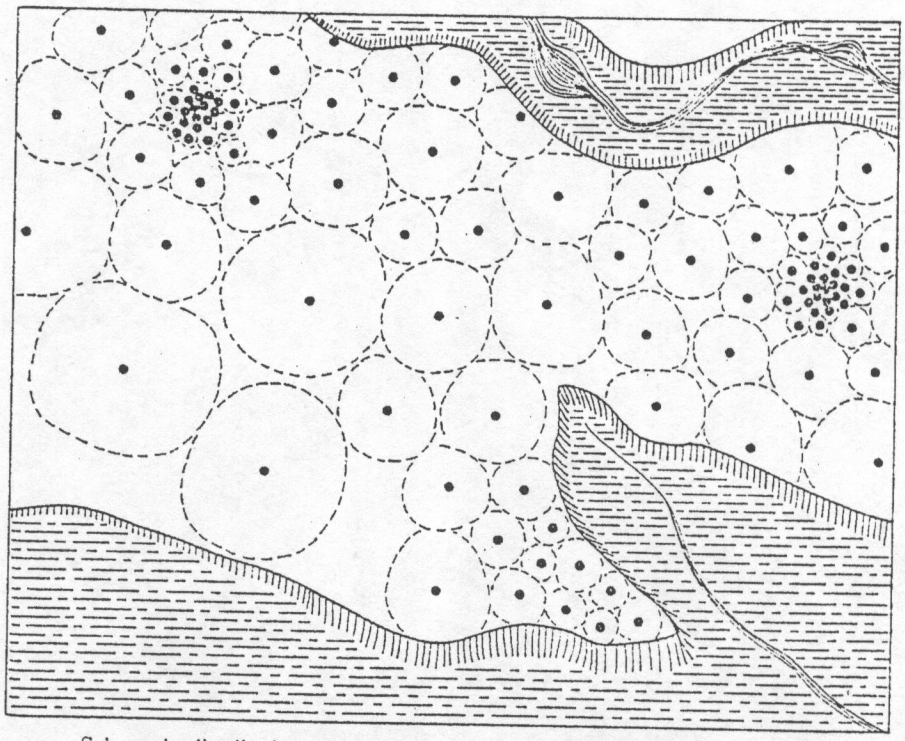
5. Contrast aggressive behaviour associated with (a) defence rage (b) Predation, and briefly outline the neural pathways involved in such aggressive behaviour.

6. What is meant by altruistic behaviour, and why was this behaviour a puzzle to ethologists who were interested in evolution.

7. Write short notes on the following terms as used in this course: (a) Ritualization (b) Ivan Pavlov (c) Homeostasis (d) Cooperative foraging.

END OF EXAMINATIONS

FIGURE



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).

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER UNIVERSITY EXAMINATIONS

AUGUST 2003

BS 341
MICROBIOLOGY

PAPER II - PRACTICAL

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS.
OBSERVE THE RULES OF SCIENTIFIC NOMENCLATURE.

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1. Describe the characteristics that a growth medium designed for the cultivation of microorganisms must possess.

2. When is it appropriate to use the following;

   (i) Fluorescence microscopy.
   (ii) Darkfield microscopy.
   (iii) Electron microscopy.

   Compare specimens to be observed, processing, resolving power and magnifications achieved.

3. Describe the steps that would be taken to obtain a pure culture of a microorganism that is found in low numbers in a soil sample. Indicate the type(s) of medium / media and conditions required to successfully isolate such an organism.

4. Anaerobic bacteria require special media and conditions for growth. Describe at least three methods and media that are employed to cultivate anaerobes. Name one important genus of anaerobic bacteria.

5. By what method(s) are microbes controlled in or on the following materials? Name the mechanism and indicate if sterility is achievable.

(i) Bacteriological media.
(ii) Tissue culture media.
(iii) Syringes, needles and other instruments.
(iv) Vaccines.
(v) Work surfaces in the laboratory.
(vi) Operating theatre in a hospital.

6. Differentiate the following types of media and give examples.

(i) Selective
(ii) Differential
(iii) Selective and differential
(iv) Enrichment

7. What properties of Agar – agar make it suitable for inclusion in bacteriological media?

8. Explain the following terms applied to a growing culture of a microorganism, indicating the nature of the culture:

(i) Colonial morphology
(ii) Growth characteristics and
(iii) Cell morphology.

What are the basic shapes found in bacteria and how are they observed? Give examples of bacteria possessing these morphologies.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER UNIVERSITY EXAMINATIONS

AUGUST 2003

BS 341
MICROBIOLOGY

PAPER I - THEORY

TIME: THREE HOURS

INSTRUCTIONS: ANSWERS TO SECTIONS **A** AND **B** SHOULD BE IN SEPARATE ANSWER BOOKS.

SECTION A: **Answer Question 1 and 2, and any other 3.**

1. (a) Define the following terms: Classification, nomenclature and identification. What is the definition of bacterial species and how are microorganisms named? (2 marks)

   (b) Discuss the criteria for classification and identification of microorganisms. Indicate the reference for laboratory identification of bacteria. (8 marks)

2. (a) How does bacterial conjugation differ from transformation and transduction with respect to: (i) the amount of DNA transferred (ii) morphological difference between donor and recipient cells. (5 marks)

   (b) What are bacterial plasmids? Give examples of three types of plasmids and their significance. (5 marks)

3. Explain why microorganisms that lack the respiratory system are not able to use molecular oxygen as the terminal electron acceptor. How do these microbes obtain the oxygen atoms that are essential / required for the biosynthesis of cellular components? Which metabolic pathway do these organisms use and what are / is the substitute electron acceptor(s)? (10 points)

4. Discuss the chemical composition, structure and functions of either the bacterial cell wall or plasma membrane. (10 marks)

5. (a) Explain the following terms: generation time, exponential growth and binary fission. (4 marks)

(b) How long will it take a bacterium with a generation time of 0.5 hours to grow from a population of 10^3 to 10^9 cells? (6 marks)

6. What are the component monosaccharides that make up the macromolecular network of the procaryotic cell wall. How are these sugars arranged and attached in both Gram positive and gram negative cell walls. (10 marks)

7. Distinguish between F^+, Hfr and F^- strains of *Escherichia coli* with respect to their physical nature and role in conjugation. (10 marks)

SECTION B: Answer all Questions

8. The relationship between any particular nucleotide sequence and its protein product is not straight forward. Discuss. (5 marks)

9. What is meant by positive or negative polarity of a viral nuclei acid? (2 marks)

10. Name any one of the viruses with the following type of nucleic acid:

(i) Linear single stranded DNA, minus sense and with Polandromic sequences at ends. (1 mark)

(ii) Circular double stranded DNA with region of single stranded DNA. (1 mark)

(iii) Segmented genome; 7 or 8 molecules of linear single stranded RNA, minus sense. (1 mark)

11. Describe the symmetry to the capsid of the adeno virus. (10 marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER UNIVERSITY EXAMINATIONS – APRIL 2002.

BS 341 MICROBIOLOGY

PAPER II PRACTICAL

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS 20 points

1. Two cultures are provided:

   i. Mixed broth culture in bijou bottle labelled I
   ii. Agar culture labelled II

   Culture No. II was derived from culture No. I. Using Gram stain, determine the morphological types of bacteria growing in culture I and II

   Describe the colonial and cultural characteristics of the organisms growing on culture II. Compare the organisms growing on the two cultures. How many morphology types are present in both cultures? What type of medium is medium No? II and of what value is it to the study of microorganisms?

   8 points

2. In what ways does microbial growth vary within a colony. What factors might cause variation in growth? 2 points

3. Describe the following kinds of media and their uses. Give examples of each.

   1. Defined media
   2. Complex media
   3. General purpose media
   4. Selective media
   5. Differential media and
   6. Enriched media

   4 points

4. If you wished to obtain a pure culture of bacteria that could degrade benzene and use it as a carbon and energy source, how would you proceed?

   3 points

5. What are the functions of substage condenser and immersion oil in microscopy? 2 points

6. What is meant by aseptic techniques? Give examples. 1 point

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS
AUGUST, 2003

BS 351 : ENTOMOLOGY

THEORY PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS. TWO QUESTIONS FROM SECTION A AND TWO QUESTIONS FROM SECTION B. THE LAST QUESTION CAN BE SELECTED FROM EITHER SECTION.

SECTION A

INSECT MORPHOLOGY, ANATOMY AND ORDERS

1. **One politician on a campaign trail for General elections in Zambia was heard saying, "Our children in schools should not be made to waste their time studying insects, as these creatures mean no good to mankind. Instead, the children ought to study English, Mathematics and the Sciences which will give them jobs after school". Argue for or against this statement.**

2. **Discuss the major modifications of insect legs, including those involving specialized structures and indicate the adaptive significance of each leg modification.**

3. **Name six Arthropod features exhibited by a grasshopper and five features found on the insect that are unique to Class insecta. Which of these features contributed to the evolutionary success of insects as terrestrial animals?**

4. **Describe the arrangements of retinular and pigment cells in an insect's compound eye and explain their roles in insect vision.**

SECTION B

INSECT PHYSIOLOGY AND BIOCHEMISTRY

5. **Distinguish between the, "Selective gene depression" and, "Ionic gene action" hypotheses in the explanation of the mode of action of ecdysones in insects. In your view, which of the two is more acceptable?**

6. **Distinguish between moulting and sclerotization during insect development and explain the roles played by named hormones in the two processes.**

7. **How does diapause differ from aestivation in insects? In your answer, also explain how diapause is induced and terminated.**

8. **Insect ecdysones have been proved to be responsible for initiating moults, while the juvenile hormone determines the morphological outcome of a given moult by suppressing the development of adult features or by promoting the retention of juvenile features. Explain how these two types of hormones interact to produce adult characters in the PUPA → ADULT moult.**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS

AUGUST, 2003

BS 411 : INSECT BEHABIOUR AND ECOLOGY

THEORY : PAPER I.

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

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1. **Distinguish between termite and ant insect societies, in terms of caste differentiation, labour, communication and colony establishment.**

2. **Discuss the basis of the diel rhythm of activities observed in cockroaches and explain under what circumstances such a rhythm can be altered.**

3. **What is innate and learned insect behaviour? In your answer, also explain what motivates fixed action patterns of behavior in insects.**

4. **What are social hormones? Give specific examples of those that are associated with reproduction and explain their mode of action.**

5. **Distinguish between strigilation and stridulation in insect behaviour, giving specific examples and explain the biological significance of these types of behaviour.**

6. **Explain what kinds of plant stimuli and insect responses are involved in host plant selection by phytophagus insects. What is it that finally makes such insects accept feeding on a particular host?**

7. **Distinguish between "token stimulus" and "phagostimulus" in insect behaviour, giving specific examples and the insects involved, including the biological significance of the stimuli.**

8. **How do insects produce light? In your answer, also compare and contrast insect light with that produced by the Zambia Electricity Supply Corporation (ZESCO).**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – AUGUST 2003

BS475

POPULATION ECOLOGY

(PAPER I)

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS AND USE ILLUSTRATIONS WHEREVER POSSIBLE.

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1. What are the advantages of seed dormancy in plants that inhabit seasonal and unpredictable environments.

2. How can you investigate the presence of seed dormancy in a plant species.

3. The quadrat is the foundation of plant demography and vegetation succession. Discuss this statement.

4. Discuss the fate of seed banks in an ecosystem.

5. A population with non-overlapping generations had 40 adult plants at time t. Each adult produced 10 seeds, with a germination rate of 25% and a recruitment rate of 50%. Prepare a diagrammatic life table for the population and calculate the new adult population in the succeeding generation. What assumption is associated with your analysis.

6. How does seed predation affect the distribution and population dynamics of a plant species.

7. How does variation in individual fecundity affect the genetic structure of future generations of a plant population.

8. Discuss conditions under which a biennial plant has competitive advantage over an annual plant.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGICAL SCIENCES

FIRST SEMESTER EXAMINATIONS: AUGUST 2003

BS 491 Freshwater Biology **Practical Paper**

Maximum Time Allowed **Three Hours**

Instructions

Attempt **all** questions in this paper. At the end of the examination, please hand in all the answer booklets and question papers.

Q1. A Freshwater ecologist assigned to study the limnology of a lake has completed one year of data collection. Table 1 below shows temperature measurements recorded during each month from July 1988 to June 1989 at different depths.

Table 1 Temperature data °C from the lake at different depths for one annual cycle

Depth (m)	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0	16	17	18	20	23	25	27	27	27	25	21	19
2	16	16	18	20	23	25	26	27	27	25	21	19
4	16	16	17	20	22	24	25	26	27	25	21	18
6	16	16	17	18	22	24	24	25	26	25	20	18
8	16	16	17	18	20	23	24	24	25	24	20	18
10	16	16	17	17	20	23	23	24	25	24	18	16
15	16	16	16	17	18	20	20	23	24	23	18	16
20	16	16	16	16	18	19	19	20	23	22	16	16
25	16	16	16	16	18	18	18	18	20	20	16	16
30	16	16	16	16	16	18	17	17	18	18	16	16
35	16	16	16	16	16	16	17	17	18	17	16	16
40	16	16	16	16	16	16	16	17	17	16	16	16
45	16	16	16	16	16	16	16	17	16	16	16	16
50	16	16	16	16	16	16	16	16	16	16	16	16
55	16	16	16	16	16	16	16	16	16	16	16	16
60	16	16	16	16	16	16	16	16	16	16	16	16

i) Construct an appropriate diagram designed to aid in describing the annual thermal regime of the lake under investigation.

ii) Briefly describe the thermal regime for the lake based on the diagram constructed in i. above.

iii) What is the appropriate category for the lake being investigated according to classification of lakes based on annual temperature regimes.

iv) In which part of the world would such a lake most likely be found.

Q2 Two small lakes with morphometric features indicated below are reported to occur within the same catchment area:

Lake A Depth(m)	Area(m2)	Lake B Depth(m)	Area (m2)
0m	550	0	1,500
20	350	10	800
40	240	20	80
60	160	30	50
80	60	50	10
100	20		
120	5		

i) Applying the formula:

$$V = \frac{h}{3}\{A_1 + A_2 + (A_1 \times A_2)^{1/2}\}$$

Estimate the volume of water that is in lake A and in lake B

ii) Construct hypsographic depth area and depth volume curves for both lakes.

iii) Based on the graphs constructed in ii above compare both lakes.

iv) Indicate which lake, A or B, is most likely more productive that the other. Give reasons for your answer.

Q3 A sample of water was collected from Lake A from a depth of 8 m for the determination of phyto-plankton concentration and the Utermoh's 1958 method was used. In this procedure, a 50 cm^3 sedimentation chamber was used and he counting chamber had radius of 1.0 cm. The diameter of the transect under the microscope was estimated at 0.1 cm. A transect across the entire diameter of the counting chamber recorded a mean value of 50 cells of *Melosira granulata*.

i) Estimate the number of *Melosira granulata* cells in a cm^3 at this depth. Explain the various stages of your calculations.

ii) From Lake B a sample was collected for the analysis of zooplankton. The sample was collected using a plankton net which was raised from a depth of 10 metres to the surface. The diameter of the plankton net used was 50 cm^3 and the volume of the bottle attached to the plankton net was 100 cm^3. From the bottle attached to the net a small sample of 1 cm^3 was collected for microscopic examination.

Twenty (20) *Daphnia sp.* individuals were enumerated in the 1 cm^3 put on the glass slide.

Estimate the mean number of *Daphnia sp.* organisms per cubic meter above the depth of 10m.

Q4 Morphometric parameters of water bodies have been used to estimate potential fish yields of reservoirs, floodplains and rivers. Table 2 below provides surface areas of selected common water bodies in Zambia

Table 2 Mean surface areas of selected water bodies.

Water Body	Mean Surface Area
Lake Itezhi-tezhi	360km^2
Kafue Floodplains	3,600 km^2
Lake Kariba	5,360 km^2
Zambezi River (Part of Zambezi now flooded by Lake Kariba)	300 km

i) Based on the relationships

$Y = 4.32 \times A^{1.005}$ for Floodplains

$Log_e Y = 3.57 + Log_e A$ for lakes and

$Y = \frac{L^2}{300}$ for rivers

Compute potential fish yields for the water bodies indicated above.

ii) Fish stock Assessments conducted after the formation of the Lake Kariba and Itezhi-tezhi indicated maximum sustainable yields as follows:

Lake Kariba	3,000 tonnes of fish per year
Lake Itezhi-tezhi	1,000 tonnes of fish per year

Give reasons for the differences between the predicted yields from morphometric parameters and those obtained from results of fish stock assessment studies.

iii) Briefly explain why reservoirs have different potential fish yields in comparison to natural lakes What can be done to improve the fishery potential performance of man made lakes?

END OF PRACTICAL EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATIONS

AUGUST 2003

BS 915

BIOLOGY OF SEED PLANTS

Theory Paper

TIME: ***Three Hours***

ANSWER: ***Five*** questions, ***One*** from ***Section A*** and ***Four*** from ***Section B***.
Use a **separate** *Answer Book* for **each** Section.

SECTION A

1. Describe three most important root and stem crops with their full botanical names. Describe their production techniques and ecology, and explain what measures you would take to popularise them as staple food.

2. Discuss seed structure and explain factors that govern seed viability. Explain measures that you would take to overcome seed dormancy.

3. Compare legumes with cereals and discuss their relative importance in human nutrition. Give examples of four different legumes and four different cereals with their full botanical names.

SECTION B

4. Compare and contrast structures relating to growth forms, morphological and anatomical features displayed by species of the genera *Cycas* and *Pinus*.

5. Describe the floristic contribution made by members of the leguminous tribes known as Amherstieae and Detarieae in the evolution of the mopane and miombo woodland in southern Africa.

6. Write brief notes on any **Five** of the following:
   a) International Code of Botanical Nomenclature
   b) Status of epiphytes in woodlands
   c) Syringic acid in Chemotaxonomy
   d) Role of mycorrhizae in plants
   e) Ring porous wood pattern
   f) Phytochoria of southern Africa

7. Comment on the importance of vegetation science to foresters, geologists, soil scientists and wildlife biologists.

8. To what extent would stipules be of diagnostic value in the identification of members of the tribes Amherstieae, Caesalpinieae and Detarieae within the family Fabaceae?

9. Describe changes in stele forms associated with the growth of a tree species from its primary phase to secondary phase of plant development. Comment on the nature of anatomical transformations simultaneously developing external to the cortex region.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATION - SEMESTER I 2003

INTRODUCTORY CHEMISTRY I - C101

August 2003

DURATION: 3 hours

INSTRUCTIONS TO THE CANDIDATES

Indicate your **computer number** and **TG number** on your answer booklet.

The Examination consists of two (**2**) sections: **A** and **B**

Section **A** has ten (**10**) short answer questions. **ANSWER ALL** (Total marks = **40**).
Questions carry equal marks.

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

YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.

DATA SHEET

- **THE PERIODIC TABLE IS PRINTED AT THE BACK OF THIS PAGE**

- **USEFUL DATA**

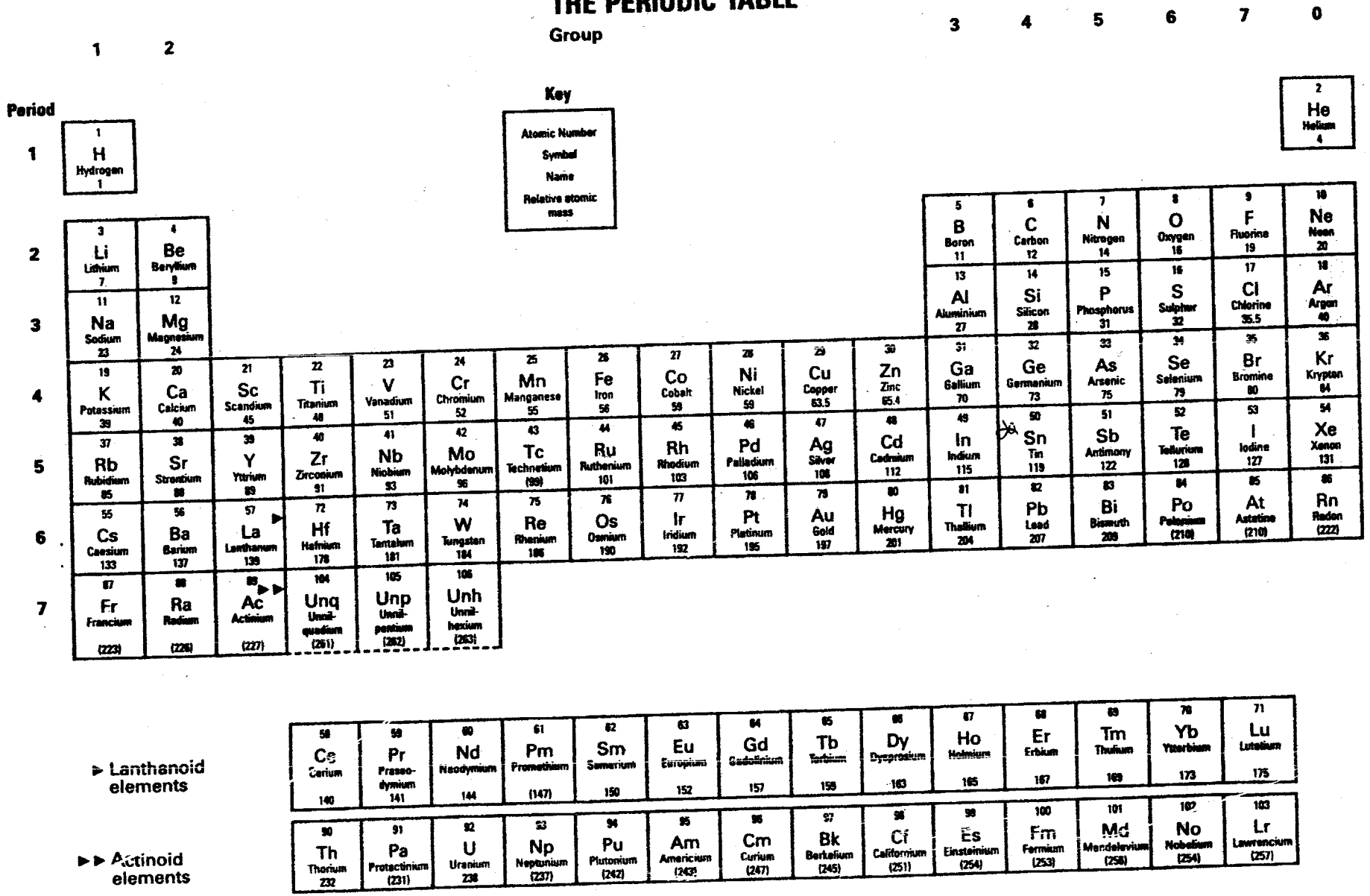
Avogadro's constant, N_A	= 6.02×10^{23} mol^{-1}
Molar volume of gas at S.T.P	= 22.4 dm^3
Universal gas constant, R	= 8.314 J K^{-1} mol^{-1}
	= 0.0821 L. atm. K^{-1} mol^{-1}
Planck constant, h	= 6.63×10^{-34} J sec.
Speed of light, c	= 3.00×10^8 m sec^{-1}
Faradays constant, *F*	= 96,485 C mol^{-1}
Rydberg constant, A	= 2.18×10^{-18} J
Mass of a Proton	= 1.007825 Mu
Mass of a neutron	= 1.008665 Mu

1 Pa = 1 N. m^{-2} = 1 J. m^{-3}
ln *x* = 2.303log *x*
1 eV = 1.60218×10^{-19} J
1 Mu = 1.661×10^{-27} kg
1 atm = 101325 Pa = 101325 Nm^{-2}

- **STANDARD ELECTRODE POTENTIALS (HALF-CELL)**

	E^O (volts)
Cl_2 (g) + 2 e^- → 2 Cl^-	1.360
Hg^{2+} + 2 e^- → Hg (l)	0.854
Ag^+ + e^- → Ag	0.800
I_2 + 2 e^- → 2 I^-	0.535
O_2 (g) + 2 H_2O(l) + 4 e^- → 4 OH^-	0.401
Sn^{2+} + 2 e^- → Sn	- 0.136

THE PERIODIC TABLE



SECTION A - ANSWER ALL QUESTIONS

A1 (a) Distinguish between *precision* and *accuracy* of measurement.

(b) Two students determined the density of a metal. Their results were as follows:

Experiment	1	2	3	4
Student 1 (g cm^{-3}):	4.49,	4.50,	4.52,	4.50
Student 2 (g cm^{-3}):	4.48,	4.57,	4.44,	4.53

If the density of the metal is 4.51 g cm^{-3},

(i) which student is more accurate and

(ii) which student is more precise?

A2 Calculate the binding energy in kJ mol^{-1} of ^{7}Li isotope [Ar of ^{7}Li = 7.01435]

A3 A small volume (100 cm^3) of a gas of unknown molar mass was allowed to effuse from a container and compared with the time that it took with the same volume of Argon to effuse under the same conditions. While the argon took 10.00 s to effuse, the other gas took 19.10 s. Calculate the molar mass of the gas.

A4 Tin reacts with oxygen when heated to give Tin(IV)Oxide, SnO_2. If 15.1 g of SnO_2 was produced. How much tin was used?

A5 Write the most plausible Lewis structure of the nitrosyl chloride, NOCl, one of the oxidising agents present in *aqua regia*, a mixture of concentrated nitric acid and hydrochloric acids capable of dissolving gold.

A6 Trimethylamine, Me_3N, reacts with boron trifluoride to form a compound of $Me_3N.BF_3$ (Me = CH_3). How may this reaction be written in terms of the shapes of the reactants and products?

A 7. (i) Noble gas elements exhibit stability not observed in other elements. Explain why and show the configuration in the electronic shell of highest principal quantum number.

(ii) State and explain which noble gas ionises most readily.

A8. A solution containing vanadium in unknown oxidation state was electrolyzed with a current of 1.50 A for 30 minutes. It was found that 0.475 g of vanadium was deposited on the cathode.

(i) How many moles of electrons were transferred in the electrolysis?

(ii) How many moles of vanadium were deposited?

(iii) What was the original oxidation state of the vanadium ion?

A9. Consider the following reaction, which occurs at 298.15 K and at 101,325 Pa:

$$Cl_2(g) + 2\,I^-(aq) \rightarrow 2\,Cl^-(aq) + I_2(s)$$

(i) Write the shorthand notation for the cell that could be set up to utilize the reaction. A salt bridge connects the two half-cells.
(ii) Calculate E^o for the cell.
(iii) Calculate the equilibrium constant K_{eq} for the reaction.

A10 (i) For the cell: $Sn \mid Sn^{2+} \mid\mid Ag^+ \mid Ag$

(a) Calculate E^o at 298 K and a pressure of 1 atmosphere.
(b) Write a balanced cell reaction.

(ii) Liquid mercury is a troublesome pollutant. It is transformed by natural processes into various chemical compounds harmful to biological systems. One such proposed process is the spontaneous oxidation of mercury by dissolved oxygen in water:

$$2\,Hg(l) + O_2(g) + 2H_2O(l) \rightarrow 2Hg^{2+}(aq) + 4OH^-(aq)$$

Is the proposed process reaction feasible? Explain your answer.

SECTION B - ANSWER ANY FOUR

B1. (a) (i) State *Charles law.*
(ii) Draw a graph to show the variation of volume of a fixed mass of a gas with temperature (°C) at a constant pressure.

(b) If a volleyball was inflated with a natural gas (CH_4) instead of air, it would be firm only if 180 g of the gas were pumped in at 25 °C.
(i) Compute the pressure exerted by the gas if the volume of the inflated ball was 3.00 dm^3.
(ii) Calculate the number of *molecules* of methane in the volleyball.

(c) Hemoglobin transports oxygen from lungs to the rest of the body. One molecule of hemoglobin combines with four molecules of oxygen. If 1.00 g of hemoglobin combines with 153 cm^3 of oxygen at 37°C and 0.987 kPa, calculate the molar mass of hemoglobin.

B2. (a) 0.500 g of Na_2CO_3 were treated with 32.5 cm^3 of hydrochloric acid, HCl, which was in excess. After the reaction, the excess HCl was titrated with sodium hydroxide, NaOH, solution, of which 12.3 cm^3 was required. In a separate experiment 12.6 cm^3 of same HCl required 13.9 cm^3 of NaOH solution. What are the molarities of solutions of NaOH and HCl?

(b) An alloy contains iron and manganese only. On warming with dilute nitric acid, 2.30 g of this alloy gave a solution containing iron(III) ions and manganese(II) ions. Treatment of this solution with excess sodium bismuthate(V) completely oxidised all Mn^{2+} ions present to MnO_4^- ions. The excess bismuthate ions were then completely destroyed and the solution made up to 250 cm^3 with distilled water and thoroughly shaken. Titration of 25.0 cm^3 of this solution required 25.0 cm^3 of standard 0.1000 mol dm^{-3} solution of iron(II)sulphate. If the unbalanced reaction for the titration is

$$Fe^{2+} + MnO_4^- + H^+ \rightarrow Fe^{3+} + Mn^{2+} + H_2O$$

(i) Balance the reaction.

(ii) Calculate the percentage of manganese in the alloy.

B3. (a) The elements in the third period show a change from metallic to non-metallic nature which is reflected in the bonding of their compounds.

(i) Describe the two major physical properties of the chlorides of the elements sodium and phosphorous.

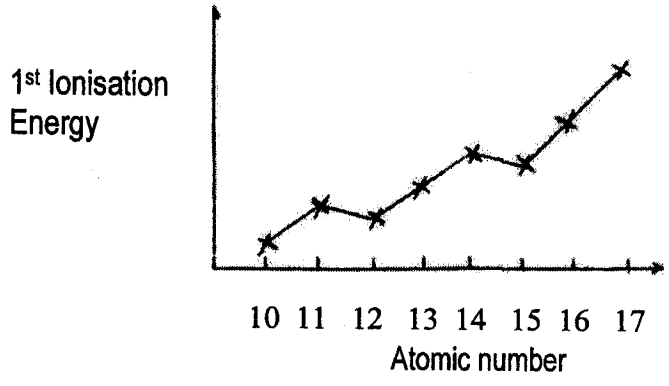
(ii) Relate the properties in (i) above to the structures and bonding in the chlorides.

(b) Explain the term *principle electronic shell (level)*.

(i) What do you understand by the term *photon*?

(i) In order for a photon of light incident upon metallic potassium to eliminate an electron from it, the photon must have a minimum energy of 4.33 eV (photoelectric work function for potassium). What is the wavelength of a photon of this energy?

(c) The variation of the first ionisation energy with proton number for the elements of the third period is shown below (Na – Ar). ***[Questions are on the next page]***



5. A large protein molecule, when dissolved in water with a pH of 4.0 has a +2 charge. At pH 7.0 the molecule has no charge (neutral). What would you expect the charge on the molecule to be in water that has a pH of 10.0?

1. a positive charge of unknown value
2. +2
3. between +2 and neutral
4. neutral
5. a negative charge of unknown value
6. I do not know

6. Cholestrerol ...

1. holds membrane bound proteins within the lipid bilayer
2. helps to control the fluidity of cell membranes
3. has a role as a hormone receptor on the surface of membranes
4. is a water soluble molecule found in both prokaryotes and eukaryotes
5. is a toxic molecule not found in the body of healthy humans
6. I do not know

7. Homologous pairs of chromosomes line up at the equatorial zone of a cell during ...

1. mitosis
2. meiosis
3. metaphase
4. meiosis I
5. meiosis II
6. I do not know

8. What happens when oxygen is not available during respiration?

1. the process of glycolysis stops
2. the production of ATP stops
3. reduction of NAD to NADH in the Krebs cycle stops.
4. there is increased production of ATP in the electron transport chain system
5. less ATP is produced during glycolysis
6. I do not know

9. A plant cell with a thick cell wall and an animal cell were placed in distilled water. What would you expect to happen if the solute concentration of the animal cell cytoplasm was the same as the fluid in the vacuole.

1. both cells would decrease in size and collapse
2. the animal cell would decrease in size but the plant cell would remain the same
3. both cells would remain the same size
4. the plant cell would increase in size and burst but the animal cell would remain about the same size
5. the animal cell would increase in size and burst but the plant cell would remain around the same size
6. I do not know

10. Which of the following characteristics are found in both chloroplasts and mitochondria

I. DNA
II. membranes
III. reproduce by binary fission

1. I, II and III
2. II and III only
3. I and II only
4. III only
5. I only
6. I do not know

11. Some biological material was collected. To which of the following would a positive test indicate the material was from a plant?

1. fat
2. cellulose
3. sugar
4. simple carbohydrate
5. protein
6. I do not know

12. In which of the following is the surface area to volume ratio of the cell most important to its function?

1. bone marrow cell
2. red blood cell
3. tooth enamel cell
4. white blood cell
5. plant fibre cell
6. I do not know

13. Which of the following would be best viewed using a transmission electron microscope?

1. surface of a pollen grain
2. the body of an insect
3. the internal structure of a mitochondrion
4. live microorganisms in a sample of water.
5. the bonding of hydrogen to oxygen in the water molecule
6. I do not know

14. Prokaryotes are different from eukaryotes because prokaryotes ...

1. have membrane bound organelles
2. are all autotrophic
3. posses a cell wall and a nucleus with a double membrane
4. lack ribosomes
5. reproduce by asexual reproduction only
6. I do not know

15. Natural fibres such as cotton and wool are widely used in clothing. Cotton is primarily composed of ... and wool is primarily composed of ...

1. protein; protein
2. protein; carbohydrate
3. protein; waxes
4. carbohydrate; protein
5. carbohydrate; carbohydrate
6. I do not know

16. An animal was discovered which had DNA that contained an additional two nucleotide bases. These two nucleotide bases form a base pair, so that the DNA contains six different bases which form base pairs. What would be the maximum number of amino acids that its DNA could code for, assuming that there are three stop codons that do not code for an amino acid and that there are the normal three bases per codon.

1. 213
2. 141
3. 125
4. 65
5. 61
6. I do not know

17. Large bodies of water like seas and oceans provide constant environmental conditions for life in them because …

1. water is transparent
2. the volume of water does not change drastically over a short period of time
3. water flows slowly
4. water is a useful nutrient for aquatic life.
5. some aquatic organisms drink water
6. I do not know

18. Define gel as in protoplasm.

1. non ionic substances in a large volume of water
2. proteins in a solution in which water is in higher proportion
3. a restricted loose network of polar substances in a small volume of water
4. ions in solution in protoplasm
5. water is the suspending medium of the non-ionic substance
6. I do not know

19. A functional group of a biological chemical compound

I. is soluble in water
II. determines the reactivity of the chemical compound
III. takes part in a chemical reaction

1. I only
2. II and III only
3. I and II only
4. I, II and III
5. I and II only
6. I do not know

20. Which carbohydrates are important as an intermediate stage in the glycolysis pathway?

1. trioses
2. tetroses
3. pentoses
4. hexoses
5. disaccharides
6. I do not know

21. The following features are some of those found in a prokaryotic cell.

I. cell surface membrane
II. plasmids
III. mitochondria

1. I only
2. I and II only
3. I and III only
4. II and III only
5. I, II and III
6. I do not know

22. The following features are some of those found in a eukaryotic cell.

I. RNA
II. Ribosomes
III. Mitochondria

1. I only
2. I and II only
3. I and III only
4. II and III only
5. I, II and III
6. I do not know

23. Proteins are composed of long chains of monomers called … which are linked together by … bonds. These bonds are formed by …

1. monosaccharides; glycosidic; condensation
2. nucleotides, glycosidic; condensation
3. glycerol; hydrogen; dehydration
4. amino acids; peptide; dehydration
5. amino acids; peptide; condensation
6. I do not know

24. What are the waste products of glycolysis in yeast cells?

1. oxygen and water
2. carbon dioxide and lactic acid
3. alcohol and carbon dioxide
4. oxygen, water and carbon dioxide
5. carbon dioxide, lactic acid and alcohol
6. I do not know

25. Which of the following features are present in DNA?

I. uracil
II. pentose sugar
III. cytosine

1. I only
2. II only
3. I and III only
4. I, II and III
5. II and III only
6. I do not know

26. The two peptide chains in insulin are held together by … bonds which form between … amino acids.

1. hydrogen; three atoms of
2. disulphide; two chains of
3. peptide; adjacent
4. covalent; similar
5. ionic; residual
6. I do not know

27. Which of the following sets of words would construct a lipid?

I. Glycerol; fatty acids
II. Fatty acids; triglycerides
III. Triglycerides; glycerol

1. I, II and III
2. II only
3. I only
4. I and III only
5. III only
6. I do not know

28. The lipid used for cooking is ... which is classified as ...lipid.

1. an oil; an unsaturated
2. a fat; a saturated
3. a fat; an unsaturated
4. an oil; a saturated
5. a triglyceride; a saturated
6. I do not know

29. What is the function of acetyl co-enzyme A in the process of respiration?

1. accelerates the break down of pyruvic acid to provide raw materials for the Krebs cycle
2. it is a kind of enzyme which helps with the formation of ATP
3. forms a temporal intermediate complex with pyruvic acid to enter the mitochondrion
4. it provides the necessary energy for the production of ATP
5. the electron transport chain is less efficient in its presence
6. I do not know

30. The secondary structure of a protein may be a coil, known as ... which is held in shape by ... bonds between different monomers in the chain.

1. a pleated sheet; disulphide
2. an alpha helix; hydrogen
3. a double helix; ionic
4. a quarternary structure; polar
5. a tertiary structure; hydrogen
6. I do not know

31. Where in the cell are glycoproteins found?

1. in the cytosol as temperature stabilisers
2. in mitochondria as sources of energy
3. in bacteria as a carbohydrate storage substance
4. in the plasma membrane as sensory structures
5. in the plasma memrane as passage gates for non polar substances
6. I do not know

32. If the magnification of a specimen is 10u and the actual size of the specimen is 2u, what is the size of the image?

1. 0.2u
2. 5.0u
3. 20u
4. 0.5u
5. 50.0u
6. I do not know

33. Water is an important … in living organisms because most biochemical reactions take place in aqueous solution. Water also has a high … that means that its temperature remains relatively stable despite large changes in the temperature of the surrounding environment.

1. solvent; viscosity
2. substance; force of cohesion
3. solvent;specific heat capacity
4. organic substance; boiling point
5. inorganic substance; melting point
6. I do not know

34. Which of the following sets of information is/are true for sucrose?

I. fructose is part of the molecule
II. it is a reducing sugar
III. a glycosidic bond is part of the molecule

1. I and II only
2. II only
3. II and III only
4. I, II and III
5. I and III only
6. I do not know

35. Which carbon donates its hydroxyl group during the condensation of two glucose molecules?

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

36. Which of the following statements is **correct**?

1. alpha glucose has its hydroxyl group on carbon 1 below the plane of the benzene ring
2. beta glucose has its hydroxyl group on carbon 1 below the plane of the benzene ring
3. galactose is an isomer of glucose
4. adenine and guanine are pyrimidines
5. cytosine always pairs up with thymine
6. I do not know

37. Which of the following statements is **true**?

1. alpha glucose joined to another glucose molecule forms cellobiose
2. beta glucose joined to another glucose molecule forms cellobiose
3. the pentose sugar in nucleic acids is always a hexose sugar
4. deoxyribose sugar and ribose sugar are the same depending on the molecule in which they are found
5. fructose has only five carbons in its molecular structure
6. I do not know

38. The true starches which occur naturally are … and …whereas … is a starch produced by animals

1. amylose; glucose; glycogen
2. cellulose; glucose; glycogen
3. amylose; amylopectin; glycogen
4. wax; sphingolipid; glucose
5. amyopectin; amylose; glucose
6. I do not know

39. When the alkyl group in an amino acid is replaced by the methyl group, the amino acid is called …

1. cysteine
2. leucine
3. valine
4. alanine
5. glycine
6. I do not know

40. Identify parts of a nucleotide.

I. hexose sugar
II. methyl group
III. pentose sugar
IV. glycosidic bond
V. ester bond
VI. carboxyl group
VII. base
VIII. amino group

1. I, II and VI
2. I, VI and VIII
3. II, IV and VI
4. III, VII and V
5. III, IV, and VII
6. I do not know

41. Milk becomes sour when ...

1. the milk solution is above the isoelectric point of its protein
2. the milk protein in solution becomes negatively charged
3. the pH of the milk solution is about the same as that of its protein
4. the solution of milk makes its protein develop a positive charge
5. the milk protein goes into a colloidal solution and therefore the protein precipitates out
6. I do not know

42. Which of the following pairs of terms are matched correctly?

I. Protein – peptide bond
II. DNA – hydrogen bond
III. Lipids – ionic bond

1. I and II only
2. I and III only
3. II and III only
4. I, II and III
5. III only
6. I do not know

43. In DNA a triple bond is found between …

1. A and C
2. G and T
3. C and T
4. A and G
5. C and G
6. I do not know

44. When a eukaryotic cell is examined under the light microscope at high magnification, the most prominent structure is likely to be the …

1. nucleus
2. ER
3. SER
4. golgi body
5. ribosome
6. I do not know

45. Enzymes are synthesized by/in the …

1. lysosomes
2. rough endoplasmic reticulum
3. smooth endoplasmic reticulum
4. nucleus
5. mRNA
6. I do not know

46. Chiasma formation takes place in … of …

1. prophase; meiosis II
2. metaphase; meiosis
3. prophase; meiosis I
4. prophase; mitosis
5. metaphase; mitosis
6. I do not know

47. Mitosis is a useful cell division because it …

1. brings about variation in genetic material
2. sets the stage for sexual reproduction
3. restores the haploid number of chromosomes in a cell
4. only takes place when an organism is ready for reproduction
5. replaces damaged cells in an organism
6. I do not know

48. What is the end product of glycolysis?

1. acetyl co-enzyme A
2. ATP
3. pyruvic acid
4. phosphoglyceraldehyde
5. adolase
6. I do not know

49. Which of the following statements is **false**?

1. the most useful product of the Krebs cycle is ATP
2. in the formation of lactic acid NADH is oxidized while pyruvic acid is reduced
3. glycolysis is not the main pathway for ATP production
4. in the Krebs cycle, reactions can not proceed in the absence of oxygen
5. glucose finally yields two 3 – carbon compounds during glycolysis
6. I do not know

50. The electron transport chain of respiration takes place in the…

1. nucleoplasm of the nucleus
2. cytosol of the cell
3. stroma of the mitochondria
4. outer membrane of the mitochondria
5. inner membrane of mitochondria
6. I do not know

SECTION B: GENETICS

51. Which of the following is **not** a function of mitosis in humans?

1. repair of wounds
2. production of gametes
3. growth
4. multiplication of somatic cells
5. None of the above
6. I do not know

52. Which of the following traits is determined by one or few genes and is not amenable to environmental influences?

1. Sickle cell anemia
2. Crop yield
3. Skin pigmentation
4. Height
5. Two of the above
6. I do not know

53. Which of the following statements is **not** true about the ABO blood system?

1. Blood group is according to the proteins or antigens found on the surfaces of red blood cells.
2. The synthesis of proteins called, antigen A and B, is determined genetically, and is an example of the interaction of multiple alleles
3. If only antigen A is present, then anti-B antibodies will be in the plasma.
4. Group O people have neither of the antigens so may donate their blood to all other groups.
5. None of the above
6. I do not know

54. The condition in which one pair of alleles code for contrasting phenotypic characteristics; one allele is dominant and one recessive is termed as…

1. genotype
2. gene interaction
3. heterozygote
4. phenotype
5. Polydactyl
6. I do not know

55. One of the coincident factors for erythroblastosis fetalis to occur in certain pregnancies in humans is:

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. Non of the above
6. I do not know

56. Genetic screening involves certain tests to assess whether an individual possess an abnormal gene or a chromosome mutation. The presence of a triple X Syndrome in a fetus can be determined by amniocentesis. A small amount of amniotic fluid is removed for cell culture, and the nuclei stained with a special dye. How many barr bodies do you expect to see in the cell nuclei of a triple X syndrome patient?

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

57. Phenylketonuria means ketone bodies appearing in the urine in abnormally excessive amounts. It is a symptom of a group of genetic diseases affecting the metabolism of amino acids phenyalanine and tyrosine. In this disease a single mutant gene is involved. This is an example of ....

1. pleiotropy
2. modifiers
3. variable expressivity
4. epistasis
5. dominance
6. I do not know

58. A photograph of a dividing cell from *Drosophila melanogaster* showed 4 chromosome pairs each consisting of homologous chromosomes. During which of the following stages of cell division could this picture have been taken?

1. Prophase II of meiosis
2. Telophase of meiosis
3. Prophase I of meiosis
4. Anaphase of meiosiss
5. Prophase of mitosis
6. I do not know

59. Which of the following statements is **false**?

1. sister chromatids separate from each other in anaphase of mitosis
2. in humans the males are the homogametic sex
3. the diploid phase of the human life cycle begins with fertilization
4. homologous chromosomes carry the same information for the same trait.
5. Genes carried on the X chromosome are called sex-linked genes.
6. I do not know

60. In the short horn breed of cattle, all the offspring of a white cow and a red bull were spotted with red and white colours. The simplest explanation for this pattern of inheritance is…

1. Autosomal inheritance
2. Independent assortment
3. Co-dominance
4. Hypostatic alleles
5. Incomplete dominance
6. I do not know

61. In question 60 above what would be the phenotypic ratio of the of the progeny from a cross among the red- and white-spotted animals?

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

62. In some of his experiments, Mendel studied the inheritance of patterns of two traits at once – flower colour and pod shape, for example. He did this to find out…

1. how sex linked genes behave
2. whether factors for different traits are inherited together or separately
3. how many genes are responsible for determining a particular trait
4. whether genes are on chromosomes
5. how many different genes are on chromosomes
7. I do not know

63. A man who has type O blood and a woman who has type A blood could have children of the following phenotypes?

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

64. Hemophilia is a recessive sex linked trait which leads to the lack of a blood clotting factor in affected individuals. If a normal woman with a history of the condition in the family marries a normal man. What would you tell the couple about the chances that they would have a hemophilic child?

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

65. One of the explanations for the high frequency of sex linked traits in males as compared to females is that.....

1. males are a weaker sex
2. males have the male hormone called progesterone
3. females have the female hormone called Oestrogen
4. the sex chromosomes in males are of unequal size
5. males have Y- linked genes
6. I do not know

66. What would be the phenotypic ratio of the cross AaBb x aabb?

1. 1AB : 1Ab:1 aBY :1 ab
2. 3AB :3Ab:1 aB :1ab
3. 9AB: 3AB: 4ab
4. 3AB: 1Ab:3aB:ab1
5. 9AB:3Ab:3 aB :1ab
6. I do not know

67. The cross in Question 66 above is called:

1. A back cross
2. A dihybrid cross
3. A double heterozygote cross
4. A test cross
5. Two of the above
6. I do not know

68. Variable expressivity can be defined as...

1. the percentage of individuals with a particular gene combination which exhibit the corresponding character
2. the degree of the effect produced by a penetrant genotype
3. the modification of the effect of a particular allele by the environment
4. masking of the effect produced by one pair of alleles by another pair of alleles
5. the combined effect of sub-lethal genes
6. I do not know

69. The tall aggressive syndrome is associated with what type of chromosome change?

1. Chromosome deletion
2. Change in a single DNA base (point mutation)
3. Primary non-disjunction
4. Non –disjunction in one of the autosome chromosomes
5. X –ray damage to the germplasm
6. I do not know

70. Individuals of genotype BB will have a bald head whether they are females or males. On the other hand heterozygotes (Bb) will only show baldness if they are males. Homozygous (bb) males and females have no pattern baldness. Patten badness is therefore an example of ...

1. Sex limited trait
2. Sex influenced trait
3. Autosomal recessive trait
4. Autosomal dominant trait
5. Holandric trait
6. I do not know

71. In peas , the gene for smooth seeds is dominant to the gene for wrinkled seeds. Pea plants from homozygous smooth seeds were crossed with pea plants from wrinkled seeds. What were the ratios of the progeny phenotypes in the F2?

1. 1 smooth : 1 wrinkled
2. 3 smooth :1 wrinkled
3. all smooth
4. 1 smooth:2 oval:1 wrinkled
5. all wrinkled
6. I do not know

72. A sex linked dominant allele causes hypophosphatemia in humans. A man with hypophosphatemia marries a normal woman. What proportion of their daughters will be affected?

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

73. In *Drosophila*, the recessive white eye gene (w) is sex linked. The phenotypic ratio of the F2 progeny of the cross WW x wy would be

	red females	white females	red males	white males
1.	2	1	2	1
2.	1	1	1	1
3.	1	-	-	1
4.	2	-	1	1
5.	1	-	1	-
6.	I do not know			

74. In rabbits, the coat colour is determined by the following series of multiple alleles: Agouti (C^+)> Chinchila(C^{ch})>Himalayan (C^h)>Albino (c). What is the phenotypic ratio of the progeny of the cross : $C^h C^h$ x C^+c

	albino	himalayan	chinchilla	agouti
1.		1	1	
2.	1	1		
3.	2	1	1	1
4.	1	1	1	1
5.		1		1
6.	I do not know			

75. Which of the following is **not** a feature of meiosis?

1. crossing over
2. gamete formation
3. source of variation
4. maintenance of a species
5. none of the above
6. I do not know

76. Which of the following is not a sex linked trait

1. red-colour blindness
2. absence of central incisors
3. muscular dystrophy
4. rhesus factor
5. 2 and 4 together
6. I do not know

77. Which of the following theories forms the core of the modern genetic theory?

1. acquired characteristics
2. vapour and liquids
3. preformation
4. particulate
5. 2 and 3 together
6. I do not know

78. Several black guinea pigs of he same genotype were crossed and produced 65 black and 22 white offspring. What would you predict the genotypes of the parents to be?

1. Bb x Bb
2. BB x Bb
3. BB x BB
4. Bb x bb
5. None of the above
6. I do not know

79. 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?

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

80. 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. 100%
2. 33%
3. 50%
4. 75%
5. 25%
6. I do not know

81. 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

82. 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

83. If an organism with a diploid number of chromosomes of 20 produced four cells by meiosis, how many chromosomes would each cell have?

1. 40
2. 4
3. 5
4. 12
5. None of the above
6. 6. I do not know

84. 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

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

1. Monosomy
2. abnormal mitosis
3. Primary non-disjunction
4. abnormal meiosis
5. Trisomy
6. I do not know

86. 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

87. In a particular variety of corn, the kernels turn 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

88. 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

89. 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

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

91. 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. 3:1:6:2:4
2. 9:3:3:1
3. 3:1:6:2
4. 3:1:6:2:1
5. none of the above
6. I do not know

92. 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

93. 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. 1 and 2 together
6. I do not know

94. Which of the following statements is **false** about continuous characters
1. they are influenced by both genotype and environment
2. they are determined by polygenes
3. phenotypic measurements form a spectrum
4. also called quantitative characters
5. single gene effects can easily be detected
6. I do not know

95. 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

96. A gene such as the one responsible for the Tay-sachs disease (ganglioside lipidosis) which kills individuals before reproductive age is referred to as

1. a recessive lethal gene
2. a sublethal gene
3. a complete lethal gene
4. a dominant lethal gene
5. a super lethal gene
6. I do not know

97. A brown-eyed man marries a blue-eyed woman, and they have eight children all brown-eyed. What are the genotypes of all the children in the family?

1. Both the dominant and recessive alleles are expressed equally in all the eight children
2. Homozygous for the dominant allele for brown eyes
3. Some children are homozygous for the dominant brown eye allele while others are hererozygous
4. Homozygous for the recessive allele for blue eyes
5. Heterozygous for the dominant allele for brown eyes
6. I do not know

98. A blood test for Mr. Hantobolo gave the reactions indicated below.

Antisera-A	Antisera-B	Anti-Rh sera	Antisera-M	Antisera-N
-	+	-	+	-

What are the probable genotypes of Mr. Hantobolo in relation to the above blood tests?

1. $I^{B}irrMM$
2. $I^{A}iRRNN$
3. $I^{B}I^{B}RRMM$
4. $I^{A}I^{A}RRNN$
5. $I^{B}I^{B}rrNN$
6. I do not know

99. What are the probable genotypes of Mr. Hantobolo's parents

	Mother	Father
1.	I^AiRRMN	I^AI^B rrMM
2.	I^AiRrMN	I^AI^B rrMM
3.	I^AirrNN	I^BI^A RrMN
4.	I^AI^ArrMN	I^BI^B rrMM
5.	iirrMN	I^AI^B rrNN
6.	I do not know	

100. Given that Turner's syndrome patients have a genotype 45 AAXO. Turner's syndrome individuals are phenotypically

1. Bisexual (have both male and female features)
2. moon faced sterile males with a cat cry
3. sterile males with breasts and long legs
4. sterile females with underdeveloped sex organs
5. are females with cancer of the bone marrow
6. I do not know

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS – AUGUST 2003

Analytical Chemistry C225

ANSWER ALL QUESTIONS
TIME: 3 HOURS

1. (a) Express the concentration in parts per million of chloride in a 1.6×10^{-5} M HCl solution.

   (b) Suppose you have a bottle of aqueous solution labeled "53.4 (±0.4) wt% NaOH and density = 1.52 (±0.01) g/mL." How many milliliters of 53.4% NaOH are needed to prepare 2.000L of 0.169 M NaOH?

   (c) The Ti content (wt%) of two different ore samples was measured several times by the same method. Are the mean values significantly different at the 95% confidence level?

Sample 1	Sample 2
0.0134	0.0135
0.0138	0.0142
0.0128	0.0137
0.0133	0.0141
0.0137	0.0143

   (d) Write the mass balance equations for K^+ and for phosphate in a solution prepared by mixing 0.0250 mol KH_2PO_4 plus 0.0300 mol of KOH and diluting to 1.00L.

   (e) Write the charge balance equation for a solution containing H_2O, H^+, OH^-, ClO_4^-, $Fe(CN)_6^{3-}$, CN^-, Fe^{3+}, CH_3OH, HCN, NH_3 and NH_4^+.

2. (a) A 0.0450 M solution of H_2A is 0.60% dissociated. Calculate pKa for this acid.

   (b) Find the pH and fraction of dissociation (α) of a 0.100 M solution of a weak base B with $K_b = 1.00 \times 10^{-5}$.

   (c) What fraction of cis-butenedioc is in each form (H_2A, HA^-, A^{2-}) at pH 6.33? ($K_1 = 1.23 \times 10^{-2}$ and $K_2 = 4.66 \times 10^{-7}$)

   (d) Given that pK_b for nitrite (NO_2^-) is 10.85, find the quotient $[HNO_2]/[NO_2^-]$ in a solution of sodium nitrite at pH 2.00.

3. (a) Calculate the pH after adding 25.0 mL of 0.200 M HNO_3 to100.0 mL of 0.100 M cocaine ($K_b = 2.6 \times 10^{-6}$).

(b) Calculate pCa after addition of 50.0 mL of 0.0100 M $CaSO_4$ to 25.00 mL of 0.0200 M EDTA at pH 10.00. ($K_{f\,CaY} = 1.0 \times 10^{12}$ and $\alpha_Y{}^{4-} = 0.054$)

(c) Calculate the voltage of the following cell:

$$Fe_{(s)} \mid FeBr_2\ (0.010\ M) \mid\mid NaBr\ (0.050\ M) \mid Br_{2(l)} \mid Pt_{(s)}$$

Data: $E^0 Br_2 / Br^- = +1.078V$
$E^0 Fe^{2+} / Fe = -0.440V$

(d) Consider the titration of 100.0 mL of 0.0100 M Ce^{4+} in 1 M $HClO_4$ by 0.0400 M Cu^+ to give Ce^{3+} and Cu^{2+}, using Pt and saturated Ag | AgCl electrodes to find the end point. Calculate E at the following volumes of Cu^+: 12.5, 25.0, 30.0 mL.

Data: $E^0 Cu^{2+} / Cu^+ = +0.161V$
$E^0 Ce^{4+} / Ce^{3+} = +1.70V$

4. (a) A solution containing 10.00 mL of LiF was titrated with 0.0100 M $Th(NO_3)_4$ to precipitate ThF_4. Calculate:

(i) the volume of $Th(NO_3)_4$ needed to reach the equivalence point
(ii) pTh when 1.00 mL of $Th(NO_3)_4$ has been added.

(K_{sp} $ThF_4 = 5 \times 10^{-29}$)

(b) State four desirable properties of a gravimetric precipitate.

(c) A 100g sample of unknown gave 2.500 g of bis(dimethylglyoximate)nickel (II) (MW 288.91) when analyzed by the given reaction below. Find the weight percent of Ni in the unknown.

$$Ni^{2+} + 2C_4H_8N_2O_2 \rightarrow Ni[C_8H_{14}N_4O_4] + 2H^+$$

bis(dimethylglyoximate) nickel (II)

THE PERIODIC TABLE

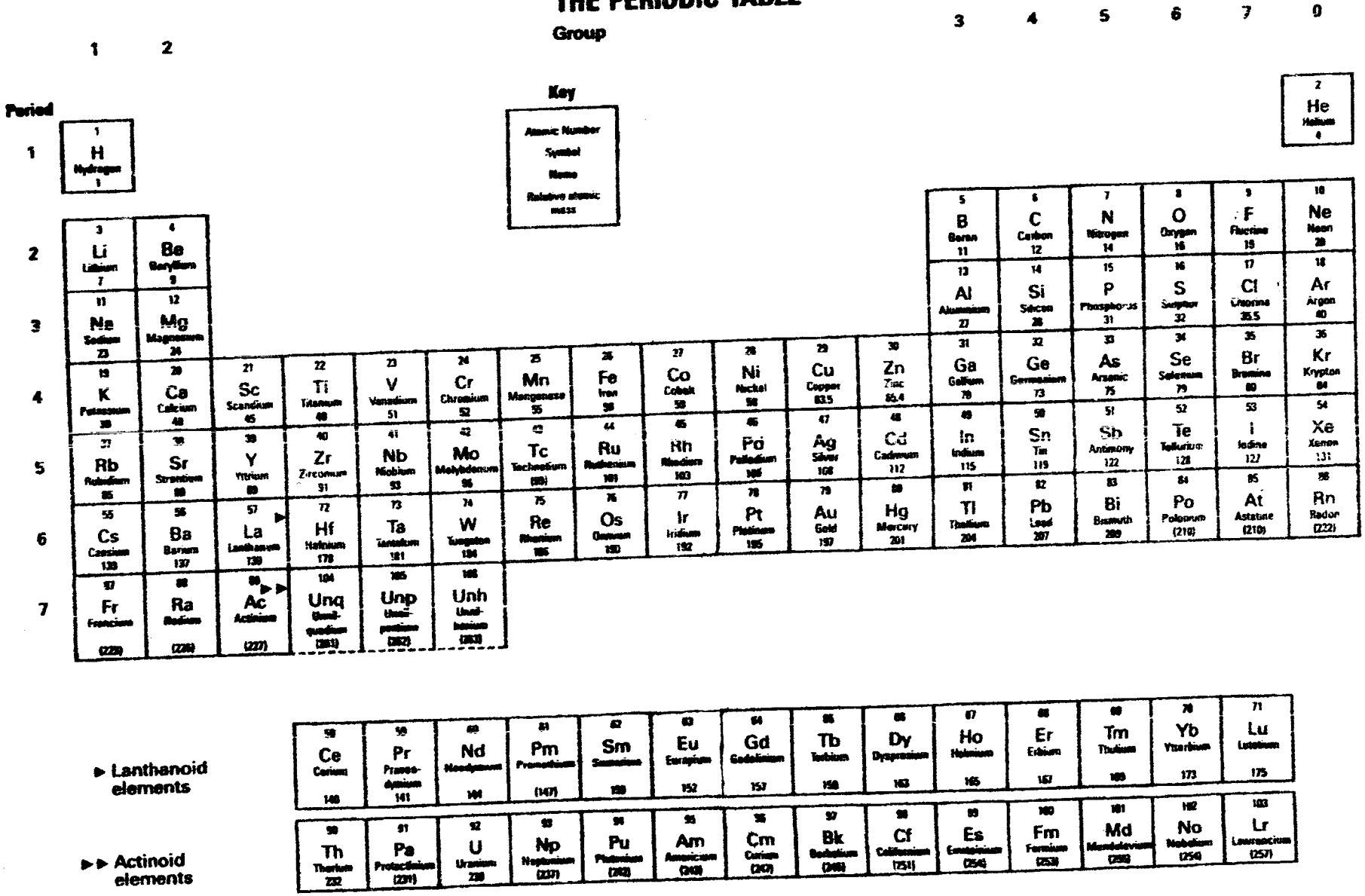


Table A.1. The t-distribution

Value of t for a confidence interval of	90%	95%	98%	99%
Critical value of $\|t\|$ for P values of	0.10	0.05	0.02	0.01
Number of degrees of freedom				
1	6.31	12.71	31.82	63.66
2	2.92	4.30	6.96	9.92
3	2.35	3.18	4.54	5.84
4	2.13	2.78	3.75	4.60
5	2.02	2.57	3.36	4.03
6	1.94	2.45	3.14	3.71
7	1.89	2.36	3.00	3.50
8	1.86	2.31	2.90	3.36
9	1.83	2.26	2.82	3.25
10	1.81	2.23	2.76	3.17
12	1.78	2.18	2.68	3.05
14	1.76	2.14	2.62	2.98
16	1.75	2.12	2.58	2.92
18	1.73	2.10	2.55	2.88
20	1.72	2.09	2.53	2.85
30	1.70	2.04	2.46	2.75
50	1.68	2.01	2.40	2.68
∞	1.64	1.96	2.33	2.58

Table A.2. Critical values of F for a one-tailed test ($P = 0.05$)

ν_2 \ ν_1	1	2	3	4	5	6	7	8	9	10	12	15	20
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.9	245.9	248.0
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45
3	10.13	9.552	9.277	9.117	9.013	8.941	8.887	8.845	8.812	8.786	8.745	8.703	8.660
4	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999	5.964	5.912	5.858	5.803
5	6.608	5.786	5.409	5.192	5.050	4.950	4.876	4.818	4.772	4.735	4.678	4.619	4.558
6	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147	4.099	4.060	4.000	3.938	3.874
7	5.591	4.737	4.347	4.120	3.972	3.866	3.787	3.726	3.677	3.637	3.575	3.511	3.445
8	5.318	4.459	4.066	3.838	3.687	3.581	3.500	3.438	3.388	3.347	3.284	3.218	3.150
9	5.117	4.256	3.863	3.633	3.482	3.374	3.293	3.230	3.179	3.137	3.073	3.006	2.936
10	4.965	4.103	3.708	3.478	3.326	3.217	3.135	3.072	3.020	2.978	2.913	2.845	2.774
11	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.896	2.854	2.788	2.719	2.646
12	4.747	3.885	3.490	3.259	3.106	2.996	2.913	2.849	2.796	2.753	2.687	2.617	2.544
13	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.714	2.671	2.604	2.533	2.459
14	4.600	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.646	2.602	2.534	2.463	2.388
15	4.543	3.682	3.287	3.056	2.901	2.790	2.707	2.641	2.588	2.544	2.475	2.403	2.328
16	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.538	2.494	2.425	2.352	2.276
17	4.451	3.592	3.197	2.965	2.810	2.699	2.614	2.548	2.494	2.450	2.381	2.308	2.230
18	4.414	3.555	3.160	2.928	2.773	2.661	2.577	2.510	2.456	2.412	2.342	2.269	2.191
19	4.381	3.522	3.127	2.895	2.740	2.628	2.544	2.477	2.423	2.378	2.308	2.234	2.155
20	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447	2.393	2.348	2.278	2.203	2.124

ν_1 = number of degrees of freedom of the numerator and ν_2 = number of degrees of freedom of the denominator.

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS SEMISTER I
C245 INORGANIC CHEMISTRY I

Time Allowed: 3 Hours

Instructions: Attempt 4 out of 6 Questions.
Indicate your ID Number.
Periodic Table is attached.
Neatly and orderly work needed.

Physical constants

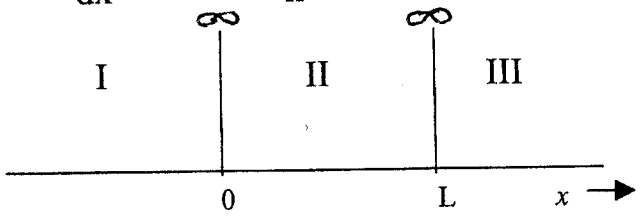
Quantity	Symbol	Value and Units
Avogadro's Number	N_A	6.022×10^{23} mol^{-1}
Bohr radius	a_o	5.922×10^{-11} m
Electron mass	m_e	9.109×10^{-31} kg
Electronic charge	-e	1.602×10^{-19} C
Planck's constant	h	6.603×10^{-34} Js
Permitivity of free space	ε_o	8.854×10^{-12} C^2N^{-1} m^{-2}
Speed of light	c	2.998×10^{8} ms^{-1}
Rydberg constant	R	1.097×10^{7} m^{-1}

Slater's Rules for screening constant calculations:

(i) σ for (n+1) electrons = 0
(ii) σ for n electrons is 0.35; except for 1s orbital when $\sigma = 0.3$
(iii) σ for (n-1) electrons = 0.85
(iv) σ for <(n-1) electrons = 1.0
(v) σ for d and f orbitals = 1.0

1. (a) The Schrodinger wave equation for a particle moving in a one dimension x is

$$\frac{d^2\psi}{dx^2} + \frac{8\pi^2 m}{h^2}(E-V)\psi = 0$$



(i) write the Hamiltonian if the particle is in region (II).

(ii) one solution to the Schrodinger equation for this region is $\psi = A \sin(n\pi x/L)$. Compute the expression for energy levels for region (II).

(b) What is zero point energy? Calculate the zero point energy for a nitrogen molecule (N_2) placed in an infinite potential well of length 1×10^{-6} m.

(c) Write down the Schrodinger equation for a *stationary* hydrogen atom.

2. (a) Calculate the velocity of an electron emitted from a clean potassium surface ($\Phi = 3.68 \times 10^{-19}$J) irradiated light at 300 nm.

(b) What will be the wavelength in Å of a beam of electrons accelerated through 54eV? [1eV $= 1.6022 \times 10^{-19}$J]

(c) A particle of mass *m* moves in a circular orbit under the influence of a for *kr* directed towards the centre (*k* is a constant). If Bohr's postulate are valid for this system, derive the equation for the radii of the permissible orbits in terms of *k*, *n* and *m*.

3. (a) Molecular oxygen is known to be paramagnetic. Write down the molecular electronic configuration of this molecule. Comment on the magnitude and stability of the O_2^- bond relative to that of O_2.

(b) Ligands have been classified as hard or soft depending on the nature of the donor atom. Using NH_3 and PH_3 as examples distinguish between hard and soft ligands.

(c) Give a complete description of the bonding in $O{=}PCl_3$.

---

4. (a) Discuss the contribution of each of the following to modern Chemistry:

(i) Niels Bohr (ii) Werner Heisenberg
(iii) Louis de Broglie

(b) The wave function for a hydrogen-like atom is

$$\psi = (\sqrt{\pi})^{-1} (Z/a_o)^{3/2} e^{-Zr/a_o}$$

(i) Derive the general expression for the most probable distance to find an electron.

(ii) What is the probable distance to find the electron in $_3Li^{2+}$ ion?

---

5. (a) Using Slaters' Rules complete the effective nuclear charge, Z_{eff}, for the outer most electron in Li and Be. Comment on the results.

(b) Study the table below:

R(r)	$\Theta(\theta)$	$\Phi(\phi)$
(i) $(2\sqrt{2})^{-1}(Z/a_o)^{3/2}(2 - Zr/a_o)\, e^{-Zr/2ao}$	$(2\sqrt{2})^{-1}$	$(\sqrt{2\pi})^{-1}$
(ii) $(2\sqrt{6})^{-1}\,(Z/a_o)^{3/2}\,(Zr/a_o)\, e^{-Zr/2ao}$	$(\sqrt{6}/2)\,\mathrm{Cos}\theta$	$(\sqrt{2\pi})^{-1}$

(i) Derive $\psi(r, \theta, \phi)$ for *(ii)* in the table.

(ii) Sketch the angular wave functions for *(i)* and *(ii)*, and state the type of orbital.

(iii) What is the shape of Radial Distribution Function for *(ii)*?

---

6. (a) Name the Complex $[Fe(py)_4]Cl_3$
(py= pyridine)

(b) Discuss bonding in an octahedral field in terms of Crystal Field Theory (CFT).

(c) Discuss the variation by the p-block elements of their

(i) radius (ii) ionization energy

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
AUGUST 2003.

C251 ORGANIC CHEMISTRY I

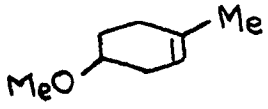
Time: Three (03) Hours

Instructions:

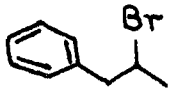
1. Answer any FOUR questions.
2. All questions carry equal marks.
3. Marks allocation for each question is shown.
4. Maximum marks = 100

QUESTIO N ONE

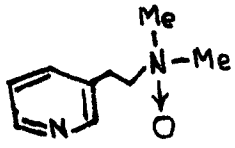
a) Give the structures of the major organic products, including pertinent stereochemistry, where necessary, of the following reactions and show the mechanisms of the reactions involved.

(i) 

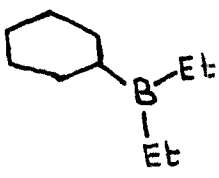
$\xrightarrow[2.\ NaBH_4,\ Ba(OH)_2]{1.\ Hg(OH)_2,\ MeOH}$? **(8 marks)**

(ii) 

$\xrightarrow[2.\ HBr,\ (C_6H_5CH_2)_2O_2,\ THF]{1.\ EtOH,\ KOH,\ \Delta}$? **(8 marks)**

(iii) 

$\xrightarrow{\Delta}$? **(2 marks)**

(iv) 

$\xrightarrow[NaOH]{H_2O_2}$? **(2 marks)**

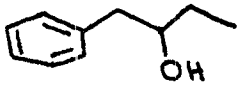
b) Give the products and show how many molar equivalents of each would be formed when squalene is subjected to ozonolysis and the ozonide formed is subsequently treated with zinc and water.

Squalene

(5 marks)

QUESTION TWO

a) Assume that you have available any necessary organic halides, aldehydes, ketones, esters and any necessary inorganic reagents, show how you would prepare the alcohol **A**, used in making perfumes, through a Grignard synthesis.

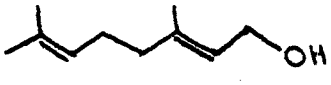


A

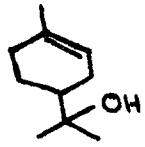
Give the mechanisms of the reactions involved.

(6 marks)

b) Propose a mechanism for the isomerisation of nerol into α-terpeniol in the presence of phosphoric acid.



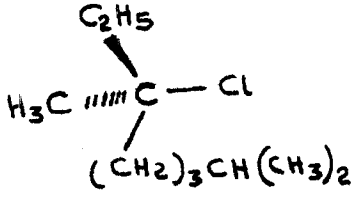
Nerol



α-Terpeniol

(9 marks)

c) The reaction of optically active compound **B**, structure shown below, with water gives an alcohol that is 80% racemised and 20% inverted. (That is the product consists of 80% racemic mixture and 20% pure (S)-alcohol).



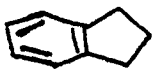
B

Suggest the mechanism of this reaction and clearly show the stereochemistry of the product(s). What is the total percentage of the (S)-alcohol in the product mixture?

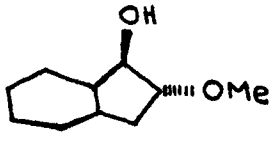
(10 marks)

QUESTION THREE

a) Propose a synthesis of compound **D**, from compound **C**. The synthesis may require several steps. State clearly the reagents and the reaction conditions required for each step of your proposed synthesis



C

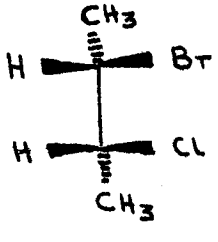


D

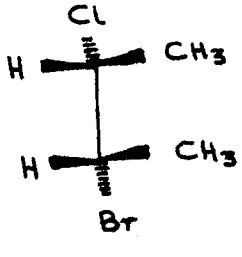
(9 marks)

b) Identify the following pairs as identical, enantiomers or diastereomers.

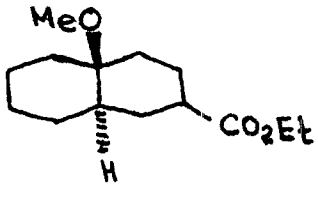
(i)



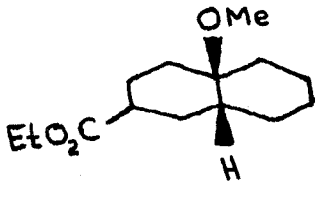
and



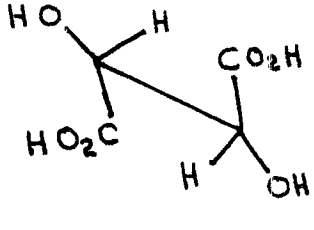
(ii)



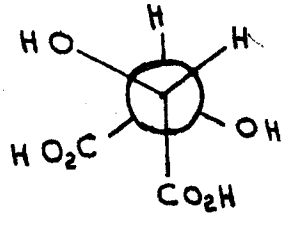
and



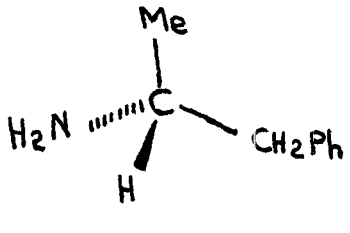
(iii)



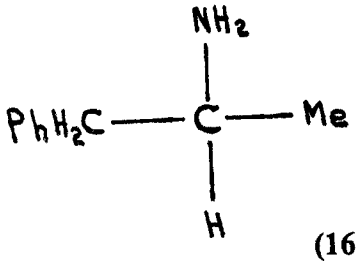
and



(iv)



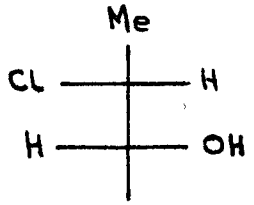
and



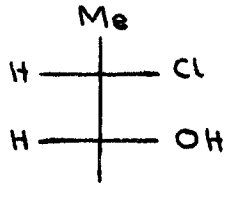
(16 marks)

QUESTION FOUR

a) Addition of chlorine water to 2-butene gives, not only 2,3-dichlorobutane, but also the chlorohydrin, 3-chloro-2- butanol. ***cis***-Butene gives only the (racemic) ***threo***-chlorohydrin, **E**, and ***trans***-2-butene gives only the (racemic) ***erythro***-chlorohydrin, **F**.



E



F

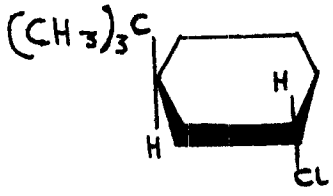
(i) Provide an explanation for the above experimental results, and show the reaction mechanisms.

(ii) State the type of stereochemistry of chlorohydrin formation in this reaction.

(iii) Label the step(s) in your mechanism which lead(s) to formation of the racemic products.

(10 marks)

b) The structure of ***trans-tertiary***-butyl-4-chlorocyclohexane and the 1,3-diaxial interactions data are shown below.



trans-tertiary-butyl-4-chlorocyclohexane

1,3-Diaxial interactions: (i) $(CH_3)_3C$-H = 2.7 kcal/mol.
(ii) Cl-H = 0.25 kcal.mol.

On the basis of this information draw the most stable chair conformational representation of this molecule, clearly showing the arrangement of the substituents, axial or equatorial. Give justification for your answer.

(5 marks)

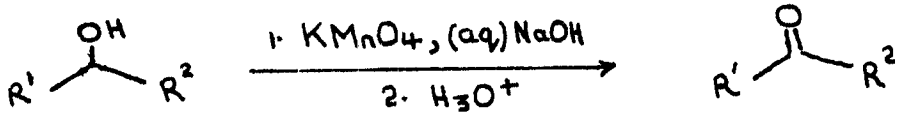
c) Alkyl halides undergo elimination reactions on treatment with strong bases such as CH_3O^-. Using the fact that axial chlorocyclohexanes are generally more reactive towards strong bases than their equatorial counterparts, state which compound you think will react faster under the same reaction conditions:

cis-tertiary-butyl-4-chlorocyclohexane or ***trans-tertiary***-butyl-4-chlorocyclohexane? Give reasons for your opinion and provide the mechanism for the faster reaction and name the product(s) formed.

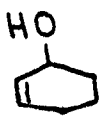
(10 marks)

QUESTION FIVE

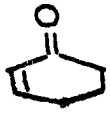
(a) Secondary alcohols can be oxidised to ketones as shown below.



However, attempted synthesis of compound **H**, by direct oxidation of compound **G** using the above reaction failed.



G



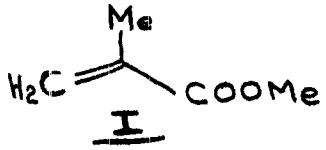
H

(i) State briefly what went wrong with direct oxidation of compound **G**?

(ii) Suggest an alternative synthesis of compound **H** from compound **G** using the above reaction.
(Reaction mechanisms are not required to be shown)

(10 marks)

b) Treatment of compound **I**, with traces of iron (II) sulfate and hydrogen peroxide at 200°C and 10 atm pressure gives a polymer **J**, which is used for making optical fibres.

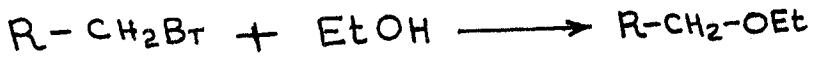


I

Suggest the structure for the polymer **J**, and show the mechanisms of the reactions involved in the formation of **J** from **I**.

(12 marks)

c) The data shown in the table below was obtained for the ethanolysis of several primary alkyl halides according to the following reaction scheme:



Exp. No.	Type of substrate	Nucleophile	Major product	Relative reaction rate
1	CH_3CH_2Br	EtOH	CH_3CH_2-OEt	1.0
2	$CH_3CH_2CH_2Br$	EtOH	$CH_3CH_2CH_2$-OEt	0.28
3	CH_3CHCH_2Br CH_3	EtOH	CH_3CHCH_2-OEt CH_3	0.03
4	CH_3 CH_3C-CH_2Br CH_3	EtOH	CH_3 CH_3C-CH_2-OEt CH_3	0.0000042

(i) State clearly which reaction(s) proceed(s) by the S_N1 mechanism and which reaction(s) proceed(s) by the S_N2 mechanism.

(ii) State the factor(s) to account for the observed relative rates of the reactions shown in the table above.

(iii) Write the mechanism for the reaction in experiment No.4 shown in the table above.

(10 marks)

END OF EXAM

UNIVERSITY OF ZAMBIA
SCHOOL OF AGRICULTURAL SCIENCES
FOOD SCIENCE AND TECHNOLOGY DEPARTMENT
FIRST SEMESTER FINAL EXAMINATION
COURSE: FOOD CHEMISTRY-321 THEORY

TIME 18 HOURS T0 21 HOURS
DATE: 11TH AUGUST 2003

INSTRUCTIONS: ALL QUESTIONS CARRY 20 MARKS
ANSWER ANY FIVE OUT OF THE SIX QUESTIONS

1. The flowing vegetables peas, carrots, and beans and the following fruits apples and pineapples and dry maize were grown and harvested in Mwinilunga . After harvest they were transported to a Lusaka factory in an open van. Upon arrival at the factory the fruits were pealed and seeds and core removed. The carrots were peeled. The pees and fresh beans trimmed and blanched. The maize was ground into breakfast mealie meal.
   Explain how the quality of these products will be affected during post harvest handling, during transportation and during the processing treatment mentioned in the background information. Mention the type of nutrient loss for each group of foods mentioned for each processing treatment mentioned. What advice would you give to all the people involved in this food chain to ensure that the quality products are produced? (20 Points).

2. In properties related to protein –protein interaction (a) –(C) define the following
   (a) Gelation (3 Points)
   (b) Polymerisation (3 Points)
   (c) Flocculation (3 Points)
   (d) What is a food additive name two? And what is a food ingredient (5 Points)
   (e) Give 3 reasons why food additives are added to foods. (3 Points)
   (f) Explain why A_W is preferred in the explanation of food perishiability that water content (3 Points)

3. (a) An industrialist producing dried vegetables comes to complain to you as a food scientist about their vegetables having hay like aroma. What explanation would you give to them about what is happening to their vegetables. What type of advice would you give this person so that they produce dry vegetables without the hay like taste or aroma? (8 Points)
   (b) What are dextrins how different are they from starch. Why is ingestion of polysaccharides in the human diet essential (4 Points)?

(c) Mention the major reactions that occur in lipids by thermal and oxidative mechanisms describe how the lipid quality is affected. Name the reaction products for each reaction. Name the type of tests and their results that would show you that there is loss of quality as a result of these reactions. (8 Points).

4. You have been given 100,000 Litres of Crude Soya Bean Oil; explain in detail how you would make this oil fit for human consumption. Mention the statutory bodies in Zambia that would enable you to come up with oil good for human consumption. In the same vein explain what would happen to the oil if it were not subjected to what you explain as way of producing consumable oil. What technological and nutritional problems are you likely to encounter during processing this oil (20 Points)

5. (a) Why is there no enzymatic browning in intact tissues (3 Points)
   (b) What are the causes of mineral deficiencies in diets (2 points)?
   (c)What is the major difference between vitamins and mineral availability during processing (3 Points)?
   (d)What are latent enzymes why are they significant in food industry (2 Points)
   (e) What is common to all oils affected by reversion name two such oils (3 Points)
   (f) Name two non-reducing disaccharides (2 Points)
   (g) When does protein putrification occur and mention 3 important putrification reactions (5 Points)

6. (a) What is HLB? Why is it important in the study of surfactants? If a substance has an HLB value of 40 and above what does this say about this product (6 Points)
   (b)Name five causes of emulsion instability (5 Points)
   (c)Name three types of non-enzymatic browning (3 Points)
   (d) What is the pH range at which the maillard reaction is most destructive to amino acids name two ways of inhibiting the malliard relation? (3 Points)
   (a) What causes sugar bloom in chocolate? (2 Points)
   (b) Starch is optically active with a specific rotation of about + 190^{o} and is a polysaccharide composed of entirely of glucose True or False. (1 Point)

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER I EXAMINATIONS

AUGUST 2003

C321 - [ANALYTICAL CHEMISTRY II]

[Spectral Analytical Methods]

TIME : **THREE(3) HOURS**

INSTRUCTIONS : **1. Answer any FOUR Questions**
2. Each Question carriers 25 Marks

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1. a) Convert the following frequencies to wavelengths in nanometers. Indicate the spectral region within which the wavelength faults.

(i) $4.283 \times 10^{14} s^{-1}$, (ii) $1.333 \times 10^{15} s^{-1}$,
(iii) $1.053 \times 10^{13} s^{-1}$

b) Convert the following wavelengths to frequencies in hertz (waves/s).
(i) 536 nm, (ii) 14.3 nm, (iii) 24.6cm

c) Convert the following percent transmittances to absorbances

(i) 0.004 (ii) 0.314 (iii) 0.100

d) Convert the following absorbances to percent transmittance.

(i) 0.100 (ii) 10.00 (iii) 1.00

e) Calculate the energy in kJ at 180nm, 400nm and at 780 nm for a mole of each.

f) What are the wave numbers at 180,400 and 780nm respectively?

[$h = 6.62 \times 10^{-34}$ Js^{-1}, $N_A = 6.02 \times 10^{23}$ mol^{-1}, $c = 3.0 \times 10^8$ m/s].

g) A 1.28×10^{-4} molar solution of potassium permanganate has a transmittance 70% at 525 nm in 2.00 cm cell.
[M.M for $KMnO_4$ = 158.04].

i. What is the absorbance and molar absorptivity of this solution?
ii. If the concentration were doubled, what would be transmittance and absorbance respectively?
iii. What concentration would have a transmittance of 50% in this cell?

h) The molar absorptivity of acetone (M.M. = 58) in hexane solvent is 900 at 188 nm.
Calculate the maximum concentration (g/*l*) that could be used in 2.0cm cell, so that absorbance will not exceed 0.9.

i) J.J Lingane and J.W. Collat determined together Cr and Mn spectorphotometricaly. They got these results: They measured molar absorptivities of mixture for $Cr_2O_7^{2}$ and MnO_4^- at two wavelengths:

Species	ε-values	
	λ_1 = 440nm	λ_2 = 545nm
$Cr_2O_7^{2-}$	369	11
MnO_4^-	95	2350

A steel sample weighing 1.00g was dissolved in appropriate acids (H_2SO_4, H_3PO_4 and HNO_3) and treated with persulfate and periodate to oxidize Mn to MnO_4^- and Cr to $Cr_2O_7^{2-}$. The final solution from the preliminary treatment is diluted to 100 m*l* in a volumetric flask, and the absorbance values are determined in a 1.00cm cell at 440 nm (A=0.108) an at 545 nm(A = 1.296). Calculate the percentages of Cr and Mn in the steel.
[Mn = 54.9380 and Cr = 51.996].

2. a) Explain principle of IR-spectroscopy and Raman spectroscopy respectively.

b) What type of stretching and bending vibrations do you know? Sketch them.

c) Explain quantum treatment of vibrations.

d) What are the differences between sources, mono-chromators, cells and detectors in UV + VIS and IR spectroscopy respectively.

e) Explain different sample handling techniques in IR-spectroscopy.

f) Calculate the wave number and wavelength of the fundamental absorption peak due to stretching vibration of C = C group. [C = 12, k = 10.10^2 dyn/cm (or k = 1.5×10^3N/m, c = 3.0×10^8 m/s, $N_A = 6.02 \times 10^{23}$].

3. a) Explain principles of flame photometry, atomic absorption and emission spectroscopy respectively.

b) What are the basic differences between atomic absorption spectroscop and emission spectroscopy, respectively.

c) Describe type of sources for atomic absorption spectroscopy and emission spectroscopy respectively.

d) Write the equation for resolution for optical grating and for optical prisma respectively.

e) Explain standard addition method for atomic absorption spectroscopy.

f) Explain Inductively coupled plasma source. Sketch a diagram.

g) Explain Matrix effects.

h) A 2.00 m*l* sample of cow's milk was diluted to 50 m*l* and analyzed for Zn, using AAS. The absorbance was 0.106. A second 2.00 m*l* sample was spiked with 12 μg of Zn before diluted to 50 m*l*. The absorbance was 0.245.

Calculate Zn concentration in the milk as part per mmillion. [Zn = 65.38].

i) 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 standards solution contained 6300 μg/ml calcium as CaO to compensate for the influence of calcium on the alkali readings. The result are shown in the table. For each cement sample 2.000g was dissolved in acid and diluted to exactly 100m*l*.

Calculate the percent of Na_2O and K_2O. [Na = 22.9898, K = 39.102, and O = 15.9994].

Concentration (μg/m*l*)		Emission reading Na_2O	K_2O
100		100	100
75		87	80
50		69	58
25		46	33
10		22	15
0		3	0
Samples:	Cement A	28	69
	Cement B	58	51
	Cement C	42	63

4. a) Explain the principle of proton nuclear magnetic resonance method.
   b) Explain chemical shift in ^1H NMR.
   c) Explain spin-spin splitting in ^1H NMR.
   d) Explain integral and derivative spectrum in ^1H NMR of diethylether.
   e) Explain ^{13}C NMR
   f) Explain proton decoupling in ^{13}C NMR.
   g) (i) An NMR instrument employ a magnet that provides a field strength of 4.69T. At what frequency would the hydrogen nucleus absorb in such a field? [$\gamma = 2.68 \times 10^8 T^{-1}s^{-1}$].
      (ii) What magnetic field will be used for 300 MHz apparatus?
   h) Predict the appearance of the high resolution protein NMR spectrum of:

      (i) methyl ethylketone, (ii) acetone, (iii) ethanol.

5. a) Explain the principle of mass spectrometry.
b) Write the basic equation for m/z.
c) Draw the graph of mass spectrometry.
d) What accelerating potential will be required to direct a singly charged water [H_2O = 18.02] molecule through the exit slit of a magnetic mass spectrometer if the magnet has a field strength 0.240 tesla and the radius of curvature of the ion through the magnetic field is 12.5 cm?

e) Describe how the following compounds will degradate; write their m/z:

i. ii. iii.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF AGRICULTURAL SCIENCES
FOOD SCIENCE AND TECHNOLOGY DEPARTMENT
FIRST SEMESTER FINAL EXAMINATION
COURSE: CHEMISTRY 321 PRACTICAL

TIME: THREE HOURS
INSTRUCTIONS: SECTION I IS COMPULSORY AND QUESTION 1 OF SECTION 2. THEN YOU CAN ANSWER ANY <u>TWO</u> OF YOUR CHOICE

SECTION I QUESTION 1 (24 Points)

1. The keldahl method of crude protein determination has three major steps (i) sample digestion, (ii) Ammonia distillation (iii) Acid titration. Explain the following in each of the three steps.

   (A) Sample digestion

   (i)Why are the following added at this step HgO, Anhydrous K_2SO_4 and Concentrated sulphuric acid (3 Points)

   (ii) If HgO and anhydrous K_2SO_4 were not available what else would you use?(2 Points).

   (iii) Mention one effect on the method you would expect from the alternative you have suggested(I Point)

   (iv) Mention two factors that can affect digestion efficiency of the sample assuming the digestion temperature, HgO content, Anhydrous K_2SO_4 content and sulphuric acid volume were added in correct amounts (2 Points)

   (B) SAMPLE DIGESTION

   (i) Why is the diluted material diluted before distillation?(2 Points)

   (ii) What is the function of NaOH, which added at the distillation stage?(2 Points)

   (iii) What is the function of Boric acid in the receiver solution? (2 Points)

   (C) ACID TITRATION

   (i) What is standardisation in titration?(2 Points)

   (ii)Explain why it is important to explain why it is important to standardise HCL used to titrate the receiver solution (2 Points)

   (iii) Explain the reaction of HCL and receiver solution during titration (2 Points)

   (iv)You have just been given a new food product explain how you would calculate its nitrogen factor and how you can further calculate the crude protein for the same food (4 Points)

SECTION II
QUESTION 1 IS COMPULSORY

(a) Describe and explain the principle of drying and distillation methods of moisture determination in foods, give one example of food suitably dried by each method.(12 Points)

(b)You are given two samples of food products whose moisture contents are 5% and 15% respectively; they all look fine and stable. Explain how you would explain to the client that these foods are both stable at these moisture levels. What explanation tool would you use to convince the owner of the samples? (12 Points)

QUESTION 2

You have been given a sample to determine its mineral content explain how you would proceed in reaching the percentage of the mineral say 3% calcium. (12 Points)

QUESTION 3

You have been given a sample to determine its fibre content explain how you would carry out this experiment. What information would you give the client on the importance of fibre in the diet (12 Points)?

QUESTION 4

Define the following

(a) Iodine value (2 Points)
(b) Free fatty acid (2 Points)
(c) Adsorbed water (3 Points)
(d) Peroxide value (2 Points
(e) Dietary fibre (3 Points)

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF CHEMISTRY

SEMESTER 1 EXAMINATION

C341 - INORGANIC CHEMISTRY II
AUGUST, 2003.

INSTRUCTIONS:

TIME : THREE(3) HOURS
Instructions: Answer only FOUR (4) QUESTIONS
Each question carries Equal marks

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1. Nitrogen forms hydrides the main of which is ammonia, NH_3.

   (i) Describe the Haber's process for the production of ammonia on a large scale.
   (ii) How does HN_3 react with: Iodine, Copper(II) Oxide, Sodium metal?
   (iii) Write down reactions of production of Hydrogen form Natural gas.

2. (i) Write balanced reactions between; Phosphorous trichloride, $[PCl_3]$ ***with*** water, acetic acid. chlorine and oxygen.

   (ii) Describe the Sulphuric acid production contact process if the raw material is FeS_2.

   (iii) Describe the catalyst and the temperatures used for SO_2 oxidation process.

3. (i) Write down the reactions production of carbon oxides:
   CO, CO_2, C_3O_2.

   (ii) Write the reactions of carbon sulfide, CS_2, with: O_2, NO, $Ca(OH)_2$, NaOH, and Cl_2

(iii) Complete and balance the following reactions:

$$SiF_2 + NaOH + H_2O \longrightarrow$$

$$SiF_4 + H_2O \longrightarrow$$

$K2SiF_6 + K \longrightarrow$

$CS_2 + PCl_5 \longrightarrow$

$C + 2H_2SO_4 \longrightarrow$

$Si_2H_6 + KOH + 2H_2O \longrightarrow$

4. (a) What are the characteristics of bands associated with MnO_4^-?

(b) The F^- ion lies on the weak end of the spectrochemical series. Account for the π-orbital interaction associated with the ion in an octahedral environment.

(c) In the presence of octahedral ligand field the ^3F is split into $^3A_{2g}$, $^3T_{2g}$ and $^3T_{1g}$.

(i) Show the magnitude of splitting of these ligand field terms in terms of Dq.

(ii) Compute the Crystal Field Stabilization Energy (CFSE) of d^8 electrons when all are placed in the ^3F orbital.

5. (a) Various explanations have been forwarded to explain Δoct. Copy and complete the table below, state the type of field associated with the Δ_{oct}.

Nature of Δoct. splitting	**Type of field**
$t_{2g} \longrightarrow eg$	
$t_{2g}^* \longrightarrow eg^*$	
$t_{2g} \longrightarrow eg^*$	

(b) The ground state cubic field term for a complex is $^4T_{1g}$.

(i) State the number of unpaired electron in the complex.

(ii) What is the d-electron configuration of this complex?

(iii) If the ligand strength is increased, what will be the new ground state term of the resulting complex.

(iv) Determine the spin only magnetic moment of this complex.

6. (a) (i) What is Laporte Rule?

(ii) Distinguish between *spin allowed* and *spin forbidden* transitions?

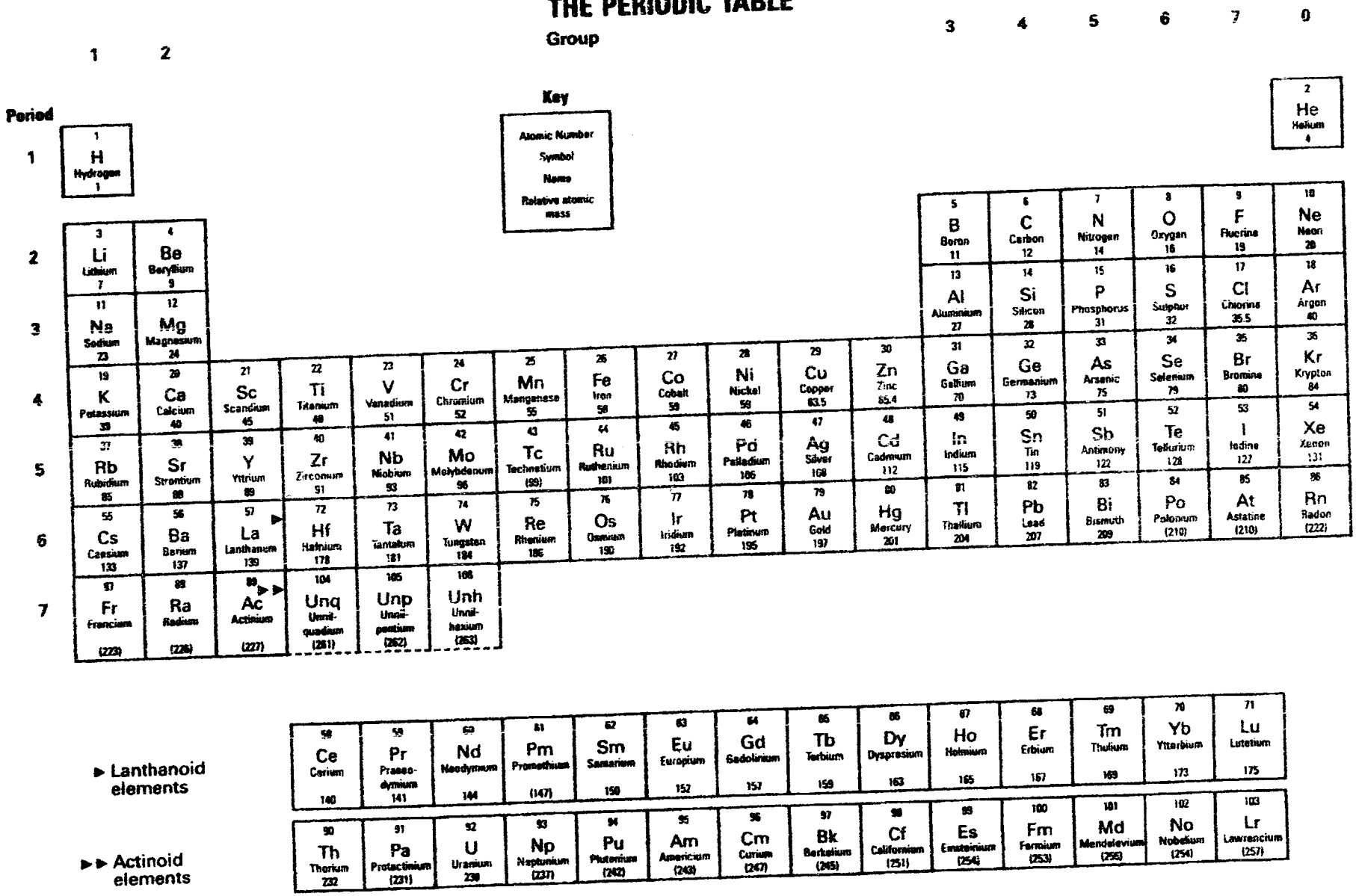
(iii) Describe the nature d-d transitions?

(b) Distinguish between VBT and CFT is explain bonding to octahedral coordination compounds.

(c) The ion $[Ni(py)_4(H_2O)]$ shows bands of extinction coefficient about 20 at 10 150, 16 500 and 27 000 cm^{-1} . Interpret the spectrum on the basis of an octahedral complex. Find Δ_{oct} and **B**.

END OF EXAMINATION

THE PERIODIC TABLE



THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
AUGUST 2003.

C351
ORGANIC CHEMISTRY III

Time: **Three (3) Hours**

Instructions:

1. **Answer any FOUR questions.**
2. **All questions carry equal marks. Marks allocation for each question is shown.**
3. **Spectral data are attached.**
4. **Maximum marks = 100.**

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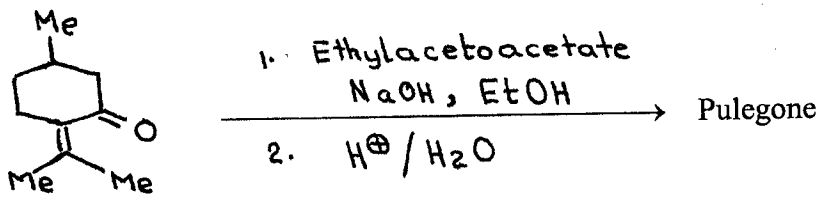
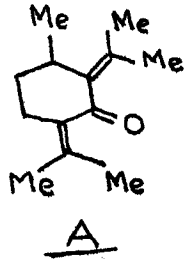
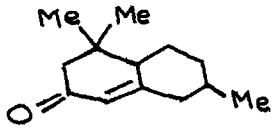
1. a) A compound called 'Pulegone' had been isolated from the following reaction.



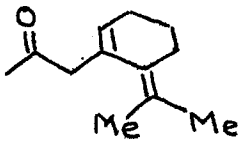
Three structures, **A**, **B**, and **C** had been proposed for 'pulegone' at various times.



A



B



C

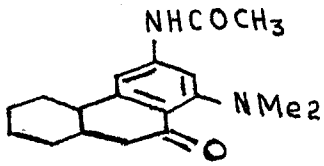
Use the following ^{1}**Hnmr** data and show the correct structure for pulegone, clearly stating your reasoning.

δ(ppm): **0.97(d, 3H);** **1.11(s, 6H);** **1.2 - 2.0(m, 6H);** **2.3(s, 2H)**

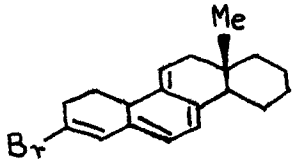
6.1 (s, 1H)

(13 marks)

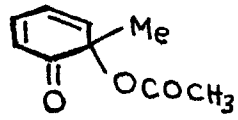
b) Predict the expected **uv** absorption maximum for the compounds **D**, **E** and **F**, structures are shown below.



D



E



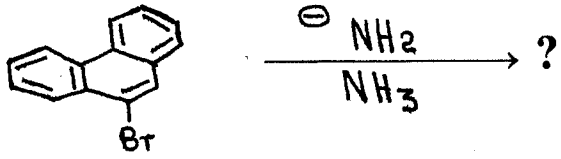
F

(12 marks)

2. a) Show the synthesis of phenanthrene by the Bogert-Cook process.

(9 marks)

b) Write a reasonable mechanism for the following reaction showing all intermediates involved and the product.



(10 marks)

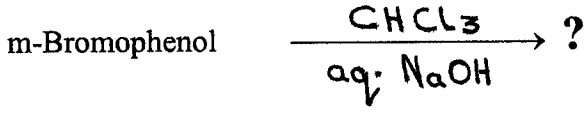
c) On the basis of the mechanism in 2(b) above what would be the course of reaction for 2-methyl-9-bromophenanthrene ?

(6 marks)

3. a) Azulene, structure shown below, has a dipole moment equal to 1.0D, and obeys Hückel's expression of aromaticity (a 4n+2 π-electron cycle), and it is isoelectronic with naphthalene. Using this information, show the product of Friedel-Crafts acetylation of azulene.

(6 marks)

b) Phenols are reactive towards electrophilic aromatic substitution. On this basis show the major product and propose a mechanism for the following reaction.



(10 marks)

c) The α-positions in the unsubstituted naphthalene are said to be the most reactive and, the first substitution takes place at one of these α-positions. This fact is clearly illustrated by the acetylation of naphthalene in carbon disulfide solution, which predominantly yields 1-acetylnaphthalene. When the same reaction is carried out in nitrobenzene, the predominant product is 2-acetylnaphthalene. Give reasons to account for the difference in the products formed.

(9 marks)

4. a) Deduce the structure of compound **H**, $C_6H_{11}BrO_2$, from the attached spectra. Show your reasoning and assign the nmr peaks to particular carbon and hydrogen atoms to your proposed structure. Explain any two peaks, other than the molecular ion peak in the mass spectrum

(16 marks)

b) Deduce the structure of compound **I**, $C_7H_6O_2$, from the attached spectra. Show your reasoning. (**Note**: The compound is not a carboxylic acid)

(9 marks)

5. a) Deduce the structure of compound **J**, from the following data.

MS : Isotopic Abundance

m/z	% Relative Abundance
86 ($M^{+\cdot}$)	100
87	4.4
88	0.08

IR (neat): **Selected Bands, $\bar{\nu}$ (cm^{-1})**

3300 – 3100 (broad); 1700 (s); 1640 (m); 1250 (s)

^{1}Hnmr: **δ (ppm)**

11.80 (s, 1H), the signal disappeared after deuteration of compound **J**, with D_2O.
7.10 (doublet of quartets, 1H, J=1.0 Hz and J=5.1 Hz)
5.80 (doublet of quartets, 1H, J=1.0 Hz and J=4.7 Hz)
1.90 (doublet of doublets, 3H, J=4.7 Hz and J=5.1 Hz)

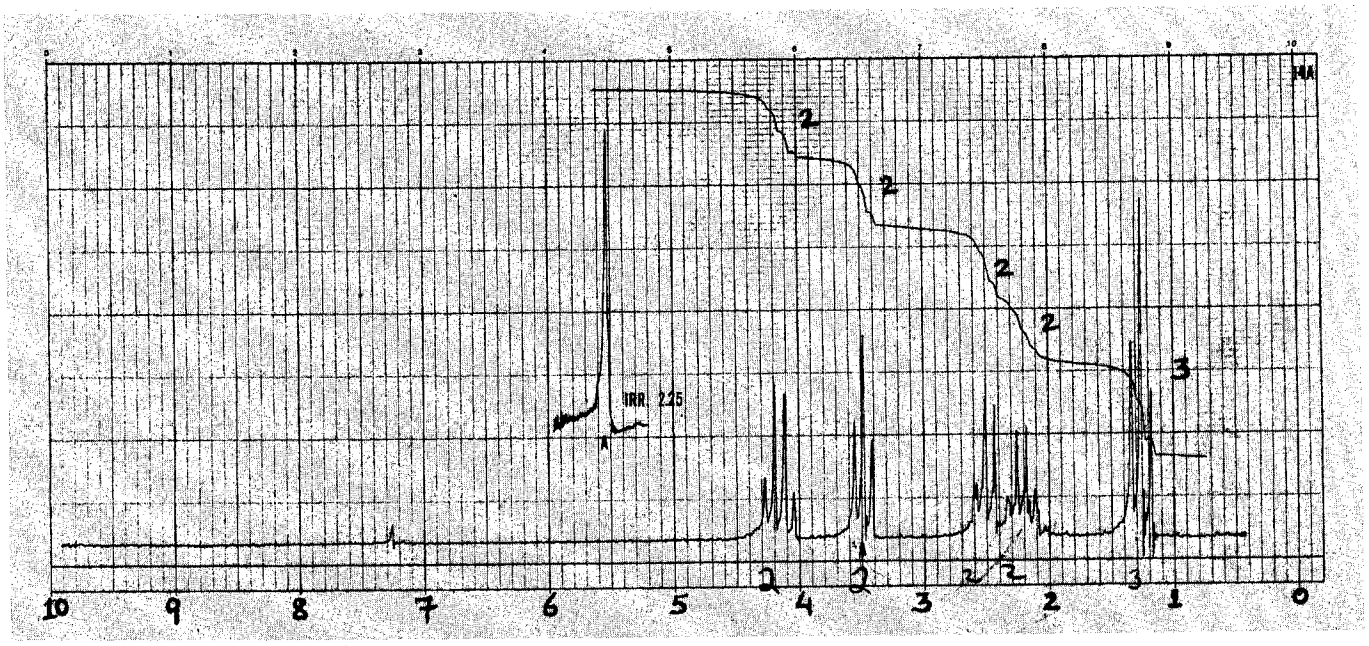
(10 marks)

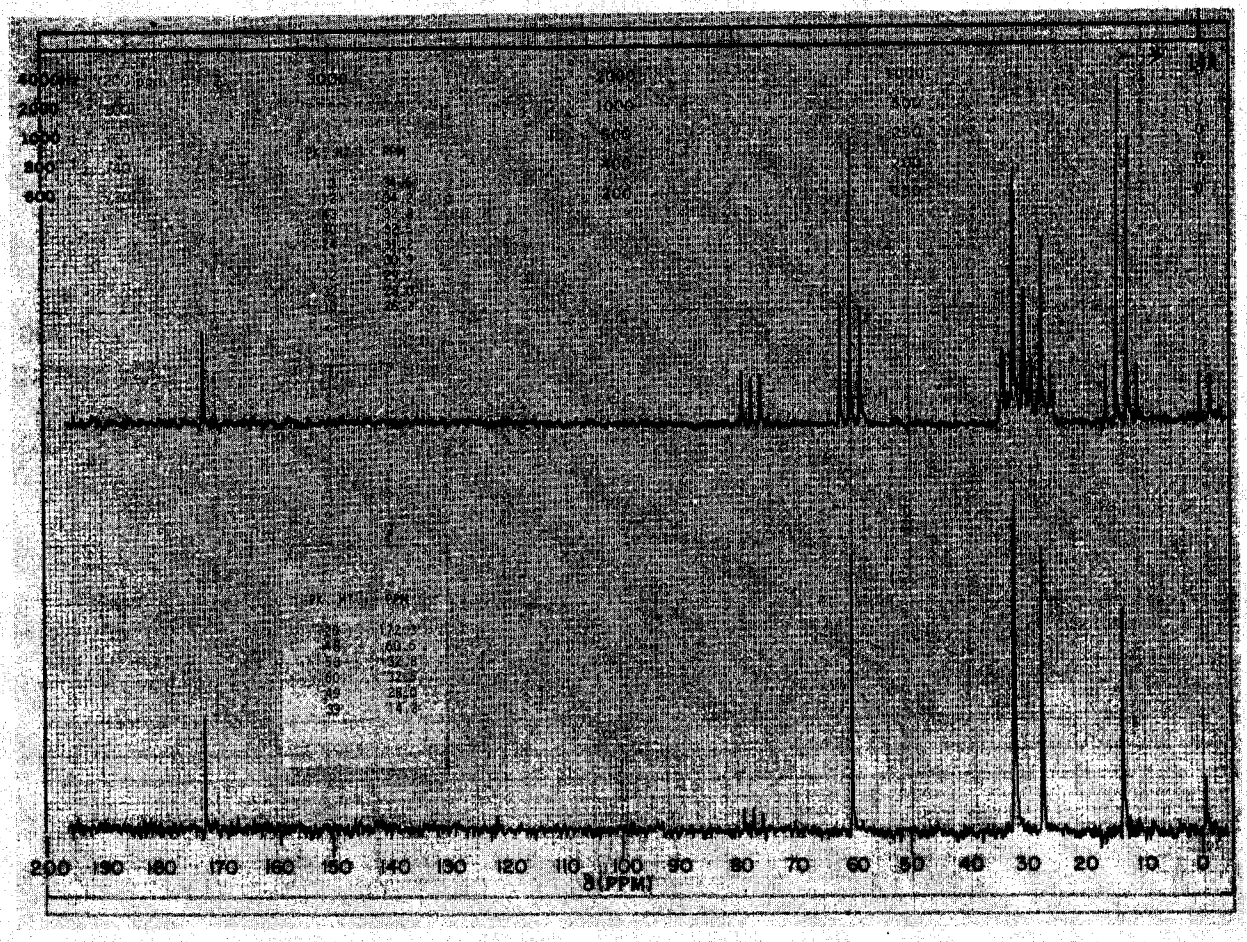
b) Deduce the structure of compound **K**, $C_7H_{16}O_4$, from the attached ir, ms and nmr spectra. Show your reasoning and assign the observed nmr peaks to particular carbon and hydrogen atoms to your proposed structure.

(15 marks)

END OF EXAM

QUESTION 4(a) COMPOUND H

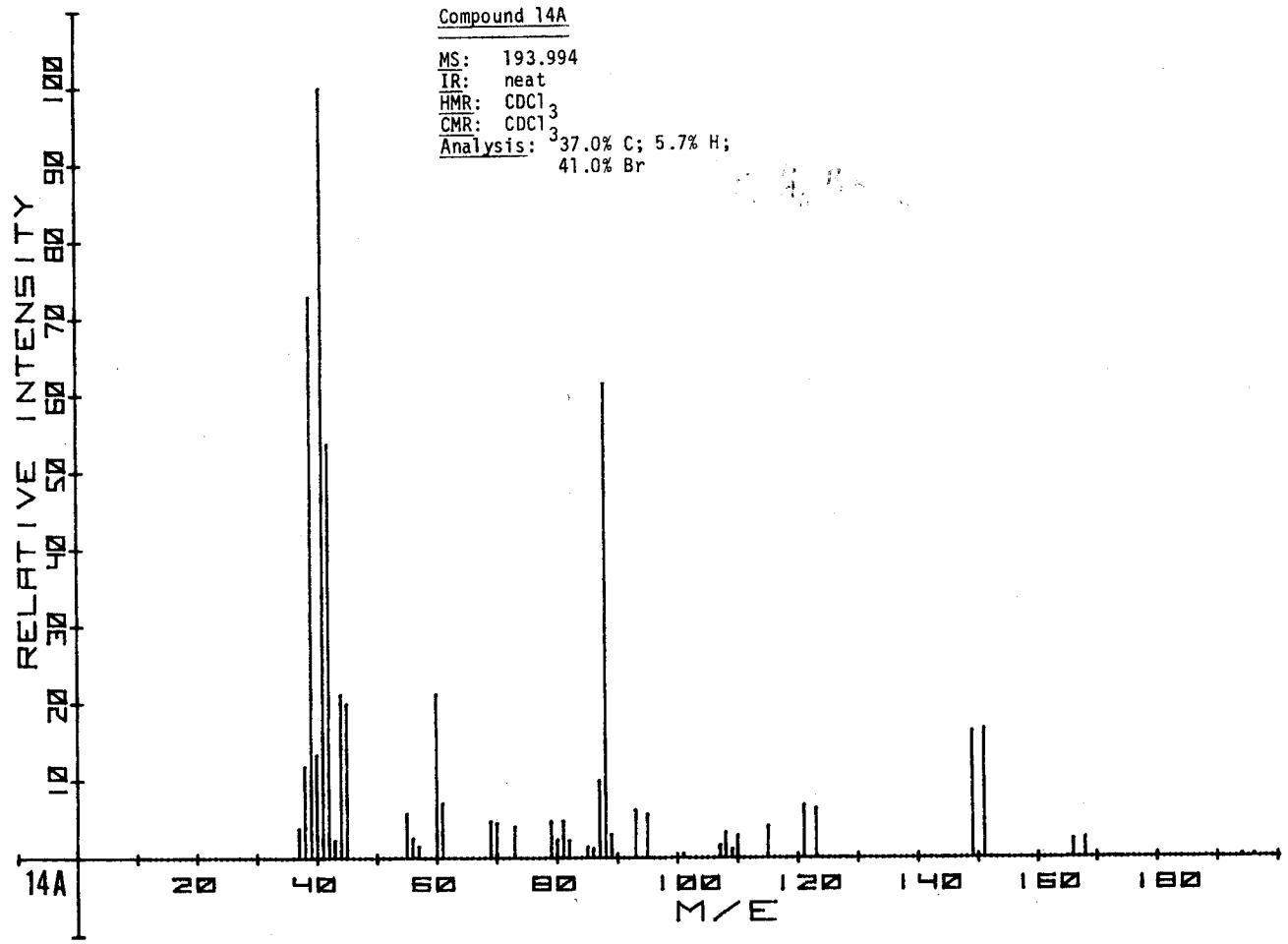


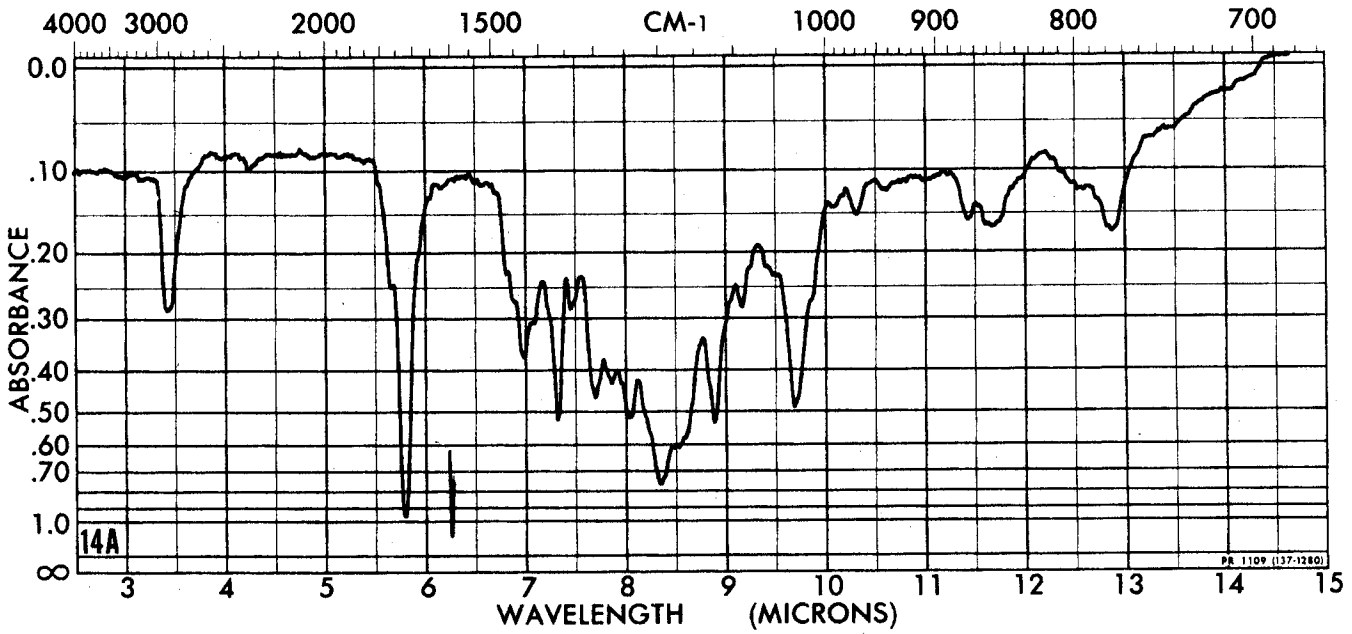


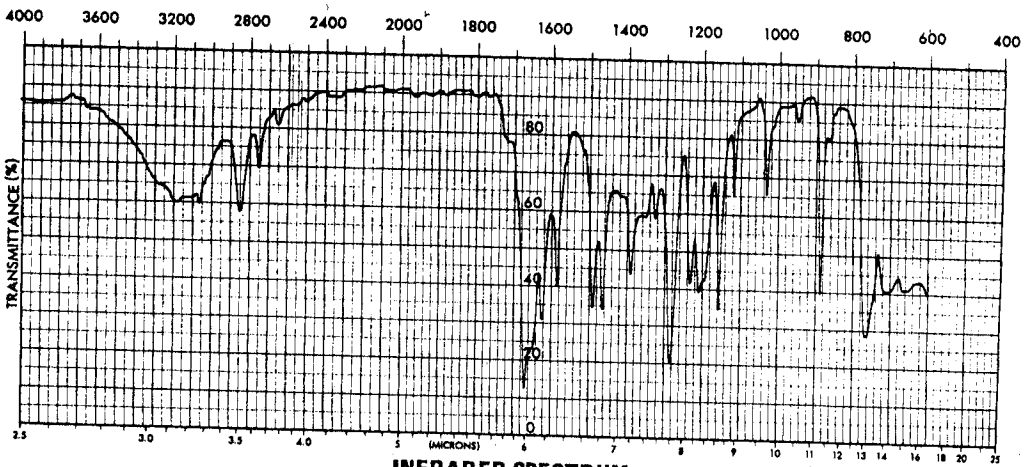
QUESTION 4 (a)

COMPOUND H

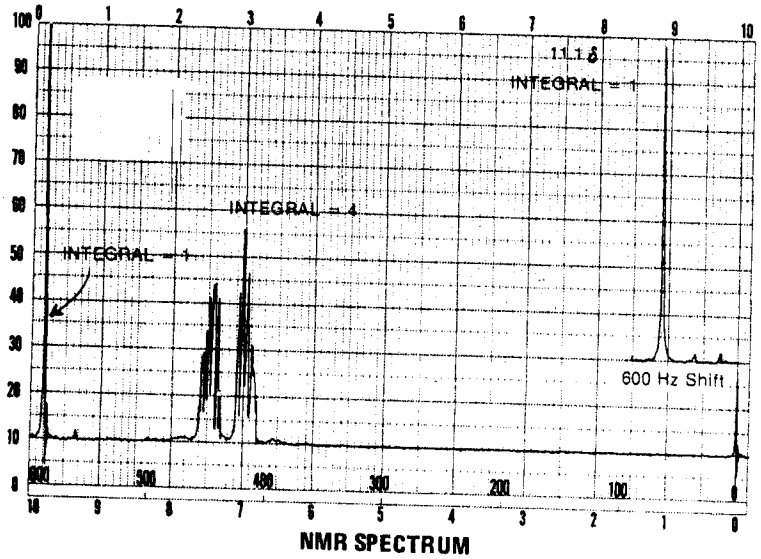
COMPOUND H







INFRARED SPECTRUM



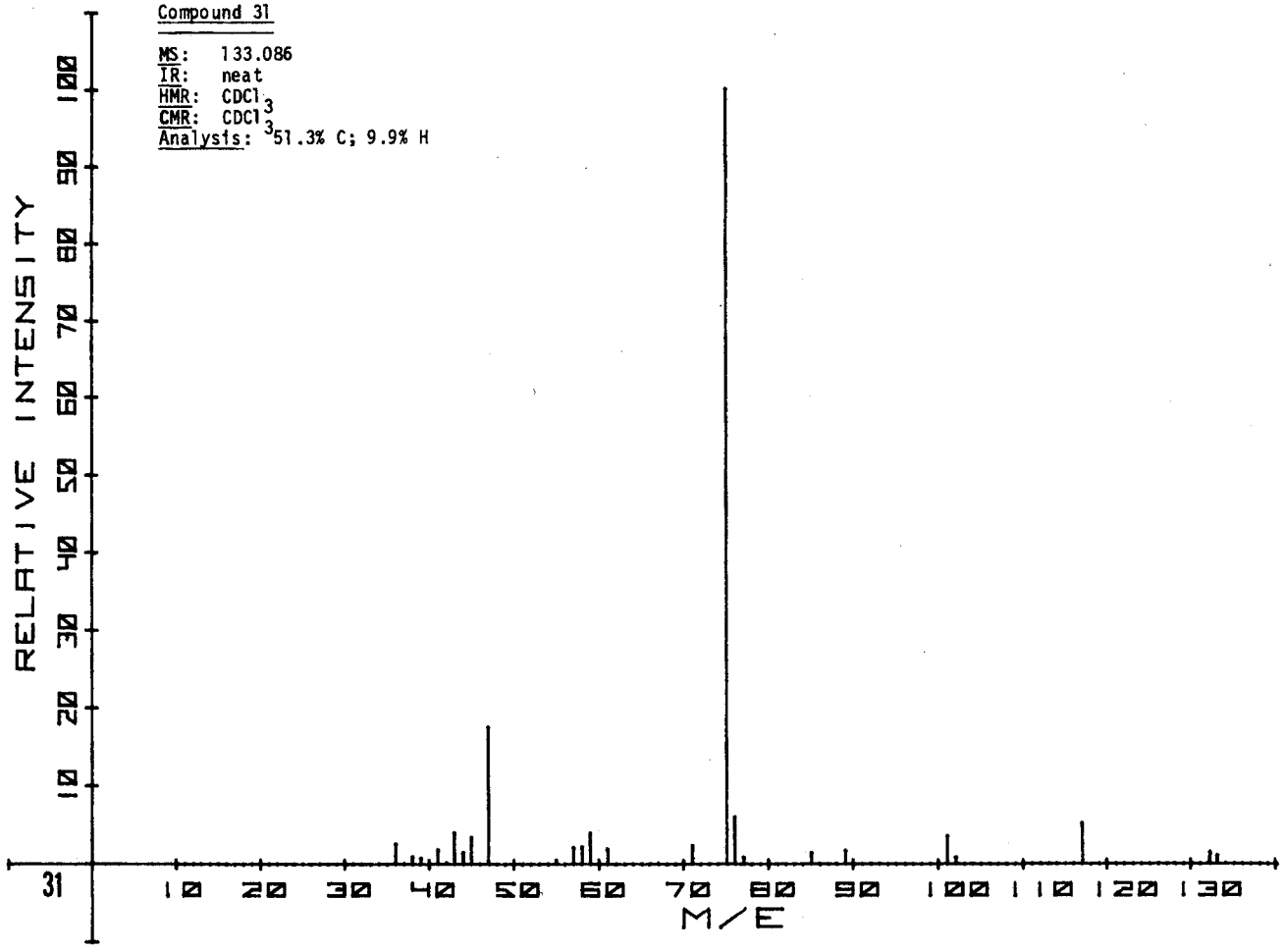
NMR SPECTRUM

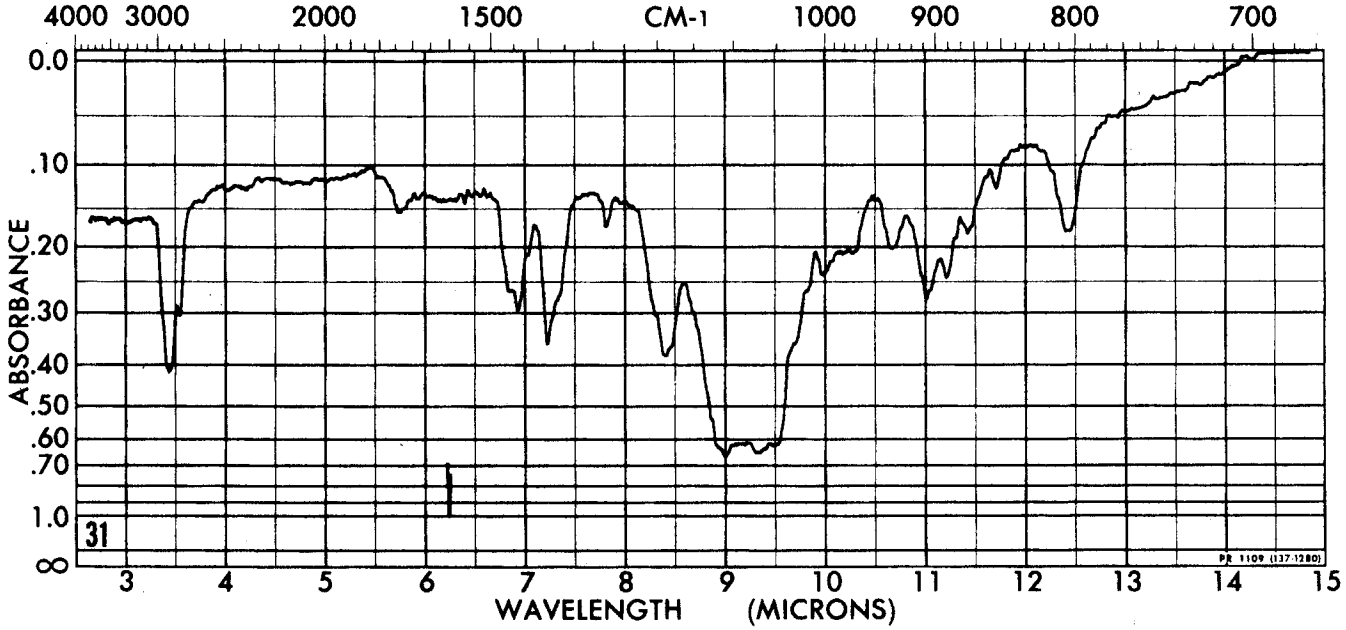
COMPOUND I

QUESTION 4 (b)

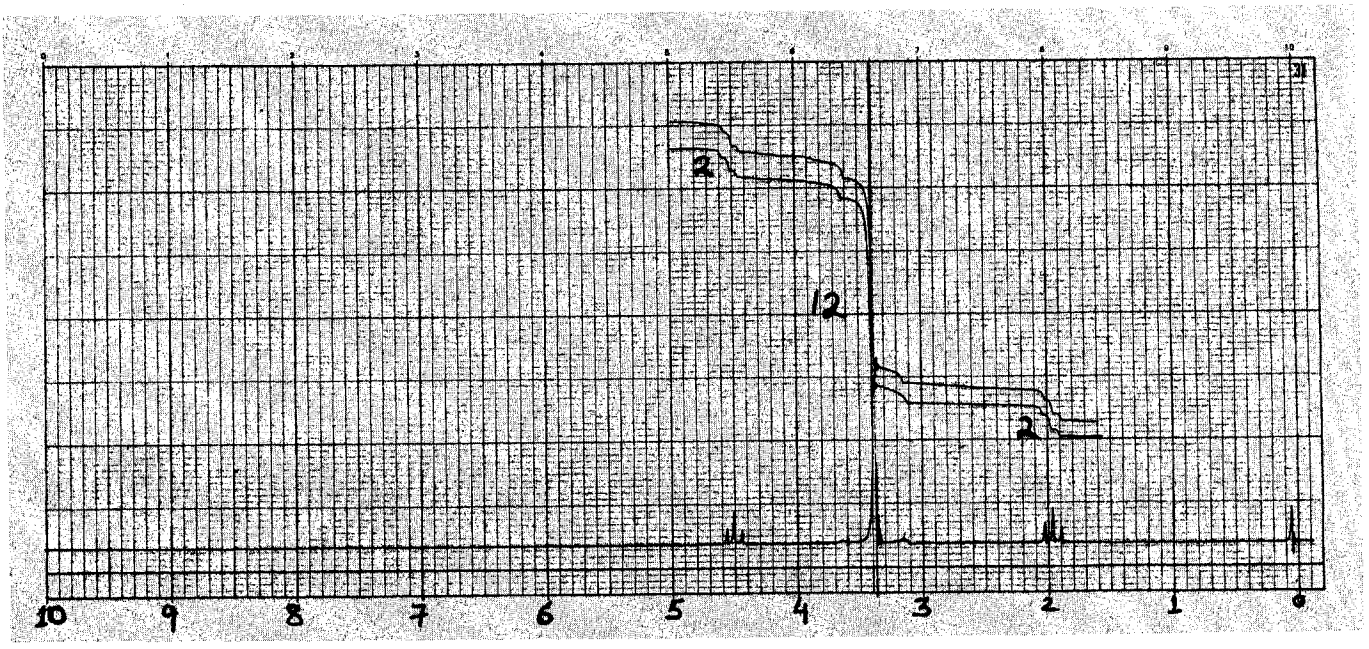
COMPOUND K

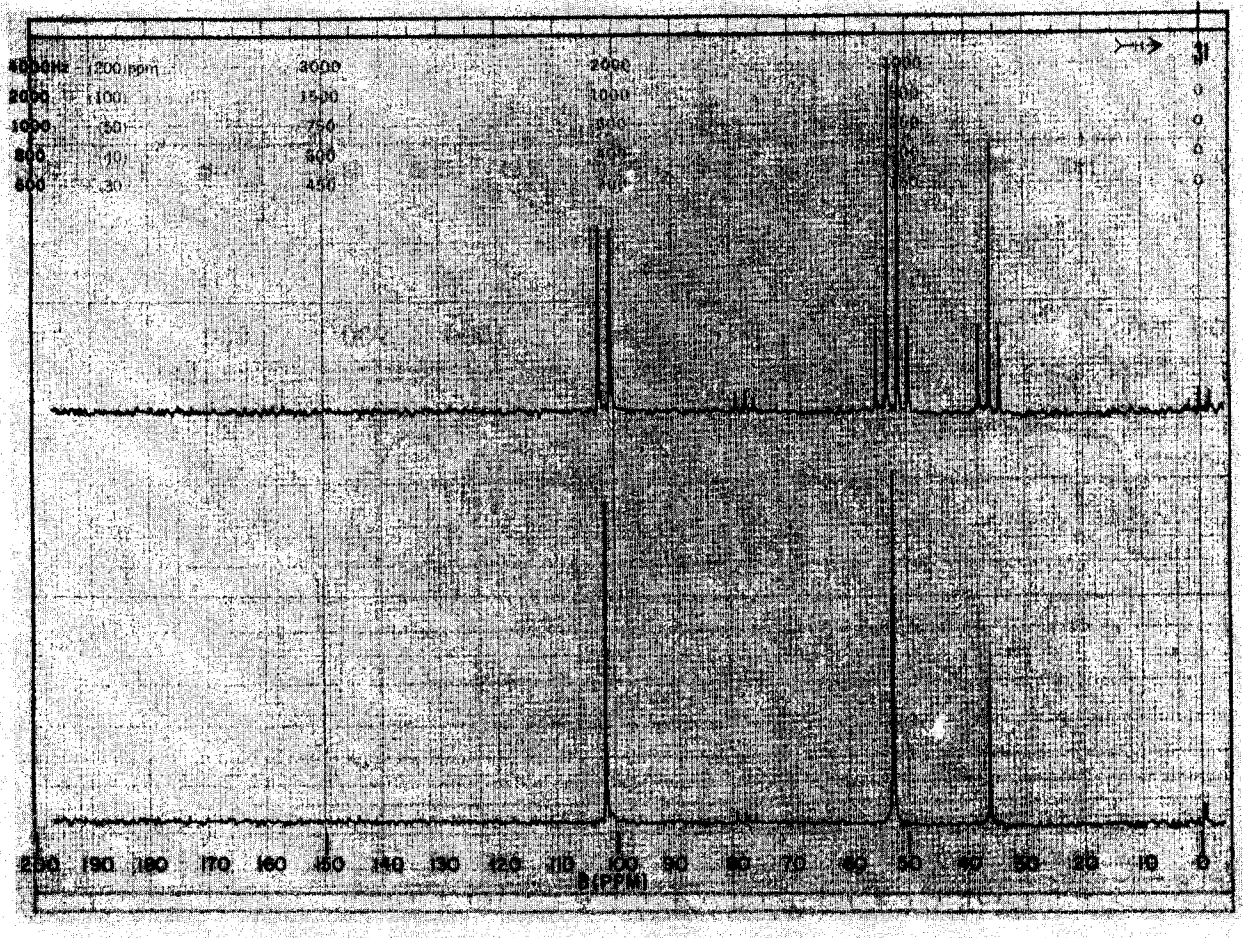
QUESTION 5(b)





QUESTION 5(b) COMPOUND K





University of Zambia
University Examinations
Semester I 2003

C411 Advanced Biochemistry I

Instructions:

Time: Three **(3)** hours

Answer **ANY FIVE QUESTIONS**

Q.1 a) Explain how the myosin head converts the energy of ATP hydrolysis into mechanical energy. 10

b) Write short notes on the functions and biosynthesis of ABA. 10

Q.2 a) You have been contracted to purify a protein from a plant used in a traditional Ugandan concoction used to relieve dysentery. Explain in clear concise points how you would purify the protein to homogeneity. 10

b) Write short notes on control of metabolism at initiation. 10

Q.3 a) Write short notes on the control of metabolism at transcription elongation. 10

b) (i) Explain in brief how Gel Permeation Chromatography (GPC) may be used to fractionate proteins of different sizes. 5

(ii) The elution volume in GPC is given by 5

$$V_e = V_o + K_{se}V_e$$

where V_e is elution volume, V_o is the void volume and V_i is internal volume.
Define K_{se} and comment on its two extreme values:

$$K_{se} = 0 \text{ and } K_{se}=1.$$

Q.4 Outline the fluid mosaic model of membrane structure in clear concise points, citing any experimental evidence that you know of to support each point. 20

Q.5 a) Adsorbents can be classified according to the forces involved in binding the solute. Identify and give a statement(s) on their nature. 10

b) Give brief comments on polar and non-polar adsorbents used in adsorption chromatography. In your comment 10

(i) Give one (1) example of each type;

(ii) Explain how the adsorption capacity in polar and non-polar adsorbents is influenced by the surface.

Q.6 A new virus has been discovered that interferes with the body's mechanisms for producing and metabolizing certain amino acids. With respect to neurotransmission, which three amino acids would this virus cause most damage by targeting? Explain. 20

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF CHEMISTRY
AUGUST EXAMINATIONS 2003

C421
APPLIED ANALYTICAL CHEMISTRY

TIME: 3 HOURS

ANSWER ANY 4 FROM THE 5 QUESTIONS IN THIS PAPER

QUESTION 1

(a) To a crude mixture of organic compounds containing some benzoic acid and benzoate was added 40mg of benzoic acid-7 ^{14}C (activity = 2000 counts/minute). After equilibration the mixture was acidified and extracted with immiscible solvent. The extracted solid of benzoic acid was purified and weighed 60mg which gave a count of 500 counts /min. Compute weight of benzoic acid in the crude mixture.(3)
(b) Describe 2 detectors used in x-ray analysis and their principles of operation.(3)
(c) What do you understand by the terms: photoelectric effect, Compton effect and *bremsstrahlung* as used in radiochemistry.(3).
(d) Discuss metal speciation techniques. (3)
(e) Discuss the uses of x-rays and radiochemistry in metal analysis. (3)

QUESTION 2

(a) Iron ore was analysed for Fe content by dissolving it in acid, converting Fe to Fe^{2+} then titrating the solution with 0.02N potassium dichromate solution. 34.5ml is required to titrate Fe in 1.54g ore. How much Fe was in the sample expressed as $\%Fe_2O_3$. What indicator should be used in the titration. (Fe = 55.8)
(b) Compare the determination of Au and that of Zn from their ores. (2)
(c) Some alloys tend to have 2 common elements, name any 2 of such alloys and describe the analysis of one of such elements. (3).
(d) How do you determine Mg in limestone and Ti in bauxite? (3)
(e) Describe the determination of Mn and Mo in steel. (3)

QUESTION 3

(a) 0.3g Sample containing Cu is dissolved and a colored complex is formed in the presence of EDTA. The solution is diluted to 50ml and the measured absorbance is 0.260. 0.5g sample containing 0.24% Cu is treated similarly and the resulting solution has an absorbance of 0.60. Calculate %Cu in the sample. (3)

(b) Most soils contain some exchangeable cations, what are they and explain in detail how any 3 of them can be determined. (3)
(c) Physical ways can be used to try and identify the type of soils in many fields, describe how soils are easily differentiated. (3)
(d) What do you understand by the following terms: alkalinity of ash, exchangeable acidity and base saturation as used in soil analysis. (3)
(e) Describe 2 methods used in the determination $CaCO_3$ in soils. (3)

QUESTION 4

(a) A water sample is analyzed for Li by FES using std addition method. Three 0.5ml aliquots of sample are added to 5ml portions of solvent. To these are added (i) 0µl (ii) 10µl and (iii) 20µl of std 0.05M LiCl solution. The emission signals are 23.0, 45.3 and 68.0 for solutions (i), (ii), and iii respectively. What is the concentration of Li in the sample in ppm (w/v) (3)
(b) In monitoring SO_2 in the environment absorption train using H_2O_2 as an adsorbent is used rather than West and Gaeke reagent. Discuss advantages and disadvantages of this for large scale monitoring. (3)
(c) Define or describe the terms: bio-concentration factor, eutrophication and green house effect. What do these terms signify? (3)
(d) Which techniques would be useful in the analysis of: (i) NO_2 in the external atmosphere at several locations, (ii) an organic solvent in a lab environment and (iii) CO in order to protect a worker in an area where there may be rapid increases in concentration. (3)
(e) An analyst notes that 1ppm solution of Na gives flame emission signal of 110, while the same solution containing 20ppm K gives a reading of 125. It was determined that 20ppm solution of K exhibited no blank reading. Explain the results. (3)

QUESTION 5

(a) For determining glucose in blood serum, 2 methods are used, a std method (Folin-Wu) and another are used. Is there a difference in the 2 methods at 95% confidence level. Tabulated value is 4.95. (3)

New method mg/dl	std method mg/dl
127	130
125	128
123	131
131	129
126	127
129	

(b) Discuss the important parameters you would consider to ensure that water for domestic use is acceptable for human consumption and include description of 2 determinations of these parameters. (3)

(c) In flame spectrophotometry, discuss the differences between emission, absorption and fluorescence spectrometry, giving examples to illustrate them. (3)

(d) Discuss 4 ways of collecting atmospheric gases for analysis and include the description of the determination of one of such gases (3)

(e) Explain the main steps in the atomization of an analyte using electrothermal furnance including the physical and chemical processes that occur in each step. (3)

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
AUGUST 2003.

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.
4. Maximum marks = 100

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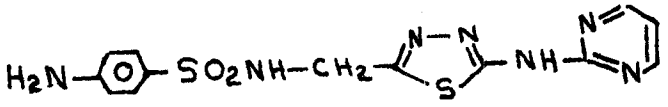
1. a) Suggest a synthesis for the anti-microbial compound **A**, structure shown below. State the reagents and the reaction conditions for each step of your synthesis.

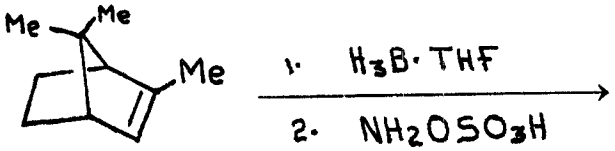


A

(13 marks)

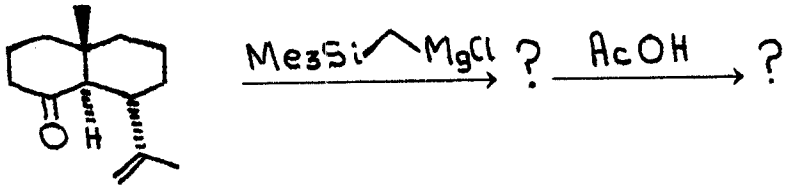
b) Write the mechanisms and clearly show the products of the following reactions.

i)



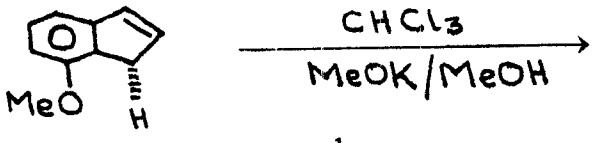
(4 marks)

ii)



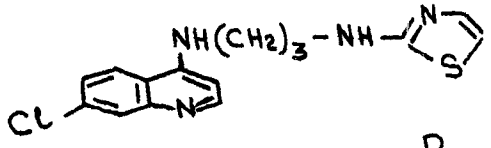
(4 marks)

iii)



(4 marks)

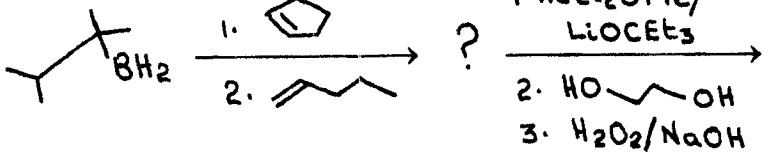
2. a) Propose a synthesis for the anti-malarial agent **B**, structure shown below, from readily available starting materials and any other needed reagents. State the reagents and the reaction conditions for each step of your synthesis.



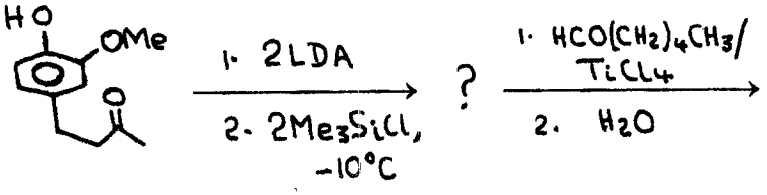
B

(13 marks)

b) Give the structures of major organic products of the following reactions:

i) 

(4 marks)

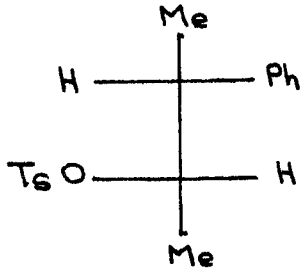
ii) 

(4 marks)

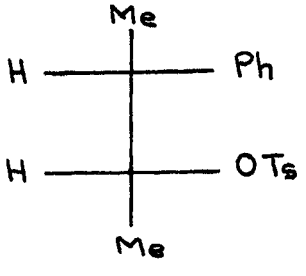
c) Discuss the structure-activity relationships in 4-amino-quinolines.

(4 marks)

3. a) Solvolysis of optically pure **threo**-3-phenyl-2-butyltosylate **C**, in ethanoic acid at 100°C gave racemic **threo**-3-phenyl-2-butylacetate. In contrast, acetolysis of optically pure **erythro**-3-phenyl-2-butyltosylate **D**, under identical reaction conditions gave optically pure **erythro**-3-phenyl-2-butylacetate. Provide a detailed explanation for these experimental results and show the reaction mechanisms.



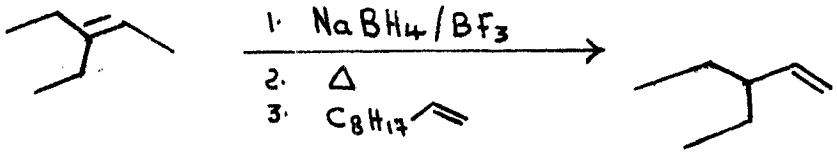
C



D

(15 marks)

b) Hydroboration has been used to induce isomerisation of tri-substituted alkenes into mono-substituted ones. This isomerisation may be represented as shown below.

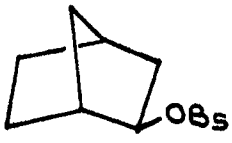


Suggest a mechanism for this reaction.

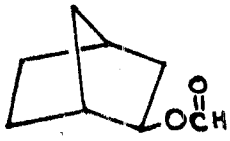
(10 marks)

4. a) Give a detailed mechanistic explanation for the following observations:

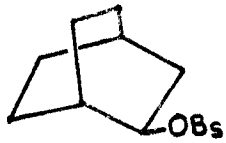
Optically active **exo**-norbornyl brosylate **E**, reacts with formic acid at 70°C to give optically inactive (racemic) **exo**-formate, **F**. However, reaction of optically active **exo**-brosylate **G**, with formic acid under identical reaction conditions gives optically active **exo**-formate **H**.



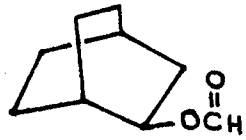
E



F



G



H

Optically active Optically inactive Optically active Optically active

(12 marks)

b) Because of high reactivity, free carbenes are usually absent in the reaction mixture, but may be present as α-halo-organometallic complexes, called carbenoids, which undergo α-elimination reactions to give carbenes. On this basis provide:

(i) Any one reaction that shows the generation of unsubstituted carbene from an appropriate carbenoid.

(ii) Any one reaction that shows the generation of a disubstituted carbene from an appropriate carbenoid.

(4 marks)

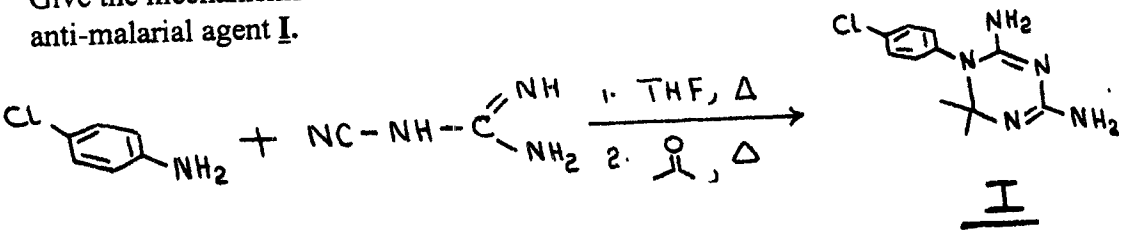
c) If the disubstituted carbene obtained in 4(a) (ii) above, were reacted with cyclopentene at –95°C, and the resultant reaction mixture were washed with aqueous silver nitrate, what product would you expect to obtain? Provide a reasonable mechanism for this reaction.

(9 marks)

5. a) Explain in detail the mode of anti-bacterial action of the β-lactam antibiotics.

(10 marks)

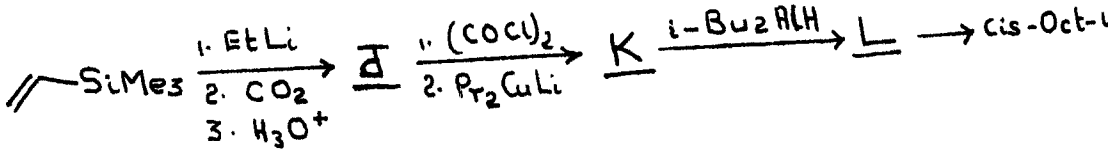
b) Give the mechanisms of the reactions involved in the following synthesis of the anti-malarial agent **I**.



I

(6 marks)

c) Conversion of β-hydroxysilanes into alkenes is a powerful tool for the synthesis of alkenes. The reaction is called the 'Peterson Olefination'. On the basis of this reaction, the synthetic steps for the synthesis of cis-oct-4-ene from 1-trimethylsilylethene are shown below:



i) Provide the structures for compounds **J**, **K** and **L**.

(3 marks)

ii) Write a reaction mechanism to show the transformation of compound **K** into cis-oct-4-ene, through compound **L**.

(6 marks)

END OF EXAM

UNIVERSITY SEMESTER I EXAMINATION

CHEMISTRY DEPARTMENT

AUGUST, 2003

C481 – INORGANIC INDUSTRIAL CHEMISTRY

TIME: THREE (3) HOURS
INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS

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1. The hydraulic-setting binding material Portland cement is produced mostly by wet method. Describe:
   (a) The raw materials.
   (b) The technological process.
   (c) The overage concentrations of alite, belite, celite and tetracalcium alumferrite in Portland cement.

2. In production of ceramic items and glasses they use the raw materials, containing sand, clay, gypsum and others.
   (a) Wright the formulas of the raw materials.
   (b) Discus the type of glasses you know, indicating the properties and main components.
   (c) Write brief on the air-setting binding materials.

3. In production of inorganic substances, such as acids, fertilizers, etc. different absorbers and gas purification apparatus are used. Describe:
   (a) Packed columns.
   (b) Absorbers with bubble cap plates and sieve plates.
   (c) Fluidized packing columns.
   Outline the advantages disadvantages associated with the discussed apparatus.

4. What do you know about crushing and grinding processes? Discuss:
   (a) Jaw crushers.
   (b) Ball grinders.
   (c) Drum crusher.
   Name the industrial processes that employ these apparatus in their operations.

5. Discuss the production and use:
   (a) Lamp black.
   (b) Carbon black.
   (c) Activated carbon.

6. (a) How do they produce and purify the Sodium chloride?
   (b) Write brief notes on the production of H_2, Cl_2 and NaOH from NaCl.
   (c) Describe the technological processes production of Hydrochloric acid.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER 1 EXAMINATIONS

21 AUGUST 2003

CAV 251

ANALYTICAL/PHYSICAL/ORGANIC CHEMISTRY

TIME: THREE HOURS

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INSTRUCTIONS

1. There are THREE Sections in this examination paper: Section A, B and C.
2. Both Section A and B have two questions each. You are to answer ONE question from each Section.
3. Section C has four questions. Answer THREE questions from this Section.
4. All questions carry equal marks. Marks are shown for each question or part thereof by means of square brackets, []
5. Show all your working, mechanisms and reasoning clearly.

IMPORTANT INFORMATION

RAM: Na = 23; C = 12.01; N = 14.01; H = 1.01

$K_w = 1.00 \times 10^{-14}$

R = 8.314J/mol. K

$C_p = C_v + R$

1 atm = $101325 N/m^2$

Statistical Tables -annex

SECTION A. ANALYTICAL CHEMISTRY

Answer only **ONE** question in this Section

QUESTION ONE

A. (i) Briefly discuss soil sampling at a farm. What possible problems would you get and how would you overcome them? [6]

(ii) State and explain the errors that would affect the accuracy and precision of experimental results. How would you correct them? [3]

B. The following results were obtained for a sample that contains 25.00% $ZnCl_2$. Does the method contain a determinate error? Explain your answer. [5]

Sample Taken (g)	$ZnCl_2$ Found (g)
0.4000	0.0978
0.3600	0.0878
0.3800	0.0927
0.4400	0.1079

C. The Director of a Hospital Clinical Laboratory was trying to decide whether or not to keep a young, recently hired Technician. The Director decided to see if the new Technician's work was of the same quality as that of the other staff. She asked both a Senior Technician and the new Technician to analyze the same sample using the same procedure, reagents, and instruments. They obtained the following results: -

Senior Technician (%)	New Technician (%)
1.38	1.28
1.33	1.36
1.34	1.35
1.35	1.40
1.30	1.31

Determine if there is a significant difference in the precision of the data at 95% confidence level. [10]

QUESTION TWO

A. Chromates, CrO_4^{2-}, ions are added to a solution containing 0.030M Ba^{2+}, 0.00030M Sr^{2+}, and 0.010M Ca^{2+}. What is the order of precipitation of chromates? [6]
Ksp for $BaCrO_4$ is $1.2x10^{-10}$
Ksp for $SrCrO_4$ is $3.6x10^{-5}$
Ksp for $CaCrO_4$ is $7.1x10^{-4}$.

B. (i) Write the steps involved in a gravimetric analysis.[3]

(ii) A 50.0 mL portion of 0.100M K_2CrO_4 solution is mixed with 50.0 mL of 0.240M $AgNO_3$ solution. Calculate the molar solubility of Ag_2CrO_4 in the solution. Ksp for $Ag_2CrO_4 = 1.9x10^{-12}$.[5]

C. The ionization constant of the weak acid, HCN, is $6.34x10^{-12}$. A solution is prepared by dissolving 9.812g of NaCN in enough water to make 1.00dm^3 of solution.

(i) Calculate the pH of the solution.
(ii) How many moles of HCl must be added to this solution for the resulting solution to have a pH of 9.60? HCl is added as a gas to avoid volume change. [10]

SECTION B. PHYSICAL CHEMISTRY

Answer only **ONE** question from this Section.

QUESTION ONE

A. What is a reversible process? Three moles of an ideal gas at 300K expand isothermally and reversibly from 20dm^3 to 60dm^3. Compute w, q, ΔE and ΔH. [10]

B. (a) Derive equations for entropy change for

(i) Isothermal expansion of an ideal gas from volume v_1 to v_2
(ii) Isochoric temperature change of a gas from T_1 to T_2. [4]

(b) Calculate the entropy change when a mono atomic gas at 25°C and one atmosphere pressure in a container of volume 500cm^3 is allowed to expand to twice its initial volume and simultaneously heated to 100°C (for mono atomic gas Cv =1.5R)[5]

(c) Find the molar entropy of neon at 500K given that its entropy at 298K is 146.22J/K.mol and its Cv is 12.47J/K.mol. Take constant volume conditions. [5]

QUESTION TWO

A. Define the Zeroth Law of Thermodynamics and give an example of its application. [6]

B. A chemical reaction occurs in a vessel of cross sectional area 25cm^2 fitted with a loosely fitted seal. During the reaction the seal is pushed 2cm against the external pressure of one atmosphere. 1 atm = 101325N/m^2 (Pa).

(i) How much work does the reaction do on the outside world?
(ii) How much work is done if the pressure of the system is replaced by a mass of 5kg acting downwards on the vertical piston? [8]

C. At 25°C the values of ΔH and ΔS for a chemical reaction are –94.5kJ and –188.9J/K respectively and these values are not changed much by temperature changes.

(i) What is the value of ΔG at 25°C?
(ii) What is the value of the equilibrium constant at 25°C?
(iii) What is the value of equilibrium constant at 727°C? [10]

SECTION C ORGANIC CHEMISTRY

Answer THREE questions from this Section

QUESTION ONE

A. (i) Draw both E- and Z-1-methylcycloheptene. Which of the two isomers would you expect to be more stable and why? [4]

(ii) Give the stereo chemical structures of the product that would be obtained when 2-butyne reacts with hydrogen in the presence of Lindlar's catalyst. [3]

B. Ethene, C_2H_4, reacts with concentrated H_2SO_4 by electrophilic addition of H^+ and HSO_4^- across the double bond to give $CH_3CH_2OSO_3H$.

(i) Give a mechanism for this electrophilic addition reaction. [3]

(ii) Describe a simple chemical test to confirm that the carbon-carbon double bond is not present in the product. [3]

C. Substitution reactions of halo-alkanes can proceed via an S_N1 or an S_N2 mechanism. When 1-bromobutane, $CH_3CH_2CH_2CH_2Br$, 2-bromobutane, $CH_3CH_2CHBrCH_3$, and 2-bromo-2-methylpropane, $(CH_3)_3CBr$ are reacted separately with aqueous sodium hydroxide solution each gives the corresponding alcohol.

(i) What is meant by the terms S_N1 and S_N2? [4]

(ii) Give the mechanism for the S_N1 reaction between optically active 2-bromobutane and aqueous sodium hydroxide and explain why the reaction product is optically inactive. [7]

QUESTION TWO

A. There are three isomeric alkanes of molecular formula C_5H_{12}. Isomer **A** gives a mixture of four monochlorination products when reacted with chlorine gas at 300°C. Under the same conditions, isomer **B** gives a mixture of three monochlorintion products while isomer **C** gives only one monochlorination product. From this information assign structural formulas to isomer **A**, **B** and **C**. [10]

B. (i) State the necessary criteria for a compound to be aromatic. Briefly explain the Huckel's Rule of aromaticity with special reference to benzene and naphthalene. [5]

(ii) Give an account of the mechanism of Friedel Craft's alkylation reactions of benzene. [5]

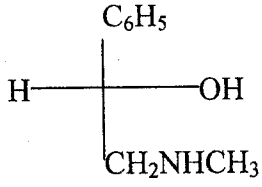
C. Show that the hydroxyl group in phenol directs the bromination to take place at para rather than meta position. [4]

QUESTION THREE

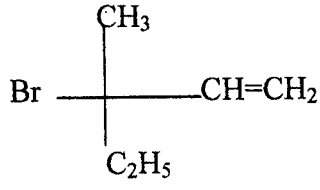
A. There are four isomeric alcohols of molecular formula $C_4H_{10}O$. Draw and name each isomer. One of the four isomeric alcohols compound **D** ($C_4H_{10}O$), on oxidation by $K_2Cr_2O_7$ in acid solution gives compound **E** ($C_4H_{10}O_2$), a carboxylic acid. Treatment of compound **D** with warm phosphoric acid brings about dehydration and yields compound **F** (C_4H_8). Treatment of compound **F** with warm aqueous sulphuric acid gives compound **G** ($C_4H_{10}O$); a new alcohol isomeric with compound **D**. Compound **G** is resistant to oxidation. Propose structures for compounds **D**, **E**, **F** and **G** consistent with these observations. [14]

B. Using the R/S system of nomenclature assign the configuration of the chiral carbon in the molecules shown below. Explain your reasoning. [10]

(i)



(ii)



QUESTION FOUR

A. (i) Explain, using formulas, the difference between a D- sugar and an L- sugar. [6]

(ii) What is the difference between the structures of D-ribose and 2-deoxy-D-ribose? [2]

B. 5-hydroxyhexanal, structure shown below, readily forms a six-membered cyclic hemiacetal.

$CH_3CH\ (OH)\ CH_2CH_2CH_2CH{=}O \longrightarrow$ a cyclic hemiacetal.

(i) How many stereoisomers are possible for 5-hydroxyhexanal? [1]

(ii) How many stereoisomers are possible for the cyclic hemiacetal? [1]

(iii) Draw the planar hexagon representations for all possible stereoisomers of the cyclic hemiacetal. [4]

C. (i) Write equations to show the reactions of the amino acid alanine, $CH_3CH(NH_2)COOH$, with

- HCl
- NaOH [4]

(ii) Alanine exists as two optical isomers. Draw stereo chemical structures of the two optical isomers.[3]

(iii) Explain why alanine has a relatively high melting temperature (290°C) [3]

END OF EXAMINATION

ANNEX

VALUES OF t FOR V DEGREES OF FREEDOMS FOR VARIOUS CONFIDENCE LEVELS.

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

v = N-1 = Degrees of freedom.

REJECTION QUOTIENT, Q, AT DIFFERENT CONFIDENCE LIMITS

Number of observation	Confidence Level		
	Q90	Q95	Q99
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 95% confidence level

v_2 \ v_1	2	3	4	5	6	7	8	9	10	15	20	30
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

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – AUGUST 2003

GEO 111

INTRODUCTION TO HUMAN GEOGRAPHY – I

TIME: **THREE HOURS**

ANSWER: **QUESTION 1 (40%) AND ANY OTHER THREE QUESTIONS.**

NOTE: **CREDIT WILL BE GIVEN FOR USE OF RELEVANT ILLUSTRATIONS. USE OF ELECTRONIC CALCULATOR AND AN APPROVED UNIVERSITY ATLAS IS ALLOWED.**

Q1. Table 1 shows population sizes of Zambia's ten largest Urban Areas in 1980.

Urban Area	Population
Chingola	54,737
Kabwe	130,875
Kalulushi	52,146
Kitwe	266,286
Livingstone	63,275
Luanshya	110,907
Lusaka	535,830
Mufulira	135,535
Ndola	250,502

Source: CSO (1990)

(a) Use the graph method to determine if the data conforms to the Rank – Size rule.
(b) Comment on the city distribution pattern which the actual set of data produces.

Q2. Explain the current trends in the development of human geography. (20 Marks)

Q3. 'Zambia's rapid urbanization is problematic'. Discuss. (20 Marks)

Q4. Write an account of the distribution of rural settlements in Zambia. (20 Marks)

Q5. To what extent does Weber's Location Theory attempt to explain the location of industries in Zambia? (20 Marks)

Q6. Write short explanatory notes on all of the following: (20 Marks)

(a) The four main stages in the diffusion of an innovation

(b) Environmental determinism and possibilism

(c) Nearest Neighbour Analysis

(d) Site in settlement geography

(e) Central Place Theory

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – AUGUST 2003

GEO 175

INTRODUCTION TO MAPPING TECHNIQUES

PAPER II

TIME: THREE HOURS

ANSWER: ANY FOUR QUESTIONS

NOTE: THE USE OF AN APPROVED ATLAS AND CALCULATORS IS ALLOWED.

CANDIDATES ARE ENCOURAGED TO USE ILLUSTRATIONS WHEREVER USEFUL

Q1. If the class marks of the first seven classes of a frequency distribution are 128, 137, 146, 155, 164, 173 and 182,

(a) Find the class interval size?

(b) What are the class boundaries of these classes?

(c) What are the class limits, if the observations are recorded to the nearest integer.

Q2. The Department of Geography at the University of Zambia has just released an historical report for the year 1920, which highlights information on world population by continents. The population data are given in Table 1 below:

Table 1

World Population by Continents, 1920

Continent	Population (5 000, 000)
Africa	140
Americas	208
Asia	967
Europe (ex. USSR)	328
Oceania	9
U S S R	158
Total	1810

You have been requested by your lecturer to present the data given in Table 1 above in a form suitable for display on the Departmental notice board. Your lecturer wants the data not only to be attractive but also easy to understand.

(a) Prepare a visual display to show the data given in Table 1 highlighting the contribution of the African population.

(b) What are the merits and limitations of the method that you have used?

Q3. A group of geography students have just completed a sample survey on the number of hours-spent watching television by fifty students at the University of Zambia. The sample was obtained from a population of students, using a table of random numbers to guarantee that the sample was random.

Table 2

Random Sample of 50 Students – Watching Television during a Randomly selected one-Week Period.

27	35	29	40	24
22	21	31	37	22
15	29	10	29	39
25	29	18	25	27
25	33	34	40	12
26	34	28	40	33
25	20	30	38	23
12	16	36	17	28
41	40	37	18	27
40	31	26	20	15

Source of data: Sample of 50 students of the University of Zambia, GEO 175, 2003.

(a) Construct a frequency distribution of the amount of time spent watching television, if it is decided to use eight classes of width 4 hours and to begin the first one at 9.5.

(b) How many students watched less than 14 hours of television that week?

(c) How many students watched ten hours or more of television that week?

(d) What percentage of students watched less than 22 hours of television that week?

(e) What percentage of students watched more than 18 hours but less than 30 hours of television that week?

Q4. Examine Figure 1, of an Island map with spot heights marked provided. The rivers, lakes and streams have been marked to help you. Remember that rivers and streams and found in the lowest parts of the valleys and that they do not flow up hill.

(a) Interprolate contours at 200 metre intervals and label them.

(b) What are the merits and imitations of the method that you have used?

Q5. (a) On the outline map of Zambia Figure 2 provided, construct a map to show the number of airline passengers flying between Lusaka International Airport and the listed provincial towns.

Table 3

Passenger Traffic From Lusaka International Airport

Destination	Number
Ndola	103,250
Livingstone	44,500
Mfuwe	15,500
Mongu	12,500
Kasama	22,850
Solwezi	3,000

(c) Comment on the merits and Limitations of the technique that you have used.

Q6. Examine the data given in Table 4 below and then answer the questions that follow:-

Table 4

Maize Production 1970/71 Season in the Zambian Provinces

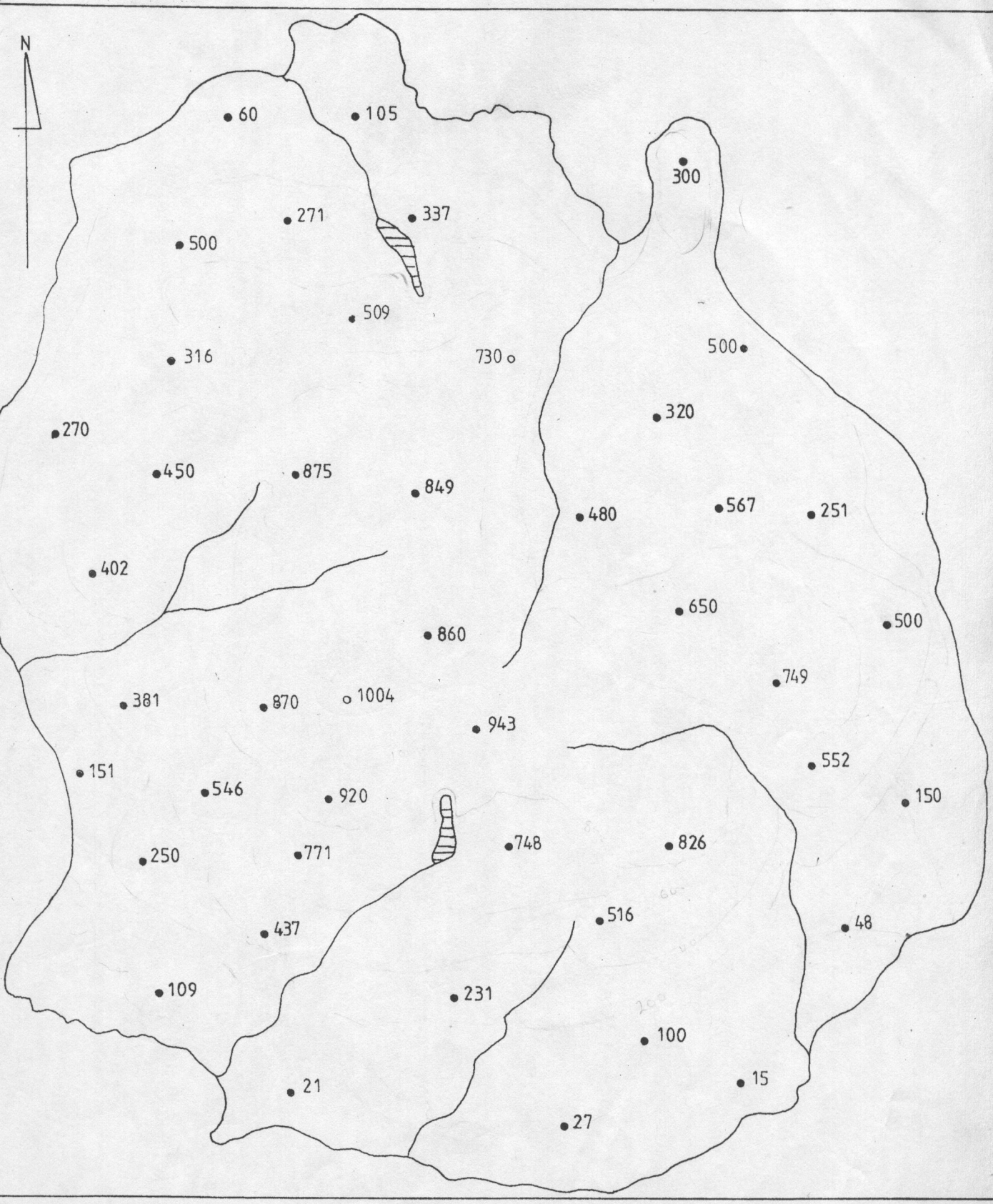
Province	Area Planted ('000 ha)	Production ('000 metric tons)
Central	3,850	10,249
Copperbelt	275	690
Eastern	4,247	4,866
Luapula	204	770
Lusaka	780	3,046
Northern	740	592
Northwestern	135	495
Southern	4,394	8,127
Western	126	530

(a) Use the most appropriate statistical mapping technique to show the data given in Table 4 above on the outline map of Zambia provided (Fig. 3).

(b) Briefly, comment on the advantages and disadvantages of the method you have used.

END OF EXAMINATION

ure 1



SCALE: 1 : 200,000

65 Spot Height (metres)

Rivers

Lake

Figure 2

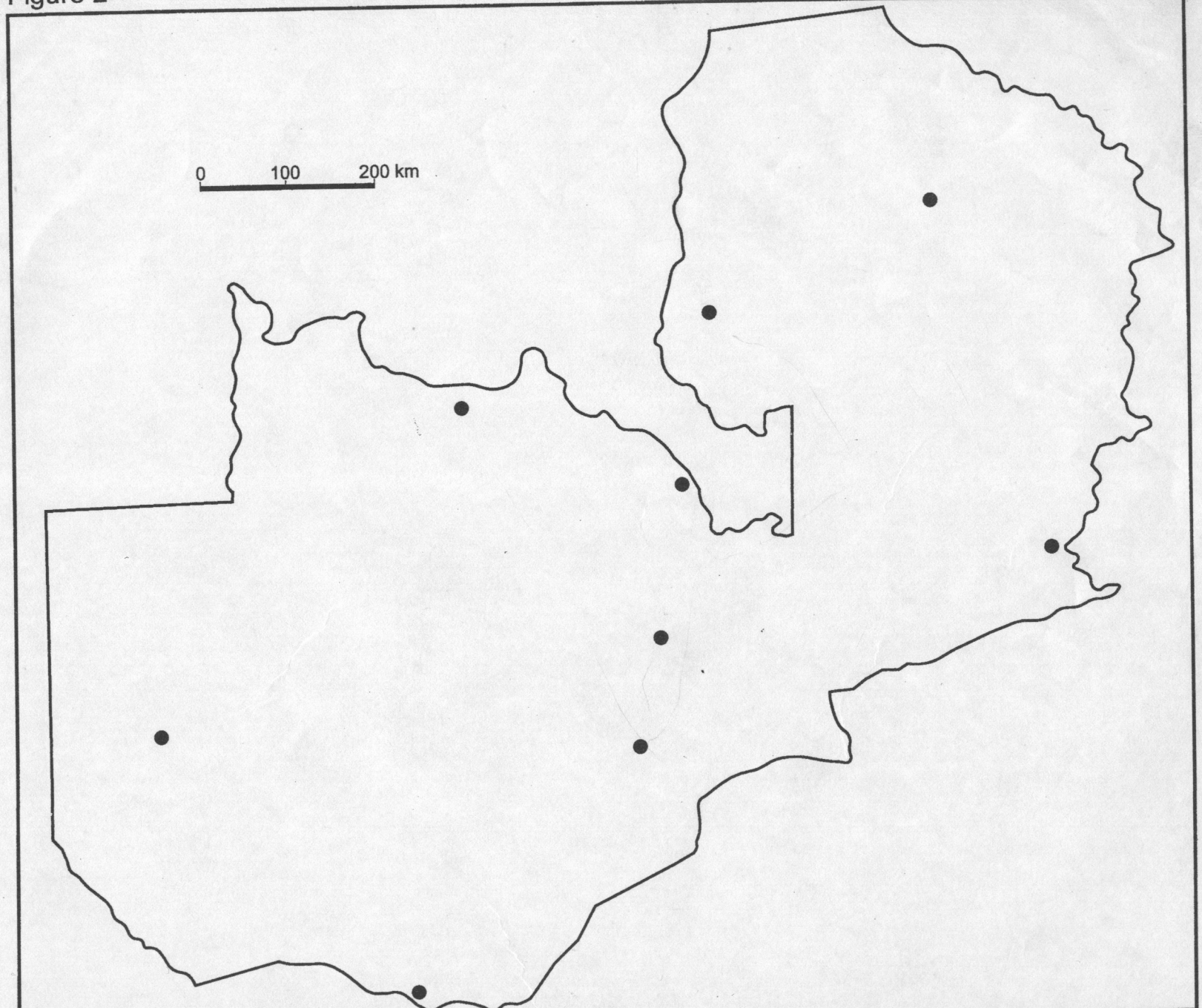
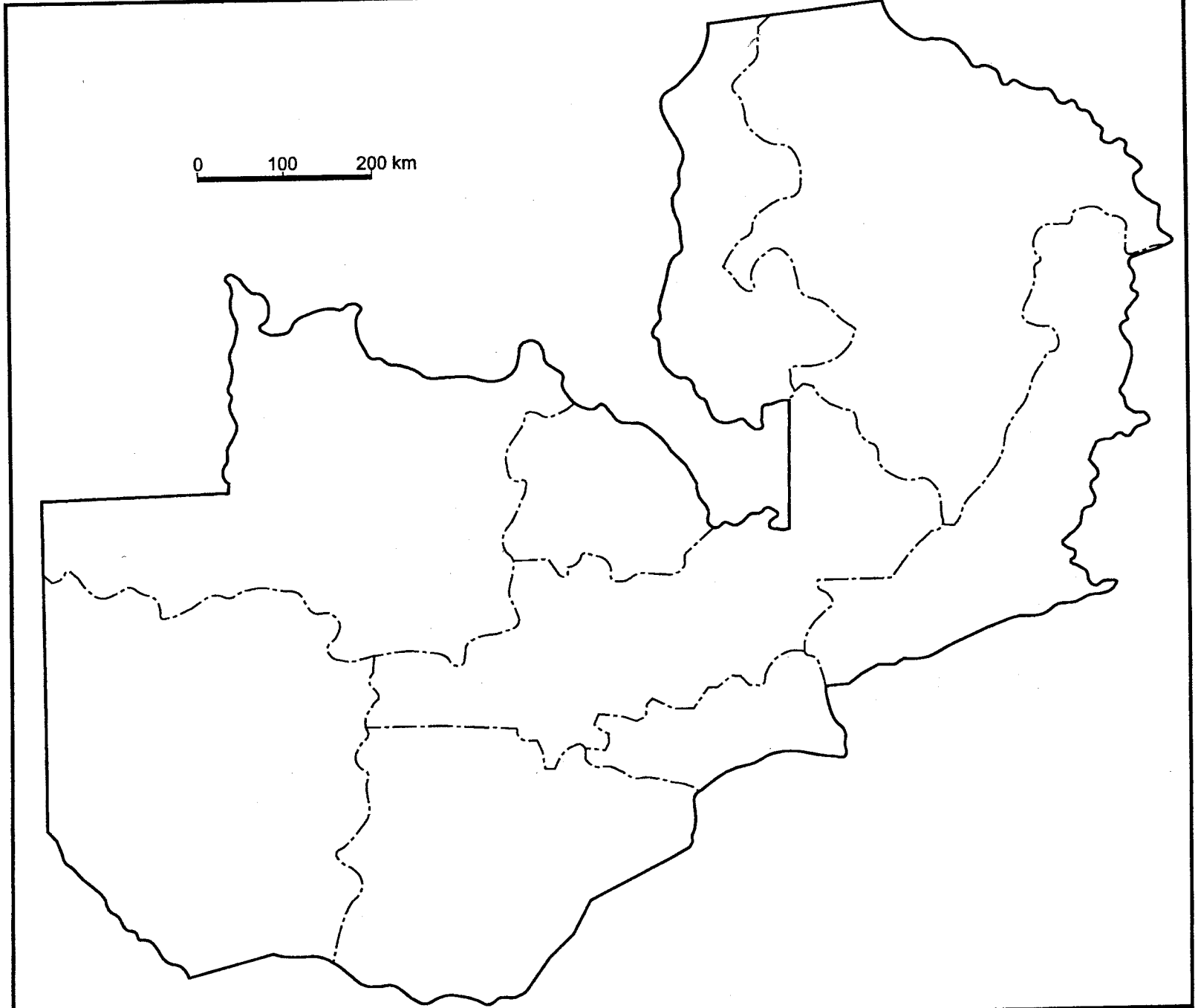


Figure 3



THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – AUGUST 2003

GEO 211

THE GEOGRAPHY OF AFRICA

TIME: **THREE HOURS**

ANSWER: **ANY FOUR QUESTIONS**

NOTE: **CANDIDATES ARE ADVISED TO MAKE USE OF ILLUSTRATIONS AND EXAMPLES WHENEVER APPROPRIATE. USE OF AN APPROVED ATLAS IS ALLOWED.**

Q1. How does rainfall distribution and soils affect human activities in tropical Africa?

Q2. What is the explanation for the environmental crisis in the Sahel region of Africa?

Q3. Explain the origins of the African socio-economic crises and show how these crises can be overcome.

Q4. Suggest possible strategies that Ghana can adopt to overcome the 'Cocoa Trap'.

Q5. Compare and evaluate the development strategies that Cote de' Ivoire (Ivory Coast) and Kenya adopted after independence.

Q6. 'Tanzania has successfully moved from Ujamaa to Structural Adjustment.' Discuss.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATION – AUGUST 2003
GEO 451
LAND RESOURCES SURVEY

TIME: **3 HOURS**
ANSWER: **ANY FOUR QUESTIONS.**
NOTE: **ALL QUESTIONS CARRY EQUAL MARKS. THE USE OF CALCULATORS, ILLUSTRATIONS AND AN APPROVED ATLAS IS ALLOWED.**

Q1. Describe the stages which are followed during the land evaluation exercise.

Q2. Evaluate at least five factors that should be considered when carrying out a social economic analysis in land evaluation.

Q3. Study the following pedon from Kabuyu Farm located 43 kilometers north east of Livingstone.

Depth (cm)	Bulk density ($g\ cm^{-3}$)	Water Content %	
		0.33 bar	-15 bar
0-17	1.6	8.6	2.4
17-32	1.75	5.8	1.6
32-54	1.72	6.1	1.7
54-94	1.69	3.9	2.5
94-144	1.72	4.4	2.8
144-167	1.70	4.7	3.4

(Source: Woode P. (ed) 1985. p 438)

(a) Assume the coefficiency of utilization is 1.0 in all horizons, calculate the Total Readily Available Moisture (TRAM) for this soil.

(b) Using two cases, explain when this kind of information is used.

Q4. Describe how you would evaluate the major climatic elements for land use planning.

Q5. Discuss the structure of the FAO land suitability classification system.

Q6. Discuss the terms Land, Land Mapping Units and Land Utilization Types (LUTs) and their relationships as they are used during natural resources evaluation.

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – AUGUST 2003

GEO 911
POPULATION GEOGRAPHY

TIME: **THREE HOURS**

ANSWER: **QUESTION 1 (WHICH CARRIES 40% OF THIS PAPER) AND ANY OTHER THREE QUESTIONS.**

NOTE: **CANDIDATES ARE ADVISED TO MAKE USE OF ILLUSTRATIONS WHENEVER APPROPRIATE. USE OF A CALCULATOR AND AN APPROVED UNIVERSITY ATLAS IS ALLOWED**

Q1. Distinguish between $P_2 = P_1 \times e (P_1)^{(rt)}$ and $P_2 = P_1 \times (1 \times r)$ and apply each one of them to a hypothetical country with a population of 20,000,000 and an annual growth rate of three percent given that `t' stands for four years and that by the end of the first two years 1,500,000 people immigrated into this country while half a million emigrated.

Q2. Account for the marked and often sudden changes in mortality rates in Developing Countries since the 1940s. (20%).

Q3. 'Children can either fulfil the needs of their parents or act as an opportunity cost.' Discuss. (20%).

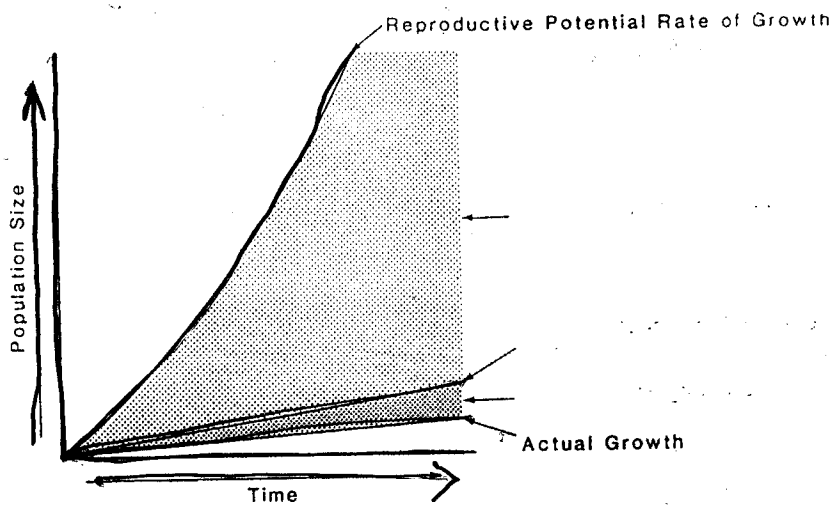
Q4. Evaluate the Roman Catholic's stance on the regulation of population growth. (20%)

Q5. Analyse Figure 1 (attached) in relation to Zambia's population dynamics during the 20th and 21st centuries. (20%).

Q6. 'Formal education negatively regulates fertility both directly and indirectly'. Discuss. (20%).

END OF EXAM

Figure 1: Population Dynamics



THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – AUGUST, 2003

GEO 921

ECONOMIC GEOGRAPHY

TIME: THREE HOURS

ANSWER: ANY FOUR QUESTIONS

NOTE: ALL QUESTIONS CARRY EQUAL MARKS. CANDIDATES ARE ENCOURAGED TO USE ILLUSTRATIONS WHEREVER APPROPRIATE.

Q1. Discuss the view that the location of the manufacturing industry is becoming less dependent on transport costs.

Q2. Outline and discuss the constraints to the development of domestic tourism in Zambia.

Q3. Evaluate the impacts of import substitution and export substitution strategies on the manufacturing sector in Zambia.

Q4. In what ways and to what extent can distance act as a barrier to trade between countries?

Q5. Compare and contrast localisation economies and urbanisation economies. Give examples from Zambia.

Q6. 'Transportation is an essentially geographical concept and it plays a great role in the space economy of Zambia'. Discuss.

END-OF-EXAM

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – AUGUST 2003

GEO 931

RURAL GEOGRAPHY

TIME: **THREE HOURS**

ANSWER: **ANY FOUR QUESTIONS**

NOTE: **CANDIDATES ARE ADVISED TO MAKE USE OF ILLUSTRATIONS AND EXAMPLES WHENEVER APPROPRIATE. USE OF AN APPROVED ATLAS IS ALLOWED**

Q1. Comment on the view that peasants in Sub-Saharan Africa are still in the making.

Q2. 'The perception and management of common property resources in Africa is dynamic, not static.' Discuss.

Q3. Show how land use has evolved in Africa.

Q4. How can women small-scale farmers be adequately integrated in rural development programmes in Africa?

Q5. 'Water is life'; evaluate this statement with respect to rural water supply and sanitation in Zambia.

Q6. 'The key to Africa's socio-economic development is transport'. Discuss.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS

AUGUST 2003

M111 – MATHEMATICAL METHODS I

INSTRUCTIONS:

1. Answer any FIVE **(5)** questions.
2. All the questions carry equal marks.
3. Show all your work to earn full credit.
4. No calculators or tables are to be used.

TIME ALLOWED: Three (3) hours

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[1] (a) (i) Define the set of rational numbers Q.

(ii) Express $0.1\overline{7}$ in the form $\frac{a}{b}$, where a and b are integers and $b \neq 0$.

(b) Find the modulus of the following complex numbers

(i) $\frac{-2i}{(1+i)^2}$ (ii) $\frac{2+i\sqrt{2}}{1+i}$ (iii) $\text{Cos}\theta + i\text{Sin}\theta$

(c) Let $z = x + iy$, if $\frac{z+i}{z-i}$ is pure imaginary find a relationship between x and y.

[2] (a) Given the equation of a quadratic function: $Q(x) = -2x^2 + 5x + 3$

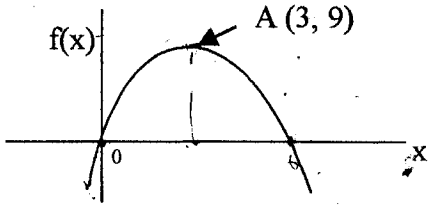
(i) Solve $Q(x) = 0$.

(ii) Complete Q(x) as a square and, hence deduce its turning point i.e. its maximum or minimum point.

(iii) Using (i) and (ii) above, sketch the graph of Q(x).

(b) The graph of a quadratic function $f(x) = ax^2 + bx + c$ is shown below. The graph passes through the origin (0, 0) and the maximum point A is (3, 9).

Find the values of a, b and c.



(c) Fencing wire is used on 3 sides of a rectangular piece of land: two sides are of length x m each and the third side is of length y m. The total length of fencing wire to be used is 30 m and should enclose an area of 100 m^2.
Find the values of x and y.

[3] (a) Solve the following inequalities

(i) $x^2 - x - 6 \geq 0$ (ii) $\frac{x-2}{x} < \frac{2}{3+x}$

(b) The polynomial $P(x) = 2x^3 + ax^2 + bx - 2$ has a factor $x - 2$ and when it is divided by $x + 3$, the remainder is -50.

(i) Find the values of a and b and the other factors and, hence

(ii) solve the equation $2x^3 + ax^2 + bx = 2$

(c) Find the real values of x for which $|2x - 4| = |x - 1|$

[4] (a) Factorize $x^4 + 2x^3 - 2x^2 + 2x - 3$ and, hence

(b) resolve $\frac{4x^3 + 4x^2 + 2x - 2}{x^4 + 2x^3 - 2x^2 + 2x - 3}$ into partial fractions.

[5] (a) Consider the functions:

$f = \{<1,3>, <2,5>, <3,3>, <4,1>, <5,2>\}$

$g = \{<1,4>, <2,1>, <3,1>, <4,2>, <5,3>\}$

from $X = \{1, 2, 3, 4, 5\}$ into X.

(i) Determine the range of f and g

(ii) Find the composition functions gof and fog

(iii) Determine if gof = fog

(iv) What properties should f and g possess for gof to equal fog?

(b) The functions f and g are defined on the set of reals R by

$f(x) = \frac{1}{x+2}$, $x \neq -2$ and $g(x) = x - 2$

(i) Show that f(x) and g(x) are one-to-one

(ii) Find fog(x)

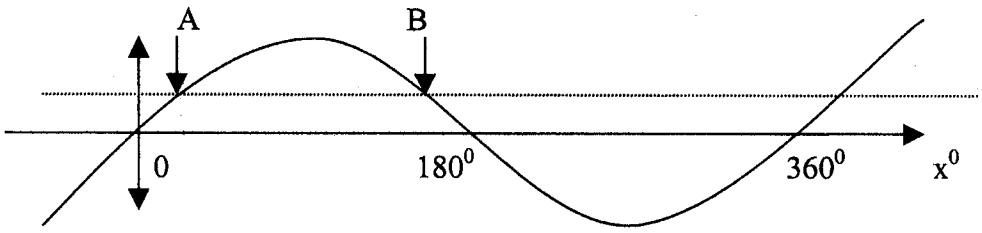
(iii) Determine the domain of fog(x)

(iv) Find $(fog)^{-1}(x)$

(c) Given $f(x) = (x-2)^2$, determine whether f(x) is one-to-one on the set R

If not, suggest a subset on which f(x) is one-to-one.

[6] (a) The diagram shows the graph of $y = \text{Sin}x$ and $y = \frac{1}{2}$, where $0^0 \leq x \leq 360^0$



A and B are points where the line $y = \frac{1}{2}$ intersects $y = \text{Sin}x$.

(i) Write down the coordinates of A and B.

(ii) State whether $y = \text{Sin}x$ is one-to-one or many-to-one on the domain $0^0 \leq x \leq 360^0$

(iii) Based on your answer in (ii), state whether $y = \text{Sin}x$ has an inverse on the domain $0^0 \leq x \leq 360^0$.

(b) Solve each of the following for $0^0 \leq x \leq 360^0$

(i) $\text{Sin}x + \text{Cos}x\text{Cot}x = 2$

(ii) $2\text{Sin}x = \text{Tan}x$

(c) Prove the following identities:

(i) $(1 + \text{Tan}^2x)(1 - \text{Sin}^2x) = 1$

(ii) $\frac{\text{Cos}x}{1+\text{Sin}x} + \frac{\text{Cos}x}{1-\text{Sin}x} = \frac{2}{\text{Cos}x}$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - AUGUST SESSIONS

AUGUST 2003

M161 - INTRODUCTION TO MATHEMATICS, PROBABILITY AND STATISTICS I

INSTRUCTIONS

1. Write your computer number.
2. ANSWER **ANY FIVE(5)** QUESTIONS.
3. Show all working to earn full marks.
4. Use of Mathematical Tables and Calculators not allowed.

TIME ALLOWED: THREE (3) HOURS.

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1. (a) Given that $m = \sqrt{5}$, $n = \sqrt{7}$,

give an expression of $\dfrac{\sqrt{45}-\sqrt{28}}{\sqrt{63}+\sqrt{80}}$ in terms of m and n in its simplest form.

(b) If $p = x^{1/3} - x^{-1/3}$, $q = x^{1/3} + x^{-1/3}$ find $p^2q^2 + 2$ in terms of x giving your answer in its simplest form.

(C) Recover the fractional form of $3.2\bar{8}$

2. (a) Let A = (2, 5), B = [4, 7) and C = (0, 6] be subsets of R the set of reals. Find $A \cap (B \cup C)$.

(b) The expression $x^3 + ax^2 + bx + 12$ is exactly divisible by x - 1 and x + 3. Find the value of a and b and the remaining factor of the expression. Hence solve the equation $x^3 + ax^2 + bx + 12 = 0$

(c) Express $Z = 3 + 4i$ in the Argand diagram. Hence find $|Z|$.

3. (a) Resolve the rational function $\dfrac{3x+1}{(x-1)(x^2+1)}$ into partial fractions.

(b) Find the solution of the simultaneous equations

$$2x - y = 4$$
$$x + y = 5$$

(c) Find the equations of two parallel lines passing through (-1, 2) and the other through (3, 4) with slope m = -2.

4. (a) Given that $f(x) = 3x^2 - 2x + 1$ and $g(x) = 4x + 7$, Find

(i) f o g

(ii) the domain of f o g

(b) Find the solution set for $\frac{10-2x}{x-2} > x+1$ expressing your answer in set builder notation.

(c) Express $\log_4 16$ in terms of the natural logarithm.

5. (a) Find the term independent of x in the expansion for $\left(x^2 + \frac{1}{x^2}\right)^{10}$. Leave your answer in factorial notation.

(b)(i) Verify the identity

$$2\text{Cos}^2\frac{x}{2}\tan x = \tan x + \text{Sin } x$$

(ii) Find an exact value for tan 67.5°. Leave your answer with radicals if necessary.

(c)(i) Solve the equation

$$\text{Sin } x \text{ Cos } x = 0$$

If $0 \leq x \leq 2\pi$

(ii) Find the value of

$$10^{-\log_{10} 5} - 10^{2\log_{10} 3}$$

6. Given $f(x) = -2x^2 - 4x + 1$

(a) Express $f(x)$ in the form $-2(x + A)^2 + B$

(b) Find the minimum or maximum value of $f(x)$

(c) Sketch the graph of $f(x)$

7. (a) Solve the system of equations

$$2x + y - z = 5$$
$$3x - 2y + 2z = -3$$
$$x - 3y - 3z = -2$$

(b) Solve $2^{2x+1} - 5(2^x) + 2 = 0$

UNIVERSITY OF ZAMBIA
SEMESTER I FINAL EXAMINATIONS - AUGUST 2003
M211 MATHEMATICAL METHODS III

INSTRUCTIONS: Answer any Five (5) Questions only
TIME ALLOWED: Three (3) hours

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1. (a) Investigate the conic section $9x^2+25y^2+18x-100y-116=0$. Determine the foci (or focus), vertices (or vertex) and eccentricity. Sketch the curve.

(b) Discuss the conic $4x^2-12xy+9y^2-52x+26y+81=0$. Hence find the directrix (or directrices).

2. (a) Given a function f, give the definition of the existence of a limit of the function as x approaches a. Hence for the function $f(x)=\dfrac{\sqrt{x}-1}{x-1}$, $a=1$, $L=\dfrac{1}{2}$, $\varepsilon=0.01$, find δ such that $|f(x)-\dfrac{1}{2}|<0.01$ whenever $0<|x-1|<\delta$.

(b) Define the continuity of a function f at a point x_0. Hence for what values is the function $f(x)=\begin{cases}x^2-6, -\infty<x<-1\\ -5, -1\le x\le 10\\ x-5, 10<x<\infty\end{cases}$ continuous? Sketch the graph.

(c) Given that $I_n=\int_0^1 x^n e^{-x}dx$, show that for $n\ge 1$, $I_n=nI_{n-1}-e^{-1}$. Hence evaluate $\int_0^1 x^6 e^{-x}dx$.

3. (a) Prove that if $f(x)\to L_1$ as $x\to a$, and $f(x)\to L_2$ as $x\to a$, then $L_1=L_2$.

(b) State the Mean Value Theorem. Hence given the function $f(x)=\dfrac{x^2-4x+3}{x-2}$ and $a=1, b=3$, discuss the validity of the Theorem.

4. Evaluate the following integrals:

(a) $\int \sin^3 x dx$

(b) $\int \frac{x+1}{\sqrt{4-x^2}} dx$

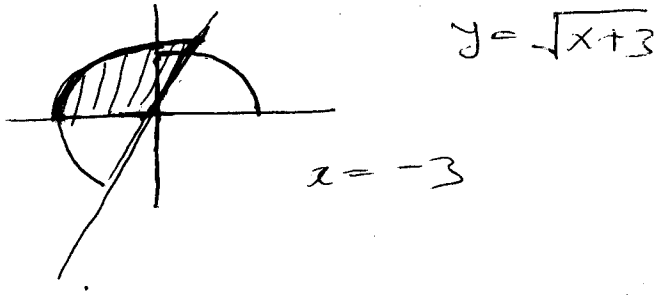
(c) $\int \frac{x+4}{x^3+3x^2-10x} dx$

(d) $\int \cos(\ln x) dx$

(e) $\int \frac{dx}{1-\sin x}$

5. (a) Sketch the region R bounded by the graphs of $y^2 = x+3$ and $y = \frac{x}{2}$. Find the area of R.

(b) The line $y = x+2$, and the parabola $y = x^2$, contain a bounded region R between them. Sketch the region. Find the volume of the solid S generated by revolving R about the x axis.



6. (a) Compute the following limits

(i) $\lim_{x \to \frac{\pi}{2}} \frac{2x-\pi}{\cos x}$

(ii) $\lim_{x \to 2} \frac{\sqrt{x^2+5}-3}{x^2-4}$

(iii) $\lim_{x \to 0} (\cos x)^{\frac{1}{x}}$

(b) Evaluate $\int \sqrt{\frac{1+x}{x-1}} dx$

(c) Find the area bounded by the curves $y = x$ and $y = x^3$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SEMESTER I FINAL EXAMINATIONS - AUGUST 2003

M221 LINEAR ALGEBRA I

INSTRUCTIONS: Answer **Five (5)** Questions only.

TIME ALLOWED: **Three (3)** hours.

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1. (a) Briefly explain the meaning of each of the following

(i) *row - echelon* form of a matrix
(ii) a *consistent* system of equations.

(b) Reduce the matrix

$$\begin{pmatrix} 1 & -2 & 1 & 1 & 2 \\ 3 & 0 & 2 & -2 & -8 \\ 0 & 4 & -1 & -1 & 1 \\ 5 & 0 & 3 & -1 & -3 \end{pmatrix}$$

to its row - echelon form.
Hence solve the system of linear equations

$$\begin{aligned} x_1 - 2x_2 + x_3 + x_4 &= 2 \\ 3x_1 \quad + 2x_3 - 2x_4 &= -8 \\ 4x_2 - x_3 - x_4 &= 1 \\ 5x_1 \quad + 3x_3 - x_4 &= -3 \end{aligned}$$

(c) Find the conditions on α, β and γ such that the system

$$\begin{aligned} 2x_1 + 3x_2 - x_3 &= \alpha \\ x_1 + x_2 + 3x_3 &= \beta \\ 3x_1 + 7x_2 - 5x_3 &= \gamma \end{aligned}$$

is consistent.

2. (a) Explain what is meant by the following terms
(i) a *non-invertible* matrix
(ii) normal form of an $m \times n$ matrix.

(b) Find the adjoint of the matrix

$$A = \begin{pmatrix} x+1 & 0 & -1 \\ 0 & x+1 & -2 \\ 1 & 1 & x-2 \end{pmatrix}$$

Hence, if

$$B = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 1 & 1 & x-1 \end{pmatrix}$$

for what real values of x is the product of $adjA$ and B non-invertible?

(c) Find invetible matrices P and Q such that PAQ is in normal form for the matrix

$$A = \begin{pmatrix} 2 & -1 & 0 & 1 \\ 1 & 1 & -1 & 1 \\ -1 & 1 & 2 & 0 \end{pmatrix}.$$

3. (a) Give the definition of

(i) a *subspace* U of a vector space V over a field K
(ii) a *basis* S for a vector space V over a field K.

(b) Prove that a subset W of a vector space V is a subspace of V if and only if $o \in W$ and $u, v \in W$ implies $\alpha u + v \in W$ for all $\alpha \in K$.

Hence verify that a subset

$$W = \{(\alpha_1, \alpha_2, \alpha_3) : \alpha_1 + \alpha_2 + \alpha_3 = 0\}$$

is a subspace of $V_3(R)$.

(c) (i) Find the basis for the vector space U spanned by vectors
$u_1 = (1,2,0,3)$, $u_2 = (2,-1,0,0)$ and $u_3 = (-1,3,0,3)$.
Extend the basis B_1 of U which you obtain to a basis B_2 of $V_4(R)$.

(ii) Let $V = \{(\alpha_1, \alpha_2, \alpha_3, \alpha_4) : \alpha_2 + \alpha_3 + \alpha_4 = 0\}$ and
$W = \{(\alpha_1, \alpha_2, \alpha_3, \alpha_4) : \alpha_1 + \alpha_2 = 0,\ \alpha_3 = 2\alpha_4\}$.
Find a basis for $V \cap W$.

4. (a) Explain what is meant by

(i) a subset $\{v_1, v_2, \cdots v_n\}$ in a vector space V is *linearly independent* over a field K
(ii) *dimension* of a vector space V over a field K.

(b) Find the basis for the solution space of the homogeneous system

$$\begin{aligned} x - 3y + z &= 0 \\ -2x + 2y - 3z &= 0 \\ 4x - 8y + 5z &= 0 \end{aligned}$$

Hence state the dimension of the solution space of the system.

(c) If $\{u, v, w\}$ is linearly independent over **C** in **C** - space V, prove that

(i) $\{u+v, v+w, w+u\}$ is linearly independent over **C**
(ii) $\{u+v-3w, w+3v-w, v+w\}$ is linearly dependent over **C.**

5. (a) Define

(i) a *linear transformation* T from a vector space V into W
(ii) *image* of T and *kernel* of T.

(b) The matrix of a linear transformation T on $V_3(R)$ relative to the standard basis $\{e_1, e_2, e_3\}$ is

$$A = \begin{pmatrix} 0 & 1 & 1 \\ 1 & 0 & -1 \\ -1 & -1 & 0 \end{pmatrix}$$

Find the matrix B of T relative to the basis $\{v_1 = (0,1,2), v_3 = (1,1,1), v_3 = (1,0,-2)\}$

(c) (i) Prove that the image of a linear transformation $T: V \to W$ is a subspace of W.

(ii) Let $T: V_3(R) \to V_2(R)$ be a linear transformation defined by

$$T(x, y, z) = (2x + y - z, 3x - 2y + 4z).$$

Find conditions for $(\alpha, \beta, 0)$ to be in the kernel of T.

6. (a) What is meant by the following terms as applied to linear transformations?

(i) a *non-singular* linear transformation T
(ii) *rank* and *nullity* of a linear transformationT.

(b) If T is a linear transformation on $V_3(R)$ defined by

$$T(\alpha_1,\alpha_2,\alpha_3) = (3\alpha_1 - \alpha_2, \alpha_1 - \alpha_2 + \alpha_3, -\alpha_1 + 2\alpha_2 - \alpha_3),$$

show that T is non-singular.

Give a rule of T^{-1} like the one which defines T.

(c) Find the bases for imT and $\ker T$ of a linear transformation $T{:}V_4(R) \to V_3(R)$ defined by

$$T(\alpha_1,\alpha_2,\alpha_3,\alpha_4) = (\alpha_1 - \alpha_2 + 2\alpha_4, -2\alpha_1 + \alpha_2 + 2\alpha_3, \alpha_2 + 4\alpha_4)$$

Hence state *rank T* and *Nullity T*.

Show that $(1,3,k)$ is in the *im T* if and only if $k = 5$.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAMINATIONS

AUGUST 2003

REAL ANALYSIS I - M231

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS.

TIME ALLOWED: THREE(3) HOURS.

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1. (a) State which of the following subsets of R x R are functions:

   (i) $F_1 = \{(x,y) : y = x^2\}$

   (ii) $F_2 = \{(x,y) : x = y^2\}$

   (iii) $F_3 = \{(x,y) : 2x^2 + y^2 = 4\}$

   (b) Prove that if f is an injection from X to Y, then $f^{-1} = \{(y,x) : (x,y) \in f\}$ is a function.

   (c) Given below are real valued functions of real variable x:

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

   $g(x) = -x^2$

   Find

   (i) Domains of f and g

   (ii) Range of f and g (iii) f o g

   (iv) g o f (v) Domain of g o f

2. (a) Let $f: X \rightarrow Y$ be a function
   Define the following sets:

   (i) f(A) where A is a subset of X.

   (ii) $f^{-1}(B)$ where B is a subset of Y.

(b) Let f: $X \to Y$ be defined by $f(x) = 1$ for all $x \in X$. Let x_1 and x_2 be distinct points of X and let

$A_1 = \{x_1\}$, $A_2 = \{x_2\}$

(i) Find $f(A_1 \cap A_2)$, $f(A_1) \cap f(A_2)$

(ii) $f(X - A_1)$, $Y - f(A_1)$ and $f(X) - f(A_1)$

(iii) $f^{-1}((2,3))$, $f^{-1}(\{1\})$

(iv) Determine the set Y so that f is surjective.

(c) If f: $X \to Y$ is a function and A and B are subsets of X, prove that $f(A \cup B) = f(A) \cup f(B)$.

3. (a) Let a and b be any two real numbers. Show the following:

(i) if $a > b$ then $a > \frac{1}{2}(a+b) > b$

(ii) if $a > 0$ then $a > \frac{1}{2}a > 0$

(iii) if $0 < a < b$ then $b^{-1} < a^{-1}$

(b) In an ordered field, let x be any element such that $x \geq -1$.

Prove that $(1 + x)^n \geq 1 + nx$ for every positive integer n.

(c) Let $a, b, c, d \in R$.

(i) If $a < b$ and $c < d$, prove that $ad + bc < ac + bd$

(ii) If $0 < a < b$ and $0 < c < d$, prove that $0 < ac < bd$

4. (a) For any a, b in R, show that

(i) $-|a| \leq a \leq |a|$

(ii) $\big|\, |a| - |b| \,\big| \leq |a - b|$

You may use the triangle inequality $|a+b| \leq |a| + |b|$

(b) Find the infimum and supremum of the following sets, provided they exist.

(i) $S_1 = \{ x \in I : x^2 < 16\}$ where I is the set of all integers.

(ii) $S_2 = \{ x \in R : |x - 1| < |x| \}$

(iii) $S_3 = \left\{\frac{1}{n} : n \in N\right\} \cup \left\{1 + \frac{1}{n} : n \in N\right\}$

(c) Define the completeness axiom.

5. (a) State and prove the Archimedean property.

(b) If A and B are two non empty subsets of R such that $a < b$ for every a in A and b in B, then prove that A has the lub and B has the glb and they satisfy the inequality $\text{lub}A \leq \text{glb}B$

(c) Let S be a non-empty bounded set in R.

Let $a > 0$ and let $aS = \{as : s \in S\}$. Prove that $\sup(aS) = a \sup(S)$

6. (a) (i) Define the limit of a sequence $X = (x_n)$ of real numbers.

(ii) Using your definition, show that the sequence $\left(\frac{1}{n}, n \in N\right)$ converges to 0.

(b) Determine whether the following sequences are convergent. If yes, find the limit.

(i) $\left(-\frac{1}{n}\right)$ (ii) $\left(\frac{\text{Sin } n}{n}\right)$

(iii) $\left(\frac{3n-1}{n-1}\right)$ (iv) $\left(\frac{n}{n^2+1}\right)$

(c) (i) Define a subsequence of a sequence of real numbers.

(ii) Discuss the convergence of the sequence $((-1)^n, n \in N)$.

7. (a) Define (i) a monotone sequence.

(ii) a bounded sequence.

(b) Show that the sequence

$\left((1+\frac{1}{n})^n\right)$ converges to a number e which satisfies $2 < e < 3$.

(c) Establish the convergence and find the limits of the following sequences:

(i) $\left((1+\frac{1}{n})^{n+1}\right)$

(ii) $\left((1+\frac{1}{n})^{2n}\right)$

UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS

AUGUST 2003

M261 – INTRODUCTION TO STATISTICS

INSTRUCTIONS:

1. Answer any FIVE **(5)** questions.
2. All the questions carry equal marks.
3. Show all your work to earn full credit.
4. You may use a calculator and the tables provided.

TIME ALLOWED: Three (3) hours

[1] (a) Classify each of the following variables on the scale of nominal, ordinal, interval or ratio:

(i) Education - measured as; primary, secondary or higher
(ii) Religion - measured as; Christian, Muslim, Traditional or Other.
(iii) House ownership - measured as; own or rented
(iv) Frequency of fights among children – measured as; often, sometimes, rare or never.
(v) Age at last birthday – measured as; years completed

(b) Family Health International (FHI) carried out a baseline survey in 2001 to determine a number of factors affecting orphans and vulnerable children in some districts of Zambia. A number of heads of households were interviewed, the ages of a sample of 36 heads of households are given in the Stem-and-Leaf plot below.

2	3	1	4	8	6	5	8	9
3	5	3	1	4	3	2	6	6
4	2	3	5	9	7	5	5	
5	2	3	4	5	5	7	8	
6	1	2	5	6	2	4		

Based on these data, find the following:

(i) the modal age
(ii) the median age
(iii) the mean age
(iv) the standard deviation
(v) the proportion of heads of households with age within 1 standard deviation of the mean.
(vi) the chance of observing a sample mean greater than that in (iii), assuming age has a normal distribution with mean $\mu = 45$ years and $\sigma = 14$ years and the sample size of $n = 36$.

(c) In 1990 the Government of Zambia carried out a census of the population in which a number of important variables were measured, including some on energy. The census was followed by a survey in 1991, this too, collected a number of important variables including those on energy. Below is a partial summary of some variables on the use of energy by households.

	Variable Label	Census Mean	Survey Mean	Census Std Dev	Survey Std Dev	Census Coeff of Variation	Survey Coeff of Variation
1	Hhd uses Candle for lighting	0.01	0.02	0.12	0.13		
2	Hhd uses charcoal for cooking	0.25	0.38	0.43	0.49		
3	Hhd. cooks on electricity	0.09	0.17	0.29	0.38		
4	Hhd uses paraffin for cooking	0.02	0.01	0.16	0.08		
5	Hhd uses wood for cooking	0.62	0.44	0.49	0.5		

Note: Hhd stands for household

(i) Calculate the coefficients of variation and, hence, copy and complete the last two columns.

(ii) Based on your answers to (i), state for each variable, which one between the census and survey measured variable better.

[2] (a) Explain briefly each of the following terms:

(i) Population
(ii) Sample
(iii) Parameter
(iv) Statistic
(v) the objective of sampling (give about five reasons)
(vi) stratified random sampling

(**b**) You are asked to carry out a survey to assess expenditure on consumption for 900 households in a small community. You have been given three lists, each giving the address, name and gender of the head of household.
List I contain 480 households in a heavy density area; List II contains 230 households in a middle class area; and List III contains the rest of the households in an upper class area. You are going to collect data using an interviewer administered questionnaire and can afford to interview 100 households only.

(i) Using this scenario, how would you select the 100 households using simple random sampling (brief but concise description).

(ii) Using the same scenario, illustrate sample size allocation in a stratified random sample design.

(iii) Discuss briefly, your preference between these two sampling designs giving reasons for your choice.

[3] A fourth-year Engineering student is studying the efficiency of a new charcoal blazer. The specifications are that once the blazer is lit, the metal casing should take an average of 20 minutes to reach a specified temperature with a standard deviation of σ minutes. After performing an experiment, he has a sample of 25 readings and chooses an α for his statistical analysis. His analysis is as follows:

1. $H_0: \mu = 20$ $H_1: \mu \neq 20$
2. A z –statistic is used with an observed z value of 3.125, calculated based on a sample mean of 23.12
3. A critical value of 2.57 is used.
4. A conclusion of no sufficient evidence that the mean heating time is different from 20 is reached.

(a) Based on these results answer the following
- (i) What was the standard deviation used in this analysis?
- (ii) What was the significance level used in this analysis?
- (iii) What was the p-value associated with the sample results?
- (iv) If any error was committed, what type was it? Justify your answer.

(b) Nails produced by a machine have a mean length of 2.5 cm. A random sample of 61 nails has a mean length of 2.52 cm with a standard deviation of 0.12 cm. Do these results indicate that the mean length of nails produced has changed at $\alpha = 0.05$?

[4] (a) Explain briefly what is meant by

- (i) a statistical hypothesis
- (ii) a Type I Error
- (iii) a Level of significance

(b) A keep-fit health club has been advertising a rigorous program for body conditioning. The club claims that after 1 month in the program, the average participant should be able to do eight more push-ups in 2 minutes than he or she could do at the start. The results for 12 participants are shown below.

Participant	1	2	3	4	5	6	7	8	9	10	11	12
Before program	38	11	34	25	17	38	12	27	32	29	30	28
After program	40	24	41	30	17	36	30	39	40	35	35	36

- (i) What special name is given to this type of design?
- (ii) State an appropriate null and alternative hypotheses to test the club's claim.
- (iii) What is an appropriate test statistic to use?
- (iv) Is the club's claim valid at $\alpha = 0.05$?

[5] A team of 32 hospital emergency workers was trained in a certain task, which had to be done within 3 minutes. Two different methods were used to train the team, 16 workers were trained under method A and the rest 16 under method B. The results of the training are given below.

Method A

2.1	2.3	1.9	2.2	2.1	2.3	2.0	2.2
1.7	2.6	2.0	1.9	1.8	2.0	2.0	2.4

Method B

2.5	2.1	2.2	2.0	2.4	1.8	2.2	2.0
1.9	2.3	2.1	1.7	2.5	2.4	2.6	1.8

Your task is to determine whether the mean response time for the two methods differ at $\alpha = 0.05$.

(a) (i) Can these two samples be considered to be coming from two independent populations? Briefly defend your answer.

(ii) What two assumptions are necessary here to carry out a statistical test?

(b) (i) State the appropriate null and alternative hypotheses to achieve your task.

(ii) State the appropriate test statistic assuming common variance for the two methods.

(iii) Calculate the critical value.

(iv) Calculate the observed value of your test statistic and make your conclusion.

[6] (a) A good experimental design is the one that attempts to manage various sources of variation. Briefly, discuss the sources of variation each of the following aspects of design attempts to manage.

(i) Blocking

(ii) Randomization

(b) In order to address the effects of persistent drought in the Southern Province, the Government embarked on the Southern Province Household Food Security Program (SPHFSP) in a number of districts in the province. A baseline study was carried out and, among the variables collected was the crop hectare planted by households in their major fields (some households had more than one field). The data below shows a summary of the relevant statistics for the Choma area.

STATISTIC	REGION				TOTAL
	Kabumbwe	Mandala	Simumbwe	Simusokwe	
n	31	28	40	59	158
Mean	1.471	1.386	2.83	1.262	1.722
Standard deviation	.943	1.08	2.456	.943	

(i) Calculate the within-groups and between-groups sums of squares

(ii) Display an ANOVA table showing; sources of variation, sums of squares, degrees of freedom, mean squares and an F value.

(iii) At a protection of level $\alpha = 0.01$, is there any evidence of a difference in the mean hectare among the four regions of Choma?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAMINATIONS - 2003 SESSIONS

AUGUST 2003

M325 - GROUP AND RING THEORY

TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS: ANSWER **ANY** FIVE (5) QUESTIONS

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1. What is meaning of each of the following terms:
   i). the order of an element g of a group G
   ii). an abelian group G

   a i). Prove that if H is a subgroup of a group G, then the order of H divides the order of G. Hence deduce that if g is an element of G,then its order divides that of G.

   ii). Show that a group G in which each element $x \neq e$ has order 2 is abelian.

   b. i). Let g be an element of order mn in a group G such that (m, n) = 1. Then show that $g = k_1k_2$, for some elements $h_1, h_2 \in G$. Hence determine the orders of h_1 and h_2.

   ii). Show that if G is a finite group whose order is a prime number p, then G is cyclic.

2. Define each of the following terms:

   i) a normal subgroup
   ii) the kernel of a group homomorphism ϕ

   (a) In what follows, $\phi : G \rightarrow H$ is a homomorphism. Then prove each of the following:

   i) the kernel Ker ϕ of ϕ is a normal subgroup of the group G; and the image imϕ is a subgroup of H

   ii) the factor group G/Kerϕ is isomorphic to the subgroup imϕ of H.

b. Let G be a group such that for a fixed integer $n > 1$, $(ab)^n = a^n b^n$ for all $a, b \in G$.

Let G^n and G_n be the subsets of G defined by

$$G^n = \{g^n \mid g \in G\}$$

And $G_n = \{g \in G \mid g^n = e\}$, where e denotes the identity element in the group G. Then prove each of the following

i) G^n is a normal subgroup of G

ii) The mapping $\phi : G \to G^n$ defined by $\phi(g) = g^n$ is a homormophism. Hence deduce that $G/G_n \cong G^n$.

3. Give the definition of each of the following terms

(i) the centre Z(G) of a group G

(ii) a conjugacy class in a group G

a. Prove each of the following:

(i) every subgroup H of the centre Z(G) of G is a normal subgroup of G

(ii) conjugate elements in the group G have the same order

b.(i) Let G be a group generated by two elements x and y which satisfy the relations

$$x^5 = 1; x^4 = yxy^{-1}; y = y^{-1}$$

Show that if G has only one conjugacy class of order 1, then the subgroup $N = \langle x \rangle$ cannot be normal in G

(ii) Determine the conjugacy classes in the symmetric group S_3 of degree 3. Hence write down the class equation for S_3. Determine whether the subgroup H of S_3 generated by the two - cycle (23) is normal in S_3.

4. Define each of the following terms:

(i) the derived subgroup G^1 of a group G

(ii) the stabilizer $stag_G(x)$ of an object $n \in X$ where G is a permutation group on the set X.

a. (i) Prove that the derived group G^1 is normal in G

(ii) Let H be a normal subgroup of a group G such that G/H is abelian. The show that $G' \subseteq H$.

b (i) Prove that stab (x) is a subgroup of G. Prove further that if G is a permutation group on the set X and G = X, then stab (x) = $C_G(x)$, where C_G is the centralizer of x in G.

(ii) Let G be a p-group of order p^3 with centre Z(g) and derived group G'. If G is non-abelian, prove that Z(G) = G'

5. What is the meaning of each of the following

(i) a sylow p-subgroup of a group G

(ii) the direct product of groups H and K

a. (i) State the first sylow theorem

(ii) Let H be a normal subgroup of a finite group G and let the index of H in G be prime to p. Then show that H contains all the sylow in subgroups of G.

b. Prove each of the following:

(i) a group of order 48 is not simple

(ii) if G is a group of order 12 with no element of order 2 in its centre, then G is isomorphic to the symmetric group S_3 of degree 3.

6. What is the meaning of each of the following:

(i) disjoint cycles in the permutation group S_n

(ii) a transposition in the group S_n

a. (i) Prove that disjoint cycles of S_n commute

(ii) Let H be a subgroup of a group G with index n. Let ϕ be the map from G to the factor group G/H given by

$$\phi(g) = \begin{pmatrix} g_1H & g_2H & \dots & g_nH \\ gg_1H & gg_2H & \dots & gg_nH \end{pmatrix}$$

where $\{g_i \mid 1 \leq i, j) \leq n\}$ is the set of coset representatives of H in G.
Then prove that ϕ is a homomorphism.

b. (i) Express the permutation

$$\sigma = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\ 3 & 4 & 5 & 6 & 1 & 2 & 8 & 7 \end{pmatrix}$$

as a product of transpositions. Hence confirm whether σ is an odd or even permutation.

(ii) Given that the alternating group A_4 of degree 4 has four conjugacy classes of orders 1, 3, 4 and 4 respectively, show that A_4 has no subgroup of order 6.

7. What is the meaning of each of the following terms

(i) are ideal of a ring R

(ii) a ring homomorphism

a).(i) Show that in a ring R, then the following properties hold

1. $a.0 = 0.a = 0$
2. $a(-b) = (-a)b = -(ab)$
3. $(-1)a = -a$
4. $(-1)(-1) = 1$

for all $a, b \in R$, and $1 \in R$.

(ii) Prove that the subset Ra defined by

$$Ra = \{r\,a \mid r \in R, a \in R\} \text{ is an ideal of R.}$$

b. (i) Show that the set

$$\sqrt{-1} = \{n + m\sqrt{-1} \mid n, \quad m \in Z\}$$

is a subring of the ring Z of integers.

(ii) Prove that if U is an ideal of the ring R, then R/U is a ring and is a homomorphic image of R.

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAMINATIONS - 2003 SESSION

M331 - REAL ANALYSIS III **AUGUST 2003**

TIME ALLOWED: THREE(3) HOURS

INSTRUCTIONS:

1. ANSWER ANY **FOUR(4)** QUESTIONS
2. FULL CREDIT WILL ONLY BE GIVEN WHEN ALL THE WORKING/LOGIC IS CORRECT.

1] a) Define the following terms:

(i) Dedekind section.

(ii) An interior point.

(iii) Closed set.

b) Prove the following:

(i) A subset B of IR is open if and only if B is a union of some collection of open intervals.

(ii) If $\{B_\lambda : \lambda \in \Lambda\}$ is any collection of open sets then
$B = \bigcup_{\lambda \in \Lambda} B_\lambda$ is open.

c) (i) Show that every point in [-2, -1] is a limit point of the set (-2, -1).

(ii) Prove that if a set A contains all its limit points then A is closed.

2] a) Define the following terms:

(i) A neighbourhood of a point.
(ii) Limit point of a set.
(iii) A compact set.

b) Prove the following:

(i) If A is a neighbourhood of y, $\exists$ a set H such that H is also a neighbourhood of y and A is a neighbourhood of each point in H.

(ii) Each bounded infinite set has at least a limit point.

c) (i) State the Bolzarno-Weierstrass theorem.

(ii) Prove the Bolzarno-Weierstrass theorem.

3] a) Define the following terms:

(i) Inverse image of a set under a function.

(ii) Limit $f(y) = a$
$y \rightarrow p$

(iii) A function is continuous at P.

b) Prove the following:

(i) A closed subset of a compact set is compact.

(ii) If $g: A \rightarrow B$ is a function continuous at b and $h : B \rightarrow H$ is a function continuous at g(b) then hog is continuous at b.

c) Prove that if f is a continuous function and H is compact then the image of H under f is compact.

4] a) Define the following terms:

(i) An ordered set.

(ii) Least upper bound.

(iii) Uniformly continuous function.

b) Prove the following:

(i) If f is continuous for each x on a compact set A, then f is uniformly continuous on A.

(ii) If A is a subset of IR and has the least upper bound x, but x is not in A, then x is a limit point of A.

c) (i) State the intermidiate value theorem.

(ii) Prove the intermidiate value theorem.

5] a) Prove that if H and V are disjoint open sets and $[a,b] \subset H \cup V$ then either $[a,b] \subset H$ or $[a,b] \subset V$.

b)

(i) Prove that a function f is continuous if and only if $f^{-1}(B)$ is open whenever B is open.

(ii) Prove that if f is a continuous function on a compact set A, then f is bounded on A and $\exists$ points x_1 and x_2 in A such that $f(x_1) \leq f(x) \quad \forall x \in A$ and $f(x) \leq f(x_2) \quad \forall x \in A$.

c) Let $f: Z \rightarrow Z$, where Z is set of integers and $f(z) = 4 - z^2$. Evaluate the following.

(i) $f\{(-3, 1)\}$ (ii) $f\{[-1, 1]\}$

(iii) $f^{-1}\{(0, 10)\}$ (iv) $f^{-1}\{[-4, 4]\}$

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAMINATIONS - 2003 SESSION

M361 - MATHEMATICAL STATISTICS

TIME ALLOWED: THREE(3) HOURS

INSTRUCTIONS

1. ANSWER ANY **FOUR(4)** QUESTIONS.
2. FULL CREDIT WILL ONLY BE GIVEN IF THE NECESSARY WORKING IS SHOWN.
3. STATISTICAL TABLES WILL BE PROVIDED.
4. CALCULATORS ARE ALLOWED.

1] a) Define the following terms:

(i) Characteristic function.
(ii) Order statistics.
(iii) Jacobian of the transformation $(X,Y) \rightarrow (U,V)$ where $U = g_1(X,Y)$ and $V = g_2(X,Y)$.

b) (i) Let X_1 and X_2 be independent Gamma variables with

$$f_{x_j}(x_j) = \frac{\lambda^{\alpha_j} x_j^{\alpha_j - 1} e^{-\lambda x_j}}{\Gamma(\alpha_j)}, \qquad x_j > 0, \quad \alpha_j > 0, \ \lambda > 0, \ j = 1, 2$$

Derive the density function for $Y = X_1 + X_2$.

(ii) Let $f_x(x,\theta) = \frac{\theta}{x^2}, \quad x > \theta, \ \theta > 0$

Find the density function of $Y = \frac{1}{X}$.

(c) Prove that if the random variables $X_1, X_2, ..., X_k$ are independent and normally distributed with means μ_j's and variances σ_j^2's, then the random variable W has a Chi-square distribution with K degrees of freedom where

$$W = \sum_{j=1}^{K} \left(\frac{X_j - \mu_j}{\sigma_j} \right)^2$$

2] a) Define the following terms:

(i) Estimator.
(ii) Sample moments.
(iii) Likelihood function.

b) Let $X_1, X_2, ..., X_n$ be a random sample from

$$f_X(x,\lambda) = \frac{x e^{-\frac{x}{\lambda}}}{\lambda^2}, \qquad x > 0, \ \lambda > 0$$

(i) Find the sufficient statistics for λ.
(ii) Find the maximum likelihood estimator (mle) for λ.
(iii) Is the mle for λ in (ii) UMVUE? Justify your answer.

c) Refer to the density function given in b above.

(i) Drive the characteristic function of X.
(ii) Use the characteristic function derived in (i) to derive the mean and variance of X.
(iii) Find the methods of moments estimator for λ.

3] a) Define the following terms:

(i) Mean-squared error of an estimator.
(ii) Consistency of an estimator.
(iii) Uniformly minimum variance unbiased estimator.

b) Let $X_1, X_2, ..., X_n$ be a random sample from Beta density $X \sim B(\alpha,\beta)$,

$$f_x(x, \alpha, \beta) = \frac{x^{\alpha-1}(1-x)^{\beta-1}}{B(\alpha,\beta)}, \quad x \in (0, 1), \ \alpha > 0, \ \beta > 0$$

(i) Find the joint sufficient statistics for $\theta = (\alpha, \beta)$.
(ii) Find the estimators of α and β using the method of moments.

c) Let $X_1, X_2, ..., X_n$ be a random sample from a density function

$$f_X(x, \theta) = (\theta + 1)\, x^{-\theta-2},\ x > 1,\ \theta > 0$$

(i) Derive the most powerful test of size α for testing

$$H_0 : \theta = 4 \text{ vs } H_a : \theta = 2.$$

(ii) Derive the uniformly most powerful test of size α for testing

$$H_0 : \theta = \theta_0 \text{ vs } H_a : \theta > \theta_0.$$

4] a) Define the following terms:

(i) Relative efficiency of two estimators.
(ii) Sufficient statistics for θ.
(iii) Monotone likelihood ratio.

b) An environmentalist group wants to monitor the temperature rise in the water 80 meters down stream from a nuclear reactor. They are concerned that the rise should not exceed 3°C. If it does, the ecological balance of the stream will be irreparably damaged. They decide to test $H_0 : \mu = 3°C$ vs $H_a : \mu > 3°C$, where μ is the true average temperature increase in water. Their plan is to collect 16 water samples and choose between H_o and H_a on the basis of the average temperature rise, $\overline{X}$. For the decision rule they decide to reject H_o if $\overline{X} \geq 3.5°C$. Assume normal distribution with $\sigma = 1$

(i) Find the size of the test.
(ii) Find type II error if the true value of μ is 3.8°C.
(iii) Sketch the power function for the test.

c) Let $X_1, X_2, ..., X_n$ be a random sample from a density function

$$f_x(x, \theta_1, \theta_2) = \frac{e^{-\frac{1}{2\theta_2}(x-\theta_1)^2}}{\sqrt{2\pi\theta_2}}, \quad x \in (-\infty,\infty),\ \theta_1 \in (-\infty,\infty),\ \theta_2 > 0.$$

(i) Derive the test of size α for testing

$H_0 : \theta_2 = 4$ vs $H_a : \theta_2 \neq 4$, with θ_1 the mean unknown.

(ii) Perform the test if $\alpha = 0.05$ and $n = 5$, $\sum_{j=1}^{5} X_i = 18$, $\sum_{i=1}^{5} X_i^2 = 82$.

5. a) Define the following terms:

(i) Power function.
(ii) Simple likelihood ratio test.
(iii) Generalized likelihood ratio.

b) (i) State Neyman - Pearson Lemma
(ii) Prove Neyman - Pearson Lemma

c) Let $X_1, X_2, ..., X_n$ be a random sample from normal with mean μ and variance 4. A test γ for testing $H_0 : \mu = -5$ vs $H_a : \mu \neq -5$ says reject H_0 if either $\overline{X} < -6$ or $\overline{X} > -4$.

(i) Determine the minimum sample size if the size of the test is 0.05.
(ii) Using the sample size determined in (i) above find the power of the test γ against each of the following alternatives:

$\mu = -6.5,\ \mu = -6.0,\ \mu = -5.5,\ \mu = -4.5,\ \mu = -4.0,\ \mu = -3.5$

(iii) Sketch the graph of the power function for the test γ.

UNIVERSITY OF ZAMBIA
DEPARTMENT OF MATHEMATICS AND STATISTICS
UNIVERSITY EXAMINATIONS
FIRST SEMESTER 2003
M411
THEORY OF FUNCTIONS OF A COMPLEX VARIABLES I

TIME: THREE HOURS
ANSWER ANY FIVE QUESTIONS
ALL QUESTIONS CARRY EQUAL MARKS
TOTAL MARKS: 100

You may need the following information:

$$\frac{\partial u}{\partial r} = \frac{1}{r}\frac{\partial v}{\partial \theta} \quad \text{and} \quad \frac{1}{r}\frac{\partial u}{\partial \theta} = -\frac{\partial v}{\partial r}$$

$$f^{(n)}(z_0) = \frac{n!}{2\pi i}\int_C \frac{f(z)dz}{(z-z_0)^{n+1}}$$

The binomial expansion

$$(s+t)^n = s^n + ns^{n-1}t + \frac{n(n-1)}{2!}s^{n-2}t^2 + \frac{n(n-1)(n-2)}{3!}s^{n-3}t^3 + \ldots$$

is valid for all powers of n provided that $|s| > |t|$.

---

1. (**a**) Prove de Moivre's theorem

$$(\cos\theta + i\sin\theta)^n = \cos n\theta + i\sin n\theta \qquad [4]$$

(**b**) Without using the polar representation of complex numbers prove that $|z_1 z_2| = |z_1|\,|z_2|$. [5]

(**c**) Show the region in the z plane represented by the inequality $|z-1| + |z+1| > 3$. [5]

(**d**) Find the values of $\left(\frac{-2}{1+\sqrt{3}i}\right)^{3/2}$ [6]

2. (**a**) The set S consists of all points $z = x + iy$, such that x and y are integers, inside and on the boundary of the rectangle with vertices at $z = 0$, 5, $7i$ and $5 + 7i$. Answer the following questions about the set.

(**i**) Is S bounded? If so, what is this bound? (**ii**) What are the limit points of S, if any? (**iii**) What are the interior and boundary points of S? (**iv**) Is S an open region or a domain? (**v**) What is the closure of S? (**vi**) Is S countable? [12]

(**b**) Obtain an upper bound for the absolute value of the integral

$$I = \frac{1}{2\pi i} \int \frac{e^{2z}}{z} dz$$

taken around the circle $|z| = 3$. [8]

3. (**a**) Prove that for a function $f(z) = u(x, y) + iv(x, y)$ to be analytic, it must satisfy the Cauchy-Riemann equations

$$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y} \quad \text{and} \quad \frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x} \qquad [8]$$

(**b**) Show that the function $e^{-x}(y \cos y - x \sin y)$ is harmonic. Assuming that it is the imaginary part of an analytic function, find the real part of the function. [12]

4.(**a**) Prove that $\left|\exp(2z + i) + \exp(iz^2)\right| \leq e^{2x} + e^{-2xy}$. [5]

(**b**) Find the real and imaginary parts $u(r, \theta)$ and $v(r, \theta)$ for the function $z^{i/2}$ and hence prove that the function is analytic. [8]

(**c**) Prove that the principal value of $\sin^{-1} z$ is $-i \ln[iz + \sqrt{1 - z^2}]$. [7]

5. (**a**) State the Cauchy-Goursat theorem. [2]

(**b**) (**i**) Prove the Cauchy integral formula

$$f(z_0) = \frac{1}{2\pi i} \int_C \frac{f(z)}{z - z_0} dz$$

where C is a contour enclosing a region in which $f(z)$ is analytic and in which z_0 lies. [10]

(**ii**) Find the value of the integral $\int_C \frac{\sin z}{z^2 + 1} dz$ when C is a circle of unit radius with centre at $z = i$. [8]

6. (**a**) Find the region of convergence of the series

$$\sum_{n=1}^{\infty} \frac{(z + 2)^{n-1}}{(n + 1)^3 4^n} \qquad [8]$$

(**b**) (**i**) Prove that if the function $f(z)$ is analytic in a region bounded by a simple closed curve C, and if both z and a are interior to C, then

$$f(z) = f(a)+f'(a)(z-a)+\frac{1}{2!}f''(a)(z-a)^2+...+\frac{1}{(n-1)!}f^{(n-1)}(a)(z-a)^{n-1}+R_n$$

where

$$R_n = \frac{(z-a)^n}{2\pi i}\int_C \frac{f(t)dt}{(t-a)^n(t-z)} \qquad [6]$$

(**ii**) Prove that the Taylor series in (**b**) (**i**) converges. [6]

7. (**a**) Explain the circumstances in which you might expand a function in a Laurent series rather than a Taylor series. [2]

(**b**) (**i**) Explain why four different Laurent expansions of the function $f(z) = \frac{1}{z(z-1)(z-2)}$ around $z = -1$ are possible and state the region of convergence of each one. [4]

(**ii**) Find explicitly the expansion which has the largest region of convergence. [14]

*****END OF EXAMINATION*****

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAMINATIONS - 2003 SESSIONS

AUGUST 2003

M421 - STRUCTURE AND REPRESENTATIONS OF GROUPS

TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS: ANSWER **ANY** FIVE (5) QUESTIONS

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1. What is the meaning of each of the following terms:
i). the direct product of groups G and H
ii). an abelian group G.

a). i). Prove that if G and H are groups then the set $\Omega = G \times H$ under the composition $(g_1,h_1)(g_2,h_2)=(g_1h_1,g_2h_2)$, for all $g_i \in G$, $h_j \in H$, $i,j = 1,2$ is a group.

ii). Let H_1,H_2 be normal subgroups of group a G such that $G=H_1H_2$ and $H_1 \cap H_2=\{e\}$, where e is the identity of G. Prove that G is isomorphic to $H_1 \times H_2$.

b). i). Let G and H be finite groups. Show that GxH is an abelian group if and only if H and G are abelian.

ii). Let G be an abelian group of order 9. Prove that G is either cyclic or a direct product of two groups each of order 3.

---

2 What is the meaning of each of the following terms as applied to finite groups :
i) the commutator $x^{-1}y^{-1}xy$ of G, where $x,y \in G$.
ii). the group G is soluble.

a). i). Let G be a group and $\overline{G} = < x^{-1}y^{-1}xy / x, y \in G >$. Then show that $\overline{G}$ is a normal subgroup of G. Show further that if H is a normal subgroup of G such that G/H is a belian, then $\overline{G} \subseteq H$.

ii). Prove that a group G is soluble if and only if the factors in a composition series of G are all of prime order 3.

b). i). Let $[x,y]$ denote $x^{-1}y^{-1}xy$ for all $x,y \in G$. Then by using the identity $[xy,z]= y^{-1}[x,z]y[y,z]$ or otherwise, show that if H ,Kand L are normal subgroups of a group G, then $[HK,L]=[H,L][K,L]$

ii). Show that every nilpotent group is soluble.

3 What is the meaning of each of the following terms as applied to permutation groups:

i). the stabilizer stab(x) of an element x in the set X .

ii). the group G is transitive on the set X.

a). i). Show that if G is a transitive group on a set X then the stabilizers stab(x), $x \in X$ are all conjugate to one another.

ii). Prove that if G is a transitive group of degree n, then each element $x \not\subset \{e\}$ in the center z(G) moves every element of X.

b). i). Let G be a nontrivial simple abelian group. Prove that $|G| = |\text{stab}(x)|\,|G(x)|$, where |G| denotes the group order and G(x) is the orbit of x.

ii). Compute and identify S_4/k_4, where k_4 is the subgroup $\{(1), (12)(34),(13)(24),(14)(23)\}$ of the symmmetric group S_4 of degree 4.

---

4 Define each of the following terms:

i). an irreducible representation of a finite group.

ii). a completely reducible represantion of a finite group.

a). i). Prove that every representation of a group G is completely reducible.

ii). Prove that every represantion is a direct sum of irreducible represantions.

b). Find a complete set of irreducible representations of a finite cyclic group C_n of order n and decompose the regular representation of C_n into a direct sum of irreducible representations of C_n .

---

5 Define each of the following terms:

i). equivalent representations of a group G.

ii). the character of a representations of a finite group G.

a). i). Prove that representations are equivalent if and only if they have the same character.

ii). Show that every irreducible representations is a component of the regular representation

b). Determine each of the following:

i). the permutation representation of the symmetric group S_3 of degree 3.

ii). the left regular representation of the symmetric group S_3 of degree 3 hence, determine a complete set of irreducible characters of S_3.

---

6. Let H be a normal subgroup of a group G. Then what is the meaning of each of the following:

i). a character table of a group G.

ii). a representation T is lifted from a representation T′ of the factor group G/H.

a). i). Show how a representation T of G may be lifted from the representation T′ of G/H.

ii). If T is a representation of a group G with character χ, show that $K = \{g \in G \mid \chi(g) = \chi(e)\}$ is a normal subgroup of G and that T is a representation of G lifted from a representation T′ of G/H.

b) i). Determine the right-regular representation of the Klein-four group V given by $V = \{a,b \mid a^2 = b^2 = 1 ; ab = ba\}$

ii). Determine the structure of G/G' where $G< a^6 = b^2 = (ab)^2 = 1>$

7. What is the meaning of each of the following:
   i). an irreducible G-module.
   ii). a G-homomorphism $\theta : V \to U$ where V and U are irreducible G-modules.

a). Prove that if $\theta : V \to U$ is a G-homomorphism from an irreducible G-module to U, then either
   i). θ is zero
or ii). θ is an homomorphism

b). Let G be a finite group of order n and K be a field of characteristics equal to zero or prime to n. Suppose that A(x) is a matrix representation of G over k such that

$$A(x) \sim \begin{pmatrix} C(x) & 0 \\ E(x) & D(x) \end{pmatrix}$$. Then prove that A(x) ~ dig(C(x) , D(x))

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SEMESTER I FINAL EXAMINATIONS - AUGUST 2003

M431 REAL ANALYSIS V

INSTRUCTIONS: Answer any **five (5)** questions only.

TIME ALLOWED: **Three (3)** hours.

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1. (a) Define
   (i) *denumerable* set
   (ii) *countable* set
   (iii) *equivalent* sets

   (b) Let $\mathbf{N}$ denote the set of natural numbers $\{1,2,\cdots\}$ and f denote a bijection $\mathbf{N}^2 \to \mathbf{N}$ that corresponds to the diagonal enumeration of $\mathbf{N}^2$ shown

$$\mathbf{N}^2 = \{(i,j)\} = \begin{cases} (1)\ \delta_1 \quad (3)\ \delta_2 \quad (6)\ \delta_3 \\ (1,1) \quad (1,2) \quad (1,3)\cdots \\ (2) \quad (5) \\ (2,1) \quad (2,2) \quad (2,3)\cdots \\ (4) \\ (3,1) \quad (3,2) \quad (3,3)\cdots \\ \qquad etc \end{cases}$$

   Compute (i) $f(5,12)$
   (ii) $f^{-1}(310)$, using the analytic version of f.

   (c) (i) Prove that the set $\mathbf{Q}$ of rational numbers is denumerable.

   (ii) Prove that set of real numbers in $(0,1)$ is uncountable.

2. (a) Define

(i) *order isomorphism* in the set of partially ordered sets
(ii) a *totally ordered* set
(iii) a *well-ordered* set.

(b) Prove that a well-ordered set is totally ordered.

(c) (i) Prove that if f is an isomormophism of a well-ordered set A onto some subset $B \subset A$, then $f(a) \geq a$ for all $a \in A$.

(ii) (1) State *Transfinite induction* for sets
(2) Prove *Transfinite* induction for sets

3. (a) Define

(i) a *linearly independent* subset of a linear space X distinguishing between finite and infinite subsets
(ii) a *basis* for a linear space X
(iii) a *normed* linear space

(b) (i) State *Zorn's lemma.*
(ii) Use *Zorn's lemma* to prove that every linear space has a basis.

(c) Let $p \in \mathbf{R}$ with $1 \leq p \leq \infty$. Prove that a linear space l_p defined by

$$l_p = \{x = (x_i) / x_i \in C; \sum_{i=1}^{\infty} |x_i|^p < \infty; \|x\|_p = (\sum_{i=1}^{\infty} |x_i|^p)^{\frac{1}{p}}\}$$

is a normed linear space.

4. (a) Define

(i) a *limit point* of a subset of a metric space
(ii) an *open set* in a metric space
(iii) a *closed set* in a metric space

(b) Prove that a subset of a metric space is open if and only if it is a union of open spheres.

(c) Prove that a close sphere in a metric space is a closed set.

5. (a) (i) State *Cantor's intersection theorem* for nested sequences in a metric space.

(ii) Prove Cantor's intersection theorem for nested sequences of sets in a metric space, clearly listing the conditions under which the theorem is valid.

(b) Compute $\cap_{n=1}^{\infty} A_n$ and $\cap_{n=1}^{\infty} B_n$ for the set sequences $A_n = (0, \frac{1}{n})$ and $B_n = [0, \infty)$ in the usual real line **R**. Reconcile your conclusion with Cantor's theorem in these two instances.

6. (a) Define

(i) a *Cauchy sequence* in a metric space
(ii) a *dense* subset of a metric space
(iii) a *first category* metric space.

(b) Prove that $(x_m = \frac{1}{mn^2}, n = 1,2,\cdots), \quad m \in N$ is a Cauchy sequence in l_∞.

(c) (i) Let G be an open subset of a metric space X and N nowhere dense in X. Prove that then there exist $x \in X$ and $r > 0$ such that $S_r(x) \subset G$ and $S_r(x) \cap N = \phi$.

(ii) Determine whether the set **Q** of rational numbers is of first category, giving reasons for your answer.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAMINATIONS - 2003 SESSIONS

AUGUST 2003

M461 - MULTIVARIATE ANALYSIS

TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS: 1. ANSWER **ANY** FIVE (5) QUESTIONS
2. MATHEMATICAL TABLES WILL BE PROVIDED AND USE OF CALCULATORS IS ALLOWED

---

1. a) Define the following:
(i) random vector **X**
(ii) population variance -covariance matrix.

b) (i) Show that if $v^{\frac{1}{2}}\rho v^{\frac{1}{2}} = \Sigma$ then

$$\rho = \left(v^{\frac{1}{2}}\right)^{-1} \Sigma \left(v^{\frac{1}{2}}\right)^{-1} \quad \text{where } v = \text{diag}\,(\sigma_{11},\ \sigma_{22}, \ldots, \sigma_{pp}),$$

hence or otherwise find ρ when

$$\sum = \begin{pmatrix} 16 & 1 & 4 \\ 1 & 81 & -9 \\ 4 & -9 & 625 \end{pmatrix}$$

ii Show that if $Y = a^T x$ with a p-dimensional vector of constants and that X is determined by $N_p(\mu, \Sigma)$ then Y is determined by $N(a^T\mu, a^T\Sigma a)$

c) The varieties $X^T = (x_1, x_2, x_3)$ and $Y^T = (y_1, y_2, y_3)$ are distributed independently according to the bivariate normal populations with respective parameters

$$\mu_x = \begin{pmatrix} 2 \\ 2 \\ 2 \end{pmatrix}, \quad \Sigma_x = \begin{pmatrix} 3 & 2 & 1 \\ 2 & 4 & 1 \\ 1 & 1 & 2 \end{pmatrix}, \quad \mu_y = \begin{pmatrix} 3 \\ 4 \\ 2 \end{pmatrix}, \quad \Sigma_y = \begin{pmatrix} 4 & 2 & 0 \\ 2 & 4 & 2 \\ 0 & 2 & 4 \end{pmatrix}.$$

Determine the distribution of $\begin{pmatrix} X - Y \\ X + Y \end{pmatrix}$.

2. a). Define the following:

i) eigen value of a square matrix A.

ii) a trace of a square matrix A

b). Let **X** have a variance -covariance matrix

$$\Sigma = \begin{pmatrix} 4 & 0 & 0 \\ 0 & 9 & 0 \\ 0 & 0 & 1 \end{pmatrix},$$

Find:

i). Σ^{-1}

ii). the eigen values and eigen vectors of Σ

iii). the eigen values and eigen vectors of Σ^{-1}

c) i) The joint density of a random sample $x_1, x_2, \ldots\ldots, x_n$ from a p-dimensional normal population with mean μ and covariance Σ is expressed as

$$f(x) = \frac{1}{(2\pi)^{\frac{np}{2}} |\Sigma|^{\frac{1}{2}}} e^{\frac{-1}{2}} \mathrm{tr}\left[\Sigma^{-1} \left(\sum_{j=1}^{n} \left(x_j - \bar{x} \right)\left(x_j - \bar{x} \right)^T + n\left(\bar{x} - \mu \right)\left(\bar{x} - \mu \right)^T \right) \right]$$

find the maximum likelihood estimator of μ based on the observed sample $x_1, x_2, \ldots\ldots x_n$.

ii) For the random sample $X = \begin{pmatrix} 2 & 5 \\ 5 & 5 \\ 2 & 4 \\ 6 & 10 \end{pmatrix}$ from a bivariate normal population, find the maximum likelihood estimates of the 2 x 1 mean vector μ and the 2 x 2 covariance matrix Σ.

3 a). Define the following:

i) independence of two random vectors

ii) the expected matrix of a random vector **X**

b) i). Given that **X** is distributed $N_2(\mu, \Sigma)$, find the conditional distribution of X_1 given that $X_2 = x_1$.

ii). If X is distributed as $N_5(\mu, \Sigma)$, find the distribution of $\begin{pmatrix} x_2 \\ x_4 \end{pmatrix}$.

iii) Let **X** be distributed as $N_3(\mu, \Sigma)$ and variance- covariance matrix given by

$$\Sigma = \begin{pmatrix} 4 & 1 & 0 \\ 1 & 3 & 0 \\ 0 & 0 & 2 \end{pmatrix}$$

Determine whether the following are independent:

α) X_1 and X_2 β) (X_1, X_2) and X_3

c). i) Let **a** and **c** be any 2 x 1 vectors. State and prove the cauchy-swahrz inequality.

ii). Verify the cauchy-swahrz inequality for $a^T = (2 \; -1 \; 4 \; 0)$ and $c^T = (-1 \; 3 \; -2 \; 1)$

4 a) Define the following terms:

i). a positive definite matrix

ii). Hotelling's - statistic for a p-dimensional normal population test of $H_0: \mu_0 = 0$ versus $H_1 : \mu_0 \neq 0$.

b).

i). Show that the Hotelling's T^2 -statistic is invariant under the transformation of the form $Y = CX + D$ with C being non -singular.

ii). Find the mean and variance-covariance matrix for the linear function

$Y = CX + D$ where $C = \begin{pmatrix} 2 & 1 \\ 1 & -3 \end{pmatrix}$, $D = \begin{pmatrix} 2 \\ 3 \end{pmatrix}$.

c).

Show that if A is a square matrix then

$|A| = |A_{22}||A_{11} - A_{12}A_{22}^{-1}A_{21}|$ for $|A_{22}| \neq 0$

Hence find the $|A|$ given that $A = \begin{pmatrix} 2 & 0 & 4 & 0 \\ 0 & 3 & 0 & 5 \\ 5 & 0 & 1 & 0 \\ 0 & 4 & 0 & 1 \end{pmatrix}$

5 a). Let the data matrix for a random sample of size n=4 from a bivariate normal population be

$$X = \begin{pmatrix} 3 & 3 \\ 7 & 10 \\ 7 & 3 \\ 8 & 2 \end{pmatrix},$$

i). Evaluate the observed T^2, for testing $H_0 : \mu^T = (9,5)$.

ii) Evaluate the Wilks lambda.

iii). Specify the distribution of T^2.

iv). Using i) and ii), test H_0 at the $\alpha = 0.05$ level of significance.

v). Comment on the result.

b). The scores obtained by 20 students on three tests X_1, X_2 and X_3 gave the following results:

$$\overline{X} = \begin{pmatrix} 4.64 \\ 45.4 \\ 9.965 \end{pmatrix}, \qquad S = \begin{pmatrix} 2.879 & 10.002 & -1.810 \\ 10.002 & 199.798 & -5.627 \\ -1810 & -5.627 & 3.628 \end{pmatrix},$$

$$S^{-1} = \begin{pmatrix} 0.589 & -0.022 & 0.258 \\ -0.022 & 0.006 & -0.002 \\ 0.258 & -0.002 & 0.402 \end{pmatrix}$$

i) Construct the 95% confidence interval for mean $\overline{x}_1$

ii). Construct the simultaneous 95% T^2 - interval for the mean $\overline{x}_1$

iii). Construct the simultaneous 95% Benferroi interval for $\overline{x}_1$

iv). Compare the three sets of results.

6. Lusaka Water and Sewerage Company (LWSC) plants are required by law to monitor their discharges into rivers and streams on a regular basis.
Concern about the reliability of data from one of these self-monitoring programs led to a study in which samples of effluent were divided and sent to two laboratories for testing. One-half of each sample was sent to the Environmental Council of Zambia (ECZ) and the University of Zambia (UNZA).

Measurements of biochemical oxygen demand and suspended solids were obtained for 11 samples from the two laboratories. The differences in the chemical analysis done by ECZ and UNZA is given by d_{1j} for biochemical oxygen demand and d_{2j} for suspended solids as shown:

d_{1j}	-27	17	-19	9	-10	-4	-18	-22	-19	-4	4
d_{2j}	15	60	-7	-2	11	-1	42	10	12	-4	10

(i) Calculate the mean difference $\bar{d} = \begin{pmatrix} \bar{d}_1 \\ \bar{d}_2 \end{pmatrix}$ and the sample variance S_d.

(ii) Test if there are any differences between the two chemical analyses at 90% confidence level.

(iii) Calculate the 90% confidence intervals for each of the mean differences.

b). Samples of sizes n_1=45 and n_2=55 were taken of homeowners with and without air conditioning respectively.
Two measurements of electrical usage (in kilowatt hours) were considered. The first is a measure of total on-peak consumption (x_1) and the second is a measure of total off-peak consumption (x_2).

The resulting summary statistics are:

$$n_1 = 45\,,\ \bar{x}_1 = \begin{pmatrix} 204.4 \\ 556.6 \end{pmatrix},\ s_1 = \begin{pmatrix} 13825.3 & 23823.4 \\ 23823.4 & 73107.4 \end{pmatrix}$$

$$n_2 = 55\,,\ \bar{x}_2 = \begin{pmatrix} 130.0 \\ 355.0 \end{pmatrix},\ s_2 = \begin{pmatrix} 8632.0 & 19616.7 \\ 19616.7 & 55964.5 \end{pmatrix}$$

i). Calculate the S_{pooled} .

ii). Construct the 95% confidence intervals for the differences $\mu_{1i} - \mu_{2i}$ for i = 1,2.

iii) Comment on the results found in ii).

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAMINATIONS - 2003 SESSION

M911 - MATHEMATICAL METHODS V

TIME ALLOWED: THREE (3) HOURS **20 AUGUST 2003**

INSTRUCTIONS:

THERE ARE 6 QUESTIONS IN THIS PAPER. ANSWER ANY 5 QUESTIONS

Question 1

(a) Let F: $(x,y) \rightarrow (u,v)$ be a differentiable transformation defined by

$$u = x^2 + py^2$$

$$v = xy$$

where p is a constant. Determine the points where F is singular.

(b) Consider the functions

$f(x,y) = e^x e^y$, $g(x,y) = x^2 + y^2 + 2(x + y + xy)$.

Show that f(x,y) and g(x,y) are functionally dependent and give the functional relationship.

Question 2

(a) Show that the vector field $F(x,y) = (\text{Cos } x - \text{Sin } x + y^2)\,\mathbf{i} + 2xy\mathbf{j}$ is exact. Hence find all functions f(x,y) such that $\nabla f(x,y) = F(x,y)$.

(b) Find the tangent plane to the cone $x^2 + z^2 = \frac{a^2}{h^2} y^2$ at the point.

$$\left(\frac{a}{\sqrt{2}}, h, \frac{a}{\sqrt{2}}\right)$$

Question 3

(a) Suppose $\overline{X}(t)$, $a \le t \le b$ is a differentiable curve in IR^3 and that $\overline{X}(h(\tau))$, $\alpha \le \tau \le \beta$ is a regular reparametrization of $\overline{X}(t)$ so that $h^1(\tau) \neq 0$, $t = h(\tau)$.

Show that the arc length of $\overline{X}(h(\tau))$ is equal to the arc length of $\overline{X}(\tau)$.

(b) Calculate the arc length of a complete arc of the cycloid $\overline{X}(t)$, $(0 \le t \le 2\pi)$ given by

$$x_1(t) = a\,(t - \sin t)$$
$$x_2(t) = a\,(1 - \cos t)$$
$$x_3(t) = 0$$

Question 4.

(a) Let $z = 2x^2 + 3xy + 4y^2$, $u = x^2 + y^2$ and $v = x + 2y$.

Determine expressions for

$$\frac{\partial z}{\partial u} \quad \text{and} \quad \frac{\partial z}{\partial v}$$

(b) Find a vector normal to the surface given parametrically by

$$x = a \cos\theta \operatorname{Cos}\phi$$

$$y = a \operatorname{Sin}\theta \operatorname{Cos}\phi$$

$$z = \operatorname{Sin}\phi$$

at the point where $\theta = \frac{\pi}{4}$ and $\phi = \frac{3\pi}{4}$

Question 5

(a) Under certain conditions a rectangular membrane of dimensions a and b will vibrate in such a way that u, the vertical displacement from equilibrium at the point (x,y) at time t, is given by

$$U = \text{Cos wt Sin } \frac{\pi x}{a} \text{Sin} \frac{\pi y}{b}$$

(i) Obtain an expression for the velocity of a particle at the point (x,y) at time t.

(ii) At time t = 0, the position of the membrane is given by $U = \text{Sin } \frac{\pi x}{a} \text{Sin} \frac{\pi y}{b}$.

What is the rate of change of U if one moves from the point $P\left(\frac{a}{4}, \frac{3b}{4}\right)$ in the direction of inclination $\frac{\pi}{4}$?

(b) Find all the critical points of the function $z = x^3 - 6xy + y^3$

Question 6.

(a) Let $\overline{A} = a_x\mathbf{i} + a_y\mathbf{j} + a_z\mathbf{k}$ be a vector. Show that div(curl $\overline{A}$) = 0

(b) Let $\overline{B} = x^2y\mathbf{i} + yz^3\mathbf{j} - zx^3\mathbf{k}$, at the point (2, 1, 1) calculate

(i) grad (div $\overline{B}$)
(ii) curl(curl $\overline{B}$)

The University of Zambia
School of Natural Sciences
2002/2003 Academic Year First Semester
Final Examinations
P-191 : Introductory Physics - I

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

Time : Three Hours. **Maximum Marks : 100.**

Write your computer number clearly on the answer script !!

Wherever necessary use :

$G = 9.8 m/s^2$: $P_A = 1.01 \times 10^5 N/m^2$: 1 cal. = 4.2 J : $\rho_{water} = 1000 kg/m^3$
Specific heat capacity of water = 4200J/kg.K : 1 pascal = 1 N/m^2 : G = 6.67×10^{-11} $N.m^2/kg^2$

Some equations you may find useful :

$v_f = v_o + at$: $v_f^2 = v_o^2 + 2ax$: $x = v_o t + (\frac{1}{2})at^2$: $f = \mu F_N$: work = F.s.cos θ

$Ft = m(v_f - v_o)$: kin. Energy = $(\frac{1}{2})mv^2$: grav. pot. energy = mgh : W = mg

$x = v_{avg.}t$: $\mathbf{Ft} = \Delta\mathbf{p} = m(v_f - v_o)$: $\Delta PE + \Delta KE + \Delta TE = 0$: power = work/time

$v_{avg.} = (\frac{1}{2})(v_o + v_f)$: $\omega_f = \omega_o + \alpha t$: $\omega_f^2 = \omega_o^2 + 2\alpha\theta$: $\theta = \omega_o t + (\frac{1}{2})\alpha t^2$: $P = Fv$

$\mathbf{p} = m\mathbf{v}$: $a_T = \alpha r$: $L = I\omega$: $\tau = I\alpha = Fr$: $[\text{Kin. Energy}]_{total} = (\frac{1}{2})mv^2 + (\frac{1}{2})I\omega^2$

1 rev = $360^o = 2\pi$ radians : $F_c = (mv^2)/r$: $I = \Sigma mr^2 = mk^2$: $F = (Gm_1m_2)/r^2$:

$Y = (F/A)/(\Delta L/L_o)$: $B = -\Delta P/(\Delta V/V_o)$: $W_{app.} = mg - B.F.$: $P = \rho gh$: $v_T = \omega r$

$W_{app.} = W[1 - (\rho_f/\rho)]$: $[(\frac{1}{2})mv^2]_{avg.} = (3/2)kT$: $\Delta Q = mc\Delta T = nC\Delta T$: $\Delta Q = mH_f$

$\Delta L = \alpha L\Delta T$: $\Delta V = \gamma V\Delta T$: $\Delta W = P\Delta V$: $P_1V_1^{\gamma} = P_2V_2^{\gamma}$: $PV = nRT$: $F = -kx$

$\Delta Q = \Delta U + \Delta W$: $\Delta W = nRT.\ln(V_f/V_i)$: $R = (2u^2 \sin\theta \cos\theta)/g$: $t = (2u \sin\theta)/g$

$(\frac{1}{2})kx^2 + (\frac{1}{2})mv^2 = (\frac{1}{2})kx_o^2$: $\omega = \sqrt{(k/m)}$: $v = \pm\sqrt{[(k/m)(x_o^2 - x^2)]}$: $v_T = \omega r$:

$v = \sqrt{(Y/\rho)}$: $f = (1/2\pi)\sqrt{(k/m)}$: $f = (1/2\pi)\sqrt{(g/L)}$: $v = \sqrt{[T/(m/L)]}$: $v = \sqrt{(B/\rho)}$

$v = \sqrt{(\gamma RT/M)}$: $f = 1/\tau$: $\omega = 2\pi f$: $I_1\omega_1 = I_2\omega_2$: $\Delta T.E. = f.s$: $a = -kx/m$

area of a sphere = $4\pi r^2$: area of a right cylinder = $2\pi rL$: 0K = 273°C

$a_{max.} = kx_o/m$: $a_c = \omega^2 x_o$: P.E. = $(\frac{1}{2})kx^2$: volume of a sphere = $(4/3)\pi r^3$

Question 1 : Sample answers : F(a), G(d).... etc. DO NOT guess the answer. For each correct answer, 2 marks will be awarded. For each wrong answer, (0.67) will be deducted. No answer, zero mark. No deduction of marks for not attempting. Minimum total marks for Question 1 is zero. [10 × 2 = 20]

(A) Two vectors **A** and **B** are such that **A** + **B** = **C** and $A^2 + B^2 = C^2$. Which of the following statements is correct ?

(a) **A** is parallel to **B;** both are in the same direction
(b) **A** is parallel to **B;** they are in opposite directions
(c) **A** is perpendicular to **B**
(d) A and B are equal in magnitude.

(B) Two balls are thrown vertically upward, one with an initial velocity twice that of the other. The ball with the greater initial velocity will reach a height :

(a) twice that of the other
(b) four times that of the other
(c) eight times that of the other
(d) $\sqrt{2}$ that of the other.

(C) A certain force gives a 5kg object an acceleration of $2m/s^2$. The same force would give a 20kg object an acceleration of :

(a) $2m/s^2$ (b) $8m/s^2$
(c) $4.9m/s^2$ (d) $0.5m/s^2$

(D) A 40kg boy runs up a staircase to a floor 5 meters higher in 7 seconds. His power output is :

(a) 29 watts (b) 1.4kW
(c) 280 watts (d) 14kW.

(E) A particle at rest suddenly disintegrates into two parts of equal masses which start moving. The two fragments will :

(a) move in the same direction with equal velocities
(b) move in any two directions with arbitrary speeds
(c) move in opposite directions with unequal speeds
(d) move in opposite directions with equal speeds

(F) A body of mass m is moving in a circle of radius r with a constant speed v. The centripetal force on the body is mv^2/r. What is the work done by this force in moving the body over half the circumference of the circle ?

(a) zero (b) $(mv^2/r)(\pi r)$
(c) mv^2/r^2 (d) $\pi r^2/(mv^2)$

(G) A gymnast is sitting on a spinning stool with his arms stretched. He suddenly lowers the arms :

(a) the angular velocity decreases
(b) his moment of inertia decreases
(c) the angular velocity remains constant
(d) the angular momentum increases.

(H) Two ropes are used to support a stationary weight W. The tensions in the ropes must :

(a) each be W
(b) each be W/2
(c) have a vector sum of magnitude W
(d) have a vector sum of magnitude greater than W.

(I) Which of the following quantities is independent of the size and shape of an object composed of a given material ?

(a) weight (b) density
(c) mass (d) volume.

(J) The volume of a gas sample is proportional to its :

(a) Celsius temperature
(b) Fahrenheit temperature
(c) Pressure
(d) Absolute temperature.

Attempt any four questions from below :

Q 2 (a) (i) Define "thermal" energy and "heat" energy. (ii) Define the coefficient of volume thermal expansion of a substance. [3]

(b) A certain steel container has a capacity of 500cm^3 at −10°C. Inside the container there is a brass sphere of radius 3.50cm. Methanol is then poured into the container to fill it to the top. By the time the container and its contents have warmed to the temperature of 27°C, how much methanol has spilled ?

[Coefficient of volume expansion of steel = 36×10^{-6} °C^{-1}. Coefficient of volume expansion of brass = 57×10^{-6} °C^{-1}. Coefficient of volume expansion of methanol = 1200×10^{-6} °C^{-1}.] [10]

(c) A force **A** is added to another force **B** that has x- and y-components equal to −5N and 4N respectively. The resultant of the two forces is in the positive x-direction and has a magnitude of 6N.

(i) Find the x- and y-components of the force **A**, and
(ii) the angle it makes with the positive x-axis. [7]

Q 3 (a) (i) Define "thermal equilibrium". (ii) Define heat of vaporization of a substance. [3]

(b) A 60g iron can contains 45g of water and 15g of ice at 0°C. To this 275g of Pb at 265°C is slowly added.
Find the final temperature of the can and its contents.

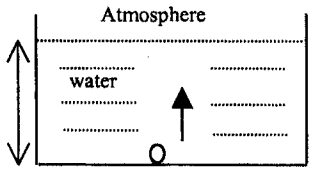
[Latent heat of fusion of ice = 80cal/g. Specific heat capacity of water = 1.0 cal/(g.°C). Specific heat capacity of iron = 0.110 cal/(g.°C). Specific heat capacity of lead = 0.0310 cal/(g.°C).] [8]

(c) A ball is thrown vertically upwards from a point 10m above the ground. It reaches a height of 55m above the ground.

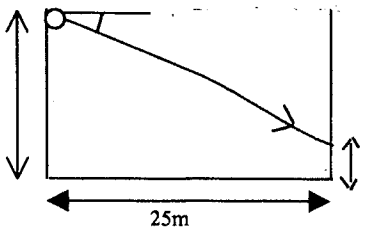
(i) find its initial velocity,
(ii) find the time it takes to reach the ground, and
(iii) find its velocity just before it reaches the ground. [9]

Q 4 (a) State two conditions that a gas has to satisfy to be called an "ideal gas". [2]

(b) A spherical air bubble is released by a submarine at the bottom of a lake. The volume of the bubble triples by the time it rises to the surface of the lake. Assuming that the temperature of the lake and the air does not change during the ascent of the bubble, estimate the depth of the lake. [9]



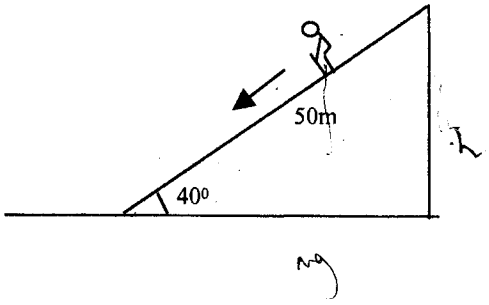
(c) A ball is thrown at 25m/s from the roof of a building 30m high at an angle 30^0 below the horizontal. At what height above the ground will the ball strike the side of another building 25m away from the first ? [9]



Q 5 (a) State (i) Hooke's law, and (ii) Pascal's principle for pressure in a fluid. [3]

(b) A skier starts from rest at the top of a slope that makes an angle of 40^0 with the horizontal and slides 50m down the slope. She then continues along the level snow.

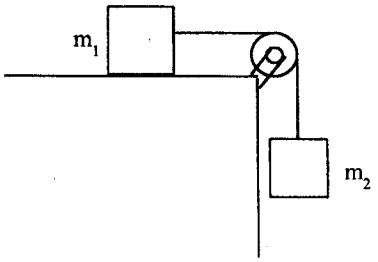
(i) If the coefficient of kinetic friction between skis and snow is 0.10 and air friction is neglected, what is her speed at the foot of the slope ?
(ii) How far away from the foot of the slope does she come to a stop ? [9]



(c) A 4.923g object has an apparent mass of 2.241g when it is completely submerged in water, and an apparent mass of 2.612g when it is completely submerged in an oil. What is the density of the oil ? [8]

Q 6 (a) (i) Define radius of gyration of a rotating object. (ii) State the law of conservation of angular momentum. [3]

(b) The pulley is massless and frictionless, and the connecting cord is massless. The mass m_1 can move without friction. The system is released from rest. After m_2 has gone down by 0.8m it is found that it has a speed of 1.5m/s. If the mass of m_2 is 1.0 kg, find the mass of m_1. [Use the energy principle]. [8]

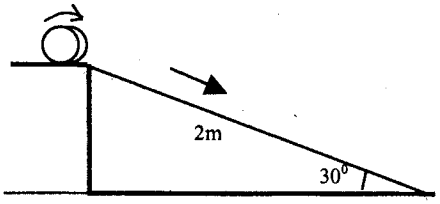


(c) A solid uniform disc with a radius of 8cm starts from rest and rolls down a frictionless plane 2m long.

(i) what is its linear speed at the bottom ?

(ii) what is its angular velocity (in rad/s) ?

(iii) how long does it take to reach the bottom ? [I for a solid disk = $(\frac{1}{2})mr^2$] [9]



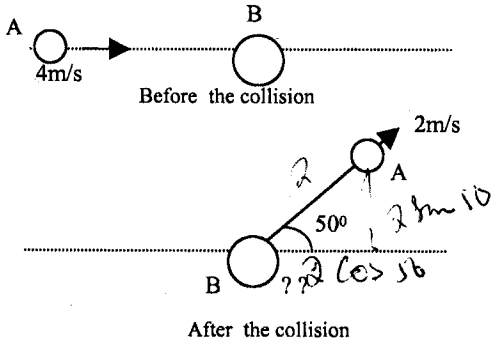
Q 7 (a). State the two conditions for an object to be in equilibrium. [3]

(b) A 1kg ball, A, has a velocity of 4m/s to the right; it strikes a second ball B (of mass 3kg) which is initially at rest. The collision is not head-on and ball A is deflected in the collision through an angle of 50° from its original direction, and its speed after the collision is 2m/s.

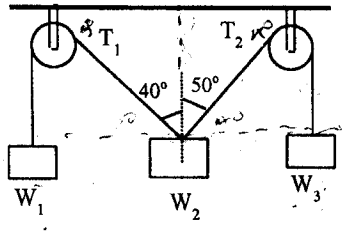
(i) what is the speed of the ball B after the collision ?,

(ii) what is the direction of motion of ball B after the collision ?

(iii) was the collision elastic ? [10]



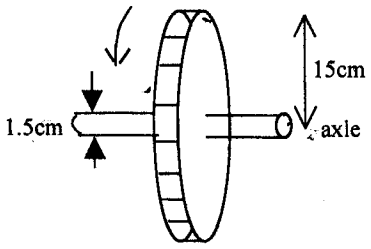
(c) Three weights W_1, W_2, and W_3 are in equilibrium. The pulleys are massless and frictionless. If W_3 = 600N, find W_1 and W_2. [7]



Q 8 (a). Write short notes on (i) torque and (ii) lever arm of an applied force. [3]

(b) A steel cable whose cross-sectional area is $2.5cm^2$ supports a 1000kg elevator. The elastic limit of the cable (maximum stress that can be applied) is 3.0×10^8 Pa. What is the maximum upward acceleration that can be given to the elevator if the tension in the cable is to be no more than 20% of the elastic limit ? [7]

(c) A uniform circular disc of mass 20kg and radius 15cm is mounted on a horizontal cylindrical axle of negligible mass and radius 1.5cm. The disc can rotate freely about an axis perpendicular to the plane of the disc.



Calculate :

(i) the angular velocity acquired from rest by the application for 12s of a force of 20N tangential to the axle,
(ii) the kinetic energy of the disc at the end of 12s, and
(iii) the time required to bring the disc to rest if a braking force of 2N were now applied tangentially to the rim of the disc.
[10]

== End of P-191 Examination ==

UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS
FIRST SEMESTER 2003
P351
INTRODUCTION TO QUANTUM MECHANICS

TIME: THREE HOURS
ANSWER: ANY FOUR QUESTIONS

---

1. (a) Prove that the solutions of the one-dimensional time-independent Schrödinger equation

$$-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}\psi(x) + V(x)\psi(x) = E\psi(x)$$

for a potential symmetric about the origin are of definite parity. Note that in one dimension, eigenfunctions cannot be degenerate. [8]

(b) (i) State the integral definition of a Hermitian operator. [2]

(ii) Hence show that the expectation value of an observable represented by a Hermitian operator is always real. [5]

(iii) Prove that if there is no degeneracy, the eigenfunctions corresponding to two different eigenvalues of a Hermitian operator are orthogonal. [4]

(c) Prove that the kinetic energy operator $T = -\frac{\hbar^2}{2m}\frac{d^2}{dx^2}$ is Hermitian. Note that it acts on functions which vanish at infinity. [6]

2. A particle of energy $E = 10$ eV approaches a potential step from the left. The potential step is

$$V(x) = \begin{cases} 0 \text{ for } x < 0 \\ -V_0 \text{ eV for } x \geq 0 \end{cases}$$

(i) Starting from first principles, obtain expressions for the reflection and transmission coefficients. [17]

(ii) Prove that they add up to unity and explain the meaning of this. [3]

(iii) If the transmission coefficient is 0.3, obtain the value of V_0. [5]

Note that

$$j = \frac{\hbar}{2mi}(\psi^*\frac{\partial}{\partial x}\psi - \psi\frac{\partial}{\partial x}\psi^*)$$

3. (a) The potential energy of a three-dimensional harmonic oscillator of mass m is given by

$$V(x,y,z) = \frac{1}{2}m(\omega_1^2 x^2 + \omega_2^2 y^2 + \omega_3^2 z^2)$$

where ω_1, ω_2 and ω_3 are the angular frequencies in the coordinate directions x, y and z.

(i) Show that for this potential, the time-independent Schrödinger equation

$$-\frac{\hbar^2}{2m}\nabla^2\psi(\mathbf{r}) + V(\mathbf{r})\psi(\mathbf{r}) = E\psi(\mathbf{r})$$

in Cartesian coordinates reduces to three ordinary differential equations for one dimensional harmonic oscillators. [5]

(ii) Given that the energy levels of a one-dimensional harmonics oscillator are given by

$$E_n = (n + \frac{1}{2})\hbar\omega, \quad n = 0, 1, 2, ...$$

obtain the energy levels of the three-dimensional harmonic oscillator. [5]

(iii) Given that in this case $\omega_1 = \omega_2 = \omega$ and $\omega_3 = 4\omega$, show that the energy levels are degenerate and deduce the degree of degeneracy of the lowest three levels, listing all the corresponding eigenfunctions. [5]

(b) A harmonic oscillator is in the state

$$\Psi(x) = \frac{1}{\sqrt{18}}\left(\psi_0(x) + 2\psi_2(x) + 3\psi_4(x) + 2\psi_6(x)\right),$$

where $\psi_j(x)$ are the normalised eigenfunctions of the harmonic oscillator.

(i) Prove that the sum of the squares of the coefficients of the eigenfunctions is unity. [4]

(ii) What is the probability of an energy measurement yielding the value E_4? [2]

(iii) Find the expectation value of the energy. [4]

4. (a) (i) Using the classical expression $\mathbf{L} = \mathbf{r} \times \mathbf{p}$, obtain the operators for the three Cartesian components of the orbital angular momentum. [2]

(ii) Using the basic commutation relations $[x, p_x] = [y, p_y] = [z, p_z] = i\hbar$ for the position and momentum operators, pick a pair of components of $\mathbf{L}$ and compute their commutator. [4]

(iii) If a system is in an eigenstate of L_z, what can you say about the values of L_x and L_y? [2]

(iii) By picking one component to illustrate the result, show that $\mathbf{L}^2$ commutes with any one component of $\mathbf{L}$. You may need the result $[L_i, L_j] = i\hbar L_k$,where i,j and k are taken in cyclic order. [6]

(iv) Explain the importance of the result in **(iii)**. [2]

(**b**) A system is in a state corresponding to orbital angular momentum $l = 3$.
(**i**)What are the possible values of L^2 and L_z? [2]
(**ii**) Draw a vector diagram illustrating this angular momentum. [3]
(**iii**) Obtain the angles between the z axis and **L** for the allowed values of the z component of **L**. [4]

5. A particle of mass m moves in the two-dimensional potential well

$$V(x,y) = \begin{cases} \infty \text{ for } x < 0,\ x > L_x,\ y < 0,\ y > L_y \\ -V_0 \text{ elsewhere} \end{cases}$$

(**i**) Starting from first principles, obtain the normalised eigenfunctions of the particle. [14]
(**ii**) Show that the energy eigenvalues are given by

$$E_{n_1 n_2} = \frac{\hbar^2 \pi^2}{2m}\left(\frac{n_1^2}{L_x^2} + \frac{n_2^2}{L_y^2}\right) - V_0 \quad [4]$$

(**iii**) Hence obtain the total wave function of the particle. [2]
(**iv**) If the particle is an electron, and the well is such that $L_x = L$ and $L_y = 2L$, deduce the well dimensions for which the first excited-state energy is 30 eV above the bottom of the well. Note that $m = 9.1 \times 10^{-31}$ kg and $e = 1.6 \times 10^{-19}$ C. [5]

6. (**a**) The Hamiltonian for the internal motion of the hydrogen atom is

$$H = -\frac{\hbar^2}{2\mu}\left[\frac{1}{r^2}\frac{\partial}{\partial r}(r^2\frac{\partial}{\partial r}) - \frac{\mathbf{L}^2}{\hbar^2 r^2}\right] - \frac{e^2}{4\pi\epsilon_0 r}$$

while the operator for the square of the angular momentum is

$$L^2 = -\hbar^2\left[\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\frac{\partial}{\partial\theta}) + \frac{1}{\sin^2\theta}\frac{\partial^2}{\partial\varphi^2}\right]$$

and the operator for the z component of the angular momentum is

$$L_z = -i\hbar\frac{\partial}{\partial\varphi}$$

(**i**) Prove that the three operators mutually commute. [10]
(**b**) A wave function of the hydrogen atom is

$$\psi(\mathbf{r}) = Ar\cos\theta e^{-\alpha r}$$

where A is a normalisation constant,
(**i**) Prove that this wave function is an eigenfunction of L_z, L^2 and H, giving the corresponding eigenvalue for each operator. Be advised that the proof will be easier if you take the operators in the order L_z, L^2 and H. [15]

*****END OF EXAMINATION*****

UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS
FIRST SEMESTER 2003
P351
INTRODUCTION TO QUANTUM MECHANICS

TIME: THREE HOURS
ANSWER: ANY FOUR QUESTIONS

---

1. (a) Prove that the solutions of the one-dimensional time-independent Schrödinger equation

$$-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}\psi(x) + V(x)\psi(x) = E\psi(x)$$

for a potential symmetric about the origin are of definite parity. Note that in one dimension, eigenfunctions cannot be degenerate. [8]

(b) (i) State the integral definition of a Hermitian operator. [2]
(ii) Hence show that the expectation value of an observable represented by a Hermitian operator is always real. [5]
(iii) Prove that if there is no degeneracy, the eigenfunctions corresponding to two different eigenvalues of a Hermitian operator are orthogonal. [4]

(c) Prove that the kinetic energy operator $T = -\frac{\hbar^2}{2m}\frac{d^2}{dx^2}$ is Hermitian. Note that it acts on functions which vanish at infinity. [6]

2. A particle of energy $E = 10$ eV approaches a potential step from the left. The potential step is

$$V(x) = \begin{cases} 0 \text{ for } x < 0 \\ -V_0 \text{ eV for } x \geq 0 \end{cases}$$

(i) Starting from first principles, obtain expressions for the reflection and transmission coefficients. [17]
(ii) Prove that they add up to unity and explain the meaning of this. [3]
(iii) If the transmission coefficient is 0.3, obtain the value of V_0. [5]
Note that

$$j = \frac{\hbar}{2mi}(\psi^*\frac{\partial}{\partial x}\psi - \psi\frac{\partial}{\partial x}\psi^*)$$

3. (a) The potential energy of a three-dimensional harmonic oscillator of mass m is given by

$$V(x,y,z) = \frac{1}{2}m(\omega_1^2 x^2 + \omega_2^2 y^2 + \omega_3^2 z^2)$$

where ω_1, ω_2 and ω_3 are the angular frequencies in the coordinate directions x, y and z.

(i) Show that for this potential, the time-independent Schrödinger equation

$$-\frac{\hbar^2}{2m}\nabla^2\psi(\mathbf{r}) + V(\mathbf{r})\psi(\mathbf{r}) = E\psi(\mathbf{r})$$

in Cartesian coordinates reduces to three ordinary differential equations for one dimensional harmonic oscillators. [5]

(ii) Given that the energy levels of a one-dimensional harmonics oscillator are given by

$$E_n = (n + \frac{1}{2})\hbar\omega, \qquad n = 0, 1, 2, ...$$

obtain the energy levels of the three-dimensional harmonic oscillator. [5]

(iii) Given that in this case $\omega_1 = \omega_2 = \omega$ and $\omega_3 = 4\omega$, show that the energy levels are degenerate and deduce the degree of degeneracy of the lowest three levels, listing all the corresponding eigenfunctions. [5]

(b) A harmonic oscillator is in the state

$$\Psi(x) = \frac{1}{\sqrt{18}}\left(\psi_0(x) + 2\psi_2(x) + 3\psi_4(x) + 2\psi_6(x)\right),$$

where $\psi_j(x)$ are the normalised eigenfunctions of the harmonic oscillator.

(i) Prove that the sum of the squares of the coefficients of the eigenfunctions is unity. [4]

(ii) What is the probability of an energy measurement yielding the value E_4? [2]

(iii) Find the expectation value of the energy. [4]

4. (a) (i) Using the classical expression $\mathbf{L} = \mathbf{r} \times \mathbf{p}$, obtain the operators for the three Cartesian components of the orbital angular momentum. [2]

(ii) Using the basic commutation relations $[x, p_x] = [y, p_y] = [z, p_z] = i\hbar$ for the position and momentum operators, pick a pair of components of $\mathbf{L}$ and compute their commutator. [4]

(iii) If a system is in an eigenstate of L_z, what can you say about the values of L_x and L_y? [2]

(iii) By picking one component to illustrate the result, show that $\mathbf{L}^2$ commutes with any one component of $\mathbf{L}$. You may need the result $[L_i, L_j] = i\hbar L_k$,where i,j and k are taken in cyclic order. [6]

(iv) Explain the importance of the result in (iii). [2]

(**b**) A system is in a state corresponding to orbital angular momentum $l = 3$.
(**i**)What are the possible values of L^2 and L_z? [2]
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UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS
FIRST SEMESTER 2003
P351
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*****END OF EXAMINATION*****

The University of Zambia
Physics Department

2002/2003 Academic Year
First Semester Examinations
P-411 : Nuclear Experimental Techniques

All questions carry equal marks. The marks are shown in brackets. Attempt <u>any four</u> questions.

Time : Three hours. **Maximum marks = 100.**

Write clearly your computer number on the answer book.

==========

Wherever necessary use :

g =	$9.8 m/s^2$
charge of an electron =	$1.6 \times 10^{-19} C$
1 barn =	$10^{-24} cm^2$
mass of an electron =	$9.1 \times 10^{-31} kg$
1 eV =	$1.6 \times 10^{-19} J$
1 a.m.u. =	931.5 MeV $= 1.66 \times 10^{-27} kg$
$N_{Av.}$ =	6.02×10^{23} per mole
1 curie =	3.7×10^{10} d/s
Planck's constant h =	6.63×10^{-34} J.s

Some equation(s) you may find useful :

$$h\upsilon' = \frac{h\upsilon}{1+\frac{h\upsilon}{m_0 c^2}(1-\cos\theta)} \qquad \Omega = \frac{\pi a^2}{d^2} \qquad N = N_0 e^{-\Sigma_i x} \qquad m = \frac{n}{1+n\tau}$$

$$n - m = nm\tau$$

Q1 (a) Derive from first principles the radioactive decay law and obtain the expressions relating the decay constant λ, and the half-life $T_{1/2}$ for a given radionuclide. Explain the term secular equilibrium. Under what condition does it exist ? [10]

(b) A 2.71g sample of radioactive *KCl* is found to decay at a nearly constant rate of 4490Bq. The decays are due to ^{40}K which constitutes 1.17% of normal potassium. Calculate the half life of ^{40}K. Molar mass of *KCl* = 74.6g/mol. $N_{Av.} = 6.02 \times 10^{23}$ per mole. [10]

(c) Describe two possible mechanisms by which $^{22}_{11}Na$ could decay to $^{22}_{10}Ne^{*}$ [5]

Q 2 (a) Describe the three significant processes through which gamma rays in the energy range of ~10keV to ~10 MeV primarily interact with matter. Describe fully the physical processes occurring in each of these interactions. [9]

(b) Sketch the form of the gamma-ray energy spectrum obtained with a *NaI(Tl)* detector from monoenergetic photons of 2.5MeV. Show how the various regions of the spectrum are related to the three interactions described above. [8]

(c) For each process, sketch the variation of cross section with the gamma ray energy and the atomic number of the material. [8]

Q 3 (a) Illustrate the differences between various types of gas counters operated in the pulse mode by plotting the amplitude of the observed pulse versus the applied voltage to the detector for events depositing two different amounts of energy within the gas. Explain in short the salient features of the figure. [9]

(b) Draw the differential pulse-height spectrum and the corresponding counting curve for a mixed alpha-beta source of typical energies for a proportional counter and explain them. Explain and show how this figure would change if instead of a proportional counter a GM counter is used. [8]

(c) An alpha particle of energy *9 MeV* loses all its energy in a proportional counter. One electron-ion pair is produced for each 30eV of energy loss. The proportional counter has a multiplication factor M = 600, and the total capacitance between the anode and the ground is 35pF. What is the voltage of the output pulse ? [8]

Q 4 (a) Write short notes on :

(i) prompt fluorescence
(ii) phosphorescence, and
(iii) delayed fluorescence.

Which process is desirable for a material to be a good scintillator; explain why ? How does the scintillation mechanism proceed in an inorganic scintillator doped with an activator ? [13]

(b) Calculate the pulse amplitude from the anode of a PM-tube used with a *NaI(Tl)* scintillator under the following conditions :

A 1 MeV electron loses all its energy in the scintillator; the light collection efficiency to the photocathode is 50%, the average quantum efficiency of the photocathode is 20%, and 80% of the photoelectrons are collected at the first dynode.
Assume that the PM-tube has 10 stages with a multiplication factor $\delta = 2.5$ per stage. The anode load resistance is 100 kilo-ohms, and the anode capacitance is 100pF.
The *NaI(Tl)* has an absolute scintillation efficiency of 13%, and 4eV energy is required to produce 1 photon. Decay time for scintillation in *NaI(Tl)* is 230 nano-seconds. [12]

Q 5 (a) Explain the principles of operation of the thermoluminescent detector. What properties are required of materials for use in TLD detectors ? How well do actual materials meet these criteria ?

Name two other methods which may be routinely used for monitoring the exposure of humans to ionising radiations ? [13]

(b) An aluminium cylinder 3cm long is used in an experiment to measure the total neutron cross section with a well-collimated neutron beam. If the neutron detector registers 2000 counters/second with the cylinder removed from the neutron beam, and 500 counts with the cylinder inserted in the beam, calculate the total cross section of aluminium for these neutrons.
[density of aluminium = 2.7g/cm^3 and the mass of a mole of aluminium = 27g. [12]

Q 6 (a) Distinguish between ionising and radiative processes in the collision of fast electrons with matter. Indicate how the importance of each depends on the electron energy and the nature of the absorber. [8]

(b) Counters *A* and *B* are "non-paralysable" with dead times of 25μs and 100μs respectively. At what true event rate will the dead time losses in counter *B* be twice as great as those for counter *A* ? [8]

(c) A ^{137}Cs source emitting 0.662MeV rays is placed in front of a 5cm by 5cm *NaI(Tl)* detector. The source-to-detector distance is 25cm. If the number of counts in the photo-peak for a 2-minute counting period is 13000, calculate the intrinsic photopeak efficiency of the detector.

Calculate also the absolute efficiency of the detector if the number of counts outside the photopeak for the same counting period is 20,000.

Given, the activity of the source is 1 micro-curie. ^{137}Cs emits a 0.662MeV gamma ray in 92% of its decays. [1 curie = 3.7×10^{10} disintegrations per second]. [9]

== End of P-411 Examination ==

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

PHYSICS DEPARTMENT

2002/2003 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

P 441: ANALOG ELECTRONICS

MAXIMUM MARKS 100

TIME : 3 HOURS

INSTRUCTIONS : ATTEMPT ANY (4) QUESTIONS
ALL QUESTIONS CARRY EQUAL MARKS
MARKS ARE INDICATED FOR EACH QUESTION

Q1. (a). Explain and discuss how the differential amplifier circuit shown below functions.

[4 Marks]

(b). Find an expression for an output voltage, V_o, of the differential amplifier circuit shown below.

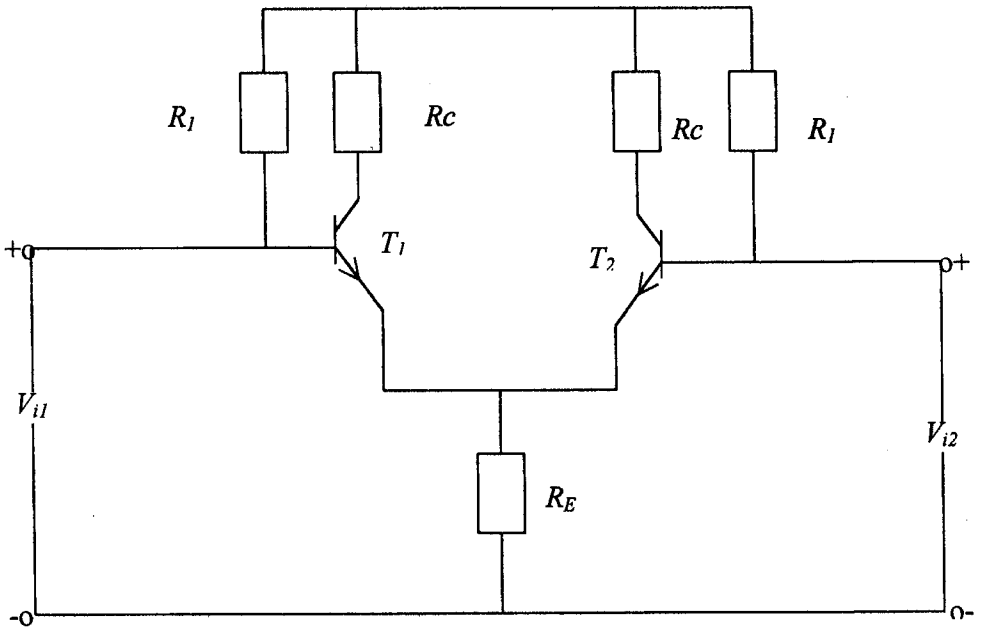
[7 Marks]

(c). Find an expression for the input impedance at each input of the differential amplifier circuit shown below:

(1). *If* $V_{i1} = V_{i2} = V_{ic}$ [7 Marks]

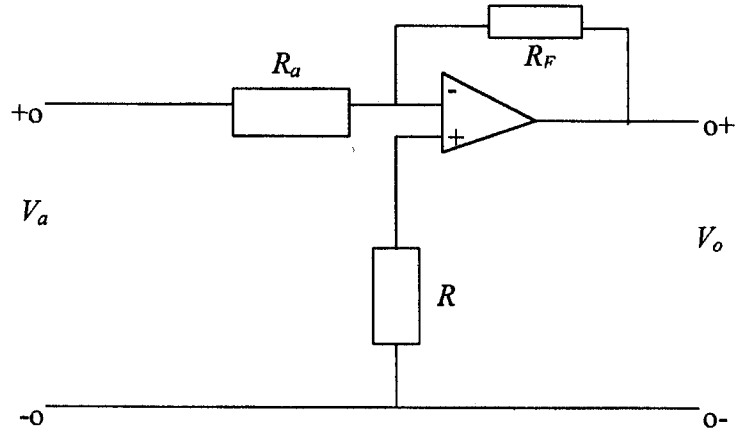
(2). *If* $V_{i1} = -V_{i2} = \frac{1}{2}V_{id}$ [7 Marks]

where V_{ic} is the common mode input voltage
V_{id} is the difference mode input voltage
V_{i1} and V_{i2} are input voltages as shown.



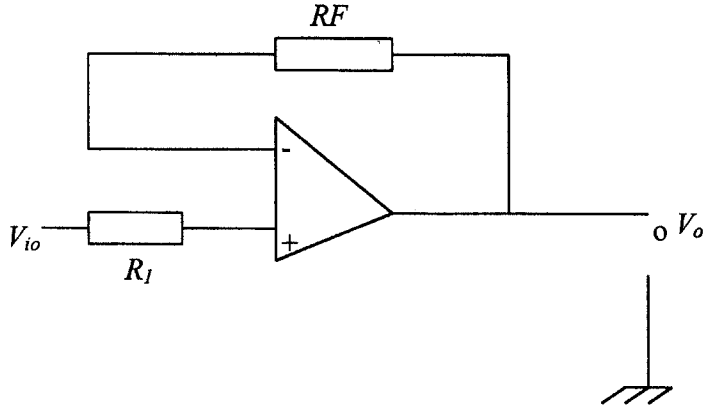
Q2. (a). Explain as to what is understood by saying that there is a virtual ground at the negative input terminal of the inverting amplifier circuit shown below and that its closed loop gain is independent of the open loop gain.

[5 Marks]



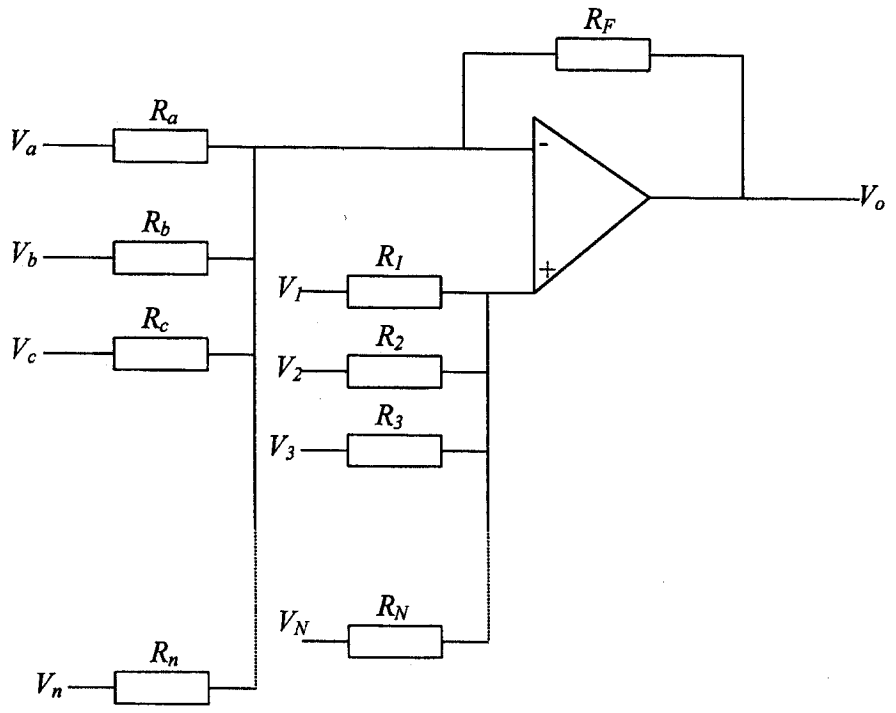
(b). When are voltage followers often used? Show that the output voltage, V_o, is equal to the input voltage, V_i, for the voltage follower shown below.

[5 Marks]



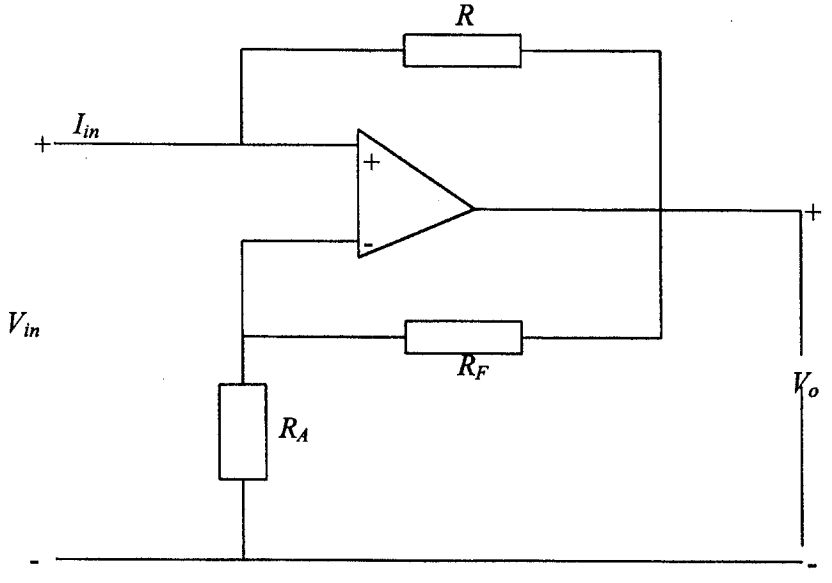
(c). Find an expression for an output voltage, V_o, for the combined inverting and non inverting inputs to the operational amplifier circuit shown below.

[15 Marks]



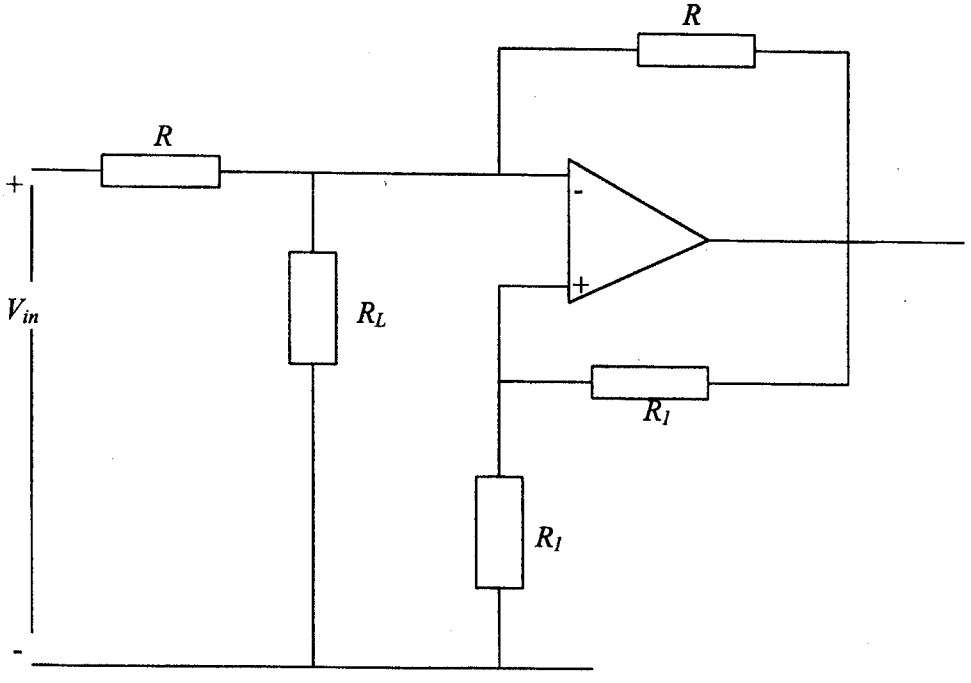
Q3. (a). Where are negative impedances used? Find an expression for the negative input impedance of the amplifier circuit shown below.

[5 Marks]



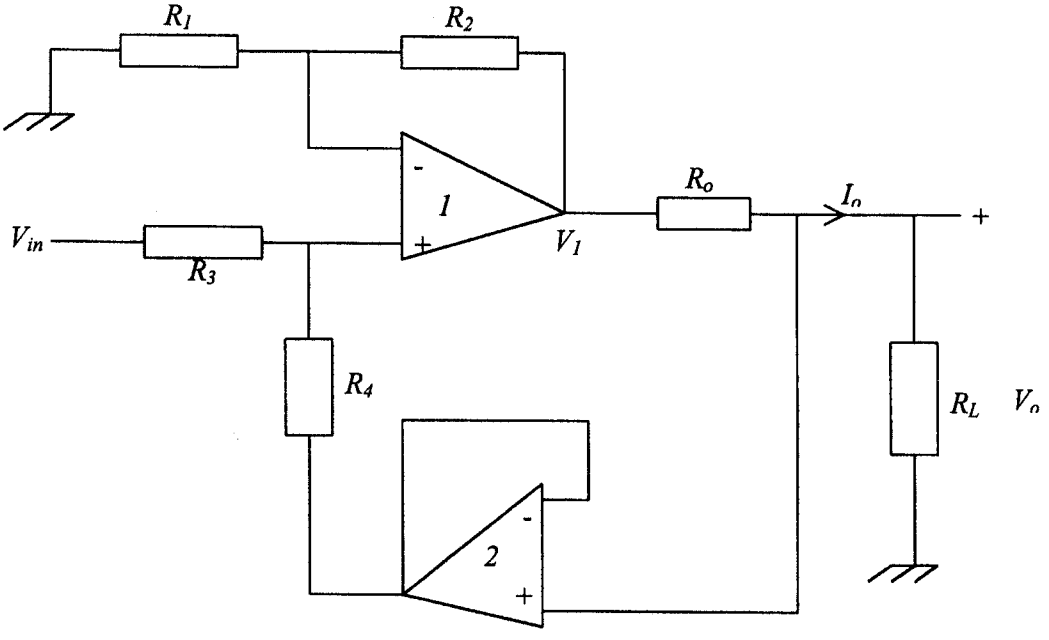
(b). Show that the load current is proportional to the input voltage and independent of the load resistance for the dependent current generator amplifier circuit shown below.

[8 Marks]



(c). Find the current, Io, in the current generator whose circuit is shown below.

[12 Marks]



$R_1 = R_2 = 10k\Omega$

$R_3 = R_4 = 22k\Omega$

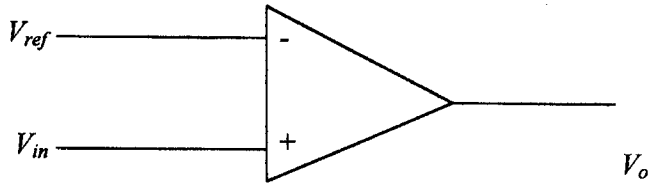
$R_o = 1k\Omega$

$V_{in} = 10V$

$R_L = 470\Omega$

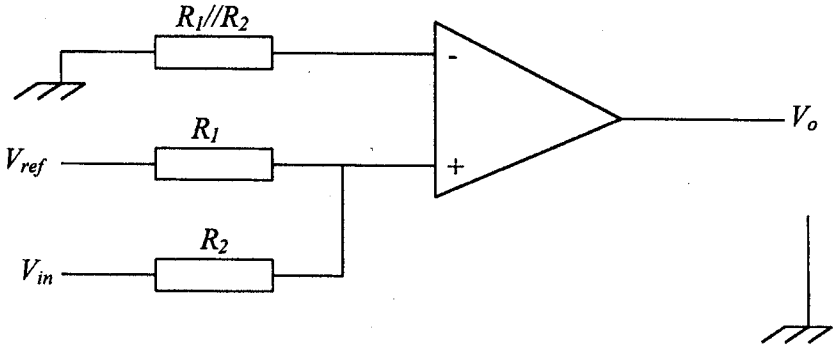
Q4. (a). Discuss and describe how a saturation comparator whose operational amplifier shown below operates.

[5 Marks]



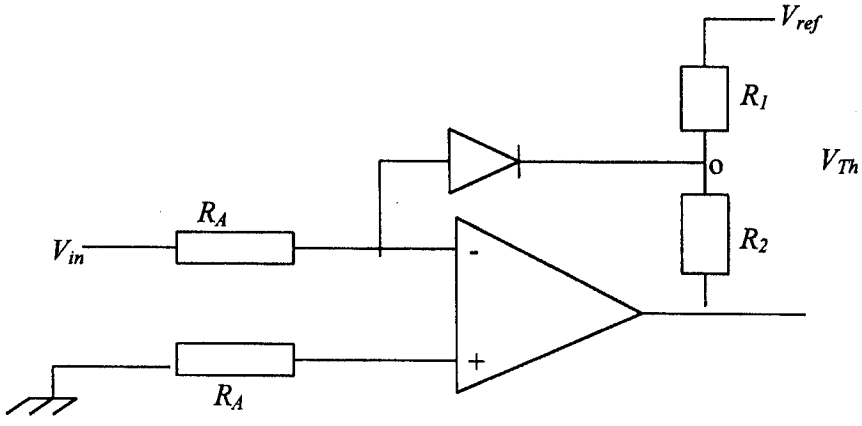
(b). Explain how a pass over comparator whose operational amplifier circuit is shown below functions.

[5 Marks]



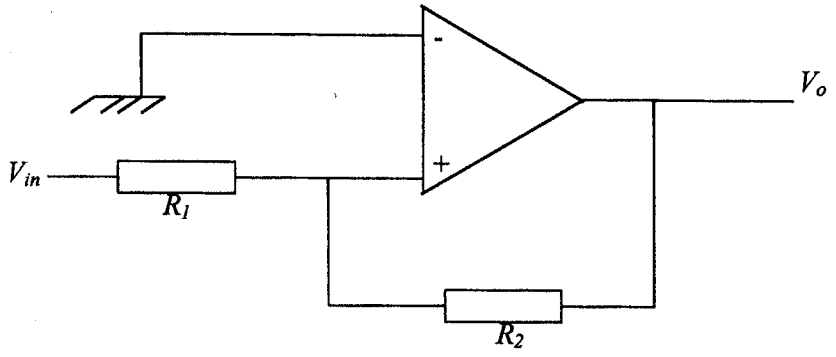
(c). With the aid of diagrams explain how a limiting comparator with a circuit shown below operates.

[15 Marks]



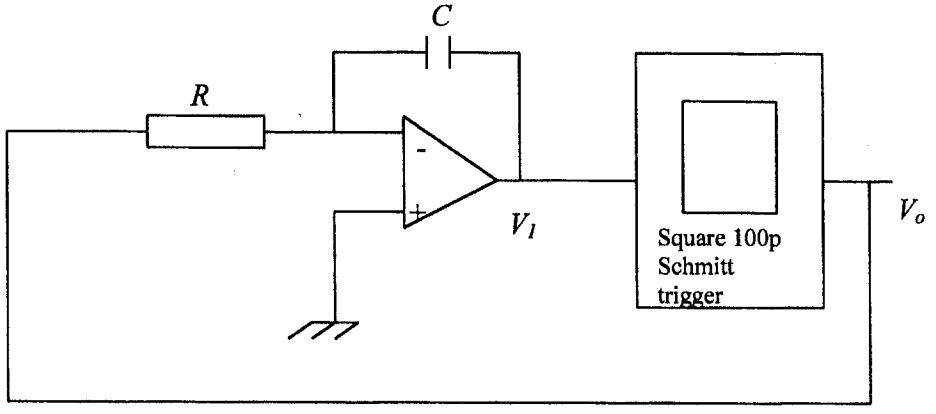
Q5. (a). A Schmitt trigger can be used not only as a square wave generator but also as a binary memory device. With the aid of the operational amplifier circuit below and hysteresis diagram show how the device is used as a square wave generator.

[9 Marks]



(b). Explain how a square and triangular waveform generator whose circuit is shown below operates.

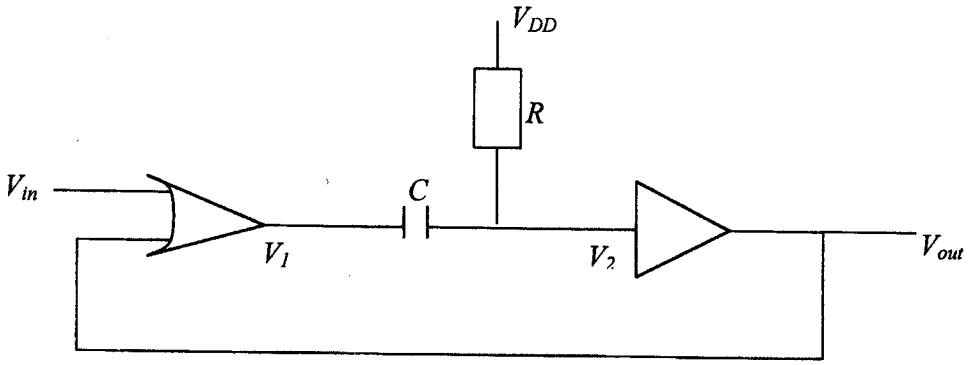
[8 Marks]

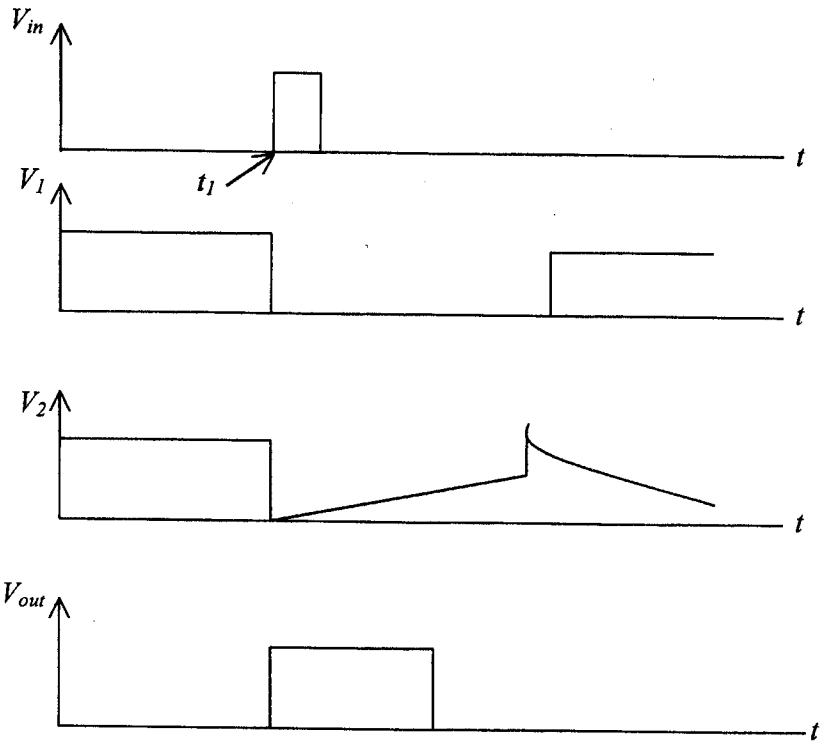


(c). A monostable multivibrator is defined as a network with one single stable state and one quasi-stable state. A trigger signal is used to put the network in quasi-stable state.

Explain a monostable multivibrator whose logic circuit and voltage time diagrams are shown below operates.

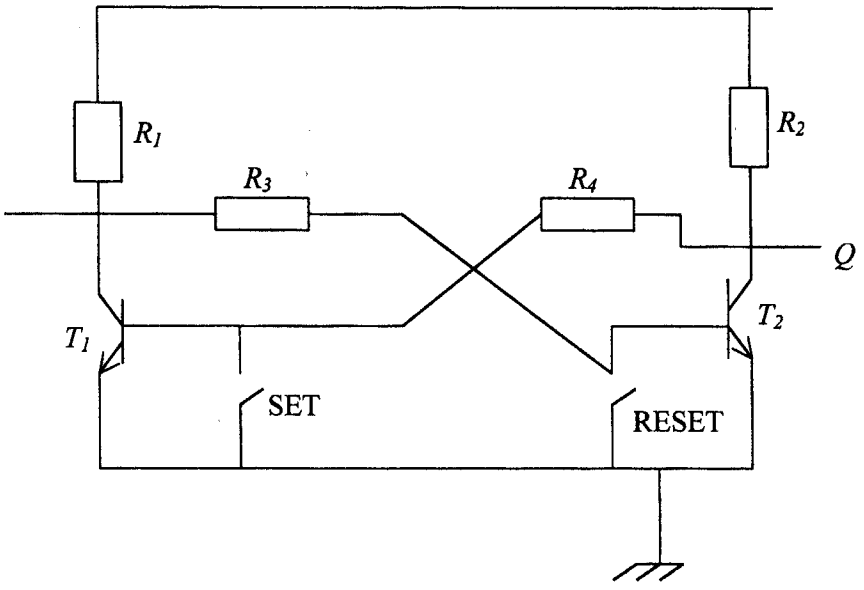
[8 Marks]





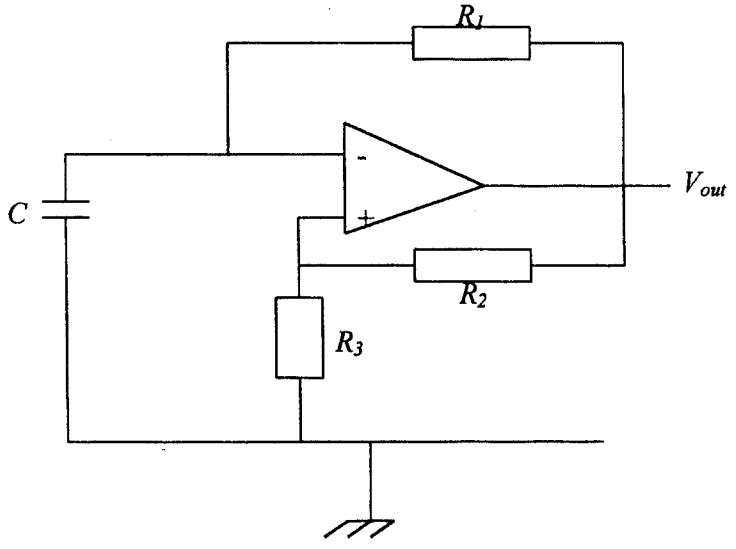
Q6. (a). Explain how a bistable multivibrator whose circuit is shown below functions.

[8 Marks]



(b). An astable multivibrator has no stable state. It oscillates with the output voltage, V_o, forming a square wave. With the help of an operational amplifier circuit shown below explain how a square wave output voltage of an astable multivibrator is formed.

[8 Marks]



(c). Show that the frequency of oscillation of the operational amplifier circuit of an astable multivibrator shown in Q6 (b) is given as:

[9 Marks]

$$F = \frac{1}{2R_1 C \ln\left(\frac{R_2 + R_2}{R_2 - R_3}\right)}$$