THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 FIRST SEMESTER EXAMINATIONS

COURSE/CODE		COURES /TITLE
BS	111	Cell biology and genetics Theory paper
BS	221	Form, function and diversity of Plants
BS	319	Biostatistics
BS	321	Ethnology and Evolution
BS	341	Microbiology Theory paper !
BS	351	Entomology
BS	411	(Insect ecology) Paper II
BS	475	Population ecology (Theory paper II)
BS	491	Fresh water Biology Theory paper
BS	41[illegible]	Insect behaviour and Ecology Theory Paper 1
C	10[illegible]	Introductory Chemistry I
C	245	Inorganic Chemistry 1
C	251	Organic Chemistry 1
C	311	Biochemistry
C	341	Inorganic Chemistry II
C	351	Organic Chemistry III
C	361	Chemical Kinetics and nuclear chemistry
C	411	Advanced biochemistry
C	421	Applied analytical chemistry
C	451	Organic chemistry
C	491	Organic Industrial Chemistry
CS	3251	Electronic for computing I
CS	3011	Algorithms and date structure
CST	3141	Object Oriented analysis and design
CST	4121	Requirements and specifications
CST	4131	Advanced object – oriented programming

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS
FIRST SEMESTER EXAMINATIONS – JUNE 2005

BS 111
CELL BIOLOGY AND GENETICS
THEORY PAPER

TIME: Three hours

ANSWER: All questions
Select the best answer to each question

MARKS:

Correct answer	+4
Wrong answer	-1
Blank space	-1
I do not know	0

NOTE:

1. The paper has two sections.
   Section A: Cell Biology and Biochemistry (1 – 50)
   Section B: Genetics (51 – 100)

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

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

SECTION A: CELL BIOLOGY

1. The five-kingdom classification of organisms uses the following groups;
   1. Prokaryotae, Plantae, Fungi, Animalia and Protoctista
   2. Viruses, Bacteria, Fungi, Eukaryotes and Prokaryotae
   3. Cells, tissues, organisms, community and population
   4. unicells, protozoa, multicells, organisms and algae
   5. Plants, Insects, Parasites, microbes and viruses
   6. I do not know

2. The maximum number of water molecules a water molecule can attach itself to are … in number.
   1. 5
   2. 4
   3. 3
   4. 2
   5. 1
   6. I do not know

3. Water floats in form of ice when its temperature reaches …
   1. $4^{o}C$
   2. $25^{o}C$
   3. $40^{o}C$
   4. $2^{o}C$
   5. $70^{o}C$
   6. I do not know

4. What happens to water when it turns into a solid?
   1. The hydrogen bonds between water molecules break.
   2. The covalent bonds in water and the hydrogen bonds between water molecules get arranged in straight lines.
   3. Water molecules occupy a larger space.
   4. Water as a solid floats on liquid water
   5. Answers 2, 3 and 4 above are all correct.
   6. I do not know

5. Determine which of the following statements is true about functional groups.
   1. They are always non polar.
   2. Only negatively charged functional groups exist.
   3. Positively and negatively charged functional groups are polar and therefore hydrophilic.
   4. Biomolecules that bear a positive or negative charge are soluble in lipid solvents.
   5. Non-polar parts of biomolecules constitute the functional part of the molecule.
   6. I do not know

6. Which of the following molecules is a carbohydrate?
   1. $C_{57}H_{110}O_6$
   2. $CH_3(CH_2)_{16}COOH$
   3. $C_3H_6O_3$
   4. $C_3H_8O_3$
   5. Lectin
   6. I do not know

7. Which of the following is an example of a monosaccharide?
   1. Glycogen
   2. Starch
   3. Maltose
   4. Sucrose
   5. Dihydroxyacetone
   6. I do not know

8. Name two monosaccharides that are isomers of Glucose.
   1. Fructose and Sucrose
   2. Glucose and Galactose
   3. Maltose and Fructose
   4. Galactose and Fructose
   5. Maltose and Galactose
   6. I do not know

9. Starch is made up of repeating units of … and … linked through … bond.
   1. glucose; glucose; a beta
   2. glucose; glucose; an alpha
   3. glucose; fructose; an alpha
   4. frcutose; galactose; a beta
   5. galactose; galactose; a beta
   6. I do not know

10. When starch is digested a disaccharide called … is normally released.
   1. maltose
   2. sucrose
   3. lactose
   4. cellobiose
   5. glyceride
   6. I do not know

11. Sucrose is the most suitabable carbohydrate for transportation in plant cells because it …
   1. is a reducing sugar
   2. is non reactive
   3. is highly reactive
   4. readily splits into its constituent monosaccharides
   5. readily gets reduced
   6. I do not know

12. Which of the following molecules have correct matching words?
    1. Cellulose; cellobiose; ester
    2. Lipid; glycerol and fatty acids; peptide bond
    3. Deoxyribonucleic acid; nucleotide; glycosidic bond.
    4. Proteins; amino acids; peptide bond
    5. Starch; phosphate group; ester
    6. I do not know

13. Enzymes are examples of the ... structure of proteins, while human nails are examples of the ... structure of proteins.
    1. primary; tertiary
    2. tertiary; secondary
    3. tertiary; primary
    4. quarternary; tertiary
    5. secondary; quarternary
    6. I do not know

14. Which of the following amino acids is responsible for the formation of disulphide bridges in proteins?
    1. glycine
    2. leucine
    3. phenylamine
    4. theomine
    5. cystein
    6. I do not know

15. What is the function of golgi bodies in a cell?
    1. synthesis of enzymes
    2. reprocessing of proteins into various cellular products
    3. site for protein synthesis
    4. site for cellular respiration
    5. site for photosynthesis in plants
    6. I do not know

16. The golgi body in plants is sometimes referred to as a ...
    1. dictyosome
    2. golgi apparatus
    3. ribosome
    4. lysosome
    5. vesicle
    6. I do not know

17. The lipids of biological membranes serve as a barrier to ...
    1. non polar molecules such as triglycerides
    2. water and sodium chloride
    3. charged molecules such as proteins
    4. uncharged molecules
    5. phospholipids
    6. I do not know

18. Name the carbon atom in glucose that forms the reactive site on the molecule.
    1. carbon 6
    2. carbon 5
    3. carbon 4
    4. carbon 2
    5. carbon 1
    6. I do not know

19. What compound is glucose converted into in the first step of glycolysis?
    1. adenosine triphosphate ATP
    2. adenosine diphosphate
    3. glucose - 6 – phosphate
    4. fructose 1,6 phosphate
    5. glyceraldehydes
    6. I do not know

20. What is the final product of glycolysis?
    1. ATP
    2. pyruvate
    3. dihydroxyacetone
    4. citric acid
    5. ethanol or lactic acid
    6. I do not know

21. NAD^+ in metabolic pathways acts as … while it gets …
    1. a reducing agent; reduced
    2. a coenzyme; oxidised
    3. a reducing agent; oxidized
    4. an oxidizing agent; oxidized
    5. electron acceptor; reduced
    6. I do not know

22. The first step of glycolysis requires the input of energy in the form of …
    1. Adenosine triphosphate
    2. heat
    3. $FADH_2$
    4. Adenosine diphosphosphate
    5. electrons
    6. I do not know

23. What are the by products of the process in which pyruvate is converted to ethanol?
    1. oxygen and the reduced form of nicotinamide adenine dinucleotide
    2. carbon dioxide and the reduced form of flavin adenine dinucleotide
    3. ATP and carbon dioxide
    4. nicotinamide adenine dinucleotide and carbon dioxide
    5. ADP and FAD
    6. I do not know

24. Name a two carbon compound that takes part in the link reaction between glycolysis and the Krebs cycle.
1. acetone
2. acetyl group
3. coenzyme – A
4. oxaloacetate
5. citric acid
6. I do not know

25. The thylakoid membranes and plasmids are found in ... and ... respectively.
1. chloroplasts; bacteria
2. animal cells; plant cells
3. bacteria; protozoa
4. chloroplasts; viruses
5. mitochondria; cytoplasm
6. I do not know

26. What are the molecular building units for lipids?
1. phospholipids and lectins
2. fatty acids and glycerol
3. glycerol and alcohols
4. alcohols and nucleotides
5. triglycerides and glycerol
6. I do not know

27. What is the role of monosaccharides in a cell?
1. energy source
2. building units for polymer sugars
3. healing process in damaged tissue
4. building units for polypeptides
5. answers 1 and 2 are both correct
6. I do not know

28. The synthesis of nucleosides involves a ... process which unites a ... to a ...
1. hydrolysis; base; phosphate group
2. hydrolysis; sugar; base
3. condensation; phosphate group; sugar
4. dehydration; sugar; base
5. condensation; protein; lipid
6. I do not know

29. What bond unites the building units of lipids?
1. oxygen bridge
2. ionic bond
3. disulphide bridge
4. glycosidic bond
5. ester
6. I do not know

30. What is the function of the rough endoplasmic reticulum?
1. lipid synthesis
2. protein synthesis
3. ribosome synthesis
4. polysaccharide transportation
5. digestion of cell debris
6. I do not know

31. Name the bond that holds the two deoxyribonucleic acid chains.
1. ionic bond
2. hydrophobic interaction
3. disulphide bond
4. hydrogen bond
5. polypeptide bond
6. I do not know

32. Identify the base pairs that are correctly matched as in a DNA molecule
1. G – A
2. A – U
3. G – T
4. A – T
5. U – C
6. I do not know

33. Which of the following base sequences represents a base sequence in mRNA?
1. GUAAUCC
2. GUTAAAG
3. AACTTGG
4. ATUTAAG
5. CGATTCU
6. I do not know

34. Name two parts of *E. coli* that are also found in an animal cell.
1. cell wall and the rough ER
2. mitochondria and the cell membrane
3. plasmid and RNA
4. golgi body and DNA
5. ribosomes and genes
6. I do not know

35. Phosphorylation is the addition of ... to a chemical compound.
1. an enzyme
2. phosphate
3. ADP
4. ATP
5. NADH
6. I do not know .

36. The cell membrane is partly made up of ...
1. lipids only
2. amino acids only
3. proteins and phospholipids
4. glycoproteins mainly
5. polysaccharides to a large extent
6. I do not know

37. State the net gain in moles of ATP from one mole of glucose.
1. 2
2. 8
3. 24
4. 30
5. 38
6. I do not know

38. Name the ultimate acceptor of electrons in respiration.
1. water
2. carbon dioxide
3. hydrogen
4. oxygen
5. cytochromes
6. I do not know

39. What part of respiration yields the highest amount of energy?
1. electron transport chain
2. fermentation
3. citric acid cycle
4. Krebs cycle
5. glycolysis
6. I do not know

40. Phospholipids are found in ...
1. most organims
2. all prokaryotes and some eukaryotes
3. in plants only
4. all organisms
5. in animals only
6. I do not know

41. 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

42. Which of the following structures/characteristic are/is found in both the choloroplasts and mitochondria?
I. DNA II. Membranes III. Reproduce by simple division

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

43. The reactions of the Krebs cycle take place in the ...
1. cytoplasm of the cell
2. stroma of a chloroplast
3. matrix of the mitochondria
4. inner membrane of the mitochondria
5. cell vacuole
6. I do not know

QUESTIONS 44 & 45

A student adds dilute hydrochloric acid to a sample, and heats the sample gently. The student adds equal amounts of sodium hydroxide and warms the test solution. The student adds equal volume of benedicts solution to the test solution and warms it. The solution turns from blue, the colour of benedicts solution to a greenish colour.

44. What is the substrate being tested?
1. a sugar
2. sucrose
3. glucose
4. lipid
5. protein
6. I do not know

45. What is the concentration of the test substance in the solution?
1. very high
2. high
3. very low
4. wrong test method used
5. 50mg per cm^3
6. I do not know

46. Collagen is an example of a ... protein structure and it is of functional importance in ... as an example.
1. primary; the cornea of the eye
2. tertiary; bones
3. quarternary; ligaments
4. primary; cartilage
5. secondary; tendons
6. I do not know

47. Structures that help to package the DNA helix in a nucleus are … in nature and they are called …
1. lipid; lysosomes
2. protein; genes
3. protein; nucleosomes
4. carbohydrate; starches
5. carbohydrate; cellulases
6. I do not know

48. The triple bonds holding two bases together in a DNA helix are found between … and …
1. cytocine; thymine
2. thymine; adenine
3. guanine; adenine
4. guanine; cytocine
5. adenine; cytocine
6. I do not know

49. Which of the following statements is **false**?
1. Starches serve as storage materials for glucose
2. Amylose is an un branched polymer of glucose
3. Cooking oil is a fluid due to its high content of double bonds
4. The chemistry of proteins is the same as that of carbohydrates
5. DNA like RNA has nucleotide bases
6. I do not know

50. A peptide bond forms between the … group of one amino acid and the … group of another by the process of …
1. carboxyl; amide; condensation
2. alkyl; hydrogen; condensation
3. carboxyl; amide; esterification
4. ketose; amide; dehydration
5. ketose; carboxyl; hydrolysis
6. I do not know

51. Crossing over occurs during
1. anaphase of mitosis
2. prophase I of meiosis
3. prophase II of meiosis
4. two of the above answers
5. Metaphase I of meiosis
6. I do not know

52. If the diploid number of a particular species is 20, the number of chromatids in one of its cells that is in telophase II is
1. 40
2. 20
3. 10
4. 5
5. none of the above
6. I do not know

53. Kernel colour in wheat is determined by
1. epistasis
2. multiple alleles
3. qualitative inheritance
4. variable expressivity
5. polygenes
6. I do not know

54. If two heterozygous organisms are crossed, and the trait being studied displays complete dominance, one may expect the following type of genotypic ratio in the offspring:
1. 3:1
2. 1:2:1
3. 9:3:3:1
4. no ratio- all the offspring look the same
5. 9:3:4
6. I do not know

55. Which of the following is not a function of mitosis in humans?
1. replacement of lost or damaged cells
2. repair of wounds
3. growth
4. production of sex cells
5. multiplication of somatic cells
6. I do not know

56. In guppies (little fish), males have flamboyant coloration, long fins, and extravagant behaviour patterns. Females never show these characteristics. The genes controlling these phenotypes are all on the second autosome, and combinations of alleles of these genes are transmitted as a unit from one generation to the next. The expression of these genes in guppies is:
1. sex-limited
2. sex-linked
3. sex influenced
4. dosage compensated
5. holandric dependent
6. I do not know

57. A geneticist has been studying sheep fertility for years. She has found 6 different genes with alleles that affect fertility. These loci are on various chromosomes in the sheep genome. None of these loci act as the sole determinant of the level of fertility. This is a case of:
1. pleiotropy
2. quantitative inheritance
3. epistasis
4. sex-linked inheritance
5. sex-influenced
6. I do not know

58. Cats that carry the C^{Blue} allele are white, they have blue eyes, and they are deaf. This is an example of:
1. pleiotropy
2. variable expressivity
3. lethal genes
4. epistasis
5. discontinuous variation
6. I do not know

59. The R/r, S/s, G/g and T/t genes are all on different autosomes. An individual who is heterozygous for all these genes makes gametes. What proportion of the gametes will have the genotype RsGT?
1. 0.5
2. 0.5^2
3. 0.5^4
4. 0.5^8
5. There is not enough information here to answer this question
6. I do not know

60. A young woman shows up in a doctor's office. She is old and has yet to enter puberty. She is short in stature, but otherwise normal. Which of the following genetic conditions could explain her condition?
1. 47AA, XXX
2. 45AA,XO
3. 47AA,XXY
4. 46AA,XO
5. Down syndrome
6. I do not know

61. Which of the following would always have a Barr body?
1. Turner syndrome
2. Klinefelter syndrome
3. XYY male syndrome
4. Down syndrome
5. Two of the above
6. I do not know

62. The gene-chromosome theory states that:
1. It takes place between homologous chromosomes and results in new gene combinations
2. Homologous chromosomes do not have alleles
3. Genes exist at definite loci in a linear sequence on chromosomes
4. Mendel's principles no longer apply to genetics
5. Alleles assort independently
6. I do not know

63. Which statement best describes the process of crossing over?
1. It takes place between homologous chromosomes and results in new gene combinations
2. It takes place between homologous chromosomes and results in an increased gene mutation
3. It takes place between nonhomologous chromosomes and results in an increased gene mutation
4. It takes place between nonhomologogous chromosomes and results in new gene combinations
5. None of the above
6. I do not know

64. Mutations can be transmitted to the next generation only if they are present in
1. brain cells
2. body cells
3. sex cells
4. muscle cells
5. somatoplasm
6. I do not know

65. Sometimes a section of a chromosome is lost during meiosis. The loss results in a change in genetic material known as
1. replication
2. polyploidy
3. deletion
4. translocation
5. two of the above
6. I do not know

66. Which statement best describes a chromosomal alteration?
1. It always produces a recessive genotype
2. It never affects the phenotype of an organism
3. It may affect the phenotype of an organism
4. It never has an effect on the phenotype
5. It always produces a dominant genotype
6. I do not know

67. Which of the genotypes below represents a sperm that can unite with a normal egg to produce a zygote that will develop into a normal human male embryo?
1. 22A + XY
2. 44A + XY
3. 22A + Y
4. 22A + X
5. 22A + 0
6. I do not know

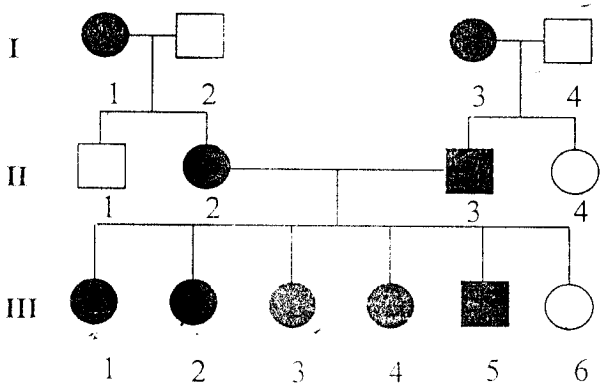
68. Given that black is dominant to brown, what ratio would you expect if the F1 hybrid is crossed with a homozygous recessive brown parent?
1. 3:1
2. 1:2:1
3. 9:3:3:1
4. 2:1
5. 1:1
6. I do not know

69. The cross in question 68 above is an example of
1. a monohybrid cross
2. a test cross
3. a dihybrid cross
4. selfing
5. Inbreeding
6. I do not know

70. A woman is heterozygous (Bb) for gene B and heterozygous (Aa) for an independent gene A. What portion of her eggs will be AB?
1. ½
2. ¾
3. ¼
4. 1/16
5. None of the above
6. I do not know

KMDG

1. The pedigree below is for a rare genetic condition. Which mode of inheritance is most likely being depicted in this pedigree?



1. autosomal dominant
2. autosomal recessive
3. X-linked dominant
4. X-linked recessive
5. Cannot tell from this pedigree
6. I do not know

2. You hypothesized that in the 4 O'clock plant, *Antirrhinum majus*, flower colour is controlled in an incomplete dominant manner. You created an F1 population by crossing red and white parents. You selfed the F1 plants and observed the following ratios: 20 red:42 pink:18 white. Based on the tabular probability value from chi-square the probability (P) is greater than 0.05 (P>0.05), we conclude that:

1. the null hypothesis cannot be accepted
2. the genes are not assorting independently
3. the genes must be linked
4. the null hypothesis is accepted
5. Mendelian genetics does not adequately explains the results
6. I do not know

3. A baby switching case involves an infant with blood type O. Which is true?

1. The woman with type A blood could not be the mother
2. The woman with type O blood could not be the mother
3. The woman with type B blood could not be the mother
4. The woman with type AB blood could not be the mother
5. Any of the four women could be the mother
6. I do not know

4. Which of the following traits is an example of a recessive sex-linked trait?

1. sickle cell anemia
2. widow's pick
3. defective tooth enamel
4. gangioside lipidosis
5. haemphilia
6. I do not know

75. Which of the following statements is **false** about sex chromosomes:
1. In drosophila genotype XXY are females
2. In Drosophila genotype X0 are females
3. In humans genotype XXY are super females
4. In humans genotype YY are non viable
5. two of the above
6. I do not know

76. Which of the following statements best describes the term penetrance?
1. the modifying effect of the environment and the genotype on a particular trait
2. the degree of effect produced by a penetrant genotype
3. the masking effect of one pair of alleles by another pair of alleles
4. the product of chromosomal changes
5. the number of individuals with a particular gene combination which shows a corresponding character
6. I do not know

77. If an autosomal trait which is not evident in the parents appears in the offspring, the parental genotypes are most likely to be…
1. homagametic
2. heterogametic
3. pure recessives
4. heterozygous
5. homozygous
6. I do not know

QUESTIONS 78 & 79
Sweet peas produce purple flowers when both the dominant genes C and P are present in the genotype but white flowers when either or both are absent.

78. Determine the ratio of the number of white flowered offspring and the number of purple flowered offspring from the cross: CcPp x ccPp
1. 3 purple :5 white
2. 3 purple: 1 white
3. 1 purple: 3 white
4. 5 purple:3 white
5. purple only
6. I do not know

79. Determine the genotypes of pairs of white flowered parents which when crossed would produce offspring about half of which would be purple-flowered and half white-flowered.
1. ccPp x Ccpp
2. ccpp x ccPp
3. Ccpp x CCpp
4. Ccpp x ccPP
5. CCpp x ccPP
6. I do not know

80. The phenomenon illustrated in questions 78 & 79 above is an example of:
1. co-dominance in action
2. incomplete dominance in action
3. epistasis in action
4. modifiers in action
5. suppresors in action
6. I do not know

81. A woman discovers that her son has Duchenne muscular dystrophy, a progressive muscle wasting caused by a recessive sex-linked allele. What is the chance that her next son will have the disease?
1. 0%
2. 25%
3. 50%
4. 75%
5. cannot be determined without knowing the father's genotype
6. I do not know

82. Coat color of mice is determined by interacting loci: bb gives albino, A_B_ gives agouti (an alternately light and dark combination), and aaB_ gives black. What are the phenotypic frequencies of the offspring from a cross between two heterozygous agouti mice (AaBb)?
1. 15 agouti : 1 albino
2. 9 agouti: 3 black : 4 albino
3. 9 agouti : 4 black : 3 albino
4. 12 agouti : 3 black : 1 albino
5. none of the above
6. I do not know

83. Hemophilia is a sex-linked trait, which appeared in the male descendants of Queen Victoria of Great Britain. The hemophilia allele is recessive. What proportion of her daughters' sons should be hemophiliac?
1. 0%
2. 12.5%
3. 25%
4. 50%
5. none of the above
6. I do not know

84. Which of the following conditions is a chromosome aberration?
1. Hemophilia
2. Penylketonuria.
3. Myloceutic leukemia
4. Hypertrichosis
5. none of the above
6. I do not know

85. A pair of chromosomes fails to separate during meiosis, producing a gamete with an extra chromosome. This process is known as
1. Recombination
2. Crosssing over
3. mutation
4. monosomy
5. Non-disjunction
6. I do not know

86. Two pea plants, each heterozygous for two gene loci when crossed produced 160 seeds. Approximately how many of the seeds are expected to exhibit the recessive trait for both loci
1. 40
2. 80
3. 10
4. 30
5. 90
6. I do not know

87. Which of the following statements is correct?
1. Erythroblastosis fetalis occurs in the offspring when the husband is Rh-, the wife is Rh+ and the offspring is Rh+
2. Individuals of blood group A and B have antibodies A and B in the serum
3. Blood group AB individuals are universal donors
4. Erythroblastosis fetalis only occurs if the mother is Rh-, father is Rh+ and fetas is Rh+
5. None of the above
6. I do not know

88. In rabbits, the coat colour is determined by the following series of multiple alleles: Agouti (c^+), Chinchilla (c^{ch}), Himalayan (c^h), Albino (c). What is the phenotypic ratio of the progeny of the cross $c^+c^h \times c^+c^{ch}$

	Agouti	Chinchilla	Himalayan	albino
1.	2	1	1	
2.	1	1	1	
3.	1	1	1	
4.	3	3	1	1
5.	3	1		
6.	I do not know			

89. Which parental pair could produce a colour blind female
1. homozygous normal-vision mother and colourblind father
2. colourblind mother and normal-vision father
3. heterozygous normal-vision mother and normal-vision father
4. heterozygous normal-vision mother and colourblind father
5. two of the above
6. I do not know

What is the result of normal chromosome replication?
1. lost or worn out chromosomes are replaced
2. Daughter cells have twice as many chromosomes as parent cells
3. Half the number of chromosomes are produced
4. Two identical sets of chromosomes are produced.
5. An organism increases in size.
6. I do not know

Traits controlled by genes on the Y-chromosome are referred to as
1. sex influenced
2. halandric
3. sex limited
4. incompletely dominant
5. incompletely recessive
6. I do not know

Which genetic concept was proposed by Mendel?
1. chromosome non-disjunction
2. multiple alleles
3. segregation
4. sex linkage
5. None of the above
6. I do not know

In a particular variety of maize, the seeds turn red when exposed to sunlight. In the absence of sunlight, the seeds remain yellow. Based on this information, it can be concluded that the colour of these seeds is due to
1. effects of sunlight on photosynthesis
2. law of incomplete dominance
3. principle of sex linkage
4. effect of polygenes
5. effect of environment on gene expression
6. I do not know

One reason for Mendel's success with genetic studies of the garden peas was that he
1. used only hybrid plants
2. used only pure breeding plants
3. studied large numbers of offspring
4. used peas with large chromosomes
5. discovered the sources of variation in peas
6. I do not know

In pea plants, the gene for tallness (T) is dominant over the gene for shortness (t). If 100% of the F1 generation offspring are heterozygous tall, what were the most probable genotypes of the parent plants?
1. TT x tt
2. Tt x tt
3. TT x Tt
4. Tt x Tt
5. tt x tt
6. I do not know

96. The chance of a YY chromosome combination occurring in humans as a result of normal meiotic division and normal gametic fusion is
1. 0%
2. 25%
3. 50%
4. 100%
5. 75%
6. I do not know

97. What percentage of male offspring produced by a father with normal vision and a colourblind mother are expected to be colorblind
1. 0%
2. 25%
3. 33%
4. 75%
5. 100%
6. I do not know

98. A human hereditary disorder that may result in mental retardation is
1. ganglioside lipidosis
2. sickle cell anemia
3. albinism
4. phenylketonuria
5. muscular dystrophy
6. I do not know

99. A cross of a red cow with a white bull produces all roan offspring. Roan is a patchwork of red and white colours. This type of inheritance is known as
1. co-dominance
2. incomplete dominance
3. sex linkage
4. mutation
5. multiple alleles
6. I do not know

100. Two parents, both heterozygous for type A produce a child. What are the chances that the child has blood type A?
1. 1 out of 4
2. 1 out of 2
3. 3 out of 4
4. 1 out of 1
5. none of the above
6. I do not know

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATIONS

June-July 2005

BS 221

FORM, FUNCTION AND DIVERSITY OF PLANTS

Theory Paper

TIME: *Three Hours*

ANSWER: A total of **Five** questions, attempting at least **Two** from **Section A,** and at least another **Two** from Section B.

Use a **separate** Answer Book for **each** of the two Sections.

SECTION A

1. What are the characteristics of Phaeophyta? Describe the structure and reproduction in *Ectocarpus* and briefly describe the economic importance of brown algae.

2. Describe the characteristics of Chaetophoraies. Describe the structural modifications shown by members of Cheetophorales. What aspects of sexual reproduction are striking in *Coleochaete*?

3. Discuss structure and reproduction in bacteria and explain their significance in agriculture and industry.

4. Write short notes on any **FOUR** of the following:
   i. Heterotrophy
   ii. Virus replication
   iii. Fungal thallus
   iv. Chloroplast types in Chlorophyta
   v. *Chara* thallus
   vi. Plurilocular gametangia

SECTION B

5. Describe growth form features that can be used in the identification of the acrocarpous and pleurocarpous mosses in the field.

6. Outline the diversity of sori patterns in homosporous true ferns ,and then comment on the significance of such sori arrangements in the identification of pteridophytes.

7. Explain the role of antheridiogen in the breeding system of the homosporous true ferns. Support your answer with elaborate illustrations.

8. Discuss the anatomical and morphological features associated with a xerophytic mode adaptation, with specific reference to the genus *Pinus*.

9. Give an illustrated account of the genus *Equisetum* in terms of some morphological and anatomical features of the stem and the principal reproductive organ.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – JUNE 2005

BS 319

BIOSTATISTICS

THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **QUESTION ONE** AND ANY OTHER **FOUR QUESTIONS**. ALL QUESTIONS CARRY EQUAL MARKS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY.

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1. (a) Investigations in which statistical methods are used in Biology are of two kinds; what are they?
   (b) How do you carry out these investigations?
   (c) What is a
   - (i) completely randomised design
   - (ii) completely randomised block design
   - (iii) Latin square design

2. In an experiment to investigate the effect of light quality on the rate of photosynthesis of ***Anacystis*** (blue-green alga) six replicate cultures of the alga were irradiated with each of the seven wavelength ranges of equal energy level. Net photosynthesis was estimated in terms of oxygen produced and was determined by the Wrinkler method. Results are given below.

	Replicates					
Light quality	***1***	***2***	***3***	***4***	***5***	***6***
Blue	5.5	5	6.2	5.5	5	6.6
Green	6.1	5.7	6.2	6.1	6.4	5.6
Yellow	15.7	16.6	16.8	17.1	17.4	16.6
Red	19.2	19	19	18.7	18.9	18.7
Far-red	4.7	3.9	4.35	4.4	3.53	3.75
Flourescent white	21	21.85	22	21.5	21	20.25
Incandescent white	21.1	22	21.5	22	20.2	21.3

Is the rate of photosynthesis the same at different wavelength ranges?

3. As part of an investigation on the effect of temperature variation on mice, the rate of water loss by a group of mice was determined for a series of temperatures by absorbing the water evolved by a group in a particular time. The following results were obtained.

Temperature (°C) X	15	20	25	30	35
Water evolved (mg) Y	2794	2924	3175	3340	3576

- (I) Is there a relationship between temperature and water evolved?
- (II) If a relationship exists, summarise it in the form of an equation?
- (III) Draw the regression line that summarises the relationship
- (IV) Is there significant regression of X on Y?

An ecological study was carried out to determine the relationship between the occurrence of a certain moss and the depth of raw humus layer on the soil surface. The moss where present was seen to either grow in pure stands excluding other species or in mixed stands with other species. Three classes of moss occurrence were determined. 0 = moss was absent; 1 = moss present in mixed stands and 2 = moss was present in pure stand. The depth of raw humus was scored as follows: 0 < 1 cm; 1 = 1-2cm and 2 > 2cm. The results are shown in the table below. Is there association between moss occurrence and the depth of raw humus?

	Moss		
Humus	***0***	***1***	***2***
	36	15	7
	65	37	44
	43	40	13

In a dihybrid cross in tomato plants, the following frequencies were obtained for the four phenotypes: Tall, cut-leaf tomatoes = 926; Tall, potato-leaf tomatoes = 288; Dwarf, cut-leaf tomatoes = 293 and Dwarf, potato-leaf tomatoes = 104. Do the results fit into the expected 9:3:3:1 ratio?

The relief in hours obtained from two antitussive drugs used by patients is given in the table below. Use an appropriate statistical test to determine whether the mean relief given differs significantly between the two drugs.

P	13	11	10	10	11	10	10	10	12	10	13	10	11	11	12	
Q	12	13	13	14	14	14	14	14	14	13	15	14	13	11	13	13

To assess the usefulness of 3 new varieties (B, C, D) of daffodil flowers for the cut-flower market, samples of each variety and of one standard variety (A) were grown at six different sites. The variable recorded for the variety was the number of days by which half of the heads of flowers at each site were ready for cutting. The data obtained is given in the table below. Are there differences between the varieties and the sites?

	Variety			
	A	***B***	***C***	***D***
	43	34	36	37
	46	30	35	43
	46	33	28	40
	42	25	27	33
	40	32	29	39
	37	22	28	35

The distance traveled (cm) by a constituent of a dye in 13 paper chromatographs using 2 different solutions are as follows:

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

e distance traveled in the two solutions different?

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
FIRST SEMESTER EXAMINATIONS, JUNE 2005

BS 321: ETHOLOGY AND EVOLUTION

PAPER ONE

TIME: THREE (3) HOURS

INSTRUCTIONS: Answer five (5) questions. Illustrate your answers where necessary.

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1. Charles Darwin proposed that evolution by natural selection was the basis for the differences that he saw in similar organisms as he travelled and collected specimens in South America and on the Galapagos Islands. Explain the theory of evolution by Natural Selection as presented by Darwin.

2. Each of the following relates to an aspect of evolution by natural selection. Explain **two(2)** of the following:
   a. Convergent Evolution and the similarities among species
   b. Natural Selection and the insecticide-resistant insects or antibiotic-resistant bacteria
   c. Speciation and Isolation

3. Provide brief definitions of the following terms as used in this course: (i)Teleology (ii) Konrad Lorenz (iii) Handicap Principle (iv) Genetic drift

4. Define the Hardy-Weinberg law, and discuss its limitations in the evolution of species

5. What is sexual selection? In your answer consider both intersexual selection and intrasexual selection and explain how the process can account for some forms of sexual dimorphism

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

7. Distinguish between Character Displacement and Habituation, and explain why each one is significant to the evolution of species

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END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS
JUNE/JULY, 2005

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. **Discuss characteristics that are unique to the following insects groups:**

   i. **Orthopteroid insect orders.**
   ii. **Paleopteroid insect orders.**
   iii. **Apterygota.**
   iv. **Endopterygota.**

2. **What does the presence of cuticular intima in an insect's organ system indicate about the origin of that part of the system? Describe insect organ systems bearing cuticular intima.**

3. **How are images formed in insect eyes and in what ways are insect eyes similar to human eyes?**

4. **Discuss kinds of modifications insect wings exhibit from the generalized condition and explain whether or not it is necessary for an insect to have two pairs of wings in order to be able to fly.**

UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

JUNE 2005

BS 411(INSECT ECOLOGY) PAPER 11

Time: Three (3) hours

INSTRUCTIONS: Answer **five** questions only

1. Compare and contrast " r and K" types of pests. How useful or not useful are these concepts in insect pest management?

2. What are insect life tables? Describe any one method you would use to construct an insect life table. Illustrate your answer with a hypothetical life table of a named insect.

3. Several theories have been advocated to account for insect population regulation. Discuss some of the recent theories to account for insect population regulation in an ecosystem.

4. Outline the ecolological mechanisms of insect outbreaks in natural and agroecosytems.

5. Distinguish between host/parasite and host/parasitoid relationships, giving specific examples in each case

6. Compare and contrast intra and interspecific competition. Illustrate your answer with diagrams and examples.

7. An insect ecologist wants to study insect abundance and distribution of a ground moving insect in an ecosystem. What problems would he/she face? What approach would he/she use in order to obtain meaningful results in such a study?

8. Write short and concise notes on **four** of the following:
   i) Contest
   ii) Degree- day method
   iii) Milne's (1957) theory
   iv) Ecological stability
   v) Deme

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS

(JUNE/JULY,2005)

INVERTEBRATE ZOOLOGY

(BS 375)

THEORY PAPER

IE:THREE HOURS

TRUCTIONS:ANSWER FIVE(5) QUESTIONS.ALL QUESTIONS CARRY

JAL MARKS.

There is a great diversity in the form and function of the feeding and digestive systems of invertebrates.Discuss this statement.

Write brief notes on the following:
a. Homeostasis versus Osmo-regulation.
b.Sense organs in Invertebrates.
c.Energy sources in Invertebrates
d.Disease epidemics:what are they?

What is an 'environment'?
Describe,with examples,how the various environmental factors have influenced the form and function of invertebrates.

Describe the mechanics behind the following locomotory arrangements seen in invertebrates:
a.Insect flight.
b.Burrowing by Annelids.
c.Walking by an Anthropod.
d.Locomotion by Amoeba using pseudopodia.

Review the 'attack' and 'defense' systems seen in invertebrates.

(a)What is excretion and how does it differ from respiration?
(b)Review with examples the excretory systems of aquatic and terrestial invertebrates.

(a)Define the terms 'monoecious' and 'dioecious'.
(b)What would be in evolutionary terms the comparative advantages and disadvantages of the phenomena represented in the two terms?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATIONS - JUNE/JULY,2005.

POPULATION ECOLOGY
BS 475

(THEORY PAPER II)

Time:Three (3) Hours

Instructions:Answer Question one and four other questions. Question 1 carries 32 marks,other questions carry equal marks.

Q1. An investor (who was also a trained Ecologist) wanted to set up a 4000 hactare game ranch.He was particularly interested in the conservation of the rhino population and wanted to know it's current population in the area.He then carried out a preliminary survey of rhinos.In his initial survey,he trapped,marked and released 126 rhinos.Three months later he had another survey.In his second survey,he trapped 96 rhinos,56 of which were marked rhinos.He then decided to enclose through a fence,30% of the ranch for the exclusive use of rhinos.

(i) what is the rhino population in the ranch and what is it's density in the enclosure?

(ii) If the natality rate is 10% and the mortality rate is 3.5%,what would be the approximate:

(a) Total rhino population in the third year of the ranch?

(b) Density of the rhino population in the third year of the ranch?

(iii) If in the same third year of the ranch,due to drought,the carrying capacity of the rhino paddock was reduced by 50%,how many rhinos would need to be culled off if the original carrying capacity of the ranch was 1.5 hactares/ rhino?

(iv) The investor also carried out another survey of the various species in the remaining 70% of the ranch.He found that there were 300 elands,150 duikers,170 giraffes and 200 elephants whose stocking densities were, respectively, 0.50, 0.25, 0.35 and 0.75 hactares/animal.Would the investor require additional land?If so, how much?

(v) Given your knowledge of animal population ecology,list the natural factors that can cause fluctuations in the rhino population,beyond the owner's management practices.

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATIONS - JUNE/JULY,2005.

POPULATION ECOLOGY
BS 475

(THEORY PAPER II)

Time:Three (3) Hours

Instructions:Answer Question one and four other questions. Question 1 carries 32 marks,other questions carry equal marks.

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(v) Given your knowledge of animal population ecology,list the natural factors that can cause fluctuations in the rhino population,beyond the owner's management practices.

Q2. From the population ecology point of view,what is :

(a) A disease epidemic?
(b)What factors cause population fluctuations in nature?

Q3. Define the following terms:

(a) Potential mortality.

(b) Population density.

(c) Niche.

(d) Population index.

(e) Life expectancy.

(f) Environment.

(g) Home range.

(h) Territoriality.

(i) Polyandry.

(j) Polybranchgyny.

Q4. Write brief notes on each of the following;

(i) Population parameters and their uses.

(ii) The food cycle and the pyramid of numbers.

(iii) Types of mating systems in natural populations.

(iv) Survivorship curves and their value in the human population.

(v) Correlates of r and k section.

Q5. (i) Develop a matrix showing the pro - and counter selected behaviours in natural populations.

(ii) Discuss with examples, the social behaviour and kin selection patterns seen in natural populations.

Q6. Construct a life table for the lessor corn borer in a maize field given the sampling data below.

Life Stage	No.of insects collected (No.Entering Life Stage)	Mortality Factors
Egg	1200	Parasite
Small larva	1080	Rainfall
Large larva	800	Predators
Pre - pupa	720	Parasites
Pupa	480	Rainfall
Adult	80	(sex ratio 1.5 : 1)(Male : Female)
Adult females	48	

. (a) Why is old age referred to as a genetic dust bin?

(b) Discuss the density dependent and density independent factors affecting animal population dynamics.

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

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGICAL SCIENCES

irst Semester Examinations June / July **2005**

S 491 Freshwater Biology **Theory Paper**

aximum Time Allowed **Three Hours**

structions

tempt all the **three** questions in **Section A** and **two** questions in **Section B**. At the end the examination, please hand in all the answer booklets and question papers.

CTION A

Define the following terms and concepts as applied in limnology and describe how each of term relates to productivity of aquatic ecosystems

i) Shore line development
ii) Allochthonous organic input
iii) Isothermy
iv) Cultural Eutrophication
v) Lake mean depth

A well-known limnologist, Hutchinson, is reported to have suggested that 'a perceptive limnologist can assess the relative productivity of a lake simply by measuring the oxygen concentration throughout the depth profile during summer stratification.'

Assess the validity of this statement and explain in detail the rational for such an observation.

Compare and contrast lontic and lentic aquatic ecosystems

ECTION B

4 Dissolved carbon dioxide in the hypolimnion is sometimes used to determine the productivity of a water body. Explain the rationale and the shortcomings for using this method for determining the relative productivity of aquatic ecosystems?

5 Discuss the circulation distribution and dynamics of phosphorous in aquatic ecosystems.

6 Discuss the dynamics of Silicon compounds in freshwater ecosystems and evaluate the role and contribution of silicates in the seasonal succession of the phytoplankton populations in monomictic lakes of temperate regions.

Provide a detailed description of factors responsible for the distribution and abundance of pelagic zooplankton in freshwater ecosystems

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS

JUNE, 2005

411I: INSECT BEHAVIOUR AND ECOLOGY

THEORY: PAPER 1

E: THREE (3) HOURS

RUCTIONS: ANSWER ANY FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

What is orientation in insect behaviour? In your answer, outline the types and mechanisms of orientation used by insects. Is this an innate or learned behaviour? Give reasons to support your answer.

Define the term stridulation in insect behaviour. What are the main mechanisms involved in the production of this type of behaviour?

The success of the Class INSECTA as terrestrial animals is in part due to their high degree of mobility. Discuss the validity of this statement.

What is bioluminescence in insect behaviour? Explain the mechanisms involved and the biological significance of this type of behaviour by a named insect species.

Distinguish between pheromones and allelochemicals. Explain, with specific examples, the importance of pheromones in insect behaviour. What role can pheromones play in insect pest management?

6 **Discuss the basis of periodicity of insect behaviour and explain how celestial navigation is used to communicate and coordinate behavioural activities such as location of food sources and location of nests by named insect species.**

7 **Distinguish between "token stimulus" and "phagostimulus" in insects, giving specific examples. Discuss the behavioural significance of these stimuli.**

8 **What is habituation in insect behaviour? Using specific examples, indicate how this behaviour differs from aggregation and courtship behaviours of insects.**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - SEMESTER I -2005

INTRODUCTORY CHEMISTRY I - C101

22nd June 2005

URATION: Three (3) hours

STRUCTIONS TO THE CANDIDATES

Indicate your **student ID number**(computer number) and **TG number** on **ALL** your answer booklets.

This examination paper consists of two **(2)** sections: **A** and **B**

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

Section **B** has five **(5)** long answer questions. (Total marks = **60**).
ANSWER QUESTION B1 and ANY THREE QUESTIONS, EACH IN A SEPARATE ANSWER BOOKLET. Questions carry equal marks.

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

DATA

Avogadro's constant, N_A	6.02×10^{23} mol^{-1}
Molar volume of gas at S.T.P	22.4 dm^3 mol^{-1}
Universal gas constant, R	8.314 J K^{-1} mol^{-1}
	0.0821 L atm K^{-1} mol^{-1}
	8.314 k Pa L K^{-1} mol^{-1}
Planck's constant, h	6.63×10^{-34} J s;
Velocity of light, c	3.00×10^8 ms^{-1},
Electron volt, 1 eV	1.602×10^{-19}J
Faraday, 1 F	96500 C mol^{-1}

Electronegativity values: B: 2.0; N: 3.0; F = 4.0

Standard Reduction Potentials	E°/ V
$MnO^-_{4(aq)} + 8H^+_{(aq)} + 5e^- \longrightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)}$	+1.52
$Cr_2O_7^{2-}{}_{(aq)} + 14H^+_{(aq)} + 6e^- \longrightarrow 2Cr^{3+}_{(aq)} + 7H_2O_{(l)}$	+1.33
$Cl_{2(g)} + 2e^- \longrightarrow 2Cl^-_{(aq)}$	+1.36
$Br_{2\,(l)} + 2e^- \longrightarrow 2Br^-_{(aq)}$	+1.07
$Fe^{3+}_{(aq)} + e^- \longrightarrow Fe^{2+}_{(aq)}$	- 0.77
$PbO_{2(s)} + 4H^+_{(aq)} + SO_4^{2-}{}_{(aq)} + 2e^- \longrightarrow PbSO_{4(s)} + 2H_2O_{(l)}$	+ 1.69
$PbSO_{4(s)} + 2e^- \longrightarrow Pb_{(s)} + SO_4^{2-}{}_{(aq)}$	- 0.36
$Mg^{2+}_{(aq)} + 2e^- \longrightarrow Mg_{(s)}$	- 2.37
$Fe^{2+}_{(aq)} + 2e^- \longrightarrow Fe_{(s)}$	- 0.44
$O_2(g) + 2H_2O_{(l)} + 4e^- \longrightarrow 4OH^-{}_{(aq)}$	+ 0.40
$Al_{(s)} + 3\,OH^-_{(aq)} \longrightarrow Al(OH)_{3(s)} + 3e^-$	-1.66

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01 Hydrogen																1 **H** 1.01 Hydrogen	2 **He** 4.00 Helium
3 **Li** 6.94 Lithium	4 **Be** 9.01 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium											13 **Al** 27.99 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.65 Copper	30 **Zn** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 71.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
37 **Rb** 85.47 Rubidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** 97.91 Technetium	44 **Ru** 101.07 Ruthenium	45 **Rh** 102.91 Rhodium	46 **Pd** 106.42 Palladium	47 **Ag** 107.87 Silver	48 **Cd** 112.41 Cadmium	49 **In** 114.82 Indium	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 tellurium	53 **I** 126.90 Iodine	54 **Xe** 131.29 Xenon
55 **Cs** 132.91 Caesium	56 **Ba** 137.33 Barium	57 – 71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.84 Tungsten	75 **Re** 186.21 Rhenium	76 **Os** 190.23 Osmium	77 **Ir** 192.22 Iridium	78 **Pt** 195.08 Platinum	79 **Au** 196.97 Gold	80 **Hg** 200.59 Mercury	81 **Tl** 204.38 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 208.98 Bismuth	84 **Po** 208.98 Polonium	85 **At** 209.99 Astatine	86 **Rn** 222.02 Radon
87 **Fr** (223.02) Francium	88 **Ra** 226.03 Radium	89 - 103	104 **Unq** 261.11	105 **Unp** 262.11	106 **unh** 263.12	107 **uns** 262.12	108 **Uno** 265.00	109 **Une** 265									

KEY

Atomic number
X
Atomic mass

Name of the element
X

57 **La** 138.91 Lanthanum	58 **Ce** 140.12 Cerium	59 **Pr** 140.91 Praseodymium	60 **Nd** 144.24 Neodymium	61 **Pm** 144.91 Promethium	62 **Sm** 150.36 Samarium	63 **Eu** 151.97 Europium	64 **Gd** 157.25 Gadolinium	65 **Tb** 158.93 Terbium	66 **Dy** 162.50 Dysprosium	67 **Ho** 164.93 Holmium	68 **Er** 167.26 Erbium	69 **Tm** 168.93 Thulium	70 **Yb** 173.04 Ytterbium	71 **Lu** 174.97 Lutetium
89 **Ac** 227.03 Actinium	90 **Th** 232.04 Thorium	91 **Pa** 231.04 Protactinium	92 **U** 238.03 Uranium	93 **Np** 237.05 Neptunium	94 **Pu** 244.0 Plutonium	95 **Am** 243.06 Americium	96 **Cm** 247.07 Curium	97 **Bk** 247.07 Berkelium	98 **Cf** 251.08 Californium	99 **Es** 252.08 Einstenium	100 **Fm** 257.10 Fermium	101 **Md** 260 Mendelevium	102 **No** 259.10 Nobelium	103 **Lr** 262.11 Lawrencium

Department of Chemistry-UNZA

SECTION A **ANSWER ALL QUESTIONS**

A1. (a) How would you mix 250 g of 95.5% (w/w) sulphuric acid with 750 g of water?
(b) Calculate the concentration of H_2SO_4 of the resulting mixture.
(Density of sulphuric acid = 1.841 g cm^{-3}) **[4 mks]**

A2. A C101 student performed an experiment in which she reacted 1 mole of H_2 (g) and 1 mole of O_2 (g). She obtained 17.6 g of H_2O (l).
(a) What was the percentage yield?
(b) Which reactant was limiting? **[4 mks]**

A3. Gas X has a density of 1.27g/dm^3 at 30°C and at a pressure of 747 mm Hg.
(a) What is the mass of 1.0 mole of gas X?
(b) Identify the gas X. **[4mks]**

A4. An atom of an element Q has a mass of 4.00×10^{-23} g.
(a) What is the relative atomic mass of Q on the Carbon - 12 ($^{12}_{6}C$ = 12.0000) scale?
(b) What mass of Q is required to combine with 0.350 mol of A atoms in a reaction requiring 2 moles of A for every 3 moles of Q? **[4 mks]**

A5. The energy of the C = O bond in organic compounds called aldehydes is 20.95 kJ mol^{-1}. Calculate the frequency, in wave number, σ, of a C = O bond. In what part of the electromagnetic spectrum would you expect to find this frequency? **[4 mks]**

A6. Consider the transition element cobalt in its ground state.
(a) What is the total number of energy levels that are populated by one or more electrons?
(b) What is the total number of orbitals populated by one or more electrons?
(c) What is the total number of sub-shells populated by one or more electrons? **[4 mks]**

A7. (a) The first ionization energies of oxygen and nitrogen are1314 kJ mol^{-1} and 1400 kJ mol^{-1} respectively. Explain this observation.
(b) Consider the following atoms and ions: O^{2-}, F^-, Na^+, Mg^{2+} and Ne. Which would you expect to be the smallest and which the largest? Explain your answer. **[4 mks]**

A8. Hydrochloric acid and aqueous sodium chloride both contain chloride ions but potassium manganate(VII) liberates chlorine only from hydrochloric acid. Why? **[4 mks]**

A9. A solution of unknown chromium salt was electrolyzed with a current of 10.0 A for 1.50 hours. If 9.71 g of chromium metal deposits at the cathode
(a) Calculate the number of moles of electron transferred in the electrolysis.
(b) How many moles of chromium were deposited?
(c) What is the oxidation state of the chromium in the salt? **[4 mks]**

A10. (a) Which one of the substances in the pair Fe^{2+}, Br^- is more easily oxididized. Explain your answer.
(b) Give the shorthand notation of the cell in which following reaction occurs:
$3Zn_{(s)} + ClO_3^-{}_{(aq)} + 6H^+_{(aq)} \longrightarrow 3Zn^{2+}_{(aq)} + Cl^-_{(aq)} + H_2O_{(l)}$ **[4 mks]**

SECTION B **ANSWER ANY THREE QUESTIONS**

B1. (a). In laboratory experiment 4 in the determination of the concentration of hydrogen peroxide, H_2O_2, potassium permanganate, $KMnO_4$, (in acidic medium) was used.

(i) Write down the reaction between potassium permanganate and hydrogen peroxide.

(ii) Calculate the mass of H_2O_2 present in the sample, if 20.0 cm^3 of 0.01 mol dm^{-3} $KMnO_4$ solution was used for titration.

(b) In the determination of the concentration of a hydrochloric acid solution, the standard solution of potassium hydrogen phthalate, $KHO_4C_8H_4$ was used.

(i) Knowing that potassium hydrogen phthalate has one titratable hydrogen write down the reaction between NaOH and $KHO_4C_8H_4$.

(ii) How would the experimental value for the molarity of the NaOH solution be affected if the conical flask used for titration is rinsed with $KHO_4C_8H_4$ solution before adding it in the flask?

(c) (i) Write the equation for the dissolution of CO_2 in water to produce carbonic acid.

(ii) Write the equations for the reaction of carbonic acid with hydroxide to produce hydrogen bicarbonate and carbonate. **[TOTAL =15 mks]**

B2. (a) A gas can effuse through a porous barrier in 3.2 minutes. Under identical conditions of temperature and pressure, it takes 5.0 minutes for an equal volume of argon to effuse through the same barrier. Calculate the molar mass of the unknown gas.

(b) Under certain specified conditions, 213 g of a gas were produced. This gas was collected in a 15.0 dm^3 container. In order to ensure that the gas pressure remained constant for easy transportation, the container of the gas was kept at 200°C. If this gas was chlorine, calculate the gas pressure:

(i) assuming the gas behaved ideally.

(ii) if it behaved non-ideally, given that, for chlorine, the value of a = 6.49 $atm.L^2.mol^{-1}$, b = 0.0562 $L.mol^{-1}$.

[TOTAL =15 mks]

B3. Consider the molecules BF_3 and NF_3. Discuss and compare these molecules by answering, among others, the following questions:

(a) Write the electronic configuration of the central atom in each molecule.

(b) How many valence electrons are there in the central atom of each molecule?

(c) If the central atom did not use hybrid bonds, what would be the expected bond angles in each molecule? Explain your answer.

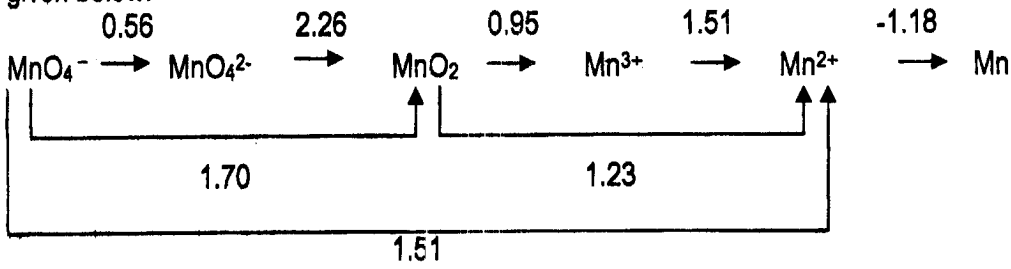
(d) What hybrid orbitals does the central atom use in each molecule?

(e) What is the molecular geometry of each molecule? Draw a sketch structure of each molecule and indicate the expected bond angles.

(f) On the sketch for each molecule indicate the direction of the dipole moment for each bond, if any? Indicate the direction of the resultant dipole moment, if any, for the whole molecule.

[TOTAL =15 mks]

(a) The reduction potentials, in volts, for the species containing manganese in acidic solutions are given below:



(i) What is the oxidation state of Mn in $MnO^-_{4(aq)}$ and MnO_4^{2-}?

(ii) What is disproportionation?

(iii) Which species is unstable towards disproportionation. Write the balanced equation and the cell potentials for the reaction.

(b) The concentration of potassium ion inside a nerve cell is about 25 times than the concentration outside the nerve cell. Calculate the potential difference that exits between inside and outside of the nerve cell. (Average body temperature = 37 °C)

[TOTAL = 15 mks]

(a) The lead acid battery is one form of storage cell. What substance is used for:

(i) the positive pole

(ii) the negative pole

(iii) the electrolyte

(b) Give the equation for the overall reaction during discharge.

(c) Calculate the cell potential.

(d) Pure sulphuric acid has a density of 1.98 g cm^{-3}. Explain what happens to the density of the electrolyte as the cell is discharged.

(e) Calculate the change in Gibbs free energy for the spontaneous reaction.

(f) Calculate the equilibrium constant for the reaction at 298 K.

(g) The lead acid battery can be recharged. Give the chemical equation for the reaction taking place during recharge.

[TOTAL = 15 mks]

THE END

The University of Zambia
School of Natural Sciences
Department of Chemistry
University Semester 1 Examinations
C245-Inorganic Chemistry 1, 2005

Time allowed: 3 hours
Instructions: Answer any four(4) questions
Each question carries equal marks

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1. a) Account for the wide variation in melting points of AlF_3 (1291°C) and $AlBr_3$ (97.5°C). Do you expect such a wide variation for the melting points of NaF and NaBr ?

b) The 2nd ionization energies of some period 4 elements in eV are given. Identify the orbital from which ionization occur and account for the trend in values.

Ca	Sc	Ti	V	Cr	Mn
11.87	12.8	13.58	14.15	16.5	15.64

c) Sketch the shapes of AsF_5 and its complex with F^-. Describe the nature of bonding using Valence Bond Theory

2. a) What is the concentration of cation vacancies when NaCl is doped with 10^{-3} mole percent of $SrCl_2$?
Hint: The number of cation vacancies created in the lattice of NaCl is equal to the number of divalent Sr^{2+} ions added.

b) Describe the bonding in $(CN)_2$. The C-C distance in cyanogen $(CN)_2$ is about 10% shorter than that in ethane. Support the above statement using necessary arguments.

c) Predict the stability of following molecules from its Molecular Orbital diagrams.
He_2, H_2^-, Be_2

3 a) Give a method to prepare 99.9% pure hydrogen. Why molecular hydrogen (H_2) is not very reactive. Give some important reactions involving molecular H_2

b) When potassium nitrate (KNO_3) is heated the nitrite (KNO_2) is formed, but the action of heat on Lithium and Sodium nitrate gives the oxide. Discuss the interpretation of the above observation.

c) ZnO is white in color but turns yellow on heating and becomes highly conducting. Account for this observation on the basis of non-stoichiometric defects.

4. (a) Name the following the following complexes

(i) $[Mn(en)_2]\,Cl_2$ (ii) $Na[Ag(HS)_2]$

(b) Discuss the crystal field split of d-orbital in a tetrahedral field

(c) Using the Valence Bond Theory explain the bonding in $[Fe(H_2O)_6]^{2+}$. Predict the hybridization and compute the spin only magnetic moment of the complex.
Using the Valence Bond Theory explain the bonding in $[Fe(H_2O)_6]^{2+}$. Predict the spin only magnetic moment of the complex.

5. (a) A wave function of an orbital is written as:

$$\Psi = \frac{1}{4\sqrt{2\pi}}\left(\frac{Z}{a_o}\right)^{\frac{3}{2}}\left(\frac{Zr}{a_o}\right)\exp\left(-\frac{Zr}{2a_o}\right)Sin\theta Cos\phi$$

(i) Re-write this orbital in atomic units.
(ii) Identify the radical wave function $\Psi(r)$ for this orbital
(iii) What is the numerical distance, (that is coefficient of $\frac{a_o}{Z}$), where we should expect the electron to mostly reside?
(iv) Sketch the radial distribution function for this orbital.

(b) What is the significance of a_o?

(c) What is the contribution of Heisenberg to the wave mechanics of the atom? What is the minimum uncertainty in position of an electron, given that the change in the uncertainty in velocity is $\approx 10^{-12}$m/s?

6. (a) Construct an energy level diagram for CO ligand?
What is the donor atom when CO bonds to a metal? Explain.

(b) By considering the type of bonding , draw

(i) π^*_{d-p} orbital (ii) σ_{d-p} orbital

(c) A particle describes the following wave.

$= ASin\left(\frac{n\pi x}{b}\right)$, where b is length of a 1-D box.

(i) What is the Schrödinger Equation for this wave?
(ii) Derive expression for its Energy level?

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
																1 **H** 1.01 Hydrogen	2 **He** 4.00 Helium
1 **H** 1.01 Hydrogen												5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
3 **Li** 6.94 Lithium	4 **Be** 9.01 Beryllium											13 **Al** 27.99 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium											31 **Ga** 69.72 Gallium	32 **Ge** 71.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.65 Copper	30 **Zn** 65.39 Zinc	49 **In** 114.82 Inkdum	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 tellurium	53 **I** 126.90 Iodine	54 **Xe** 131.2 Xenon
37 **Rb** 85.47 Rubidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** 97.91 Technetium	44 **Ru** 101.07 Ruthenium	45 **Rh** 102.91 Rhodium	46 **Pd** 106.42 Palladium	47 **Ag** 107.87 Silver	48 **Cd** 112.41 Cadmium	81 **Tl** 204.38 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 208.98 Bismuth	84 **Po** 208.98 Polonium	85 **At** 209.99 Astatine	86 **Rn** 222.0 Radon
55 **Cs** 132.91 Caesium	56 **Ba** 137.33 Barium	57 – 71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.84 Tungsten	75 **Re** 186.21 Rhenium	76 **Os** 190.23 Osmium	77 **Ir** 192.22 Iridium	78 **Pt** 195.08 Platinum	79 **Au** 196.97 Gold	80 **Hg** 200.59 Mercury						
87 **Fr** (223.02) Francium	88 **Ra** 226.03 Radium	89 - 103	104 **Unq** 261.11	105 **Unp** 262.11	106 **unh** 263.12	107 **uns** 262.12	108 **Uno** 265.00	109 **Une** 265									

57 **La** 138.91 Lanthanum	58 **Ce** 140.12 Cerium	59 **Pr** 140.91 Praseodymium	60 **Nd** 144.24 Neodymium	61 **Pm** 144.91 Promethium	62 **Sm** 150.36 Samarium	63 **Eu** 151.97 Europium	64 **Gd** 157.25 Gadolinium	65 **Tb** 158.93 Terbium	66 **Dy** 162.50 Dysprosium	67 **Ho** 164.93 Holmium	68 **Er** 167.26 Erbium	69 **Tm** 168.93 Thulium	70 **Yb** 173.04 Ytterbium	71 **Lu** 174.97 Lutetium
89 **Ac** (227.03) Actinium	90 **Th** 232.04 Thorium	91 **Pa** 231.04 Protactinium	92 **U** 238.03 Uranium	93 **Np** 237.05 Neptunium	94 **Pu** (244.06) Plutonium	95 **Am** (243.06) Americium	96 **Cm** (247.07) Curium	97 **Bk** (247.07) Berkelium	98 **Cf** (251.08) Californium	99 **Es** (252.08) Einsteinium	100 **Fm** 257.10 Fermium	101 **Md** 260 Mendelevium	102 **No** 259.10 Nobelium	103 **Lr** 262.11 Lawrencium

KEY

Atomic number
X
Atomic mass

Name of the element X

Some Universal Constants

Quantity	**Symbol**	**Value and Units**
Avogadro's number	N_A,L	$6.022 \times 10^{23}\ mol^{-1}$
Bohr radius	a_0	$5.292 \times 10^{-11}\ m$
Electron mass	m_e	$9.109 \times 10^{-31}\ kg$
Electron charge	-e	$1.602 \times 10^{-19}\ C$
Planks constant	h	$6.626 \times 10^{-34}\ Js$
Permittivity of free space	ε_0	$8.854 \times 10^{-12} C^2 N^{-1} m^{-2}$
Speed of light	c	$2.998 \times 10^{8}\ ms^{-1}$

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY SEMESTER I 2005 EXAMINATIONS
ORGANIC CHEMISTRY I – C251
JUNE 2005

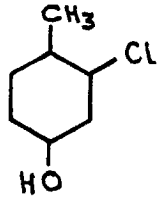
TIME ALLOWED: THREE (3) HOURS.

INSTRUCTIONS:

1. **This paper has five (5) questions. Answer any four (4) questions.**
2. **Each question carries thirty marks.**
3. **Marks for each part of the question are indicated.**

QUESTION ONE.

(a) Draw the most strained conformation and the least strained conformation of 3-chloro-4-methylcyclohexanol, the structure is shown below.



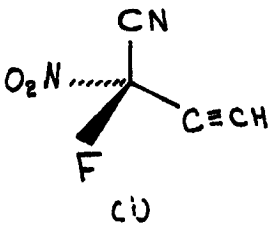
3-chloro-4-methylcyclohexanol

Using the table provided below, calculate how much energy is relieved by converting the most strained conformation to the least strained conformation?

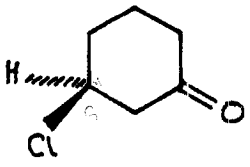
Type of interaction		Energy cost in kcal/mol
Cl – H	1,3-diaxial interaction	0.25
OH – H	1,3-diaxial interaction	0.50
CH_3 – H	1,3-diaxial interaction	0.90
Cl – OH	1,3-diaxial interaction	0.60
Cl – CH_3	gauche interaction	0.90

14 marks

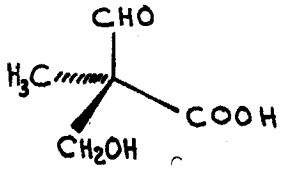
(b) Assign R, S configurations to the stereogenic centres in following molecules.



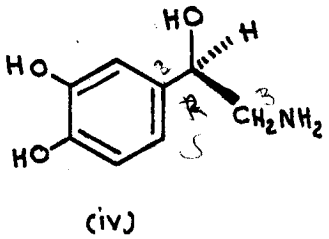
(i)



(ii)



(iii)

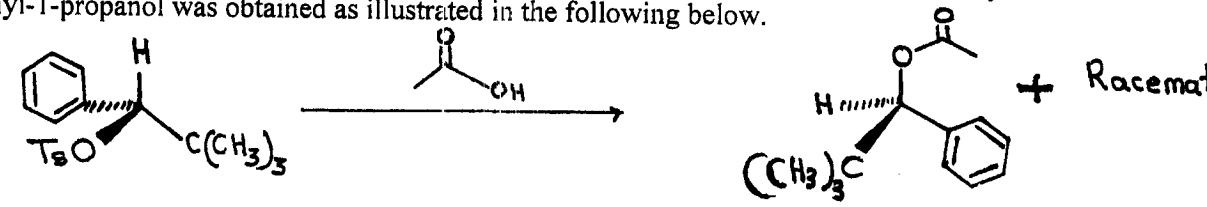


(iv)

04 marks each

QUESTION TWO.

(a) When the optically pure tosylate of (S)-2,2-dimethyl-1-phenyl-1-propanol was heated in acetic acid, a product consisting of 80% racemate and 20% of a pure acetate of (R)-2,2-dimethyl-1-phenyl-1-propanol was obtained as illustrated in the following below.



(i) Calculate the percentage retention of configuration.

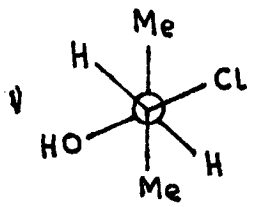
(ii) Calculate the percentage inversion of configuration.

10 marks

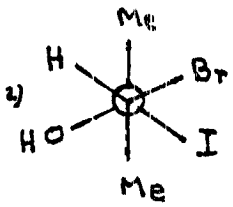
(b) (i) Using examples, provide a brief explanation to show the difference between molecular structural isomerism and molecular stereoisomerism.

04 marks

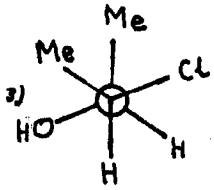
(ii) Identify pairs of enantiomers, diastereomers and identical molecular structures shown below.



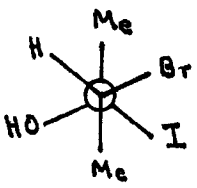
1)



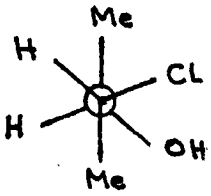
2)



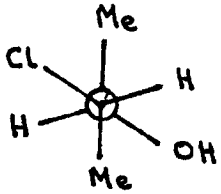
3)



4)



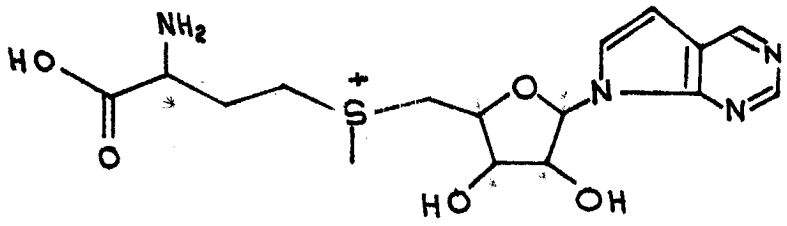
5)



6)

06 marks

(iii) If the number of stereogenic centres in a given molecule is known, the number of stereoisomers in that molecule can be predicted. On this basis, how many stereoisomers of the following molecule are possible in principle?



04marks

c) In a few sentences, explain what is meant by the following organic chemistry laboratory techniques:

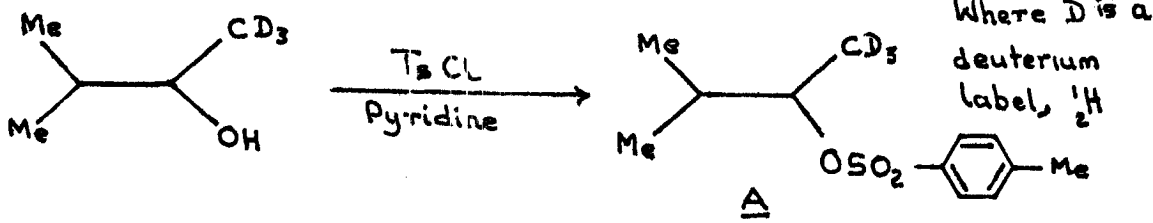
(i) Distillation

(ii) Extraction using a solvent

06 marks

QUESTION THREE.

a) (i) Give the mechanism of the following reaction:



04 marks

(iii) Hydrolysis of the product of the above reaction, **A**, in water at 22°C gave a complex mixture from which two compounds **B** and **C**, structures are shown below, were isolated. Propose a mechanistic explanation to account for the formation of compounds **B** and **C** in this hydrolysis.

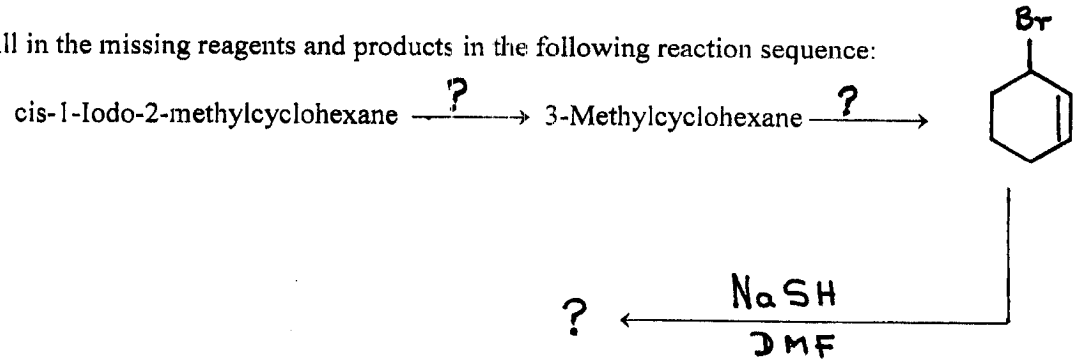
08 marks

structures

) (i) Show the stereochemical for cis-1-iodo-2-methylcyclohexane and 3-methylcyclohexene.

04 marks

(ii) Fill in the missing reagents and products in the following reaction sequence:

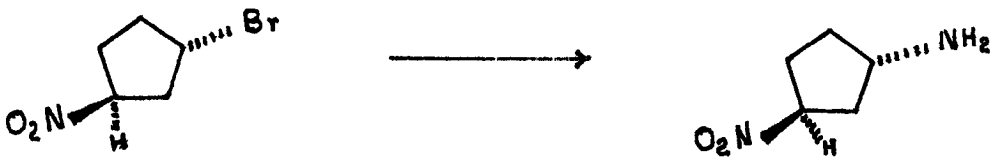


05 marks

(iii) Give the mechanism for the formation of 3-methylcyclohexene in **step1** of the above reaction sequence. Reaction rate of **step1** = K [Substrate][Base].

04marks

) Show clearly how the following transformation can be achieved in good yield. Two or more steps may be required. Take note of chiral centres that may be present in compounds **D** and **E**.

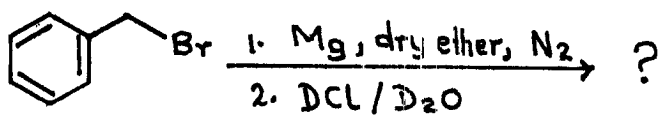


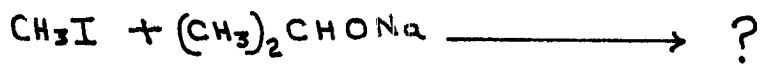
Compound **D** Compound **E**

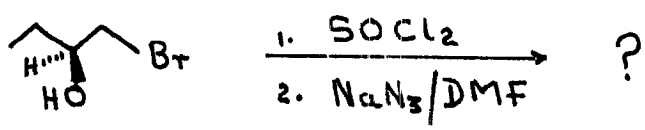
05 marks

UESTION FOUR.

Show the structures, including stereochemistry, where pertinent, of the major organic product(s) of the following reactions:

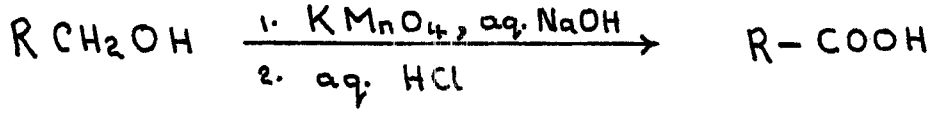
(i) 

(ii) 

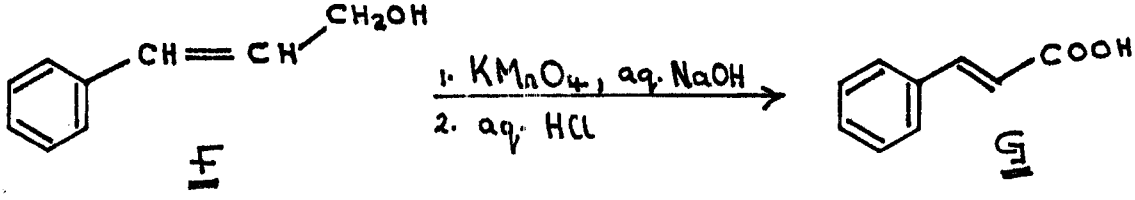
(iii) 

12 marks

b) Primary alcohols, RCH_2OH, are oxidized to carboxylic acids, RCOOH, by treatment with alkaline potassium permanganate as follows.



However, attempted synthesis of cinnamic acid, G, by oxidation of an unsaturated alcohol, F, with alkaline permanganate failed because in addition to oxidizing primary alcohols, alkaline potassium permanganate also oxidizes alkene double bonds.



(i) Suggest what could be done to prepare cinnamic acid from compound F by using alkaline potassium permanganate oxidation as a key reaction.

04 marks

(ii) Propose a synthesis for cinnamic acid from compound F.

10 marks

) Draw the Fischer projection formulas for the following molecules:

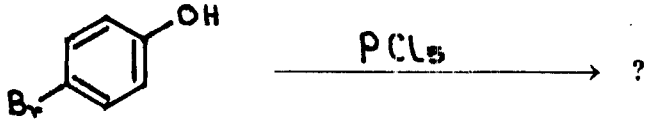
(i) (R)-3-Methylpentan-1-ol

(ii) (2S,3R)-2,3-Dichloropentane

04marks

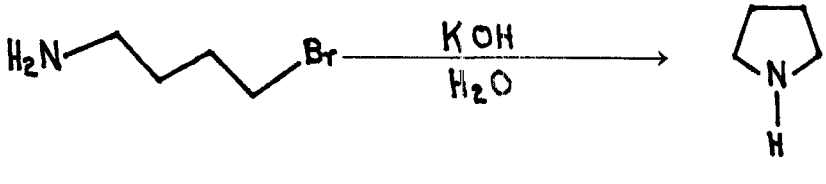
UESTION FIVE.

) Predict the major organic product and give the mechanism of the following reaction



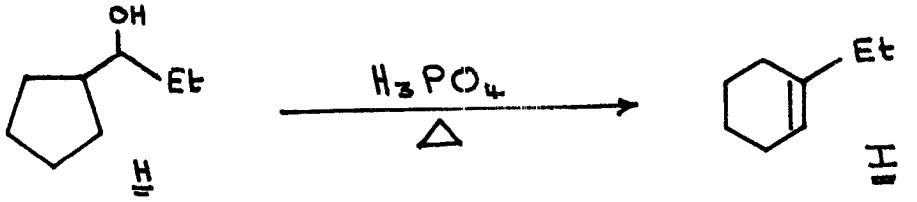
8 marks

) Give a mechanism for the following reaction.



8 marks

Acid catalysed dehydration of an alcohol **H**, by phosphoric acid (H_3PO_4), unexpectedly gave a compound **I**.



The reaction follows E1 mechanism. Recall that E1 reactions proceed through carbocation intermediates, which undergo a variety of rearrangements. Give the mechanism of this reaction.

14 marks

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

5 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

BIOCHEMISTRY- C311

ME: **THREE HOURS (3:00 HOURS)**

STRUCTIONS TO CANDIDATES:

RITE YOUR COMPUTER NUMBER ON **ALL** ANSWER BOOKLETS

E EXAMINATION CONSISTS OF TWO (2) SECTIONS **A** AND **B.**

CTION **A: ANSWER ALL QUESTIONS. (40 MARKS)**

CTION **B. ANSWER ANY THREE QUESTIONS (60 MARKS)**

SECTION A (EACH QUESTION CARRIES 10 MARKS)

The following statements are either true or false or incomplete. If the answer is False, wha should the statement be in order to be correct?

a) True or False. Hemoglobin and myoglobin are products of gene duplication

b) The enzyme hexokinase catalyses the conversion of ..... into .....

c) True or False. Fluorocitrate inhibits citrate synthase.

d) The main function of the pentose phosphate pathway is to provide .....and .....

e) True or False. An aldose is always a donor of two or three carbon units in the PPP.

---

a) How does pyruvate enter the mitochondria? Does it require energy? Explain.

b) How are hydrogen ions moved from the matrix into the inter membrane space and vice versa?

OR

a) How does oxygen affinity change in the presence of 2,3- bisphosphoglycerate (BPG in the fetus and adult hemoglobin?

b) Compare and contrast between hemoglobin and myoglobin.

---

a) Discuss the control of glycolysis with reference to PFK. Which other enzymes are likely to be regulated in glycolysis and why?

b) Define free energy and state the number of calories produced from the oxidation of mole of glucose

OR

a) What is the fate of pyruvate in the generation of metabolic energy under aerobic and anaerobic conditions? Explain by using biochemical reactions and give names of enzymes involved.

b) Write the chemical reactions for the conversion of glucose 1-phosphate into Uridine diphosphate glucose

---

4. **Prove kinetically that a competitive inhibitor increases K_m while V_{max} remains constant making important assumptions.**

SECTION B (EACH QUESTION CARRIES 20 MARKS)

a) Discuss the Ramachandran plot in detail (250 - 300 words)

b) A peptide isolated from brain tissue of a laboratory mouse was found with opioid action and bound to receptors that bind morphine and naloxone, opiate drugs. Complete hydrolysis of the peptide by 6N HCl at 110°C followed by amino acid analysis indicated the presence of G, L, F and Y in a 2:1:1:1 molar ratio. Treatment of the peptide with 1-fluoro-2,4-ditrobenzene followed by complete hydrolysis and chromatography indicated the presence of the 2,4-dinitrobenzene derivative of Y. No free Y could be found. Complete digestion of the peptide with pepsin followed by chromatography gave a dipeptide containing F and L plus a tripeptide containing Y and G in a 1:2 ratio.
Deduce the sequence of this peptide.

---

a) Distinguish between the terms glycogenesis and glycogenolysis.

b) Outline the biochemical reactions taking place in glycogenolysis and illustrate your answer by using a well labeled diagram and state the names of enzymes involved.

c) Write short notes on the structure and function of ANY two of the following:

i) Glycogen ii) Amylopectin iii) Cellulose iv) ATP

'ou carried out a quantitative assay of glucose content in fruit. The following data was ollected.

DATA COLLECTED

) Standardization of sodium thiosulphate solution.
Molarity of potassium iodate= 0.0167 mol/dm^3 (25cm^3 was used)
Average volume of thiosulphate used= 25.35cm^3

) Standardization of Iodine solution
Average volume of thiosulpahte used= 5.0 cm^3
Volume of iodine used= 10.0cm^3

) glucose content before hydrolysis
Average volume of thiosulpahte used= 0.07 cm^3
Volume of iodine used= 3.0cm^3

) glucose content after hydrolysis
Average volume of thiosulpahte used= 0.04 cm^3
Volume of iodine used= 2.0cm^3

Necessary information: reacting ratios of IO_3^-: $S_2O_3^{2-}$ (1:6) and I_2:$S_2O_3^{2-}$ (1:2)

stimate the glucose content in 5cm^3 (equivalent to 2.5 g of fruit) and 5cm^3 (equivalent to .25 g of fruit) as

a) g glucose

b) g/100 g before and after hydrolysis.

Draw a schematic diagram showing the sites at which a proton gradient is generated in the electron transport chain.

Give reasons why the oxidation of NADH yields three (3) ATP molecules, whereas the oxidation of $FADH_2$ yields only two (2) ATP molecules.

The aerobic oxidation of glucose requires the participation of the electron transport chain machinery. Outline the transfer of electrons from NADH to oxygen (O_2), giving the names of the enzyme/protein complexes involved.

---

nolase has a K_m of 4.5 x 10^{-5}M for 2-phosphoglycerate, its natural substrate. If the V_{max} is) µmoles/L/min, what velocity would be observed in the presence of 1 x 10^{-4}M substrate nd 5 x10^{-4}M of

a fluoride ion which is a competitive inhibitor K_i = 3 x 10^{-4}M)

What will be the degree of inhibition?

END OF EXAMININATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY
2005 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C 341: INORGANIC CHEMISTRY - II
TIME: 3 HOURS
ANSWER ANY 5 FROM THE 6 QUESTIONS IN THIS PAPER

---

rbon monoxide, CO is a notoriously poor σ donor ligand yet it is found on the
ronger side of spectrochemical series. Why?

r CS_2 all vibrations that are Raman active are Infra red inactive and (vice versa), whereas for
ous oxide (N_2O) the vibrations are simultaneously Raman active and Infra red active. What can
conclude about the structures of N_2O and CS_2?

mment on the intensity of bands in $[Mn(H_2O)_6]^{2+}$ and $[Co(NH_3)_5Cl]^{2+}$.

aw all possible isomers of the following complex compounds.
$[IrCl_3(PMe_3)_3]$, (2) square planar $[Pt(H_2O)_2Br_2]$.

redict whether there is Jahn Teller distortion:
) d^5 high spin (oh), (2) d^7 low spin (oh).
) d^4 high spin (td), (4) d^6 low spin (td).

ne lattice enthalpies of the following oxides with octahedral coordination are given. Account for
e trend:

CaO	TiO	VO	MnO
3460	3878	3913	3810 kJ/mol

nd the term symbol for an electron in less than half filled orbital for which L=2 and S = 1.

the compound PF_5 there are two F environments, F_{ax} and F_{eq}. Draw the splitting patterns of NMR
gnals obtained for F_{eq}.

count for the observation: (1) $[V(OH)_4]^+$ is colourless, (2) $[V(OH)_2]^{2+}$ is blue.

gen forms hydrides the main of which is ammonia, NH_3.

Describe the Haber's process for the production of ammonia on a large scale.

How does ammonia reacts with: iodine, copper (II) oxide and sodium metal?

Write down reactions of production of hydrogen from natural gas.

lustry the nitric acid is produced by Oswald process.

Describe in detail giving all the reactions, involved in the manufacture of nitric acid.

Describe the action of nitric acid on metals, sulphur dioxide and ferrous sulphate in presence of sulphuric acid.

What is an ammonium amalgam and how is it prepared?

State the basic oxides of the group VI of the periodic table of the elements.

Describe the laboratory method for the preparation of hydrogen peroxide.

Write down the reactions between acidic oxides and alkalis and acidic oxides and water.

==========

End of examination

PERIODIC TABLE OF THE ELEMENTS

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

KEY

Atomic number
X
Atomic mass

Name of the element X

1 H 1.01 Hydrogen																1 H 1.01 Hydrogen	
3 Li 6.94 Lithium	4 Be 9.01 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	
11 Na 23.00 Sodium	12 Mg 24.31 magnesium											13 Al 27.99 Aluminium	14 Si 28.09 Silicon	15 P 30.99 Phosphorus	16 S 32.07 Sulphur	17 Cl 35.45 Chlorine	
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.88 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.65 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 71.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 selenium	35 Br 79.90 Bromine	
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc 97.91 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Inidum	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 tellurium	53 I 126.90 Iodine	
55 Cs 132.91 Caesium	56 Ba 137.33 Barium	57 – 71	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantalum	74 W 183.84 Tungsten	75 Re 186.21 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.97 Gold	80 Hg 200.59 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po 208.98 Polonium	85 At 209.99 Astatine	
87 Fr (223.02) Francium	88 Ra 226.03 Radium	89 - 103	104 Unq 261.11	105 Unp 262.11	106 unh 263.12	107 uns 262.12	108 Uno 265.00	109 Une 265									

57 La 138.91 Lanthanum	58 Ce 140.12 Cerium	59 Pr 140.91	60 Nd 144.24 Neodymium	61 Pm 144.91 Promethium	62 Sm 150.36 Samarium	63 Eu 151.97 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.93 Terbium	66 Dy 162.50	67 Ho 164.93 Holmium	68 Er 167.26 Erbium	69 Tm 168.93 Thulium	70 Yb 173.04 Ytterbium	71 Lu 174.97 Lutetium
89 Ac 227.03 Actinium	90 Th 232.04 Thorium	91 Pa 231.04 Protactinium	92 U 238.03 Uranium	93 Np 237.05 Neptunium	94 Pu 244.0 Plutonium	95 Am 243.06 Americium	96 Cm 247.07 Curium	97 Bk 247.07 Berkelium	98 Cf 251.08 Californium	99 Es 252.08 Einstenium	100 Fm 257.10 Fermium	101 Md 260	102 No 259.10 Nobelium	103 Lr 262.11

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
UNIVERSITY SEMESTER I 2005 EXAMINATIONS
ORGANIC CHEMISTRY III – C351
JUNE , 2005

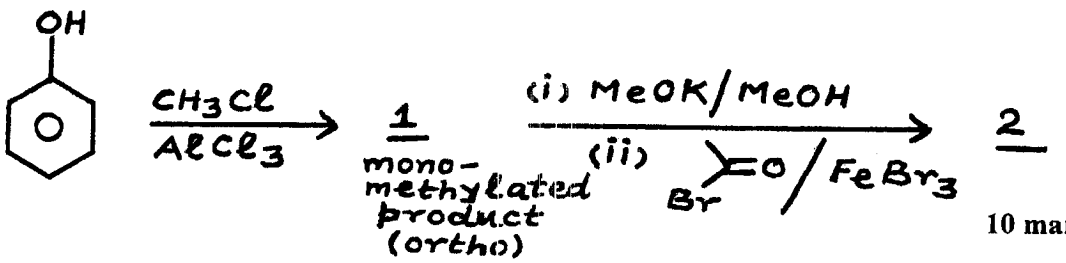
ME ALLOWED: THREE (3) HOURS.

STRUCTIONS:

This paper has five (5) questions. Answer any four (4) questions.
Each question carries thirty marks.
Marks for each part of the question are indicated.

ESTION ONE.

Predict the major organic products and give the mechanisms for the following set of reactions:



10 marks

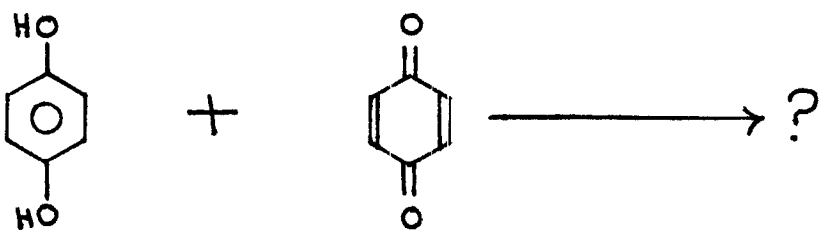
If product 2 were treated with a hot aqueous solution of potassium permanganate what product would you expect to obtain? Give the IUPAC or the common name of this product.

04 marks

Phenols are reactive towards acylation under the Williamson ether synthesis procedure. Basing on this information show the major and most stable product of the following reaction and write the mechanism for its formation.

12 marks

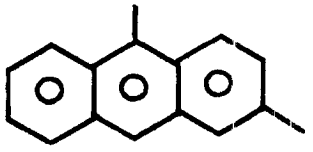
Write the product of the redox reaction shown below.



04 marks

UESTION TWO.

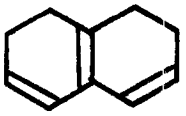
) Starting with benzene and using any other necessary and readily available laboratory reagents suggest a synthesis of 2,9-dimethylanthracene; the structure is shown below.



2,9-Dimethylanthracene

12 marks

) Partial hydrogenation of a triene **A**, structure is shown below, gave two compounds, **B** and **C**, both of molecular formula $C_{10}H_{14}$. Compound **B** showed a UV λ_{max}^{hexane} at 235 nm and compound **C** showed a UV λ_{max}^{hexane} at 275 nm. Assign the structures for compounds **B** and **C**, which are consistent with this UV data.



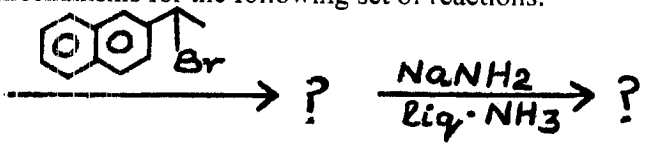
06 marks

(i) The chlorine atom is more electronegative than the bromine atom. Using this information, show the Grignard reagent that would be produced if 1-bromo-3-chlorobenzene was refluxed with magnesium powder in ether.

02 marks

(ii) Predict the products and write the mechanisms for the following set of reactions.

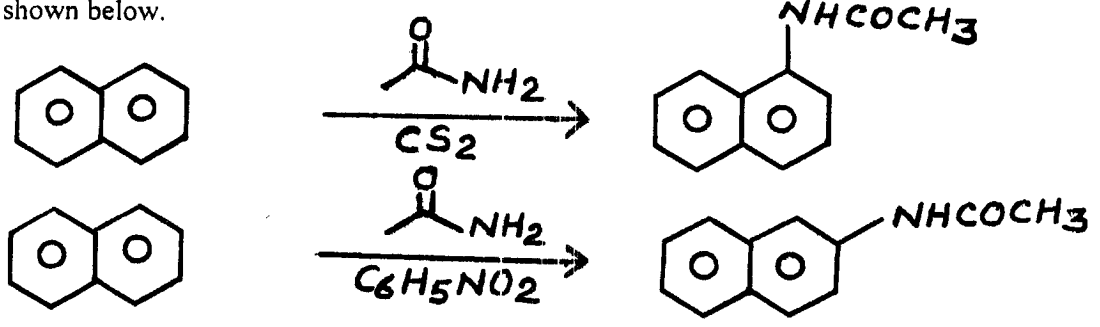
A Grignard reagent produced
In **question 2(c)**(i) above



10 marks

UESTION THREE.

When naphthalene is reacted with acetamide in the carbon disulfide solution, it predominantly yields 1-acetamidonaphthalene. When the same reaction is carried out in nitrobenzene, the predominant product is 2-acetamidonaphthalene. The two reactions are shown below.



Give brief reasons to account for the difference in the two products formed.

06 marks

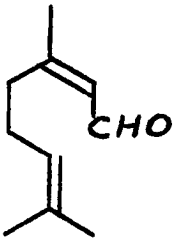
Deduce the structure, including pertinent stereochemistry, of a carboxylic acid **D**, $C_4H_6O_2$, from the following ^{1}**Hnmr** data. Justify your answer.

Compound D: ^{1}**Hnmr** ($CDCl_3$), δ **(ppm):**

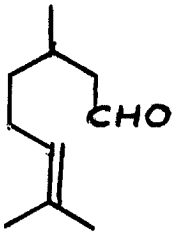
1.90 (dd, 3H, J=7.5 Hz, 1.5 Hz); 5.83 (qd, 1H, J=16 Hz, 1.5 Hz);
7.10 (qd, 1H, J=16 Hz, 7.5 Hz) **and** 12.18 (s, 1H, broad), this signal disappeared after deuteriation.

12 marks

Ants emit minute quantities of chemicals called *alarm pheromones* to warn ants of the same species of the presence of an enemy. Two pheromones, citral and citronellal, structures are shown below, have been isolated from a certain species of ants. Which of these two pheromones is represented by the attached **ir**-spectrum? State your reasoning.



Citral

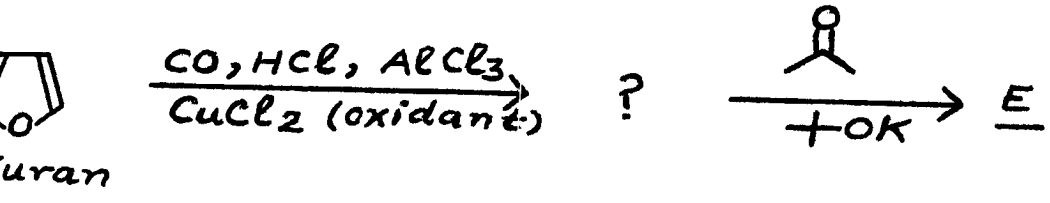


Citronellal

12 marks

ESTION FOUR.

ubstituted furan **E**, was synthesised from an aromatic compound furan as follows and sequently analysed by ms, ir, ^{1}Hnmr and ^{13}Cnmr spectroscopy. The spectral data is given below:



uran

n/z): 136 (M^+ ion peak); 121; 94; 93; plus other peaks.

Cl_4): Selected bands, cm^{-1}: 1695 (S), 1675 (S), 1260 (S); bands in aromatic region

r (CCl_4): δ **(ppm):** 7.48 (dd, 1H, J=1.7 Hz, 1Hz); 7.2 (d, 1H, J=16 Hz); 6.7 (d, 1H, J=16 Hz); 6.62 (dd, 1H, J=3.5 Hz, 1 Hz); 6.46 (dd, 1H, J+3.5 Hz, 1.7 Hz); **and** 2.29 (s, 3H)

r (CCl_4): δ **(ppm):** 198 (s); 145 (s); 142 (d); 128 (d); 123 (d); 112 (d); 110 (d) **and** 27.8 (q)

Deduce the structure for compound **E**. (Position of substitution is important in this question).

12 marks

Provide an explanation for the observed ms peaks for compound **E**.

06 marks

Suggest mechanisms for both reactions in the above synthesis.

12 marks

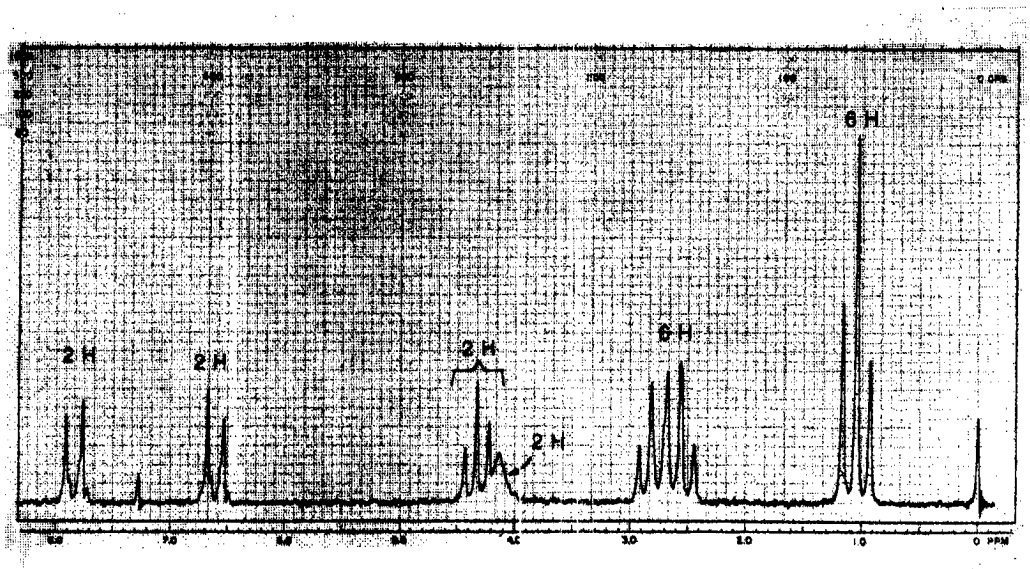
ESTION FIVE.

Deduce the structure of compound **F**, from the attached spectra. Show your reasoning clearly and assign the **nmr** data to particular hydrogens and carbons of your proposed structure.

14 marks

The ^{1}**Hnmr** spectrum for a local anaesthetic novocaine, $C_{13}H_{20}N_2O_2$, is shown below. The quintet at about δ2.7 ppm (6H) actually arises from the overlap of two nmr signals: an upfield quartet (4H) and a downfield triplet (2H). An impurity appears at δ 7.25 ppm. The **ir** spectrum of novocaine showed two absorption bands near 3350 cm^{-1} and other principal absorption bands at about 3000 cm^{-1}, 1700 cm^{-1}, 1600 cm^{-1}, 1450 cm^{-1} and 1280 cm^{-1}. What is the structure of novocaine? Give a brief justification for your answer.

16 marks

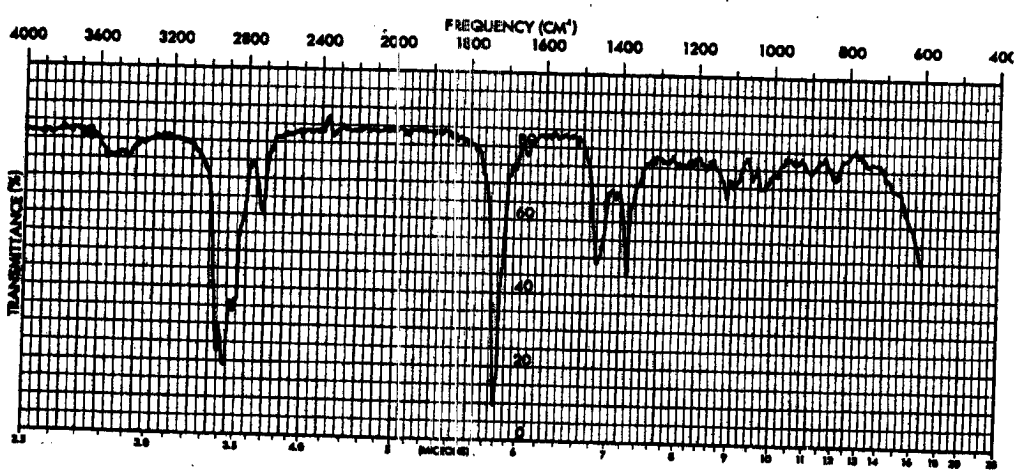


NMR SPECTRUM

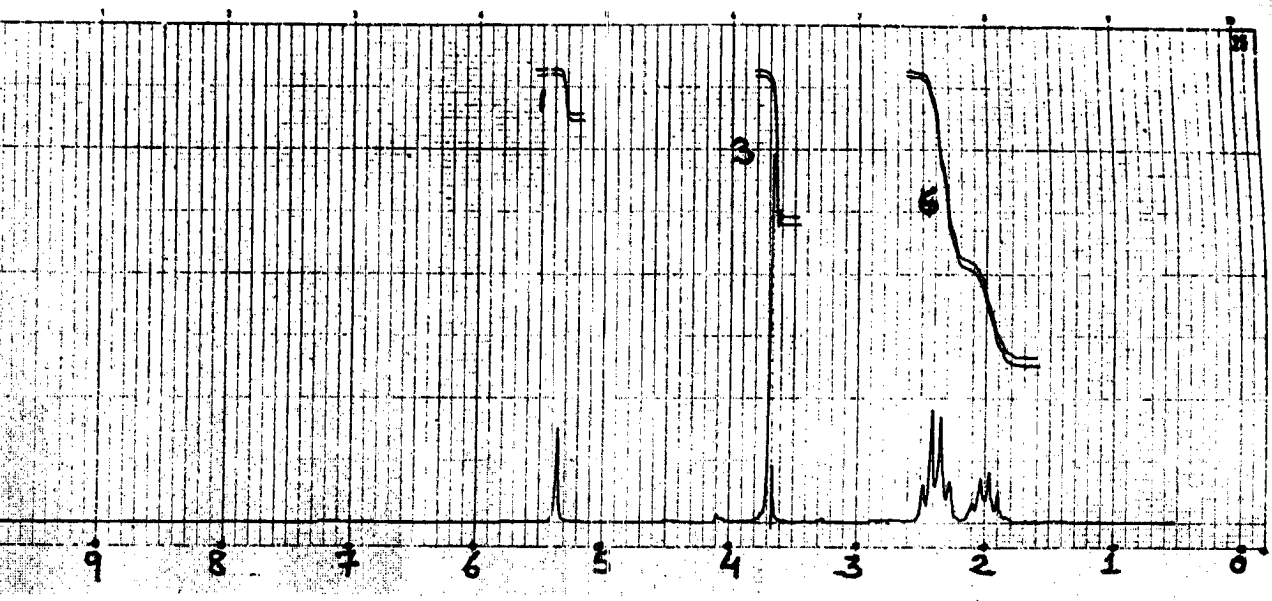
END OF EXAM

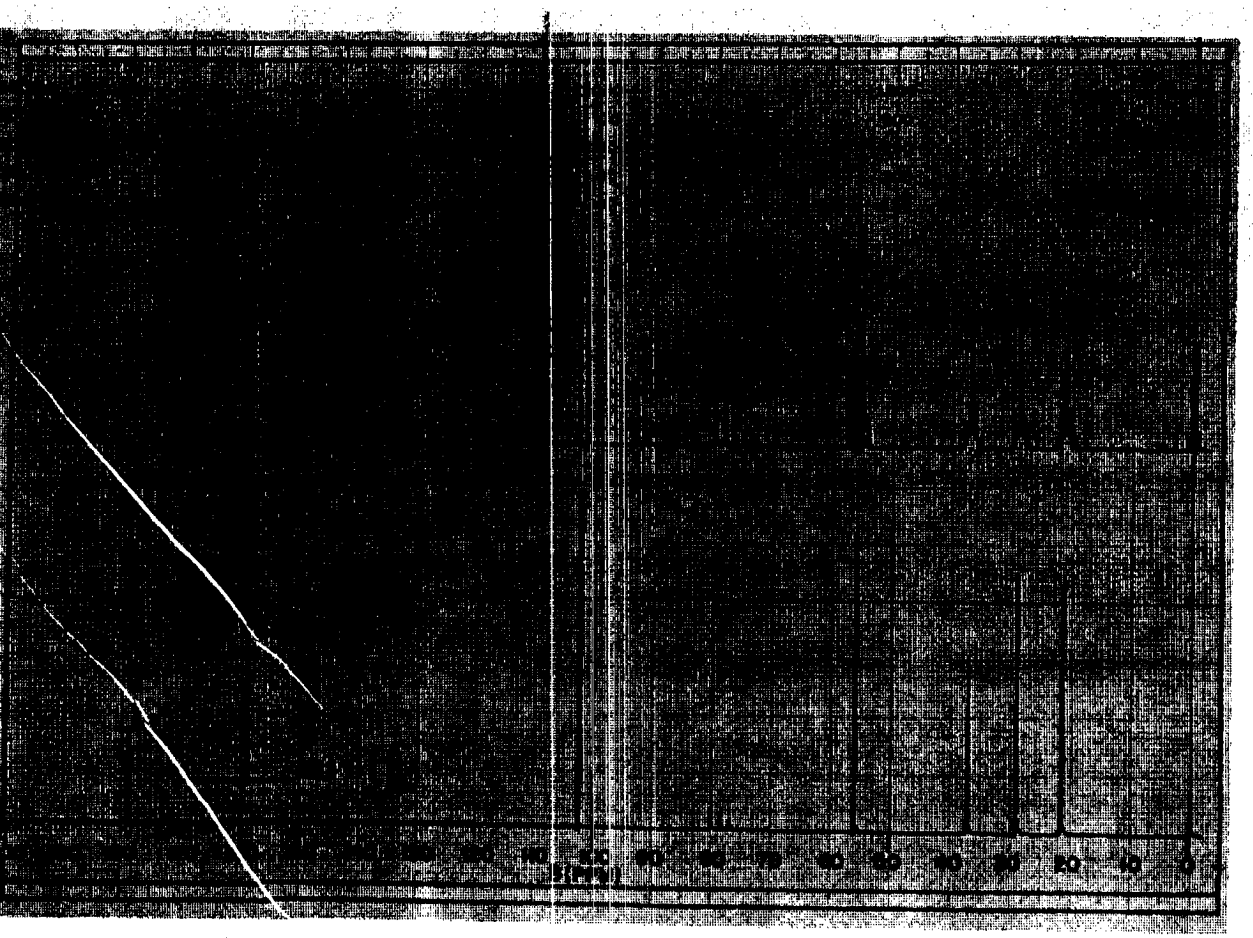
IR SPECTRUM FOR QUESTION 3 (c)

3 (c)



Compound F





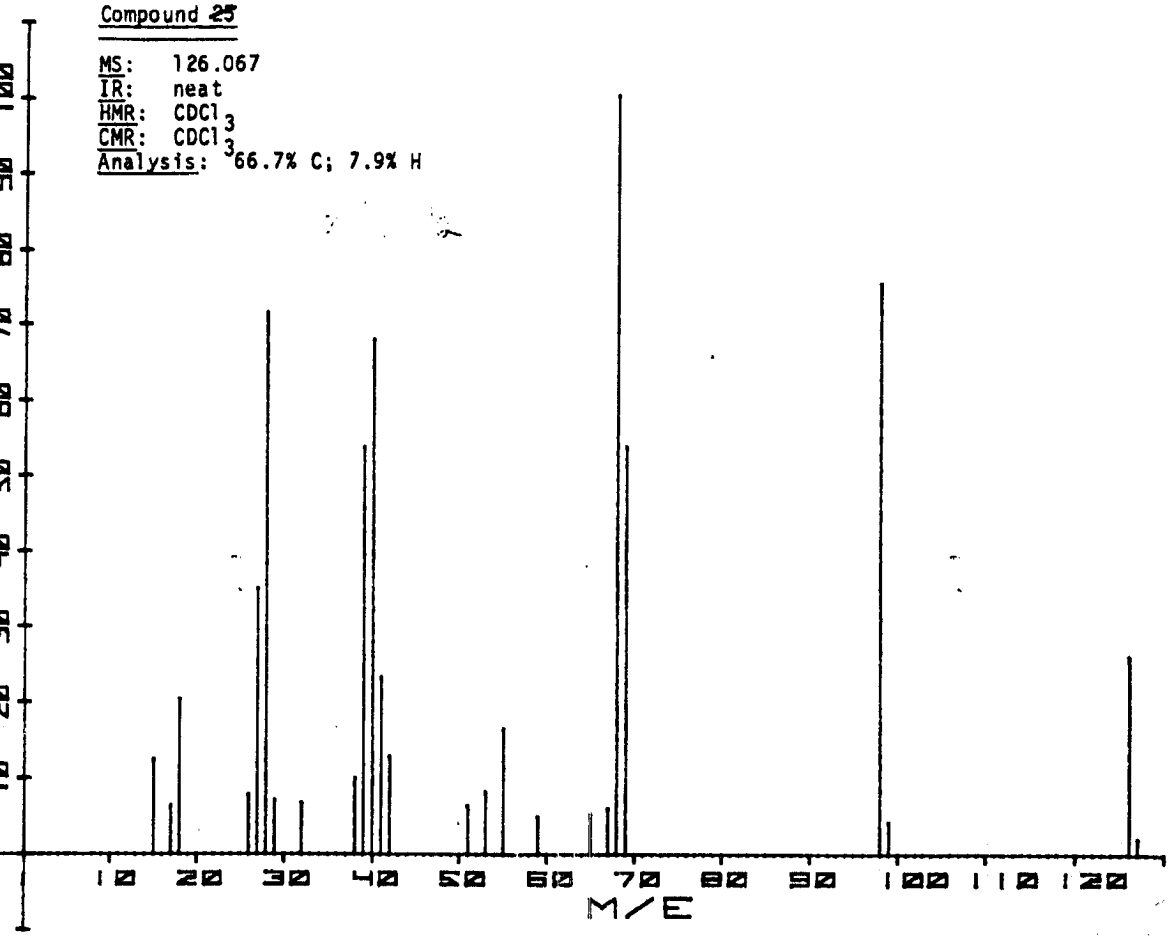
Q 5(a)

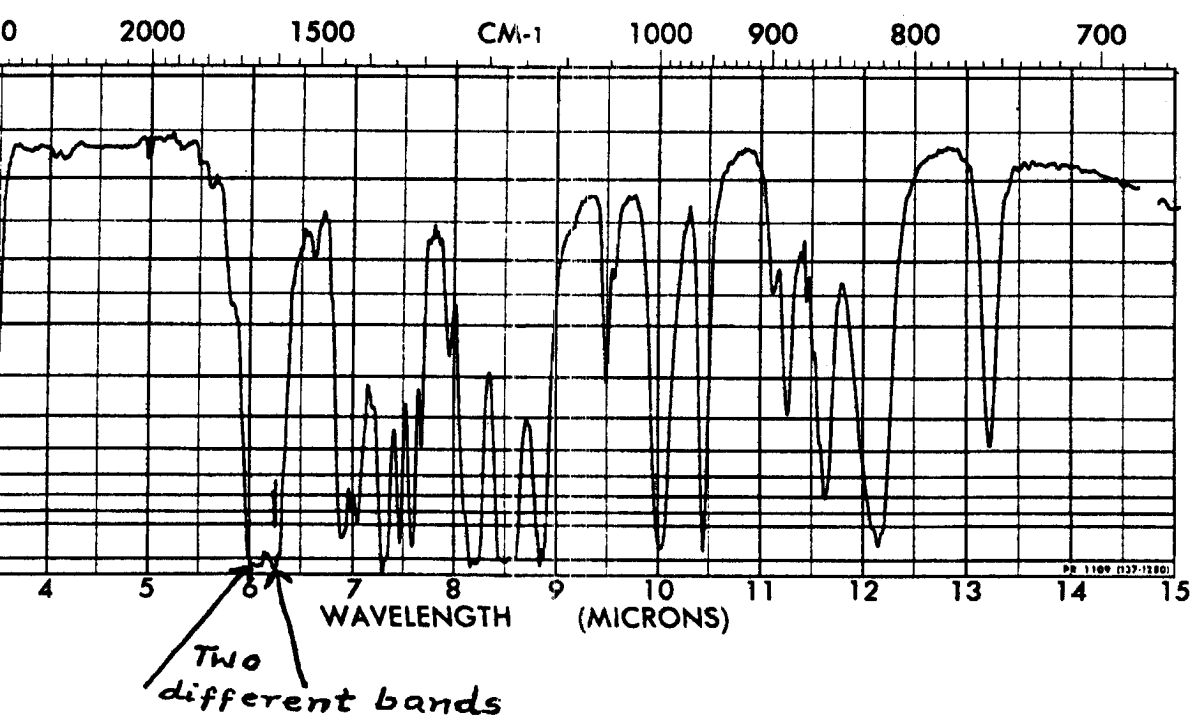
OMPOUND: F

Question 5 (a)

Compound 25

MS: 126.067
IR: neat
HMR: $CDCl_3$
CMR: $CDCl_3$
Analysis: 66.7% C; 7.9% H





Two different bands

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY

29 JUNE 2005

UNIVERSITY SESSIONAL EXAMINATIONS: SEMESTER I
C 361: CHEMICAL KINETICS AND NUCLEAR CHEMISTRY

INSTRUCTIONS: THERE ARE A TOTAL OF SIX (6) QUESTIONS
1. ANSWER ANY FIVE (5) QUESTIONS
2. ANSWER EACH QUESTION IN A ***SEPARATE*** ANSWER BOOK.

TIME ALLOWED: THREE (3) HOURS.

DATA

$N_A = 6.02 \times 10^{23}$ mol^{-1}; $R = 8.314$ J K^{-1} mol^{-1}, $k_B = 1.38 \times 10^{-23}$ J K^{-1};

$e = 1.602 \times 10^{-19}$ C ; Electron affinity of chlorine = 230 kJ mol^{-1};

Ionisation energy of sodium = 495 kJ mol^{-1}; 1 eV = 1.602×10^{-19} J

1 Atomic Mass Unit (AMU) = 1.66057×10^{-27} kg ; $m_p = 1.007838$ AMU;

$M_n = 1.008665$ AMU; $m_e = 0.00005486$ AMU ;

$c = 2.99792 \times 10^8$ m s^{-1} ; 1 J = 1 kg m^2 s^{-2}

THE PERIODIC TABLE IS ON THE NEXT PAGE 2

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01 Hydrogen				KEY Atomic number **X** Atomic mass Name of the element X												1 **H** 1.01 Hydrogen	2 **He** 4.00 Helium
3 **Li** 6.94 Lithium	4 **Be** 9.01 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium											13 **Al** 27.99 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.65 Copper	30 **Zn** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 71.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
37 **Rb** 85.47 Rubidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** 97.91 Technetium	44 **Ru** 101.07 Ruthenium	45 **Rh** 102.91 Rhodium	46 **Pd** 106.42 Palladium	47 **Ag** 107.87 Silver	48 **Cd** 112.41 Cadmium	49 **In** 114.82 indium	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 tellurium	53 **I** 126.90 Iodine	54 **Xe** 131.29 Xenon
55 **Cs** 132.91 Caesium	56 **Ba** 137.33 Barium	57 – 71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.84 Tungsten	75 **Re** 186.21 Rhenium	76 **Os** 190.23 Osmium	77 **Ir** 192.22 Iridium	78 **Pt** 195.08 Platinum	79 **Au** 196.97 Gold	80 **Hg** 200.59 Mercury	81 **Tl** 204.38 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 208.98 Bismuth	84 **Po** 208.98 Polonium	85 **At** 209.99 Astatine	86 **Rn** 222.02 Radon
87 **Fr** (223.02) Francium	88 **Ra** 226.03 Radium	89 - 103	104 **Unq** 261.11	105 **Unp** 262.11	106 **unh** 263.12	107 **uns** 262.12	108 **Uno** 265.00	109 **Une** 265									

57 **La** 138.91 Lanthanum	58 **Ce** 140.12 Cerium	59 **Pr** 140.91 Praseodymium	60 **Nd** 144.24 Neodymium	61 **Pm** 144.91 Promethium	62 **Sm** 150.36 Samarium	63 **Eu** 151.97 Europium	64 **Gd** 157.25 Gadolinium	65 **Tb** 158.93 Terbium	66 **Dy** 162.50 Dysprosium	67 **Ho** 164.93 Holmium	68 **Er** 167.26 Erbium	69 **Tm** 168.93 Thulium	70 **Yb** 173.04 Ytterbium	71 **Lu** 174.97 Lutetium
89 **Ac** 227.03 Actinium	90 **Th** 232.04 Thorium	91 **Pa** 231.04 Protactinium	92 **U** 238.03 Uranium	93 **Np** 237.05 Neptunium	94 **Pu** 244.0 Plutonium	95 **Am** 243.06 Americium	96 **Cm** 247.07 Curium	97 **Bk** 247.07 Berkelium	98 **Cf** 251.08 Californium	99 **Es** 252.08 Einstienium	100 **Fm** 257.10 Fermium	101 **Md** 260 Mendelevium	102 **No** 259.10 Nobelium	103 **Lr** 262.11 Lawrencium

(a) (i) Briefly, describe the essential features of the **harpoon** mechanism.

(ii) Estimate the value of the steric factor for the harpoon reaction between sodium and chlorine.

$$(d = 350 \text{ pm}, \varepsilon_0 = 8.854 \times 10^{-12} \text{ C J}^{-1} \text{ m}^{-1})$$

) (i) Nitrogen dioxide reacts bimolecularly in the gas phase to give NO and O_2. The temperature dependence of the second order rate constant for the rate law $\frac{d[P]}{dt} = k[NO_2]^2$ is given below:

T (K)	600	700	800	1000
k ($dm^3 mol^{-1} s^{-1}$)	4.6×10^{-4}	9.7×10^{-3}	1.3×10^{-1}	3.1

Calculate the steric factor (P) and reactive cross section for the reaction.

(ii) Calculate the magnitude of the diffusion controlled rate constant at 298 K for a species in pentane. The viscosity of water is 2.22×10^{-4} kg m^{-1} s^{-1}.

2. (a) Write a short note on specific acid base catalysis.

(b) Consider the acid catalyzed reaction

$HA + H^+ \rightarrow HAH^+$ k_1 fast

$HAH^+ \rightarrow HA + H^+$ k_2 fast

$HAH^+ + B \rightarrow BH^+ + AH$ k_3 slow

Derive the rate law and show that it can be independent of the specific term $[H^+]$

(c) The hydrolysis of a substance is specifically catalyzed by hydrogen ions, and the rate constant is given by

$$k \text{ (dm}^3\text{mol}^{-1}\text{s}^{-1}) = 4.7 \times 10^{-2} \times [H^+] \text{ (mol dm}^{-3})$$

When the substance is dissolved in 10^{-3} mol dm^{-3} solution of an acid HA the rate constant was 3.2×10^{-4} $dm^3 mol^{-1} s^{-1}$. Calculate the dissociation constant of the acid.

a) Enzymatic reactions are said to occur by the Michaelis and Menten Mechanism. Write the equations of the chemical reactions that constitute the Michaelis-Menten mechanism.

b) On a labelled diagram indicate how the rate of the reaction varies with the substrate concentration. On the diagram indicate the zero-order, first-order regions and the value of the maximum rate R_{max}.

c) The reaction:

$$HCO_3^-(aq) + H^+(aq) \rightarrow CO_2(g) + H_2O(\ell)$$

is catalysed by the enzyme carbonic anhydrase. The following data was obtained for this reaction at pH 7.0:

Initial concentration of $[HCO_3^-]$, (M)	Initial Rate $(M s^{-1})$
1.0×10^{-3}	0.57×10^{-5}
2.0×10^{-3}	1.07×10^{-5}
5.0×10^{-3}	2.22×10^{-5}
10.0×10^{-3}	3.50×10^{-5}

From the above data, determine K_M and R_{max} for the reaction. Give the units for each constant.

The amino acid alanine may be prepared from propionic acid by ammonolysis of α-bromopropionic acid according to the following reaction:

$$\underset{\text{P}}{CH_3CH_2COOH} \xrightarrow{k_1} \underset{\text{BP}}{CH_3CHBrCOOH} \xrightarrow{k_2} \underset{\text{A}}{CH_3CH(NH_2)COOH}$$

Propionic acid — α-Bromopropionic acid — Alanine

Discuss the kinetics of the above reaction by answering, among others, the following questions:

a) What type of reaction is this?

b) Outline, by using appropriate kinetic equations but without solving them, how the concentrations of reactants and products may be obtained. State any simplifying assumptions.

c) Indicate, using appropriately labelled diagrams and relationships between the rate constants, the variation of the concentrations of reactants and products as functions of time.

d) Show how the relationships between the rate constants lead to simplifications in the solution of the kinetics of this type of chemical reaction.

a) When chlorine-37 is bombarded with neutrons only one product is produced. The product is unstable and spontaneously decays by β emission.

(i) Write and balance the equations for the reactions.

(ii) Calculate the n : p ratio of the final product.

b) The isotope potassium-40 is radioactive and decays to argon-40 with a half-life of 1.2×10^9 years.

(i) Write a balanced equation for the reaction.

(ii) A sample of moon rock brought to earth by Apollo 11 astronauts was found to contain 18 percent potassium-40 and 82 percent argon-40 by mass. Calculate the age of the rock.

c) The atomic masses of the elements $^{27}_{13}Al$ and $^{28}_{14}Si$ are, respectively, 26.98154 and 27.976928 atomic mass units.

(i) Calculate the binding energy per nucleon for each element.

(ii) Comment on the stability of the two elements relative to each other on the basis of your answer to part c) (i) and on any other bases.

The reaction between nitrogen dioxide and carbon monoxide is proposed to occur by the following mechanism:

1. $2NO_2 \xrightarrow{k_1} NO_3 + NO$

2. $NO_3 + CO \xrightarrow{k_2} NO_2 + CO_2$

a) What is the net reaction?

b) Derive the rate law for production of carbon dioxide. State any assumptions, if any, you have used in your derivation.

c) The experimentally determined rate constant was found to be:

$$\log k_{obs} = -\frac{3163.0}{T} + 11.899$$

at 10 °C. The initial concentration of nitrogen dioxide was 0.008 *M*. If the time was measured in seconds, calculate the half-life of the reaction.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

ADVANCED BIOCHEMISTRY- C411

TIME: **THREE HOURS (3:00 HOURS)**

INSTRUCTIONS TO CANDIDATES:

WRITE YOUR COMPUTER NUMBER ON **ALL** ANSWER BOOKLETS

THE EXAMINATION CONSISTS OF TWO (2) SECTIONS **A** AND **B.**

SECTION **A: ANSWER ALL QUESTIONS. (40 MARKS)**

SECTION **B. ANSWER ANY THREE QUESTIONS (60 MARKS)**

SECTION A (EACH QUESTION CARRIES 10 MARKS)

1. Explain briefly the principles involved in the following processes.

   i. 2 dimensional electrophoresis

   ii. Differential centrifugation

   iii. Salting out

   iv. SDS-PAGE

   v. Molecular sieve chromatography

---

2. Write short notes on autoradiography and factors affecting scintillation counting.

---

3. C^{14} is a good beta emitter that is produced continuously in the upper atmosphere by the bombardment of N^{14} with neutrons of cosmic radiation. Calculate the specific activity of pure C^{14} in terms of:

   i. DPM/g

   ii. Ci/g

---

4. Write a short note on the fluid mosaic model of membranes.How does cholesterol affect membrane fluidity?

SECTION B (EACH QUESTION CARRIES 20 MARKS)

1. a) What is the composition of the thick and thin filaments of striated muscle? Rigor Mortis is a term used to describe stiffness of muscle upon death. Explain from a biochemical point of view how this happens.

   b) Calcium plays a vital role in muscle contraction. Using the model of smooth muscle, elucidate the mechanism of muscle contraction.

   c) Calculate the energy needed to pump Na^+ out of a muscle cell when the cytosolic concentration is 0.4mM, the extracellular concentration 1.5mM, and the membrane potential being -60 mV at 37°C.
   (R= 8.314×10^{-3}k J/mol/K and F=96400 J/V/mol)

---

2. a) Bacteria are able to utilize glucose when its readily available. When its in low concentrations of is absent, they switch on to other sugars such as lactose. How do they undertake such a switch? Explain using welled labeled diagrams.

   b) With reference to the trp-operon, explain in detail how bacteria respond to varying amounts of Tryptophan. Starting from chorismate, give the pathway for the synthesis of tryptophan, showing all the enzymes involved.

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3. a) Elucidate the pathway for the synthesis of dopamine, epinephrine and norepinephrine.

   b) Write a note on EDRF, its synthesis and mode of action.

   c) How does ethylene form in plants? What is the major function of ethylene?

---

4. a) Nicotine and Bungarotoxin are the natural agonist and antagonist of which receptor? What is their mode of action?

   b) An activated squid membrane resulted in the following equilibrium concentrations ([in]:[out]); Na^+ 40:450; K^+ 385:15 and Cl^- 47:530 in (mM) and their permeability constants being 0.04, 1 and 0.45 respectively. Calculate the Nernst potential resulting from the above equilibrium conditions.

END OF EXAMININATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY
2005 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

C 421: APPLIED ANALYTICAL CHEMISTRY
TIME: 3 HOURS
ANSWER ANY 4 FROM THE 5 QUESTIONS IN THIS PAPER

QUESTION 1

(a) An ore is analyzed for the Mn content by converting Mn to Mn_3O_4 and weighing it. If a 2.1g sample yields Mn_3O_4 weighing 0.15g. what would be the % MnO_3 in the sample and %Mn?
(b) Describe 2 methods used to separate Pb from rocks and one technique used to determine it from a solution of the rock.
(c) Photometric methods are not ideal for the determination of metals in rocks. Why is this so and how would you overcome such difficulties?
(d) Discuss 2 schemes used to determine silica in rocks.
(e) In flame spectrophotometry, discuss the differences between emission and absorption spectrometry, giving examples to illustrate them.

QUESTION 2

(a) A solid mixture of $Ca(OH)_2$ and $CaCl_2$ is analyzed by titration with HCl. It is found that a sample weighing 0.6g needs 25ml of 0.2M HCl. Determine the %$Ca(OH)_2$ and %$CaCl_2$ in the mixture.
(b) Discuss the determination of C and K in soils.
(c) Describe what is meant by "exchangeable acidity" of soils and how it can be determined in soils.
(d) How would you determine total N and ammonia N in soils?
(e) What weight of pyrite (impure FeS_2) must be used in analysis so that $BaSO_4$ precipitate formed will be equal to half of the %S in the sample.

QUESTION 3

(a) A metal sample weighing 0.6g was ashed and diluted to a fixed volume of 50ml and gave a reading of 30. Solutions B and C containing same quantity of unknown plus 20 and 30 µg of Ba gave readings of 42 and 76 respectively. Calculate Ba in the original sample.

(b) What are the main elements of steel and describe how to determine one of such elements of your choice.
(c) What is "German Silver" and how would you analyze for one of the elements?
(d) A soda ash sample is analyzed by titration with standard HCl. The analysis is done in triplicate with the following results: 93.50, 93.58 and 93.43% Na_2CO_3. Within what range are you confident that the true value lies? (t = 4.303)
(e) Most soils contain some exchangeable cations, what are they? Explain in detail how any 3 of them can be determined in soils.

ESTION 4

(a) What are the main components of glass other than silica. How would you determine silica in glass?
(b) How would you determine Fe_2O_3 and Al_2O_3 in limestone?
(c) A solution of $Na_2S_2O_3$ is standardized iodometrically against 0.13g $KBrO_3$ requiring 45.0ml $Na_2S_2O_3$. What is the molarity of $Na_2S_2O_3$?
(d) Discuss how to determine K in the presence of sulfates but not phosphates in fertilizers.
(e) 0.3g sample containing Cu is dissolved and a complex is formed in the presence of EDTA. The solution is then diluted to 50ml and absorbance measured as 0.260. A 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.

ESTION 5

(a) You have sampled natural water and are about to store it for future analysis of the parameters listed below. For each type of analytes, suggest one critical step that you will need to do in order to minimize analyte loss. (i) Nitrates, (ii) Pesticides and (iii) Metal ions.
(b) Discuss the Winkler method for the determination of dissolved oxygen (DO) in water.
(c) It is suspected that Ibuprofen, a drug that can be protonated to form positively charged species in solution was accidentally dropped in a water tank. You are asked to analyse a water sample from the tank using liquid chromatography interfaced to a quadruple ion trap (QIT) mass spectrometer using electrospray ionization. Explain this ionization technique and the operations of a (QIT) using sketches where appropriate. To simplify your explanation use the following sub-headings: (i) Electrospray ionization, (ii) Types of analytes in water (that can be analysed by this technique), (iii) Mass analysis in the QIT and (iv) Detection of ions.
(d) What methods would you use for the analysis of the following in the atmosphere: (i) Nitrogen oxides and (ii) SO_2
(e) What does the acronym LIDAR mean in remote sensing and very briefly discuss this technique.

= 137; Cu = 63.5; I = 126.9; S = 32.1; Fe = 55.8; Ca = 40.1; Cl = 35.5; Mn = 54.9

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY SEMESTER I, 2005 EXAMINATIONS
ORGANIC CHEMISTRY V – C451
JUNE, 2005

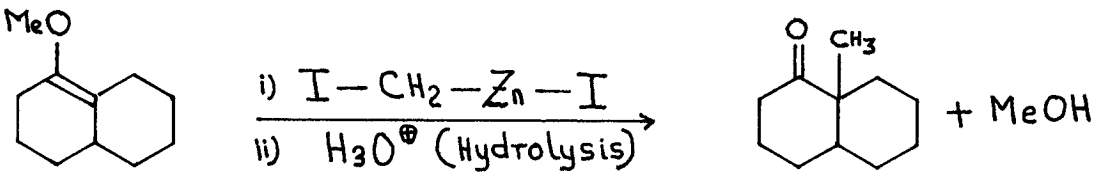
E ALLOWED: THREE (3) HOURS.

RUCTIONS:

This paper has five (5) questions. Answer any four (4) questions.
Each question carries thirty marks.
Marks for each part of the question are indicated.

STION ONE.

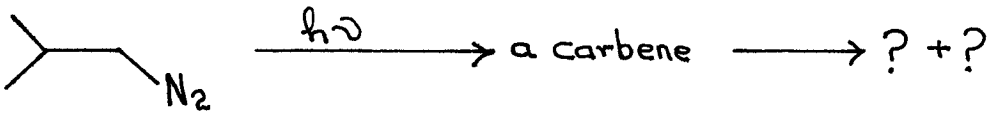
Carbenoids are generally used as sources of carbenes during organic synthetic reactions. For example, (iodomethyl)zinc iodide, I-CH_2-Zn-I, is a carbenoid that was used for angular methylation as shown in the following reaction.



Suggest a full mechanism for this reaction and clearly show the intermediate product(s) that may be involved.

08 marks

Using the reaction given below, explain the meaning of the term "intramolecular methylene insertion" and show the molecular structures of the products of this reaction.



04 marks

Tri-alkylhalosilanes have been used as protective agents for hydroxyl group and also for carbonyl group. On this basis, show the product and write the mechanism for the treatment of 1-methoxy-2-methyl-3-pentanone with trimethylchlorosilane in the presence of triethylamine.

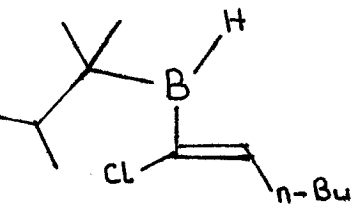
08 marks

If the product obtained in **question 1(c)** above is reacted with acetaldehyde under Lewis acid catalysis followed by acidic hydrolysis, what product will you expect to be obtained? Suggest a mechanism for this reaction.

10 marks

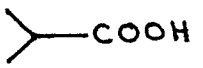
TION TWO.

t the major organic products and write the mechanisms of the following reactions:



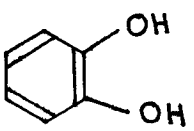
i) $HC\equiv C\,CH_2CH_2CH_3$

ii) NaOMe

iii) 

→ ?

07 marks



(1 mole)

i) $H_3B\cdot THF$ (1 mole)

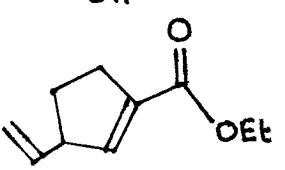
ii) 3,3-Dimethylbutyne

iii) 

→ ?

08 marks

Thexylborane



i)

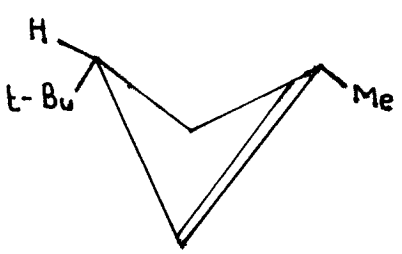
ii) 

iii) CO/H_2O

iv) $H_2O_2/NaOAc.$

→ ?

09 marks



i) $H_3B\cdot SMe_2$

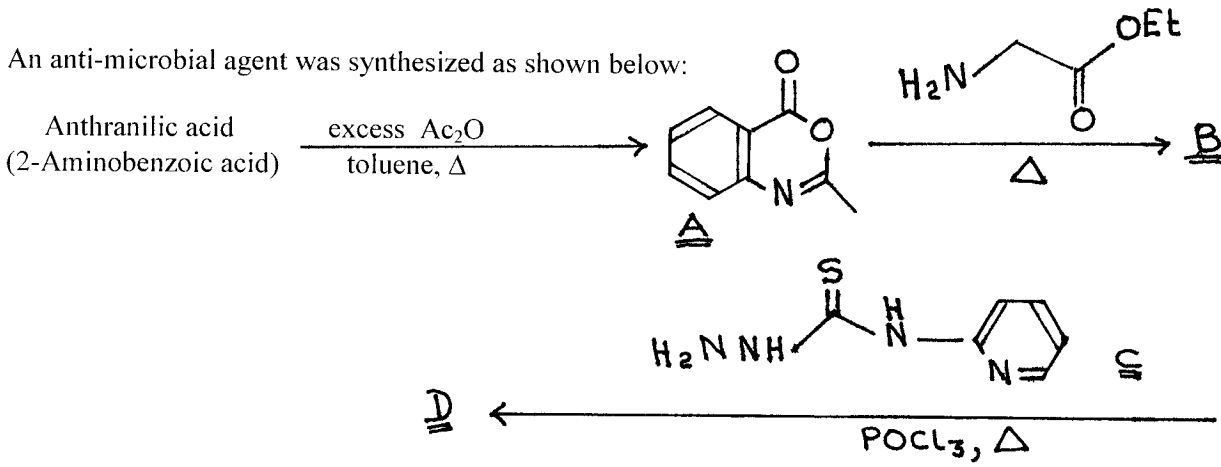
ii) $I_2/NaOMe$

→ ?

06 marks

STION THREE.

An anti-microbial agent was synthesized as shown below:



(i) Deduce the structure of the anti-microbial agent **D** from the above synthesis and show its pharmacophore.

08 marks

(ii) Suggest plausible mechanisms for the reactions involved in the formation of compound **A** from anthranilic acid.

06 marks

(iii) Show the structure of compound **B** and give a synthesis for compound **C** used in the last step of the above synthesis.

10 marks

Provide an explanation to account for the following observations:

(i) Insulin tablets are completely ineffective in the treatment of diabetes mellitus.

03 marks

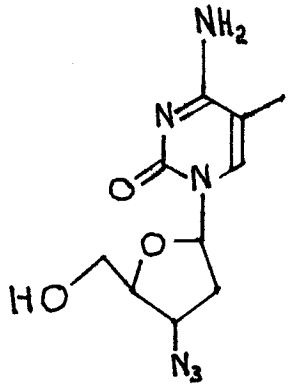
(ii) Naturally occurring penicillins are sensitive to acids.

03 marks

STION FOUR.

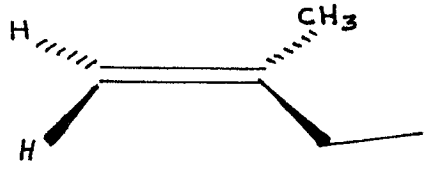
Propose a synthesis for an anti-retroviral drug **E** used for the treatment of HIV/AIDS, structure shown below, from 2-deoxyribose and other readily available non-heterocyclic materials. Show the reagents and the reaction conditions for your proposed synthesis.

Anti-retroviral Drug **E**:



20 marks

Diisopinocampheylborane, Ipc_2BH, is thought to be a good agent for asymmetric hydroboration. For example, treatment of 2-methyl-1-butene, the stereochemical structure is shown below, with Ipc_2BH yields a racemic mixture of (S)- and (R)- products. Rationalise this observation and account for the formation of the racemic mixture.



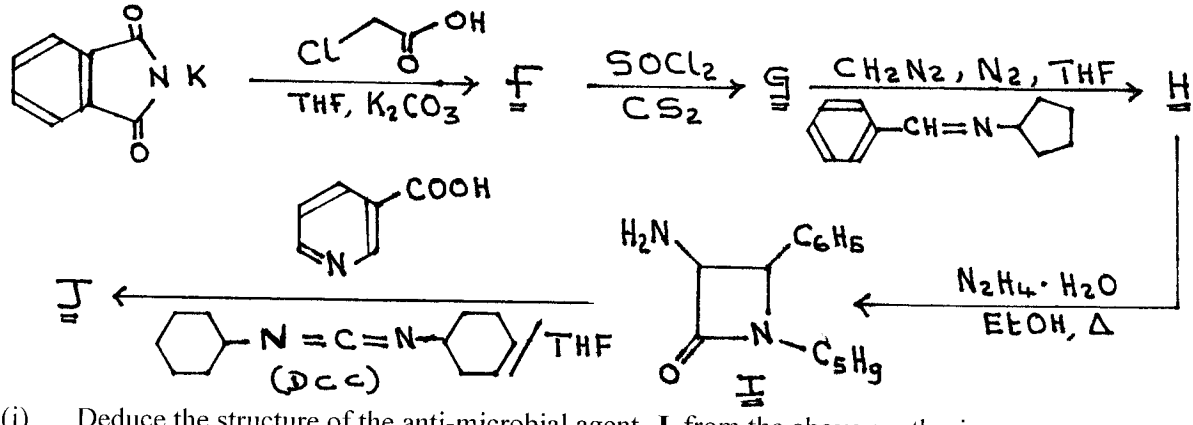
10 marks

STION FIVE.

Briefly explain how penicillins are inactivated by some Gram- positive bacteria.

06 marks

A synthesis of an anti-microbial agent, **J**, designed to overcome the problem of bacterial inactivation of penicillins, is shown below.



(i) Deduce the structure of the anti-microbial agent, **J**, from the above synthesis. Show the structures of the intermediates **F** to **H**.

08 marks

(ii) Give mechanisms of the reactions involved in the formation of compound **G**.

08 marks

Discuss the structure-activity relationships in 4-aminoquinoline anti-malarial drugs.

08 marks

END OF EXAM

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER EXAMINATIONS, JUNE 2005

C491 – Organic Industrial Chemistry

3 hours
tions: Answer question 1 and any other three questions

(a) What do you understand by the term viscosity as it relates to a fluids.
(b) In choosing size and type of pump, one takes into account the resistance to be met through the pipe. Explain the resistance likely to be encountered in pumping a liquid from point A to B in the following situations:

(i) pumping to a tank 10 m vertically above the ground;
(ii) to a tank at high pressure;
(iii) through a heat exchanger.

c) (i) Show by means of a sketch diagram streamline and turbulent flow.
(ii) Explain the statement that "Eddies are a wasteful form of energy".
(iii) Why is turbulent flow preferred when heating or cooling a fluid in a pipe?

d) Size reduction maybe carried out by a process known as *Open Circuit grinding.* Draw a flow diagram to illustrate this process.

a) The separation process in crude oil refining is based on the distillation theory. The Clausius-Clapeyron equation may be used to determine the approximate boiling point of a fraction.

(i) Give the Clausius-Clapeyron equation defining the parameters in it.
(ii) Show how this equation may be used to obtained approximate boiling points of a component at a given external pressure.
(iii) Explain the term relative velocity and its significance ascertaining the ability to separate components in a binary mixture.

b) Fractionators form part of any petroleum refining complex and consists of two operations: distillation and rectification.

(i) Distillation separates the crude oil into *cuts* comprising overhead and bottom products in an atmospheric fractionator. Explain how this is achieved. Identify fraction in the overhead and bottom products.

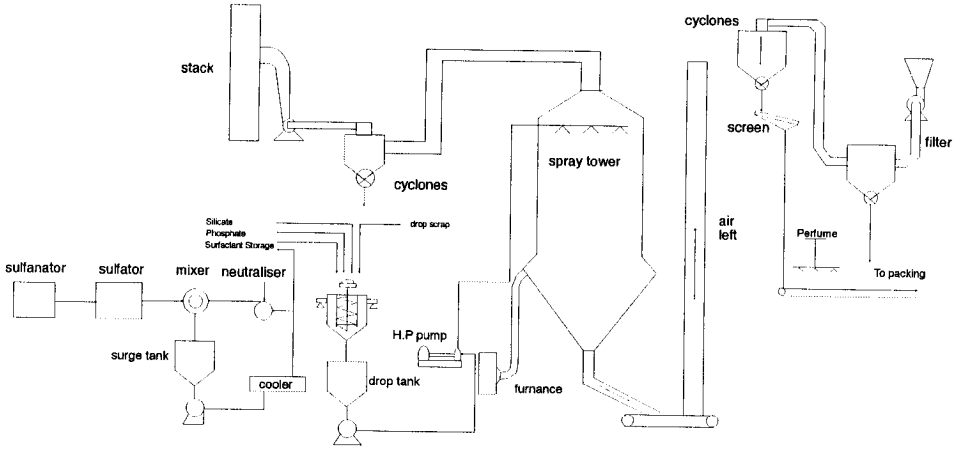
(ii) Products obtained from the base of an atmospheric fractionator is sent to vacuum flasher. Give reasons why the bottom product is sent to this unit and describe the process and conditions taking place in the unit.

(c) Thermal processing is a technique used to convert fractions into usable products. Explain the process, conditions and products from thermal cracking.

(a) (i) What do you understand by the term *Gasification of Coal*?
(ii) Write the five basic chemical reactions in the gasification chemistry of coal.
(iii) Using sketch diagrams show the effects of temperature and pressure on the reactions.

(b) One classification of gasification processes is on the basis of the heat transfer process. Two processes are identified: allothermic and autothermic process. Give details of each process and its advantages or disadvantages.

The flowchart for the production of heavy detergent granules is Shown below.



Simplified Continuous Flowchart for the Production of Heavy-Detergent Granules (Procter & Gamble Co.)

(a) Outline in point form the steps involved in the production of detergent powders.
(b) What process is involved in the sulfator. Give the process conditions and explain the significance of the product in the cleaning action of the detergent.
(c) Give reasons why it is necessary to cool the liquid coming form the surge tank.

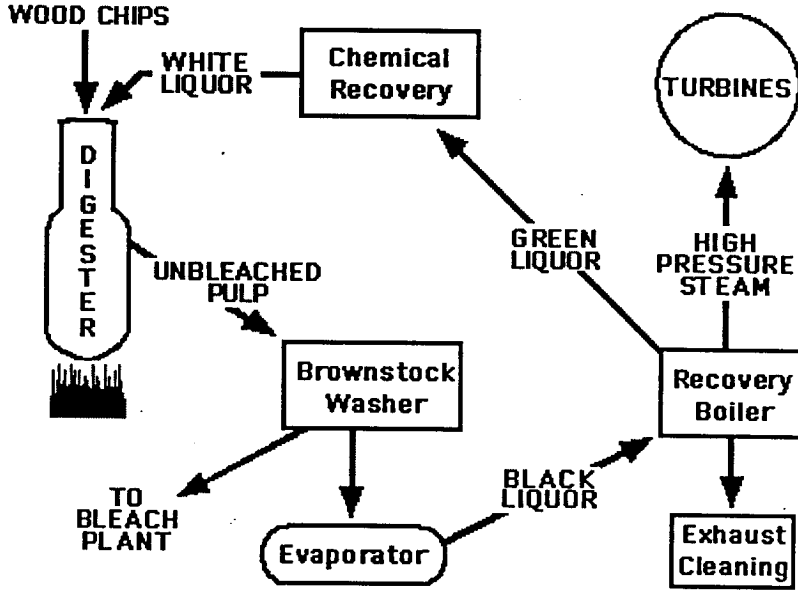
(d) In the crutcher sodium tripolyphosphate is added to the liquid from the surge tank. What is the function of this compound in soaps and detergents.

(e) Describe the process occurring in the spray tower and explain the role of cyclones as shown in the flowchart.

5. (a) Explain in brief the following terms relating to the composition of wood:

(i) Cellulose
(ii) Hemicellulose
(iii) Lignin

(b) The flow chart below shows major operations in the production pulp by the Kraft process. Explain using the flow chart processes occurring in the major units.



THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF COMPUTER STUDIES
FIRST SEMESTER EXAMINATION 2005

CS3251: ELECTRONICS FOR COMPUTING I

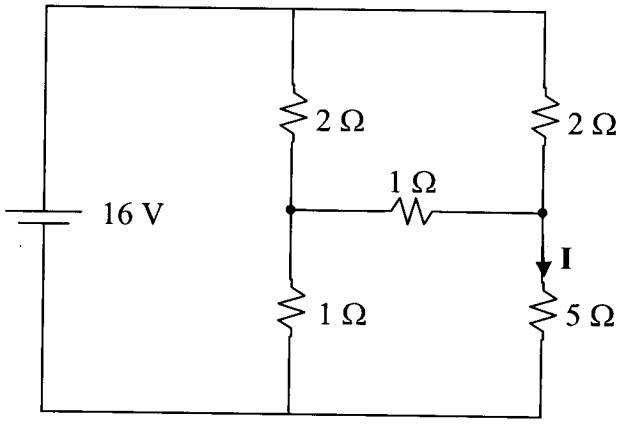
ME: 3 HOURS

STRUCTIONS: ANSWER ANY FOUR QUESTIONS
TOTAL MARKS 100
ALL QUESTIONS CARRY EQUAL MARKS

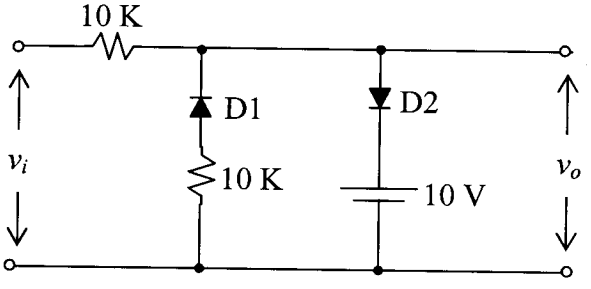
Find the current **I** in the circuit below using

a) Thevenin's theorem [13]

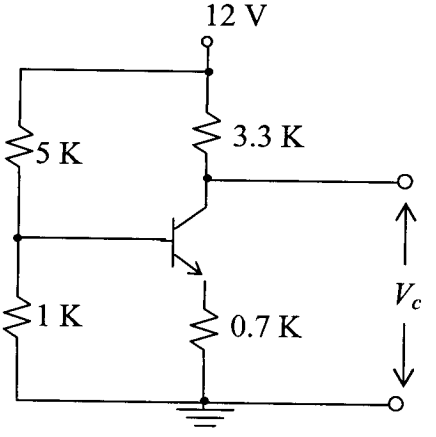
b) Norton's theorem [12]



a) For the circuit below plot v_o against v_i, indicating all intercepts, slopes and voltage levels. **Assume that the diodes are ideal.** [11]



b) For the circuit below find the voltage V_c, given $\beta = 100$, $V_{be} = 0.7$ V [14]

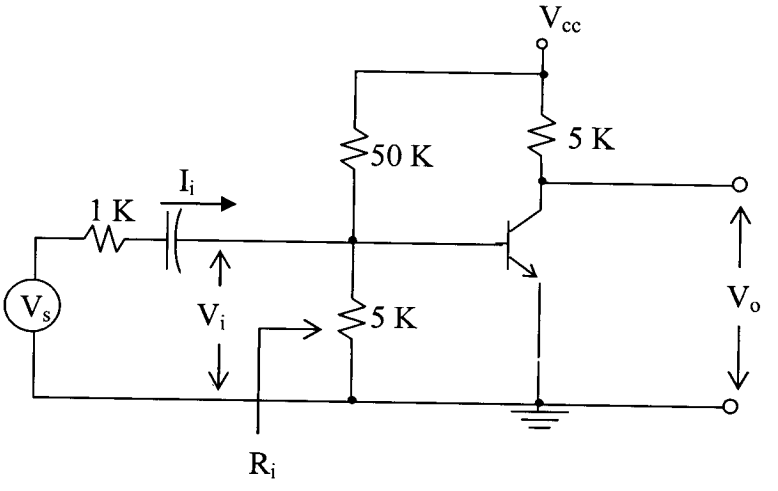


For the circuit given below draw the small signal equivalent circuit and use it to calculate [6]

a) The input resistance R_i [8]

b) The Small signal current gain $A_I = I_o/I_i$ [3]

c) The small signal voltage gains A_V and A_{vs} [4]+[4]



Use the following transistor parameters: $h_{ie} = 1.1K$, $h_{fe} = 200$

a) Convert each pair of decimal numbers into binary and add using 8-bit 2's complement. Convert the answer back to decimal. [12]

i) 86 and -57 ii)-10 and -84

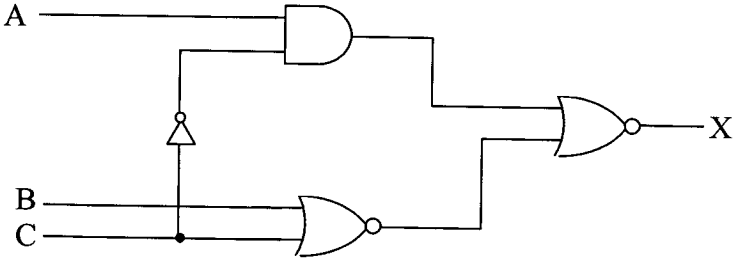
b) Convert each of the following decimal numbers to Hexadecimal and perform Hexadecimal addition (Show work) [5]

240 and 255

c) Use Boolean algebra to prove the expression below [8]

$$A\overline{C} + A\overline{B} + BC = A + BC$$

Q.5 a) For the circuit below write the the Boolean equation relating the output as a function of the inputs [5]



b) Simplify the Boolean expression to its simplest form using Boolean algebra theorems and De Morgan's theorems. [9]

c) Verify the result in part b) by simplifying the Boolean expression in part a) using the K-Map method. [9]

d) Redraw the circuit. [2]

6

a) From the following truth table obtain a SOP expression. [7]

A	B	C	D	Y
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	1
1	0	0	1	1
1	0	1	0	1
1	0	1	1	0
1	1	0	0	1
1	1	0	1	0
1	1	1	0	1
1	1	1	1	0

b) Create a K-Map from the SOP expression [8]
c) Use the K-Map to find a simplified Boolean expression [8]
d) Draw the corresponding logic circuit [2]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF COMPUTER STUDIES
CST 3011: ALGORITHMS AND DATA STRUCTURE
SEMESTER ONE (1) EXAMINATION 2005

ISTRUCTIONS : Answer Any Five (5) Questions.
ME ALLOWED : Three (3) Hours.

ATE: MONDAY, 27 JUNE 2005
ME: 14:00 - 17:00 HOURS

. In order for any programmer to write a computer program, one needs to understand data structures to be used in the program.

a). Describe three (3) important elements of the data structure.

b). What are data types?

c). What are the functions of the data structures?

d). List and describe any five (5) Abstract Data Types (ADTs).

. Linked data representation can be supported by any addressable storage medium. Explain:

a). How Pointers are used on files stored on a disk? Give an illustration.

b). How Windows Operating System uses pointers? Give an example?

c). What does it mean to:

1). Dereference a pointer;

2). Reference a pointer;

Q3. Stacks are useful for processing nested structures for managing algorithms in which such processes call sub-processes.

a). Explain other means in which stacks can be used.

b). Define the stack (in the context of programming);

c). Describe were the terminology associated with stack comes from;

d). Describe several uses of queues in time-shared operating systems and computer networks?

Q4. They are different ways of decomposing a problem into sub problems.

a). Explain by providing an example how recursive program works.

b). What is the base case in the recursive program?

c). What is the natural way to consider decomposing a linked list into substructures helpful for devising a recursive solution to a problem?

d). What is a trace of a recursive function call?

Q5. Different programming methods are used to develop computer programs. Explain the following programming terms:

a). What is top-down programming?

b). What is bottom-up programming?

c). When might it be useful to plan to implement a software system using top-down, or bottom-up programming?

Q6. a). Write an algorithm to construct the union of two sets A and B of integers in descending order.

b). Write an algorithm to construct the union of two sets A and B of integers in ascending order.

c). State the insertion sort algorithm for sorted (increasing order) array Element of integers containing NumItems element to which you wish to add one more item NewItem.

Q7. It is frequently hard to anticipate where the inefficiencies in a program lie. Program measuring and tuning are methods which ensures that the program is running efficiently.

a). What do you do to measure the program?

b). What do you do when tuning the program?

c). Give some examples of cases in which small changes in a program can cause surprising differences in efficiency.

d). Does experience show that most programs consume running time approximately uniformly throughout the code, or is the distribution of time consumed often more evenly? Explain

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End of Examination (jtk)

THE UNIVERSITY OF ZAMBIA
Department of Computer Studies

UNIVERSITY EXAMINATION 2005
Friday, June 24, 2005

CST3141 –OBJECT - ORIENTED ANALYSIS & DESIGN

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tructions: This examination consists of SEVEN **(7)** Questions. You are required to answer only **FIVE (5)** of them according to the instructions given for each question. All questions have the same weight
Good Luck!

ration: 3 Hours

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1. Discuss the following object-oriented concepts?
   i. Object
   ii. Class
   iii. Method
   iv. Message passing/invocation
   v. Inheritance
   vi. Object reuse
   vii. Encapsulation

2. Given the Java code below

```
interface Actor{
        public void act();
}
class Animal{
        private String name;
        public void cry(){
                System.out.println("Default");
        }
}
class Fox extends Animal implements Actor{
        public void cry(){
                System.out.println("Fox cry");
        }

        public void act(){
                //fox acting
        }
```

```
}

class Dog extends Animal implements Actor{
        public void cry(){
                System.out.println("Bark");
        }

        public void act(){
                //dog acting
        }
}
public class Client{
        public static void main(String[] args){
                Actor a = new Fox();
                a.act()
                a = new Dog();
                a.act();
        }
}
```

Identify the following

i. A class
ii. An object
iii. A method
iv. Message passing
v. Inheritance
vi. Example of object reuse

c. Do reverse engineering by drawing a UML class diagram derived from the program above.
d. Draw a sequence diagram depicting the events in the main method of the client class.

a. What is object-oriented analysis and design? In not more than 3 sentences.
b. What are high-level phases of the Unified Process? State in a sentence what the purpose of each phase.
c. Discuss the two main characteristics of the unified process, stating the advantage of each.
d. Consider a system that keeps track of DVD rentals at a video store.

Customers who have registered can borrow a DVD and this is recorded against the inventory item for the DVD. Sales staff can check availability of any DVD from the inventory. DVD titles and stock can be added and adjusted by the supervisor. Supervisors can also obtain a list of those customers who have not returned their DVDs by the agreed date.

From this initial information

i. Draw a UML use case diagram describing what the system has to do.
ii. Based on all the previous information, list the preliminary classes required.
iii. Give a scenario in the form of a UML sequence diagram to show a customer renting and returning a DVD.
iv. Based on all the previous information, develop a preliminary class diagram showing attributes and methods.

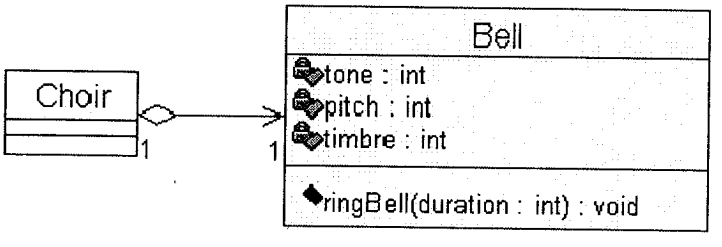
a. What is a design pattern as used in the object-oriented software development?
b. Give the outline of the essential elements that are used to describe a design pattern. Describe each element in not more than two sentences.
c. Consider the case below:

You are required to implement the clock software that is to be displayed as a digital clock as well as an analog clock (the circle with hands). You want the displays to automatically up date themselves when the time is adjusted.

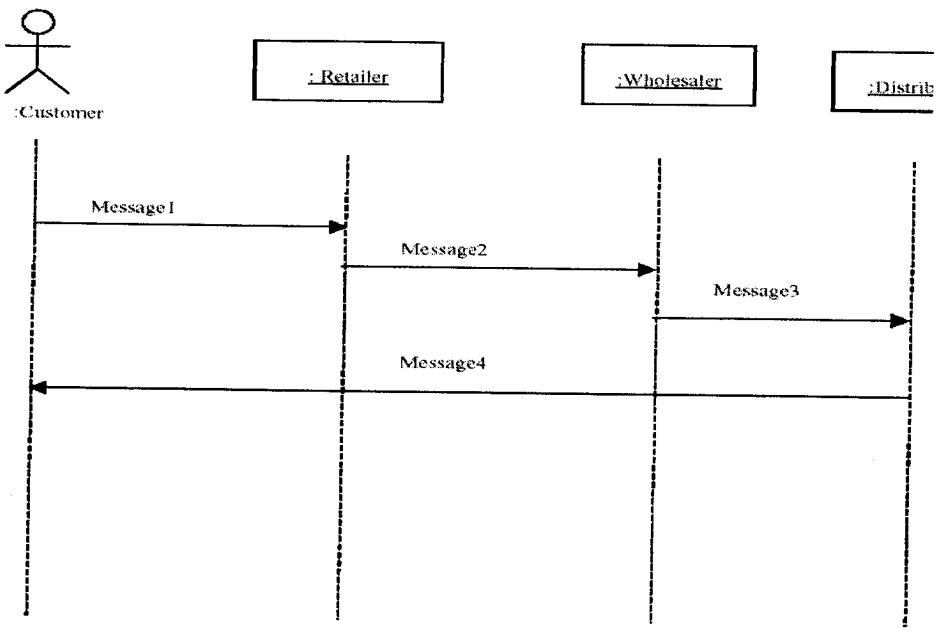
i. What design pattern can you use for this implementation?
ii. What is the intent of this pattern?
iii. Outline the participants in this pattern, stating, in a sentence or two, the role of the participant in the pattern.
iv. Draw the static relationship among these participants using a UML class diagram.
v. Draw an interaction diagram to depict the runtime interaction of these participants when the clock is adjusted

a. What is UML?
b. Define a static model and a dynamic model of UML?
c. Describe the following stating the role that it plays, whether it is a static or dynamic model, and a sample drawing of each.
i. Use-case diagram
ii. Class diagram
iii. Sequence diagram
iv. Collaboration diagram

d. Give the Java code and the file names that would be generated by Rational Rose from the following Class diagram:

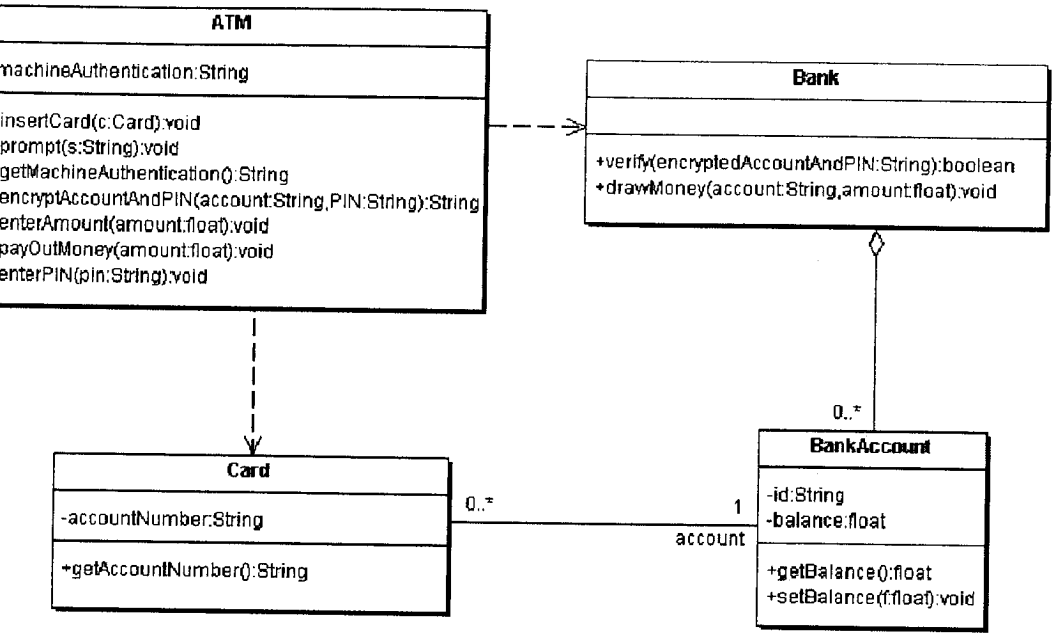


e. Model the sequence diagram below onto a Java Program



. Create a sequence diagram for the following collaboration. Use the classes and methods below

- A customer wants to draw money from his bank account. He enters his card into an ATM (automated teller machine).
- The ATM machine prompts „Enter PIN".
- The customer enters his PIN.
- The ATM (internally) retrieves the bank account number from the card.
- The ATM encrypts the PIN and the account number and sends it over to the bank.
- The bank verifies the encrypted Account and PIN number.
- If the PIN number is correct, the ATM displays „Enter amount", draws money from the bank account and pays out the amount.



b. What is the difference between aggregation, association and composition? Which one is the most general concept, which one is the most specific? Please explain.

c. Model the relationship between a car (that has an engine and a color) and its owners (having a name) in a UML class diagram. A car can have several owners over time, but only one or none owner at a time. Do not forget cardinalities, role names, attributes and their types.

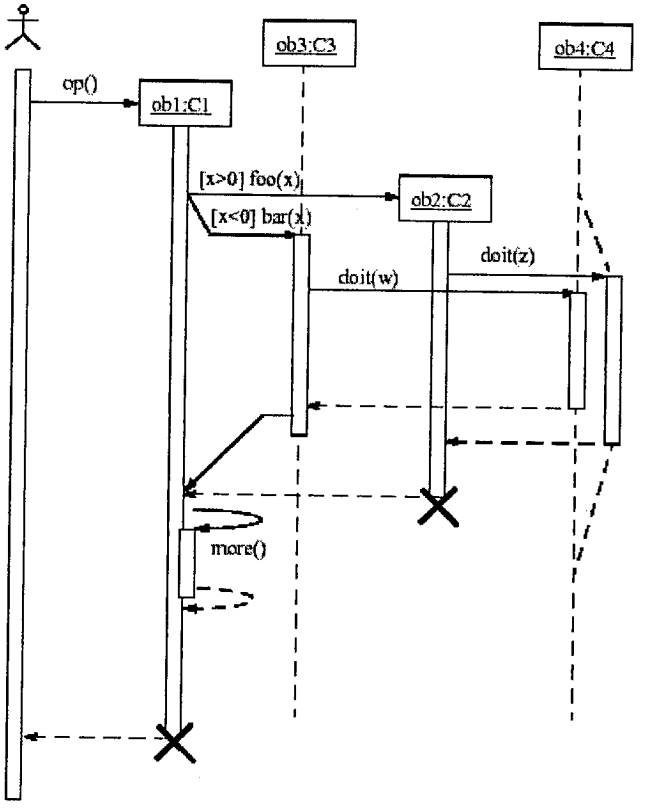
d. Draw diagrams to link the following classes using Aggregation, Inheritance and Multiplicity where appropriate:

i. University Staff, Academic, Administrator, Technician, Domestic
ii. Subscriber, Paying Subscriber, Complimentary Subscriber, Individual Paying Subscriber, Corporate Paying Subscriber
iii. Zoo, Animal, Bird, Mammal, Reptile, Cage, Keeper

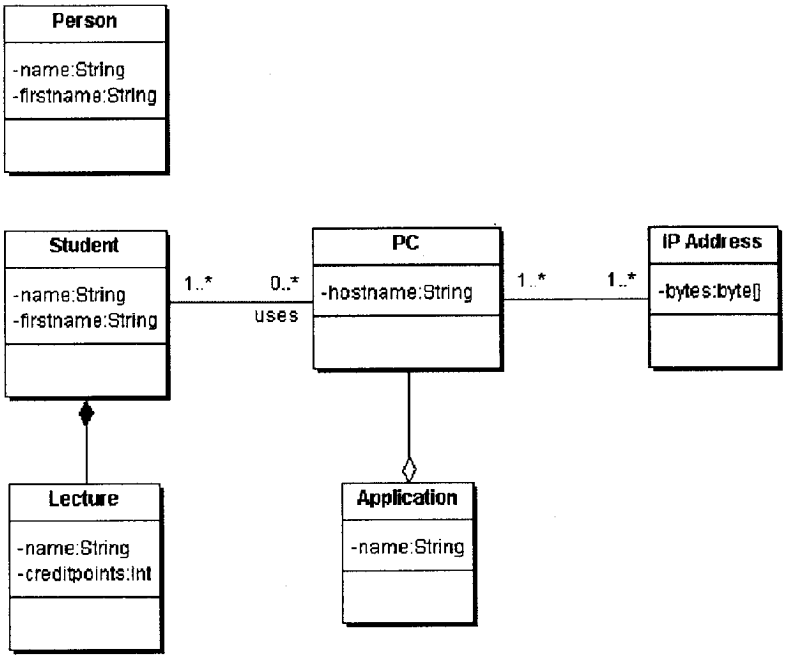
The questions below are based on the diagram below. Please note that the word symbol" is used to refer generically to all UML notations on this model.

What type of UML model is shown below?

Consider the message shown below, named [x>0]foo(x)
What symbol sends this message? Explain the name shown for that symbol.
What symbol does the work required by this message? What information is contained by that symbol to enable it to do the work?
Consider the two messages shown below, named doit(w) and doit(z).
i. Which symbol(s) does the work required by these messages?
ii. Under what conditions will doit(w) or doit(z) be performed?
What does the large X signify on this diagram?
Draw a corresponding Collaboration diagram with decimal numbering.


ob3:C3
ob4:C4
op()
ob1:C1
[x>0] foo(x)
ob2:C2
[x<0] bar(x)
doit(z)
doit(w)
more()

a. The class diagram below is wrong. Redraw it so it can depict a true relationship that exists between the PC, the student and the lectures in the department of computer studies, where a student uses any computer that is available.



b. Analyse the following Java program and answer the questions that follow

```
import java.lang.Object;
import java.util.Vector;
import java.awt.*;
/*
*
* Shape
*
* This is the basic shape class.
*
*/
abstract class Shape extends Object implements Cloneable
{
        // Position and size of the shape
        protected Dimension m_Dimension; // size
        protected Dimension m_TopLeft; // position

        protected Shape(Dimension TopLeft, Dimension Size)
        {
                m_Dimension = Size;
                m_TopLeft = TopLeft;
        }
        public abstract void Draw(Graphics g);
        public void ReSize(int iNewWidth, int iNewHeight)
        {
                m_Dimension = new Dimension(iNewWidth, iNewHeight);
```

```
        }
        public void ReSize(Dimension dimNewDimension)
        {
                m_Dimension = dimNewDimension;
        }
        public void MoveTo(int iNewLeft, int iNewTop)
        {
                m_TopLeft = new Dimension(iNewLeft, iNewTop);
        }
        public void MoveTo(Dimension dimNewTopLeft)
        {
                m_TopLeft = dimNewTopLeft;
        }
        public Dimension GetTopLeft()
        {
                return m_TopLeft;
        }
        public Dimension GetDimension()
        {
                return m_Dimension;
        }
        public abstract String GetShapeName();

}

        /*
        * CompoundShape
        *
        * This class represents a shape made up of a collection
        * of Shapes - which maybe basic shapes or other compound shapes.
        *
        */
class CompoundShape extends Shape
{
        // The component shapes that makeup this ComponentShape
        private Vector m_ComponentShapes;
        String m_ShapeName;

        public CompoundShape (String strShapeName, Dimension TopLeft, Dimension
Size)
        {
                super(TopLeft, Size);
                m_ShapeName = strShapeName;
        }
        public void Draw(Graphics g)
        {
                // for each shape in the list of shapes that
                // make up this CompoundShape invoke its Draw
                // method.

        }
        public void AddShape(Shape NewShape)
        {
                m_ComponentShapes.addElement(NewShape);
        }
        public String GetShapeName()
        {
```

```
                return m_ShapeName;
        }
        // Clone is part of implementing the Prototype design pattern
        public Shape clone() throws CloneNotSupportedException
        {
                // for each shape in the list of shapes that
                // make up this CompoundShape invoke its Clone
                // and add it into the new CompoundShape.

        }

}

// The concrete shapes
abstract class ConcreteShape extends Shape
{
        protected ConcreteShape(Dimension TopLeft, Dimension Size)
        {
                super(TopLeft, Size);
        }
}

class Square extends ConcreteShape
        {
        protected Square(Dimension TopLeft, Dimension Size)
        {
                super(TopLeft, Size);
        }
        public Square()
        {
                super(new Dimension(0,0), new Dimension(0,0));
        }
        public void Draw(Graphics g)
        {
                //code for drawing a square
        }
        public String GetShapeName()
        {
                return new String("Square");
        }
        // Clone is part of implementing the Prototype design pattern
        public ConcreteShape clone()
        {
                return new Square(GetTopLeft(), GetDimension());
        }
}

class Circle extends ConcreteShape
{
        protected Circle(Dimension TopLeft, Dimension Size)
        {
                super(TopLeft, Size);
        }
        public Circle()
        {
                super(new Dimension(0,0), new Dimension(0,0));
        }
```

```
        public void Draw(Graphics g)
        {
                //code for drawing a Circle
        }
        public String GetShapeName()
        {
                return new String("Circle");
        }
        // Clone is part of implementing the Prototype design pattern
        public ConcreteShape clone()
        {
                return new Circle(GetTopLeft(), GetDimension());
        }
}

class Star extends ConcreteShape
{
        protected Star(Dimension TopLeft, Dimension Size)
        {
                super(TopLeft, Size);
        }
        public Star()
        {
                super(new Dimension(0,0), new Dimension(0,0));
        }
        public void Draw(Graphics g)
        {
                //code for drawing a star
        }
        public String GetShapeName()
        {
                return new String("Star");
        }
        // Clone is part of implementing the Prototype design pattern
        public ConcreteShape clone()
        {
                return new Star(GetTopLeft(), GetDimension());
        }
}
```

Derive a UML class diagram from the code. Do not pay too much attention to the Cloneable interface and the runtime interactions. Concentrate on the static relationships – association, aggregation, and inheritance.

Using the diagram, identify the design pattern that was used to implement the program.

What is the intent of this design pattern?

Draw the generic class diagram for this design pattern.

****************END OF EXAMINATION**************

THE UNIVERSITY OF ZAMBIA

Computer Science Department

CST4121 Requirements and Specifications (2005)

Date: Monday 20th June 2005
Time: 09:00hrs
Exam Duration: 3 hours *Total marks for this Exam: 100*

Authorised materials:

Writing materials (e.g. pens, pencils) and dictionaries are allowed. Books and calculators are not allowed.

Instructions to Students:

- ***Attempt question 1 and 4 other questions.***
- *All questions carry equal marks*
- *Use the marks as a guide to the detail required in your answers while keeping your answers concise and relevant. Generally, a brief explanation should be around 40 words.*
- *Answer questions in the script book(s) provided.*
- *Clearly number your answers.*
- *Bullet points are acceptable in answering descriptive questions.*
- *Any unreadable answers will be considered wrong.*

TION 1 [20 marks]

correct answer carries 2 marks. A wrong answer will attract a deduction of 0.5 . Only letter options should be included in the answer book e.g. i. a), ii. b) etc.

What term is used to describe system requirements that are constraints in the system?

a) Functional requirements

b) Non functional requirements

c) Enduring requirements

d) Volatile requirements

Which description of requirements is often generated using customer supplied information and targeted at a managerial level.

a) Requirements specification

b) Software specification

c) Requirements definition

d) Use case

. Identify the sequence that correctly shows the order in which the stages in the requirements engineering process are carried out.

a) Feasibility study, Requirements analysis, Requirements definition, Requirements Specification

b) Feasibility study, Requirements definition, Requirements analysis, Requirements Specification

c) Requirements analysis, Feasibility study, Requirements definition, Requirements Specification

d) Requirements definition, Requirements analysis, Feasibility study, Requirements Specification

. What term describes an IT personnel who plays a significant role in the requirements analysis process.

a) System architect

b) System developer

c) System analyst

d) System designer

. Viewpoint-oriented analysis is among a number of different approaches that help discover end-user and organizational requirements. What is the major advantage of adopting this approach?

a) It helps identify stakeholders

b) It helps recognize the overlaps and conflicts between different viewpoints

c) It models real world objects

d) They are relatively low costs of adopting such a method

. The major reason behind developing a formal specification is

a) It is cost effective

b) Errors can easily be detected

c) It is easier to understand than a informal specification

d) It is easier to test the specification

. Which costs are significantly reduced thus leading to the reduction in software costs when comparing formal specification to a conventional process?

a) Validation costs

b) Specification costs

c) Design

d) Implementation

i. Identify the most widely used notations for developing model based specifications

a) UML and Z

b) Semantic Data Models and VDM

c) DFD and VDM

d) VDM and Z

x. What are the most commonly used constructs in model-based specifications?

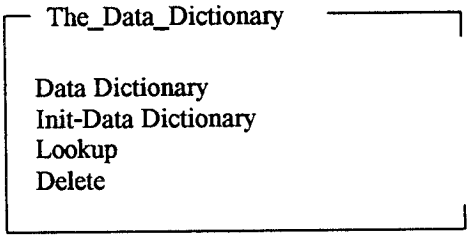
a) Functions

b) Operations

c) Methods

d) Procedures

x. Shown below is an incomplete specification of a Data Dictionary.



Which are the most likely operations that need to be included in order to make this specification complete?

a) Add, Extract, Replace

b) Keep, Replace, Add

c) Remove, Extract, Add

d) Search, Replace, Add

TION 2

a) Define a formal specification. **[2 marks]**

Formal specification techniques are not widely used in industrial software development.

b) Outline four reasons as to why formal specification and formal development methods are not popular. **[4 marks]**

c) Provide four core reasons of adopting a formal method in software development. **[4 marks]**

d) With the aid of a carefully labeled diagram, show how the software development costs with formal specification compare to those without formal specification. **[6 marks]**

e) With reference to part d) above, explain which method is cost effective in overall. **[2 marks]**

f) Suggest two approaches to formal specification that have been used to develop relatively complex systems. **[2 marks]**

TION 3

ification consists of a mathematical model of the system state and definition of ions on that state.

a) Draw and label the major features of a Z schema. **[1 mark]**

b) State the major stages in the development of a Z specification. **[2 marks]**

c) Outline six conventions used in Z to identify particular types of schema and state variables used in operation specification. **[6 marks]**

d) Explain how Z's schema combination mechanism may be used to construct complex specifications. **[2 marks]**

e) The Z schema shown below defines the state space of a lending library.

Library

$stock : \mathbb{P}\ Book$

$onLoan : Book \pfun Borrower$

$dom : onLoan \subseteq Stock$

f) Define an operation called **Borrow** that takes inputs called reader? and book? and which defines the effect on the state of a book being borrowed. The notation **P S** means Powerset **S**. That is, the type of stock is defined as the set of all sets of books. The notation $\subseteq$ can be read as 'is a subset of'. **[3 marks].**

g) Define two further operations on **Library**, namely **New** which adds a new book to the current stock and **Return** that returns a book which has been on loan to the Library. **[6 marks]**

TION 4

a) What do you understand by the term Requirements Engineering? **[2 marks]**

b) Outline problems that can arise during the Requirements Engineering process. **[3 marks]**

c) How can the above-mentioned problems be overcome? **[6 marks]**

d) Give reasons why it is virtually impossible to define a complete and consistent set of requirements. **[3 marks]**

e) *Validity, Consistency, Completeness* and *Realism* are among the several aspects of the requirements that must be checked. Briefly explain what each of these terms mean (examples are welcome). **[6 marks]**

ION 5

he outputs of the requirements analysis process is a set of system models that bstract descriptions of the system to be developed.

a) Give three examples of different types of System Models and what they may be used to represent. **[6 marks]**

b) Suggest three reasons as to why the requirements analysis is often a difficult problem. **[6 marks]**

c) A software system is to be developed to automate a library catalogue. This system will contain information about all the books in a library and will be usable by library staff and by book borrowers and readers. The system should support catalogue browsing, querying and should provide facilities allowing users to send messages to library staff reserving a book that is on loan.

Identify the principal viewpoints that might be taken into account in the specification of this system. Show their relationships using a viewpoint hierarchy diagram. **[8 marks]**

I

TION 6

Discuss three problems of using natural language for requirements specification using small examples, how structuring natural language into forms can help avoid some of these difficulties. **[6 marks]**

List four alternatives to the use of natural language that add structure to the specification. **[4 marks]**

Describe three different types of non-functional requirements which may be placed on a system. Give examples of each of these different types of requirements. **[6 marks]**

Suggest how an engineer responsible for drawing up a requirements specification might keep track of the relationships between functional and non-functional requirements. **[4 marks]**

TION 7

ave been asked to design a software system for the University of Zambia's *ERC tion Resource Center)* Library using object-oriented design techniques and UML n.

sity staffs and students are usual users of the ERC library. A staff or student has to nember in order to be able to use library services (e.g. searching the catalog, ing items, etc.). Each member has a unique id number. Personal information about nember (e.g. name, address and contact number) is stored in the system. Staff rs can borrow up to 50 items at a time, but the limit is only 20 items for students.

ans are running the library and provide services (e.g. managing membership, items) to the members. Each librarian has a unique login name and has to login to stem before using it. The library has a manager, who is a librarian with certain ges (e.g. being able to manage other librarians and managing the library's ion).

brary maintains a large collection of diverse educational resources (e.g. Books, Videos, DVDs, educational kits, maps, etc.). Each item has a unique call number as s a title and year of publication/release. The maximum loan period varies for nt items. There are reserved items that can only be borrowed by staff for one day. are also seven days and 28 days loan items that can be borrowed by both staff and ts.

llowing is a typical scenario for borrowing an item from the ERC:

A member arrives at a checkout with items to borrow.

The member presents his/her membership id to a librarian, who enters it into the system.

The system presents membership information, and status of the member's other loans (if any). If the membership is valid and there is no overdue item, the process will continue. Otherwise, if there is any overdue item, the loan process cannot be

completed until the overdue item(s) are returned and any incurred penalties are paid.

For each item, the librarian records the item call number into the system.

The system presents an accumulated list of borrowed items that includes their corresponding due dates.

The system generates a loan report.

The librarian gives the loan report to the customer, who then leaves the library with the borrowed items.

er to simplify the problem, you may assume that the ERC library is a stand-alone (not part of a larger system) and not interacting with other systems.

on the above information, you are required to:

Draw a use case diagram for the system. **[4 marks]**

Draw a collaboration diagram for adding a new member. **[4 marks]**

Draw a sequence diagram for borrowing an item. **[4 marks]**

Draw a class diagram for the *ERC* library system based on the above requirements. **[8 marks]**

Include as much relevant detail from the above description as possible on the ms, including attributes, associations, constrains and operations. Details such as nd range of attributes and arguments of operations are *not* required.

End of exam

THE UNIVERSITY OF ZAMBIA
Department of Computer Studies

UNIVERSITY EXAMINATION 2005
Wednesday, June 22, 2005

CST4131 - ADVANCED OBJECT - ORIENTED PROGRAMMING

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structions: This examination is divided into two (2) parts. There 40 Multiple-choice questions in PART I and you are required to answer all of them by selecting the letter representing the most correct option. There are four questions in PART II and you are required to attempt three of them
Good Luck!

uration: 3 Hours

RT I : 40 MULTIPLE CHOICE QUESTIONS. 1MARK EACH

What is the output of the following code when compiled and run? Select one correct answer

```
import java.io.*;
public class Question01 {
        public static void main(String[] args) {
                Question01Sub myref = new Question01Sub();
                myref.test();
        }
        void test() throws IOException{
                System.out.println("In Question01");
                throw new IOException();
        }
}
class Question01Sub extends Question01 {
        void test() {
                System.out.println("In Question01Sub");
        }
}
```

A. In Question01Sub
B. In Question01
C. In Question01
   In Question01Sub
D. In Question01Sub
   In Question01
E. The code does not compile, because myref.test is called without a try..catch block

What will happen when you attempt to compile and run this code?

```
abstract class Base{
    abstract public void myfunc();
    public void another(){
    System.out.println("Another method");
    }


public class Abs extends Base{
    public static void main(String argv[]){
        Abs a = new Abs();
        a.amethod();
    }
    public void myfunc(){
        System.out.println("My Func");
    }

    public void amethod(){
        myfunc();
    }
```

a. The code will compile and run, printing out the words "My Func"
b. The compiler will complain that the Base class has non abstract methods
c. The code will compile but complain at run time that the Base class has non abstract methods
d. The compiler will complain that the method myfunc in the base class has no body, nobody at all to love it

What will happen when you attempt to compile and run this code?

```
class Base{
  public final void amethod(){
    System.out.println("amethod");
  }
}

public class Fin extends Base{
  public static void main(String argv[]){
    Base b = new Base();
        b.amethod();
    }
}
```

A. Compile time error indicating that a class with any final methods must be declared final itself
B. Compile time error indicating that you cannot inherit from a class with final methods
C. Run time error indicating that Base is not defined as final
D. Success in compilation and output of "amethod" at run time.

What happens when you attempt to compile and run these two files in the same directory?

```
//File P1.java
package MyPackage;
class P1{

      void afancymethod(){
            System.out.println("What a fancy method");
     }
}
//File P2.java
public class P2 extends P1{
  public static void main(String argv[]){
     P2 p2 = new P2();
     p2.afancymethod();
  }
}
```

A. Both compile and P2 outputs "What a fancy method" when run
B. Neither will compile
C. Both compile but P2 has an error at run time
D. P1 compiles cleanly but P2 has an error at compile time

What best describes the appearance of an application with the following code?

```
import java.awt.*;
public class FlowAp extends Frame{
  public static void main(String argv[]){
   FlowAp fa=new FlowAp();
   fa.setSize(400,300);
   fa.setVisible(true);

  }

  FlowAp(){
      add(new Button("One"));
      add(new Button("Two"));
```

```
    add(new Button("Three"));
    add(new Button("Four"));
  }//End of constructor


}//End of Application
```

A. A Frame with buttons marked One to Four placed on each edge.
B. A Frame with buttons marked One to four running from the top to bottom
C. A Frame with one large button marked Four in the Centre
D. An Error at run time indicating you have not set a LayoutManager

How do you indicate where a component will be positioned using Flowlayout?

A. North, South,East,West
B. Assign a row/column grid reference
C. Pass a X/Y percentage parameter to the add method
D. Do nothing, the FlowLayout will position the component

How do you change the current layout manager for a container

A. Use the setLayout method
B. Once created you cannot change the current layout manager of a component
C. Use the setLayoutManager method
D. Use the updateLayout method

Consider the code. What will be the output?

```
import java.awt.*;
public class CompLay extends Frame{
public static void main(String argv[]){
   CompLay cl = new CompLay();
   }

CompLay(){
   Panel p = new Panel();
   p.setBackground(Color.pink);
   p.add(new Button("One"));
   p.add(new Button("Two"));
   p.add(new Button("Three"));
   add(p,BorderLayout.SOUTH);
   setLayout(new FlowLayout());
   setSize(300,300);
   setVisible(true);
```

```
    }
}
```

. The buttons will run from left to right along the bottom of the Frame
. The buttons will run from left to right along the top of the frame
. The buttons will not be displayed
. Only button three will show occupying all of the frame

/hat will happen when you attempt to compile and run the following code?

```
public class Bground extends Thread{
  public static void main(String argv[]){
        Bground b = new Bground();
        b.run();
  }
  public void start(){
      for (int i = 0; i <10; i++){
            System.out.println("Value of i = " + i);
      }
  }
}
```

. A compile time error indicating that no run method is defined for the Thread class
. A run time error indicating that no run method is defined for the Thread class
. Clean compile and at run time the values 0 to 9 are printed out
. Clean compile but no output at runtime

/hat can cause a thread to stop executing? choose three
. The program exits via a call to System.exit(0);
. Another thread is given a higher priority
. A call to the thread's stop method.
. A call to the halt method of the Thread class?

or a class defined inside a method – Anonymous class, what rule governs access to the ariables of the enclosing class?
. The class can access any variable
. The class can only access static variables
. The class can only access transient variables
. The class can only access final variables

onsider the code below

```
import java.io.*;
class Base{
  public void amethod()throws FileNotFoundException{}
```

```
import java.awt.event.*;
public class MyWc extends Frame implements WindowListener{
public static void main(String argv[]){
      MyWc mwc = new MyWc();
      }
      public void windowClosing(WindowEvent we){
            System.exit(0);
            }//End of windowClosing
     public void  MyWc(){
      setSize(300,300);
      setVisible(true);
      }
}//End of class
```

A. Error at compile time
B. Visible Frame created that that can be closed
C. Compilation but no output at run time
D. Error at compile time because of comment before *import* statements

5 Which of the following statements are correct?

A. If multiple listeners are added to a component only events for the last listener added will be processed
B. If multiple listeners are added to a component the events will be processed for all but with no guarantee in the order
C. Adding multiple listeners to a component will cause a compile time error
D. You may remove as well add listeners to a component.

6 Given the following code

```
class Base{}
public class MyCast extends Base{
   static boolean b1=false;
   static int i = -1;
   static double d = 10.1;
   public static void main(String argv[]){
      MyCast m = new MyCast();
      Base b = new Base();
      //Here
   }
}
```

Which of the following, if inserted at the comment //Here will allow the code to compile and run without error

A. b=m;

m=b;
d =i;
b1 =i;

Which of the following statements is correct to create a thread group and a new
ead in the group?
ThreadGroup tg = new ThreadGroup(); Thread t1 = new Thread(tg, new
Thread());
ThreadGroup tg = new ThreadGroup(); Thread t1 = new Thread(tg, new Thread("
"));
ThreadGroup tg = new ThreadGroup(" "); Thread t1 = new Thread(tg, new
Thread());
ThreadGroup tg = new ThreadGroup(" "); Thread t1 = new Thread(tg, new
Runnable());

ich of the following statements are true. Choose two.
An inner class may be defined as static
There are NO circumstances where an inner class may be defined as private
A programmer may only provide one constructor for an anonymous class
An inner class may extend another class

ich of the following will compile without error? Choose three
File f = new File("autoexec.bat");
DataInputStream d = new DataInputStream(System.in);
OutputStreamWriter o = new OutputStreamWriter(System.out);
RandomAccessFile r = new RandomAccessFile("OutFile");

en the folowing classes which of the following will compile without error?

```
interface IFace{}
class CFace implements IFace{}
class Base{}
public class ObRef extends Base{
   public static void main(String argv[]){
      ObRef ob = new ObRef();
      Base b = new Base();
      Object o1 = new Object();
      IFace o2 = new CFace();
   }
}
```

A. o1=o2;
B. b=ob;
C. ob=b;
D. o1=b;

```
class Base{
public Base(int i){}
}
public class MyOver extends Base{
public static void main(String arg[]){
        MyOver m = new MyOver(10);
        }
    MyOver(int i){
        super(i);
    }

    MyOver(String s, int i){
        this(i);
         //Here
    }
```

A. MyOver m = new MyOver();
B. super();
C. this("Hello",10);
D. Base b = new Base(10);

Which of the following method is a member of the Vector class and allow you to input a new element

A. addElement
B. insert
C. Append
D. addItem

Which of the following are correct event handling methods

A. mousePressed(MouseEvent e){}
B. MousePressed(MouseClick e){}
C. functionKey(KeyPress k){}
D. componentAdded(ContainerEvent e){}

Which of the following best describes the use of the synchronized keyword?
A. Allows two process to run in parallel but to communicate with each other
B. Ensures only one thread at a time may access a method or object
C. Ensures that two or more processes will start and end at the same time
D. Ensures that two or more Threads will start and end at the same time

A FileInputStream is created as shown in the code below. Select two correct statements.
FileInputStream out = new FileInputStream("input.dat");
A. If the file "input.dat" does not exist, then one is created in the directory where the application is residing.
B. The code may throw a FileNotFoundException.
C. Instead of specifying the file name as a String, we also have the possibility of providing a File object or a RandomAccessFile object.
D. out can then be used to read from the specified file.
E. out cannot be chained to another InputStream.

What should be done to invoke the run() method on a thread for an object derived from the Thread class. Select the one correct answer.
A. The run() method should be directly invoked on the Object.
B. The start() method should be directly invoked on the Object.
C. The init() method should be directly invoked on the Object.
D. The creation of the object using the new operator would create a new thread and invoke its run() method.

What is the default priority of a newly created thread.
A. MIN_PRIORITY (which is defined as 1 in the Thread class.)
B. NORM_PRIORITY (which is defined as 5 in the Thread class.)
C. MAX_PRIORITY (which is defined as 10 in the Thread class.)
D. A thread inherits the priority of its parent thread.

Which of following correctly describes the functionality of the method drawRect(int a, int b, int c, int d) defined in jawa.awt.Graphics class. Select the one correct option.
A. Draws the outline of a rectangle with a, b being the x,y co-ordinates of top left corner, and c,d being the x,y co-ordinates of the bottom right corner.
B. Draws the outline of a rectangle with a, b being the x,y co-ordinates of top left corner, and c,d being the width and height of the rectangle.
C. Draws a filled rectangle with a, b being the x,y co-ordinates of top left corner, and c,d being the x,y co-ordinates of the bottom right corner.

Draws a filled rectangle with a, b being the x,y co-ordinates of top left corner, and c,d being the width and height of the rectangle.

ıe getSource method defined in the EventObject class returns the source of an event. hat is the return type of this getSource method?

EventObject
Event
Object
Component
Button

ıat does the following code do?

FileInputStream fis = new FileInputStream("test.dat");

It creates a new file named test.dat if it does not exist and opens the file so you can write to it.
It creates a new file named test.dat if it does not exist and opens the file so you can write to it and read from it.
It creates a new file named test.dat regardless of whether it exists or not and opens the file so you can write to it.
It creates a new file named test.dat regardless of whether it exists or not and opens the file so you can write to it and read from it.
None of the above is correct.

Which of the following methods cannot be invoked by an instance of eamTokenizer?

a. nextToken()
b. toString()
c. equals()
d. close()

Which type of exception occurs when creating a FileInputStream for a nonexistent ?

a. FileNotExist
b. FileNotExistException
c. FileNotFound
d. FileNotFoundException

nalyze the following code:

```
class Test implements Runnable
{
 public static void main(String[] args)
 {
  Test t = new Test();
 }

 public Test()
 {
  Thread t = new Thread(this);
  t.start();
 }

 public void run()
 {
  System.out.println("test");
 }
}
```

The program has a compilation error because t is defined in both the main() method and the constructor Test().
The program compiles fine, but it does not run because you cannot use the keyword this in the constructor.
The program compiles and runs and displays nothing.
The program compiles and runs and displays test.

e getSource method defined in the EventObject class returns the source of an event. at is the return type of this getSource method?
EventObject
Event
Object
Component
Button

set no layout manager, you use _____.
setLayout();
setLayout(null);
Either a or b
Neither a nor b

To listen to keyboard actions, the listener must implement the _____ interface.
A. MouseListener()
B. KeyListener()
C. WindowListener()
D. ComponentListener()

The getKeyCode() method of the KeyEvent returns _____.
A. a character
B. the ASCII code of the character
C. the Unicode code of the character
D. None of the above.

The method _____ gets the contents of the text field jtf.
A. jtf.getText(s)
B. jtf.getText()
C. jtf.getString()
D. None of the above.

The method _____ appends a string s into the text area jta.
A. jta.setText(s)
B. jta.appendText(s)
C. jta.append(s)
D. None of the above.

RT II: CHOOSE THREE (3) OUT OF FOUR (4)

Analyse the code below?

```
import java.applet.Applet;
import java.awt.Graphics;
import java.awt.Color;
public class DrawSomething extends Applet
{

    public void paint(Graphics g)
    {

        int n = Integer.parseInt(getParameter("number"));

        int width = 20;

        int x = 0;
        int y = 0;
        Color color = Color.black;
        for (int i=n; i>=0; i--)
        {
            g.setColor(color);
            g.fillOval(x,y,i*width, i*width);
            if (color.equals(Color.black)) color = Color.white;
            else color = Color.black;
            x = x + width/2;
            y = y + width/2;
        }
    }
```

this program to run, an HTML file is required.

A Write the appropriate html code to load this program considering the following
   i the title of the applet is "Drawing Something" [2]
   ii the variable n is supposed to ha a value of 10[4]
   iii the dimension of the applet to be 400 by 400. [2]

B Write two commands that can be used to run this applet?[2]

C What does the statement g.setColor(color) do? [2]

D What graphic is drawn when this applet is loaded? Draw the graphic [8]

```
2
3  public interface A {
4      final float MAX = 100;
5      private int add(int x)
6  }
7  private class B extends A {
8      float x = 0
9      public static int main(String arg)
10         add(MAX);
11         System.println("Total = "+x)
12     }
13     private int add(int x)
14     {
15         x += x;
16     }
17 }
18
```

A This code has a number of errors. Rewrite it so it *compiles* and *executes* correctly to display "Total = 100" using the interface A method and constant. Highlight your changes by underlining them. [4]

B Consider the following class that describes a worker

```
public class Worker
{
    private String name;
    private double salaryRate;
    public Worker (String name, double salaryRate)
    {
        this.name = name;
        this.salaryRate = salaryRate;
    }
    public String getName()
    {
        return name;
    }

    public double getSalaryRate()
    {
        return salaryRate;
    }
    public double computePay (int hours)
    {
        if (hours > 40)
        return (40*getSalaryRate() + (hours - 40)*1.5*getSalaryRate());
        else
        return hours * getSalaryRate();
    }
}
```

e two subclasses: SalariedWorker and HourlyWorker.

i Write a subclass called SalariedWorker with
- an appropriate constructor [2]
- and a method compute that computes the salary. The salaried worker gets paid the hourly wage for 40 hours, no matter what the actual number of hours is. [4]

ii Write another subclass called HourlyWorker with
- an appropriate constructor and [2]
- compute method (if needed). An hourly worker gets paid the hourly wages for the actual number of hours worked, if the hours worked is at most 40. If the hourly worker worked more than 40 hours, the excess is paid at a time and a half. [4]

iii write a separate static method that uses polymorphism to compute the pay of any Worker object.[4]

Discuss the purpose of a Thread in Java. [2]

Using a diagram, illustrate the various states in which a thread can be, showing the transition [6]

Describe two alternative ways to create a Thread in Java and provide an example of each using some Java code. [6]

Write an applet, using any of the methods in C, which uses a thread and a Boolean variable to display a flickering square of dimension 20, 20 pixels with its top left corner at point (50,50). i.e. it is displayed red and the next second it is displayed green. You don't need to write the html code[6]

Discuss the hierarchy of data items in, which the computer processes starting with the smallest to the most complex one. [Start with bits – binary digits] [6]

What are the two topmost classes for reading files

i as streams [1]

ii as characters [1]

What are the two topmost classes for writing data to files

i as streams [1]

ii as characters [1]

Write a program that copies one file to another. The files names are specified on the command line.

java CopyFile report.txt report.sav

Here is a skeleton of the program that you can fill in.

```
//import the necessary packages. [1]

public class CopyFile
{
  public static void main (String [] args)
  {
            // process command line arguments [2]
            // open first file for reading and second for writing[2]
            // read first file (line by line)[2]
            // and write out to the second file.[2]
            // close files[1]
  }
}
```

**********END OF EXAMINATION**********

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 175: INTRODUCTION TO MAPPING TECHNIQUES

PAPER II: THEORY

STATISTICAL MAPPING AND DIAGRAMS

IME: Three hours

NSTRUCTIONS: Answer any four questions

The use of a Philips' University Atlas and an approved calculator is allowed. You are encouraged to make use of illustrations wherever appropriate.

Geographers like their counterparts in social sciences have devised a means to classify students' performance in educational institutions according to certain social and economic variables. In this classification, the socio-economic grouping, is divided into the following groups: A, B, C, D, and E in descending order.

The data in Table 1 represents the scores obtained on the verbal portion of a Scholarstic Aptitude Test (SAT- verbal scores) by a sample of 50 students in relation to their socio-economic class:

Table 1
Socio-economic/SAT- verbal scores data of a random sample of 50 students

35 (A)	37 (B)	12 (C)	26 (D)	22 (E)
30 (D)	39 (B)	37 (A)	37 (C)	29 (E)
33 (A)	34 (B)	23 (C)	16 (D)	25 (E)
20 (E)	10 (D)	27 (C)	36 (A)	33 (B)
40 (A)	40 (B)	24 (E)	28 (C)	29 (D)
29 (B)	27 (C)	34 (A)	26 (D)	28 (E)
15 (E)	40 (A)	29 (B)	25 (C)	17 (D)
25 (B)	20 (C)	38 (A)	12 (E)	18 (D)
40 (B)	31 (A)	25 (C)	15 (D)	22 (E)
21 (D)	40 (B)	18 (E)	41 (A)	27 (C)

Construct a frequency distribution of SAT- verbal scores, using a class interval width of four units and begin the first class at 9.5.

What is the frequency of the third class interval?

What is the relative frequency of the eighth class interval?

Construct cumulative frequency distributions of SAT – verbal scores using the frequency distribution obtained in (a).

What is the frequency of scores below 26?

What is the relative frequency of scores above 33?

Construct a two-way table showing the frequencies in each score/socio-economic class combination. Consider scores in the following three groups: less than 25; 25 to 35; and more than 35.

Comment on the relationship between scores and socio-economic class.

sample consists of 34 observations, recorded as correct to the nearest tenth of a it, ranging in value from 20.1 – 33.7. If it is decided to use seven classes of width 2 its and to begin the first class at 19.5.

(a) Explain what you understand by the term class boundary and then find the class boundaries of the seven classes.

(b) Explain the term class limit and then calculate the class limits of the seven classes.

(c) What do you understand by the term class mark and thereafter calculate the class marks of the seven classes.

e Central Statistical Office in April 2001 released a Preliminary Report of the 2000 nsus of Population and Housing which includes the following information:

Table 2

Population Size in Lusaka Province by District

District	Male	Female	Total
Chongwe	72, 735	72, 001	144, 736
Kafue	83, 421	78, 841	162, 262
Luangwa	10, 686	11, 304	21, 990
Lusaka	545,551	557,862	1, 103, 413
Total	712,392	720,008	1, 432, 401

Source: GRZ (2001) ***Preliminary Report of the 2000 Census of Population and Housing,*** CSO, Lusaka, P9.

You have been requested by your lecturer to present the information in Table2 in a form suitable for inclusion in any geographical publication. He wants the data not only to be attractive but also easy to understand.

(a) Prepare a visual display to show the data in Table 1

(b) What are the merits and limitations of the method you have used?

Examine the data given in Table 3 and then answer the questions that follow:

(a) Use the most appropriate statistical mapping technique to show the frequency of mini-buses into Lusaka's city centre on a typical winter Sunday along specified roads on the outline map of Lusaka provided (Figure 1).

(b) Comment on the merits and limitations of the method that you have used.

Table 3

Frequency of Mini-buses into Lusaka on a winter Sunday

Origin	Route	Number of Buses
Matero	Lumumba Road	39
Garrapodi	Great North Road	42
Helston	Great East Road	38
Chilenje	Chilimbulu Road	19
Mawama	Kafue Road	15
Chinyama	Los Angels Road	13

Source: *Imaginary*

Assume that an audit consultant engaged to look into the operations of a named firm has produced an audit report, which includes the cash flow with comparative data from the previous year.

Table 4

Cash flow with comparative data from the previous year

m	Cash Flow 2004 (millions)	2003 (millions)
aries	30	25
xation on profit	10	08
erest on loans	05	05
ıewal of Equipment	09	08
estment Costs	12	10
airs	04	04

Source: *Imaginary*

(a) For the data shown in Table 4, show the change in circumstances from one year to the next in relative terms as a proportion of the total cash flow for each year.

(b) What are the advantages and disadvantages of the method that you have used?

tudy the data given in Table5 and then,

a) Show the production of wheat per hectare in some European countries during the 1963/64 agricultural season on the outline map (Figure 2) of Europe provided.

b) What are the merits and limitations of the method you have used?

Table 5

Wheat Production (1963/64) in some European Countries

untry	Area Planted ('000 hectares)	Production ('000 Metric Tons)
stria	275	690
gium	204	770
nmark	135	495
nce	3850	10249
rmany	1382	4856
y	4394	8127
herlands	126	530
tugal	740	592
in	4247	4866
tzerland	107	303
ted Kingdom	780	3046

Source: *Imaginary*

END OF EXAMINATION

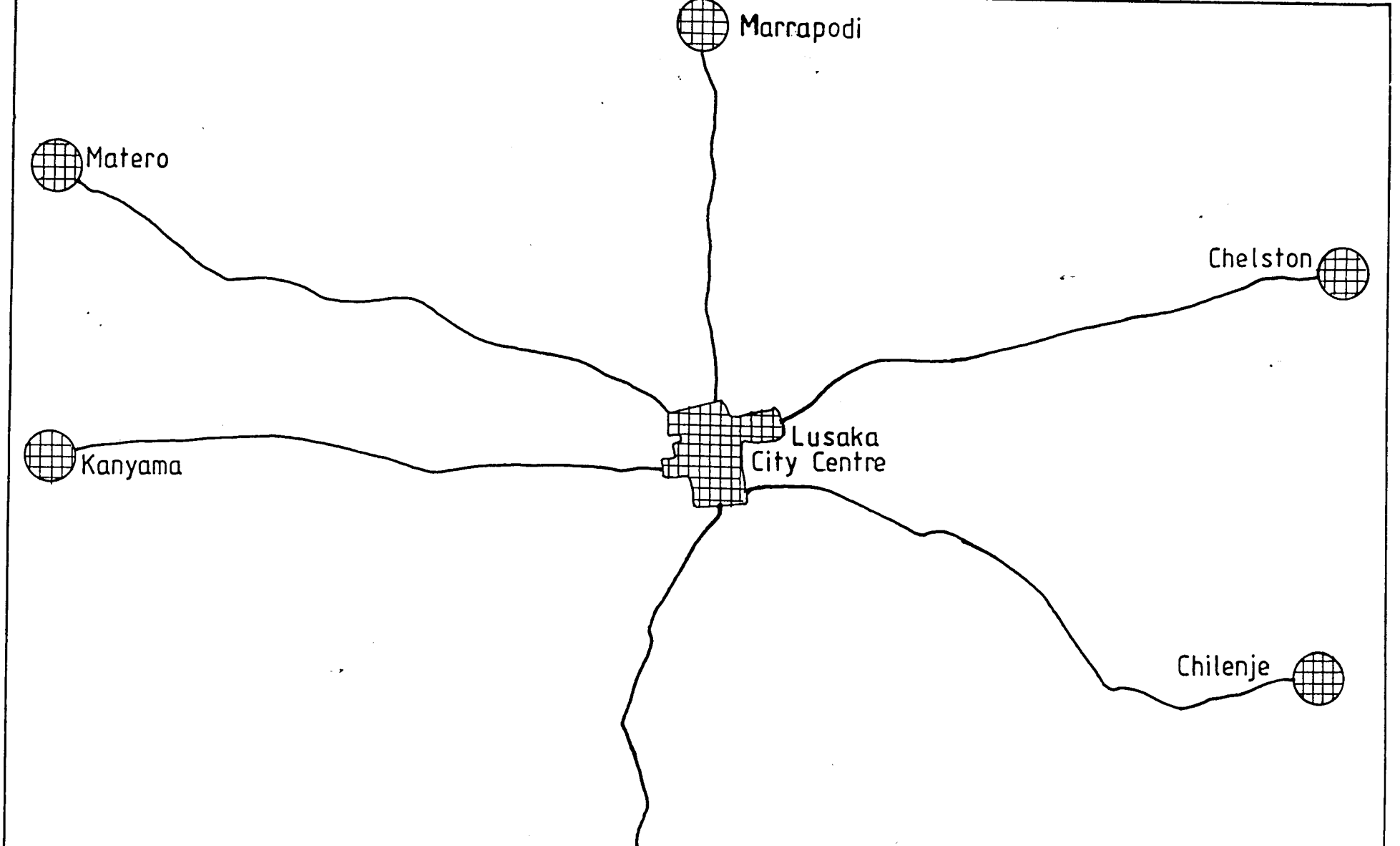
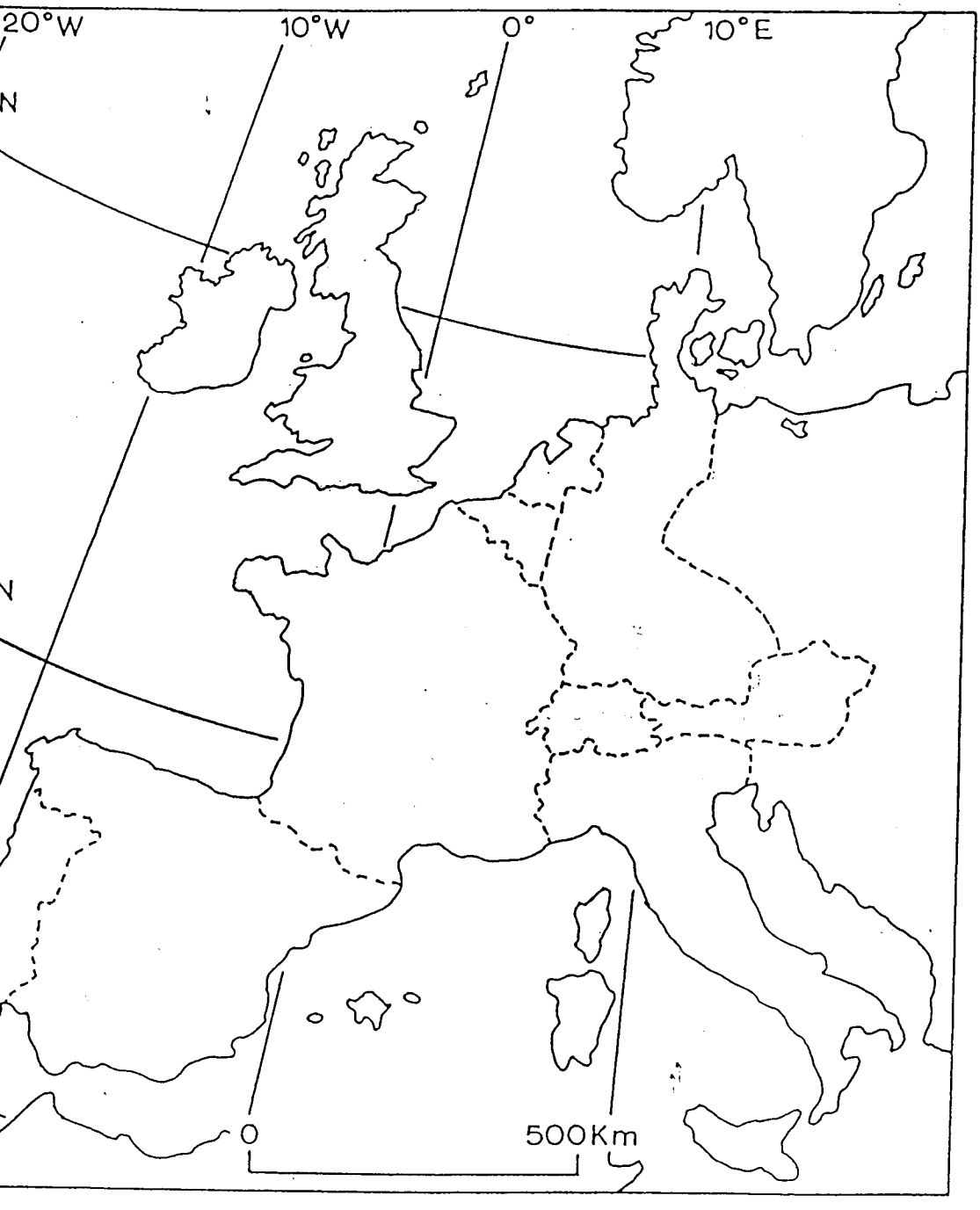

Marrapodi
Matero
Chelston
Kanyama
Lusaka
City Centre
Chilenje

Figure 2

Computer No. ----------



THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 175: INTRODUCTION TO MAPPING TECHNIQUES

PAPER I: PRACTICAL

MAP READING, ANALYSIS AND INTERPRETATION

IME: Three hours

NSTRUCTIONS: Answer all questions

The use of a Philips' University Atlas and an approved calculator is allowed. You are encouraged to make use of illustrations wherever appropriate.

ECTION A: IDENTIFICATION AND INTERPRETATION OF FEATURES ON TOPOGRAPHICAL MAP SHEET 1228 C1

nswer all questions in this section in the Examination Answer Book provided.

(a) When was Map Sheet 1228 C1 published and by whom? [2 marks]

(b) Explain clearly how you could read a Four Figure Grid Reference on Map Sheet 1228 C1. [2 marks]

(c) What other map sheet would you require if you wanted to have a full view of Mufulira Township? [2 marks]

(d) In which district is Mufulira Agricultural Station (Grid Square 2405) located? [2 marks]

(e) What drainage pattern does the Chifinsa River and its tributaries on Map Sheet 1228 C1 exhibit? [2 marks]

(f) Using map evidence only, suggest any four human activities which have had an impact on vegetation in the Luano National Forest Reserve Number 12? [2 marks]

(g) What non- – landscape feature is associated with the Kafue River on Map Sheet 1228 C1? [2 marks]

) Suggest any two reasons that may help to explain the absence of cultivation in Grid Square 3013? [2 marks]

) In which direction do the Mwambashi and Musakashi Rivers generally flow? [2 marks]

) What is the relationship between drainage and settlements between eastings 20 and 27 and northings 01 and 07? [2 marks]

a) What is the approximate distance in Kilometres along the main tarred road from the road junction in Grid Square 2194 to the bridge on the Kafue River at Grid Reference point 264022? [2 marks]

What is the Grid Bearing of the trigonometrical station in Grid Square 2805 from the Kafue/Mutundu river confluence in Grid Square 3296? [2 marks]

What is the average gradient along a straight line from Grid Reference point 230074 to Grid Reference point 240066 in degrees? [3 marks]

) With reference to the development of a drainage basin, the Kafue River can be described as a consequent stream. What terms can best describe the following: [4 marks]

(i) Itimpe River and Fikondo Rivers
(ii) Lukashi and Musakashi Rivers
(iii) Luansobe and Lukungwe Rivers
(iv) Chambeshi and Lwela Rivers

(e) On what relief feature is Kafironda located?[2 marks]

(f) What evidence is there on Map Sheet 1228 C1 to show that some farmers keep cattle? [2 marks]

g) How many districts are partially covered by Map Sheet 1228 C1? [2 marks]

a) On a sheet of metric graph paper provided, draw a straight-line profile from Grid reference points A (175090) to grid reference point B (304052). On the profile show the following positions: [18 marks]

(i) Kafue River
(ii) 66 kV power line
(iii) M4 tarred road
(iv) Trigonometrical Station in Grid Square2805

b) Are points A and B inter-visible? [2 marks]

SECTION B: MEASUREMENT AND SKETCH DRAWING

nswer all questions in this section and wherever necessary show all stages of your ork.

(a) Express 1:5 000 as a scale in words [3 marks]

(b) Express two centimetres to one kilometre as a scale in figures. [3 marks]

(c) Using a scale of 1:20 000, calculate to scale the dimensions of a rectangular area measuring 10 kilometres by six kilometres (10 Km x 6 Km). [5 marks]

(d) Calculate the exact width of a dual carriage roadway measuring 2 millimetres on a map of 2 centimetres to a kilometre. [3 marks]

(e) Draw a line scale in metric units for a map drawn at the scale of 1:20 000, given that the maximum space available is 19 centimetres. [6 marks]

(f) Using the contour method, draw a ridge at a 20 metre vertical interval showing a river flowing on the dip slope with its source near the summit. [5 marks]

(g) With the help of a diagram, describe an annular drainage pattern and briefly explain the characteristics of the area on which it develops. [5 marks]

(a) What are stereo-pairs? [3 marks]

(b) Name any two elements that can help in the identification of features on aerial photographs [3 marks]

(c) With the help of an example, explain how mean scale can be calculated on a vertical aerial photograph. [4 marks]

(d) Explain the basic difference between high and low oblique air photographs. [3 marks]

(e) An aerial photo survey was carried out in the vicinity of the University of Zambia. The flying height of the plane was 7, 625 metres above the ground and the camera used has a focal length of 152.5 millimetres. Assuming that the Goma Lakes are visible on the photograph and the distance between the two lakes is 1.2 millimetres long, what would be the actual distance on the ground?[7 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR FIRST SEMESTER DEFERED FINAL EXAMINATIONS

GEO 271: QUANTITATIVE TECHNIQUES IN GEOGRAPHY 1

IE: THREE HOURS

TRUCTIONS: ANSWER FOUR QUESTIONS. USE OF A PHILIPS UNIVERSITY ATLAS IS ALLOWED. CANDIDATES ARE ENCOURAGED TO MAKE USE OF ILLUSTRATIONS WHEREVER APPROPRIATE.

. 'Traditional medicines and some beliefs are science, but are in themselves not Scientific'. Discuss.

. Mr. Mulyambeba was asked to evaluate whether or not the following problem statement was of acceptable standard. The statement read as follows: 'the prevalence of corruption in Zambia is associated with a number of factors. These manifest themselves in terms of joblessness, meager wages, low standard of living and irregularities in procurement procedures'.

(a) What are the flaws in this problem?
(b) Present a more researchable problem.
(c) State four objectives for the problem stated in (b).

. Explain the various characteristics that a well chosen research problem should satisfy.

. Discuss the importance of 'literature review' and 'methodology' in research.

. Compare and contrast unstructured interview schedule and focus group discussion guide.

. What are the advantages and disadvantages of project impact evaluation?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR FIRST SEMESTER EXAMINATIONS

GEO 381: ENVIRONMENT AND DEVELOPMENT I

ME: Three hours

STRUCTIONS: Answer questions one (Compulsory) and any other three. All questions carry equal marks. The use of a Philip's University Atlas is allowed. Candidates are encouraged to make use of illustrations wherever appropriate.

Write short explanatory notes on **all** of the following:

(a) Environment and economic integration in sustainable development.
(b) Global warming.
(c) The effect of international conventions on the environment.
(d) Eco-development.
(e) Sustainable development.

"The potential gains from appropriate Biotechnology can be of great benefit to the farmer, ...but like any scientific discovery, Biotechnology poses risks." (Economic Commission for Africa, 2000: 100). Discuss.

Explain Land Use Planning as a tool in Environmental Planning and Management.

Discuss the behaviour of Environmental Systems over time with respect to the Dynamic Equilibrium Phenomenon.

'Strategies for sustainable development in Africa are environment driven, bureaucratic, ignore future needs, promote weak participation, with ambiguity of donor roles.' Discuss.

A large manufacturing company based in a developed country plans to relocate some of its production plants to some Third World Countries. Discuss the possible reasons for the company's plans in general, with reference to environmental welfare in particular.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR FIRST SEMESTER DEFERREDEXAMINATIONS

GEO 481: ENVIRONMENT AND DEVELOPMENT II

ME: Three hours

STRUCTIONS: Answer questions one (Compulsory) and any other three. All questions carry equal marks. The use of a Philip's University Atlas is allowed. Candidates are encouraged to make use of illustrations wherever appropriate.

Write short explanatory notes on **all** of the following:

(a) Effects of ground water extraction on the environment.
(b) Drought hazard.
(c) Geographical Information Systems.
(d) Acidification.
(e) Collective management of natural resources.

Discuss the effects of international trade on sustainable agriculture.

'Policy for the management of natural resources must address both the will for sustainable production and the ways and means'. Discuss.

Discuss sustainable practices in agriculture with respect to soil tillage, soil fertilisation, and irrigation.

Explain the core themes that bio-energy address in sustainable development.

Outline the important principles that apply to the development of natural resources policies.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 451: LAND RESOURCES SURVEY

TIME: Tree hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks. The use of a Philip's University Atlas is allowed. Candidates are encouraged to make use of illustrations wherever appropriate.

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1. Describe the three common methods of natural resources surveys and assess the situations in which they are commonly used.

2. Evaluate the use of the 'soft' and 'technical' approaches in land evaluation.

3. Discuss the importance of population and human resources in the social economic analysis.

4. Describe the Two Stage and Parallel Approaches in land evaluation and situations in which they are relevant.

5. Describe the method that is used to assess the length of a growing period for an agro-ecological region.

6. Explain the following terms used in land resources assessment:

   (a) Adaptation
   (b) Major land improvement
   (c) Compound Land Utilization Type
   (d) Gross Margin Analysis
   (e) Potential land suitability

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR FIRST SEMESTER DEFERRED EXAMINATIONS

GEO 911: POPULATION GEOGRAPHY

IME: **Three hours**

NSTRUCTIONS: **Answer any four questions.**
All questions carry equal marks. Use of an approved Calculator and a Philips' University Atlas are allowed.
Candidates are encouraged to use illustrations wherever Appropriate.

Study Table 1 and answer the questions that follow.

Table 1: Selected Demographic Indicators for Country Y in mid – 1995.

Total Population	3,507,919
Total Births	35,080
Total Deaths	38,588
Population Growth Rate	0.3

a) Provide the demographic characteristics of Country Y in mid 1995.

b) Justify the difference between the Rate of natural Increase and the Population Growth Rate.

c) At what stage of the Demographic Transition Theory is Country Y?

d) Assuming that all the demographic trends remained constant, use the continuous method to estimate the population size of country Y in 2000.

Examine the assertion that ' Malthus (1766 – 1834) and Marx (1818 – 1883) were n total agreement on the issue of population growth and the welfare of mankind.'

Discuss the developments which led to Mortality Transition in Europe in the Eighteenth and Nineteenth Centuries and show how these changes helped the Least Developed Countries to move to the early expanding stage of the Demographic Theory later.

To what extent do Hoffman and Hoffman's (1973) 8 scheme of non- economic Values of children provide an explanation of the current fertility Rates in rural Zambia.

Increasing women's access to and control of socio-economic resources is a Necessary step to reduce births voluntarily (Jacobson 1992). Discuss.

Compare and contrast the use of the census and sample surveys as demographic data Collection methods in Zambia.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

005 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 931:RURAL GEOGRAPHY

E: THREE HOURS.

RUCTIONS: ANSWER ANY FOUR QUESTIONS.
CANDIDATES ARE ADVISED TO MAKE USE OF ILLUSTRATIONS AND EXAMPLES WHEREVER APPROPRIATE. USE OF A PHILIPS ATLAS IS ALLOWED.

Why is it necessary to apply the Participatory Rural Appraisal (PRA) methodology in undertaking research in Rural Geography?

Justify the assertion that rural land use in Africa has evolved from the simple to the complex?

What is the role of transport in promoting rural development in Africa?

In what ways did the industrial development strategy in Zambia contribute to rural industrialization after independence?

What factors account for rural settlements in Africa?

Suggest an approach that can facilitate the provision of water and sanitation to rural areas of Zambia in a sustainable manner.

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 951: CLIMATOLOGY

TIME: Three Hours

INSTRUCTIONS: Answer any Four Questions.
All questions carry equal marks. Candidates are encouraged to make use of illustrations wherever appropriate.

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1. With the aid of a schematic diagram, describe the major components of the global climate system, their processes and interactions and some aspects that may change.

2. Distinguish between tropical and extratropical cyclones.

3. Outline the possible causes of global climate change and the international response to address anthropogenic climate change.

4. With the aid of a diagram, describe the major components of the hydrological cycle and explain how the components are measured and evaluated.

5. With the aid of a diagram, describe the monsoon climate system.

6. Write short explanatory notes on all of the following:

   (a) Climate classification using air masses
   (b) Atmospheric radiation budget
   (c) International Cooperation in meteorology and climatology.
   (d) EL Nino Southern Oscillation (ENSO)
   (e) Inter Tropical Convergence Zone (ITCZ)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

)5 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 961: SOILS GEOGRAPHY

Three hours.

TIONS: Answer any four questions.

All questions carry equal marks. The use of a Philips' University Atlas is allowed and candidates are encouraged to make use of illustrations wherever appropriate.

Write short explanatory notes on all of the following:

(a) Genesis of a spodic horizon
(b) Contribution of autotrophic bacteria to soil fertility
(c) Relationship between aquic moisture regime and reduction
(d) Why 1:1 clays do not expand and contract when wet and dry
(e) Influence of the precipitation factor on the Revised Universal Soil Loss Equation (RUSLE)

Discuss the properties and influences in soils of organic matter and sesquioxides.

Using specific examples, explain how you would use the factors of soil formation during air photo interpretation for soil surveys.

Explain the relationships that exist among Cation Exchange Capacity (CEC), Base Saturation ercent (BSP) and Acidity (pH)

escribe the typical characteristics of an Alfisol including the environmental conditions under hich they commonly develop.

valuate the importance of different forms of water found in soil.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 961: SOILS GEOGRAPHY

Three hours.

ONS: Answer any four questions.

All questions carry equal marks. The use of a Philips' University Atlas is allowed and candidates are encouraged to make use of illustrations wherever appropriate.

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Genesis of a spodic horizon
Contribution of autotrophic bacteria to soil fertility
Relationship between aquic moisture regime and reduction
Why 1:1 clays do not expand and contract when wet and dry
Influence of the precipitation factor on the Revised Universal Soil Loss Equation (RUSLE)

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END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 ACADEMIC YEAR
FIRST SEMESTER EXAMINATIONS

GEO971
AERIAL PHOTOGRAPHY AND AERIAL PHOTO INTERPRETATION

PAPER II

E: THREE HOURS.

TRUCTIONS: ANSWER ALL QUESTIONS. SPEND A MAXIMUM OF 45 MINUTES WITH THE MATERIAL PROVIDED FOR EACH QUESTION.

TE: 1 ft = 0.305m

'ou are provided with true colour, colour infrared and panchromatic vertical erial photographs covering parts of the area in Central Scotland shown on ne accompanying map. With respect to these photographs, answer the uestions that follow.

) What colour (tone) typifies each of the following features on the three photographs?

i. Deep water.
ii. Shallow water.
iii. Tarred roads.
iv. Gravel roads.
v. Healthy trees.
vi. Healthy crops.

Which parts of the electromagnetic spectrum were being detected on the respective film types to result in the respective tones (colours) you stated in (a)?

The photos cover only the central portion of the accompanying map. Suppose you wanted aerial photographs to be acquired for all of the area depicted by the map, and that you wanted them to be acquired from the same flying height (above sea level) used to acquire the true colour photo. How many photos would need to be acquired, assuming a camera focal

length of 152.4mm, 60% endlap, 30% sidelap and 23cm photo format? The area is approximately 5km long (East-West) and 3km wide (North-South).

Photos 20:34 and 20:35 (Contract ZA 96/2 LUSAKA CITY) are a stereopair covering the part of Lusaka shown on the attached map. Using the photos, proceed with the tasks that follow.

a) What is the land cover type at (-3.0, 4.5)cm on photo 20:35?

b) State the texture of the feature at (2.5, -0.5)cm on photo 20:35.

c) State the respective acquisition times for photos 20:34 and 20:35.

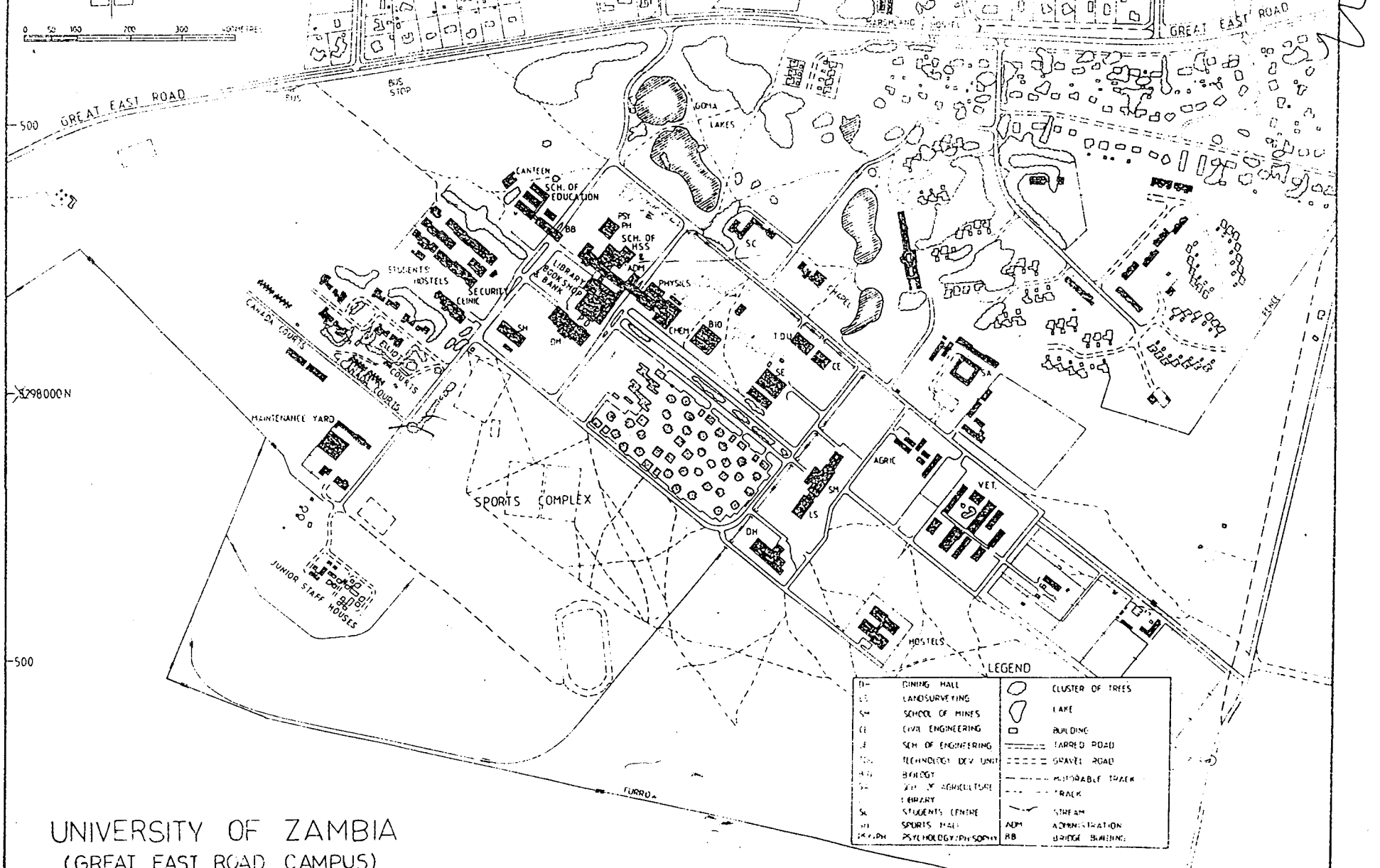
d) Given that the feature at (4.5, 4.5)cm on photo 20:34 is the same feature at (-3.0, 4.5)cm on photo 20:35, how would you explain the difference in the tone of the feature in the short time interval between these two successive exposures?

e) For the relatively flat area between (-9.5, 0.0)cm and (-7.4, -2.2)cm on photo 20:35, determine the true scale of photo 20:35.

f) Determine the height of the feature located at (-8.7, 0.0)cm on photo 20:35.

Photos 31A:10 and 31A:11 (Contract ZA 96/2 LUSAKA CITY) are a stereopair covering the rural area north-west of Lusaka (Chibombo District). On the tracing paper provided, produce a land use / land cover classification of the overlap area of the stereopair. Use the Land Use / Land Cover Categories on Zambian Maps interpretation key provided.

END OF EXAMINATION



UNIVERSITY OF ZAMBIA
(GREAT EAST ROAD CAMPUS)

ND USE/LAND COVER CATEGORIES ON ZAMBIAN MAPS (1:50 000)

Towns or areas with permanent buildings

Other populated areas

Huts, villages

Roads – main, tarred

- regularly maintained
- maintained

Motorable tracks or farm roads

Railway

Powerline

Mine

Water course

Well, spring, borehole, reservoir

Furrow, Pipeline

Sand or mud

Rock outcrop

Thick forest

Woodland

Thicket

Open bush or tree grassland

Scattered cultivation

Cultivation and plantation

Bush group

Dambo or other areas liable to flood

Marsh or swamp

Rice

UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATION – 2005

M111 MATHEMATICAL METHODS I

ISTRUCTIONS	:	(A) ANSWER ANY FIVE (5) QUESTIONS (B) CALCULATORS SHOULDN'T BE USED
ME ALLOWED	:	THREE (3) HOURS

(a) Let A and B be subsets of the universal set E. Simplify the following as one single set given that $A \subset B$.

(i) $(A \cap E)' \cup B'$ (ii) $A \cap (B \cup E)'$

(ii) $(A \cup B) \cap E$ (iv) $E \cap (A \cap B)'$

(b) (i) Show that $3.28\overline{17817817}.....$ is a rational number.

(ii) Is the operation + (addition) binary on the set $S = \{-2, -1, 0\}$. Justify your answer.

(iii) Express the expression $\frac{3-\sqrt{4}}{3+\sqrt{8}}$ in the form $a + b\sqrt{c}$, a, b, c $\in$ R.

(c) (i) Given that $Z = -1 + 2i$ and $\frac{1}{W} = 1 - 2z + z^2$ find W in the form $a + ib$, a, b E R.

(ii) Given that $\sqrt{3}$ is irrational, prove that $5 - \sqrt{3}$ is irrational.

(a) Find all values of x which satisfy the following:

(i) $|x - 1| > 1$ (ii) $\sqrt{2-x} < \frac{1}{2}$

(iii) $\frac{x+2}{x-3} \leq 3$ (iv) $x^4 + 2x^2 + 4 > 0$.

(b) Let $f(x) = 1 + 3\text{Sin}(2x)$, $x \in [0, 2\pi]$.

(i) Find the amplitude (ii) Find the period

(iii) Find the phase shift (iv) Sketch the graph of f(x)

(c) (i) The curve of the function $f(x) = ax^2 + bx + c$ passes through the point (2,1). The gradient of the curve (slope of the tangent line) at the point (1,2) is zero. Find the values of a, b and c.

(ii) Find all real values of x which satisfy the equation $x^2 - \frac{1}{x} = 0$.

3. (a) Given that $f(x) = 5 - 2x - 3x^2$

(i) Use the method of completing the square to find the maximum value of f(x).

(ii) Find the values of x when $f(x) = 0$

(iii) Sketch the graph of f(x)

(b) (i) If $A = \frac{1+Cos\theta}{Sin\theta}$, prove that $A + \frac{1}{A} = 2\,\text{cosec}\,\theta$.

(ii) Find the derivative form first principles of $f(x) = \frac{1}{\sqrt{2x+1}}$

(c) Let $g(x) = \begin{cases} x+3 & if\ x < 1 \\ 2 & if\ x = 1 \\ 3x-4 & if\ x > 1 \end{cases}$

(i) Sketch the graph of g(x).

(ii) Find $\lim_{x\to 0} it\ g(x)$.

(iii) State with justification whether f(x) is continuous at x = 1.

4. (a) (i) If Cot β =P, prove that $\text{Cos } 2\beta = \frac{P^2-1}{P^2+1}$

(ii) If $f(x) = 1 + 3 \text{ Sin } x$, find all the values of x for which

$f(x) = 1 + 3\text{Sin}(2x), \quad x \in [0, 2\pi]$

(b) (i) Given that $y = \frac{1+Cotx}{1-Cotx}$, show that $\frac{dy}{dx} = \frac{2}{Sin(2x)-1}$

(ii) Find $\lim_{x\to -2} it\ g(x)$, if $g(x) = \frac{x^2-x-6}{x+2}$

(c) Given that $h(x) = \frac{x+1}{x+2}$

(i) Find the domain and range of h(x)

(ii) Find the vertical and horizontal asymptotes of h(x).

(iii) Sketch the graph of h(x)

5. (a) Given $f(x) = \sqrt{1-x^2}$ and $g(x) = \text{Sin } x$, find the following:

(i) $(fog)(\frac{\pi}{3})$ (ii) $(fof)(x)$

(iii) Sketch the graph of $(fof)(x)$.

(b) Let $P(x) = 2x^3 + 3x^2 - 11x - 6$.

(i) Use synthetic division to show that $x + \frac{1}{2}$ is a factor of $P(x)$.

(ii) Factorize $P(x)$ completely.

(iii) Find values of x for which $P(x) \leq 0$.

(c) One very important concept in business problem is break-even analysis. A company breaks even in terms of its operations where its total revenue is equal to the operation cost. Suppose a company's total revenue and operation cost functions are given below:

Revenue function $R(x) = \sqrt{10x}$
Operation cost $C(x) = x$
x is in millions of kwacha, $x \geq 0$

(i) Sketch the graphs of $R(x)$ and $C(x)$ on the same axis.

(ii) Determine the value of x at break-even point.

(iii) Express the profit as a function of x.

(iv) Determine the value of x which maximizes the profit.

6. (a) (i) If $z = 4 + i$, find $z^2 - 2z + 5$ in the standard form $a + ib$.

(ii) Sketch the graph of $g(x) = 1 + 2\text{Cos}(x - \frac{\pi}{2})$

(b) A rectangular sheet of cardboard is 12cm long and 7.5cm wide. Squares of sides x cm are cut from each corner. The flaps are then folded to make an open box in the form of a cuboid. Let the volume of the box be $V\text{cm}^3$

(i) Show that $V = 4x^3 - 39x^2 + 90x$.

(ii) Find the value of x which maximizes the volume V.

(c) Given the function $f(x) = |2x - 1| + |x + 1|$

(i) Redefine $f(x)$ by removing the modules

(ii) Sketch the graph of $f(x)$

(iii) Find the values of x for which $f(x) > 6$.

UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATION – 2005

M111 MATHEMATICAL METHODS I

INSTRUCTIONS : (A) ANSWER ANY FIVE (5) QUESTIONS
(B) CALCULATORS SHOULDN'T BE USED

TIME ALLOWED : THREE (3) HOURS

1. (a) Let A and B be subsets of the universal set E. Simplify the following as one single set given that $A \subset B$.

(i) $(A \cap E)' \cup B'$ (ii) $A \cap (B \cup E)'$
(ii) $(A \cup B) \cap E$ (iv) $E \cap (A \cap B)'$

(b) (i) Show that 3.2817817817..... is a rational number.
(ii) Is the operation + (addition) binary on the set $S = \{-2, -1, 0\}$. Justify your answer.
(iii) Express the expression $\frac{3-\sqrt{4}}{3+\sqrt{8}}$ in the form $a + b\sqrt{c}$, a, b, c ∈ R.

(c) (i) Given that $Z = -1 + 2i$ and $\frac{1}{W} = 1 - 2z + z^2$
find W in the form a + ib, a, b E R.

(ii) Given that $\sqrt{3}$ is irrational, prove that $5 - \sqrt{3}$ is irrational.

2. (a) Find all values of x which satisfy the following:

(i) $|x - 1| > 1$ (ii) $\sqrt{2-x} < \frac{1}{2}$

(iii) $\frac{x+2}{x-3} \leq 3$ (iv) $x^4 + 2x^2 + 4 > 0$.

(b) Let $f(x) = 1 + 3\text{Sin}(2x)$, $x \in [0, 2\pi]$.

(i) Find the amplitude (ii) Find the period
(iii) Find the phase shift (iv) Sketch the graph of f(x)

(c) (i) The curve of the function $f(x) = ax^2 + bx + c$ passes through the point (2,1). The gradient of the curve (slope of the tangent line) at the point (1,2) is zero. Find the values of a, b and c.

(ii) Find all real values of x which satisfy the equation $x^2 - \frac{1}{x} = 0$.

3. (a) Given that $f(x) = 5 - 2x - 3x^2$

(i) Use the method of completing the square to find the maximum value of f(x).

(ii) Find the values of x when $f(x) = 0$

(iii) Sketch the graph of f(x)

(b) (i) If $A = \frac{1+Cos\theta}{Sin\theta}$, prove that $A + \frac{1}{A} = 2\,\text{cosec}\,\theta$.

(ii) Find the derivative form first principles of $f(x) = \frac{1}{\sqrt{2x+1}}$

(c) Let $g(x) = \begin{cases} x+3 & if\ x < 1 \\ 2 & if\ x = 1 \\ 3x-4 & if\ x > 1 \end{cases}$

(i) Sketch the graph of g(x).

(ii) Find $\lim_{x\to 0} it\ g(x)$.

(iii) State with justification whether f(x) is continuous at x = 1.

4. (a) (i) If $\text{Cot}\,\beta = P$, prove that $\text{Cos}\,2\beta = \frac{P^2-1}{P^2+1}$

(ii) If $f(x) = 1 + 3\,\text{Sin}\,x$, find all the values of x for which

$f(x) = 1 + 3\text{Sin}(2x), \quad x \in [0, 2\pi]$

(b) (i) Given that $y = \frac{1+Cotx}{1-Cotx}$, show that $\frac{dy}{dx} = \frac{2}{Sin(2x)-1}$

(ii) Find $\lim_{x\to -2} it\ g(x)$, if $g(x) = \frac{x^2-x-6}{x+2}$

(c) Given that $h(x) = \frac{x+1}{x+2}$

(i) Find the domain and range of h(x)

(ii) Find the vertical and horizontal asymptotes of h(x).

(iii) Sketch the graph of h(x)

5. (a) Given $f(x) = \sqrt{1-x^2}$ and $g(x) = \text{Sin } x$, find the following:

(i) $(fog)(\frac{\pi}{3})$ (ii) $(fof)(x)$

(iii) Sketch the graph of $(fof)(x)$.

(b) Let $P(x) = 2x^3 + 3x^2 - 11x - 6$.

(i) Use synthetic division to show that $x + \frac{1}{2}$ is a factor of $P(x)$.

(ii) Factorize $P(x)$ completely.

(iii) Find values of x for which $P(x) \leq 0$.

(c) One very important concept in business problem is break-even analysis. A company breaks even in terms of its operations where its total revenue is equal to the operation cost. Suppose a company's total revenue and operation cost functions are given below:

Revenue function $R(x) = \sqrt{10x}$
Operation cost $C(x) = x$
x is in millions of kwacha, $x \geq 0$

(i) Sketch the graphs of $R(x)$ and $C(x)$ on the same axis.
(ii) Determine the value of x at break-even point.
(iii) Express the profit as a function of x.
(iv) Determine the value of x which maximizes the profit.

6. (a) (i) If $z = 4 + i$, find $z^2 - 2z + 5$ in the standard form $a + ib$.

(ii) Sketch the graph of $g(x) = 1 + 2\text{Cos}(x - \frac{\pi}{2})$

(b) A rectangular sheet of cardboard is 12cm long and 7.5cm wide. Squares of sides x cm are cut from each corner. The flaps are then folded to make an open box in the form of a cuboid. Let the volume of the box be $V\text{cm}^3$

(i) Show that $V = 4x^3 - 39x^2 + 90x$.
(ii) Find the value of x which maximizes the volume V.

(c) Given the function $f(x) = |2x - 1| + |x + 1|$

(i) Redefine $f(x)$ by removing the modules
(ii) Sketch the graph of $f(x)$
(iii) Find the values of x for which $f(x) > 6$.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SESSIONAL EXAMINATION

M221 LINEAR ALGEBRA

INSTRUCTIONS : ATTEMPT ANY FIVE QUESTIONS

TIME ALLOWED : THREE (3) HOURS

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1. (a) Give the meaning of each of the following terms:

   (i) a solution of a system of linear equations
   (ii) the row echelon form of a matrix

   (b) Given the following system of equations in 3 unknowns x, y and z:

   $x + y - z = 1$
   $2x + 3y + \alpha z = 8$
   $x + \alpha y + 3z = 2$

   determine the value of α so that the system has:
   (i) no solution
   (ii) more than one solution
   (iii) a unique solution

   (c) Solve the system of equations:

   $x - 3y + 4z - 2w = 5$
   $2y + 5z + w = 2$
   $y - 3z = 4$

2. (a) Give the meaning of each of the following terms:

   (i) an elementary row operation
   (ii) the inverse of a matrix

   (b) Given the matrix $A = \begin{pmatrix} 1 & 0 & 2 \\ 2 & -1 & 3 \\ 4 & 1 & 8 \end{pmatrix}$

   find elementary row operations on A which reduce A to the Identity matrix I_3. By applying the same row operations to I_3, confirm that the resulting matrix B is such that $AB = I_3$ hence deduce the inverse of A.

3. (a) Give the meaning of each of the following terms:

(i) a linear combination of vectors
(iii) a linearly independent set of vectors

(b) Write the vector V = (1, –2, 5) as a linear combination of the vectors $w_1 = (1, 1, 1))$, $w_2 = (1, 2, 3)$ and $w_3 = (2, -1, 1)$.

(c) Write the matrix $A = \begin{pmatrix} 3 & 1 \\ 1 & -1 \end{pmatrix}$ as a linear combination of the matrices

$B = \begin{pmatrix} 1 & 1 \\ 1 & 0 \end{pmatrix}$, $C = \begin{pmatrix} 0 & 0 \\ 1 & 1 \end{pmatrix}$ and $D = \begin{pmatrix} 0 & 2 \\ 0 & -1 \end{pmatrix}$

4. (a) Give the meaning of each of the following terms:

(i) a generating set of a vector space.
(ii) The row space of the matrix A.

(b) Find conditions on 1, b and c so that $(a, b, c) \in IR^3$ belongs to the space generated by $u_1 = (2, 1, 0)$, $u_2 = (1, -1, 2)$, $u_3 = (0, 3, -4)$.

(c) Show that the subset $W = \{ (a, b, 0)\}$ in IR^3 is generated by $w_1 = (1, 2, 0)$, $w_2 = (0, 1, 0)$.

5. (a) Define each of the following terms:

(i) a subspace of a vector space.
(ii) The dimension of a subspace.

(b) Let $V = IR^3$. Show that W is a subspace of V where $W = \{ (\alpha, \beta, 0) : \alpha, \beta \in IR\}$.

(c) Determine the dimension of W.

. (a) Distinguish between the following terms:

(i) the dimension of the solution space of a system of equations.
(ii) the dimension of a vector space generated by a given set of vectors.

(b) Find the dimension of the solution space W of the system:

$x + 2y + 2z - s + 3t = 0$
$x + 2y + 3z + s + t = 0$
$3x + 6y + 8z + s + 5t = 0$

(c) Find the dimension of the vector space generated by the vectors $u = (3, -6, 3, -9)$, $w = (-2, 4, -2, 6)$.

7. (a) Give the meaning of each of the following terms:

(i) the kernel kerT of a linear transformation T
(ii) the image imT of a linear transformation T

(b) Show that the mapping defined by

$T(x, y, s, t) = (x - y + s + t, x + 2s - t, x + y + 3s - 3t)$ is a linear transformation, hence determine imT and kerT.

(c) Let T: $IR^3 \rightarrow IR^3$ be a linear transformation defined by $T(x, y, z) = (x + 2y - z, y + x, x + y - 2z)$. Then determine kerT.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
DEPARTMENT OF MATHEMATICS AND STATISTICS

2005 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

M331 REAL ANALYSIS III

TIME : THREE (3) HOURS
ATTEMPT ANY FIVE (5) QUESTIONS

Q1. (a) Let $A \subset \mathbb{R}$ and $f: A \to \mathbb{R}$. Define

(i) the interior point x_0 of A
(ii) the limit point x_0 of A
(iii) the direct image of A under f.

(b) Let $f: X \to Y$ be a function and let $A \subset X$, $B \subset X$.
(i) Prove that $f(A \cup B) = f(A) \cup f(B)$
(ii) If further, f is one-to-one function on X, show that $f(A \cap B) = f(A) \cap f(B)$

Q2. (a) Define
(i) An open set $A \subset \mathbb{R}$.
(ii) Separation of a set $A \subset \mathbb{R}$

(b) Let A, E and Ω be sets such that $A \subset E \subset \Omega$.

(i) If E is open in Ω and A is open in E, prove that A is open in Ω.
(ii) If E is closed in Ω and A is closed in E, prove that A is closed in Ω.

(c) Let A be a nonempty proper subset of X. If A is both open and closed in X. Show that X is not connected.

Q3. (a) State
(i) the uniform Cauchy property
(ii) the Weierstrass M-test

(b) Let f_1, f_2 .....be a sequence of real-valued functions with uniform Cauchy property on $E \subset R$. Prove that the sequence (f_n) converges uniformly on E.

(c) Let $f_1, f_2, \ldots\ldots\ldots\ldots$ be a sequence of real-valued functions on E such that $|f_n(x)| < M_n$ for all $x \in E$ and all $n \in Z^+$. Define a function S_n on E by $S_n(x) = \sum_{k=1}^{n} f_k(x)$. If $\sum_{n=1}^{\infty} M_n < \infty$, show that the sequence (S_n) has a uniform Cauchy property on E.

Q4. (a) Let $A \subset IR$ be a set. Define what is meant by:

(i) An Open Covering of A.
(ii) A sub covering of A.
(iii) A is compact.

(b) Prove that if A is a compact set and f: $A \to IR$ is a continuous function, then the set f(A) is a compact set.

(a) (i) State the Weierstrass Approximation Theorem.
(iii) Define a piecewise linear function g: $I \to IR$ where $I = [a, b]$ is a closed and bounded interval.

(b) Let $I = [a, b]$ be a closed bounded interval and let f: $I \to IR$ be continuous on I. Prove that for every $\varepsilon > 0$ there exists a continuous piecewise linear function g_ε: $I \to IR$ such that $|f(x) - g_\varepsilon(x)| < \varepsilon$ for all $x \in I$.

Q6. (a) (i) State the intermediate Value Theorem
(ii) Define a monotone function f:$A \to IR$

(b) (i) Let f b continuous on a closed and bounded interval [a, b] and let f' exist on (a, b) with $|f'(x)| \leq M$ for all $x \in (a, b)$, $M > 0$. Show that f is of bounded variation on [a, b].

(ii) Consider the function $f(x) = x^2 \cos \frac{1}{x}$ and if $x \neq 0$, $f(0) = 0$. Show that f of bounded variation on [0, 1].

Q7. (a) Let $f(x) = \frac{x^n}{2 + 3x^n}$, $0 \leq x \leq 1$

(i) Show that f_n converges pointwise.
(ii) Determine whether the sequence (f_n) of function defined above, converges uniformly on [0, 1].

(b) Let $E \subset \mathbb{R}$ and $f_1, f_2, \ldots\ldots\ldots\ldots\ldots$ be a sequence of continuous real-valued functions on E. If $f_n \to f$ uniformly on E and $x_o \in E$, show that f is continuous on E and

$$\lim_{n\to\infty} \lim_{x\to x_o} f_n(x) = \lim_{x\to x_o} \lim_{n\to\infty} f_n(x) = f(x_o)$$

UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATION - 2005

M335: Topology

ructions: Answer any five (5) Questions

e Allowed: Three (3) hours

(a) Define the following terms:

(i) Inverse image of a set under a function

(ii) Cartesian product of two sets

(iii) An equivalence relation

(b) Prove the following:

(i) Let $\{A_\lambda : \lambda \in \Omega\}$ be an indexed family of sets where $\Omega \neq \phi$ and B is any set then $B \cup (\bigcap_{\lambda\in\Omega} A_\lambda) = \bigcap_{\lambda\in\Omega} (B \cup A_\lambda)$

(ii) Let $f : A \to B$ be a function, F_1 and F_2 be subsets of B, then $f^{-1}(F_1 \cap F_2) = f^{-1}(F_1) \cap f^{-1}(F_2)$

(iii) Let A, B and D be any sets, then $A \times (B \cap D) = (A \times B) \cap (A \times D)$

(c) Let (A, d) be a metric space and define d* by $d^*(x,y) = \dfrac{d(x,y)}{1+d(x,y)}$

i.e. $d^* : A \times A \to R$. Is (A, d*) a metric space? Justify your answer.

(a) Define the following terms:

(i) Metric space

(ii) Homeomorphism

(iii) Metrically equivalent metric spaces

(b) Prove the following:

(i) Every non-empty set can be given a metric and hence can be converted into a metric space.

(ii) Let (A, d) be a metric space, then the union of any collection of open sets in (A, d) is open.

(iii) Let (A, d) be a metric space, then a subset E of A is open if and only if E is a union of open spheres.

(c) *Let* $X = \{a, b, c, d\}$, $£_x = \{\phi, \{b\}, \{a, b\}, \{a, b, c\}, X\}$
$Y = \{0, 1, 2, 3\}$ *and* $£_y = \{\phi, \{2\}, \{1, 2\}, Y\}$
if $g(a) = 0$, $g(b) = 1$, $g(c) = 3$, *and* $g(d) = 2$

(i) Find the inverse image of $\{1, 3\}$

(ii) Is g a homeomorphism? Justify your answer.

(a) Define the following terms:

(i) Topology

(ii) Neighbourhood in a topological space

(iii) Interior point in a topological space

(b) Prove the following:

(i) Let (A, d) be a metric space, then the intersection of any collection of closed sets is closed.

(ii) Let (A, d) be a metric space, and x_0 be a limit point of B a subset of A, then every neighbourhood of x_0 contains infinitely many points of B.

(iii) Let B be a subset of a topological space (A, £) then the interior of B is open.

(c) Let $X = \{1,2,3,4,5\}$ *and* $£ = \{\phi, \{3\}, \{1,2\}, \{3,4\}, \{1,2,3\}, \{12,3,4\}, X\}$

If A = {1, 3, 4}, find the following:

(i) Interior of B

(ii) Closure of B

(iii) Relative topology on B

(a) Define the following terms:

(i) Closure of a set in a topological space

(ii) Limit point in a topological space

(iv) Continuity of a function at a point in a topological space

(b) Prove the following

(i) Let $(A,£)$ be a topological space, with B and D subsets of A, then $\overline{B \cup D} = \overline{B} \cup \overline{D}$

(ii) A function $f : (X,£_x) \to (Y,£_y)$, is continuous if and only if for each $E \in £_y$, then $f^{-1}(E) \in £_x$

(iii) Let $(X, £)$ be a topological space and let Z be a non-empty subset of X, then the collection $£_z$ of subsets Z, defined as follows:

$£_z = \{Z \cap E : E \in £\}$ is a topology on Z.

(c) (i) State Heine-Borel theorem

(ii) Prove the Heine-Borel theorem

(a) Define the following terms:

(i) Subspace of a topological space

(ii) Hausdorff space

(iii) An accumulation point in a topological space

(b) Prove the following:

(i) A topological space $(X,£)$ is compact if and only if whenever for each $x \in X$ there is a neighbourhood N_x of x , then there is a finite number of points $x_1, x_2, \ldots, x_n$ of X such that $X = \bigcup_{j=1}^{n} N_{x_j}$

(ii) Let $f:(X,£_x) \to (Y,£_y)$ be a continuous function and A be a Compact subset of X, then $f(A)$ is a Compact subset of Y.

(iii) Let $(X,£)$ be a Compact topological space, then each closed subset of X is Compact.

(c) (i) State the Intermediate value theorem

(ii) Prove the Intermediate value theorem

(a) Define the following terms:

(i) Connected topological space

(ii) Connectedness of a subset of a topological space

(iii) An interval

(b) Prove the following:

(i) Let $f:(X,£_x) \to (Y,£_y)$ be a one-one and onto continuous function. If X is Compact and $(Y,£_y)$ is a Hausdorff space, then f is a homeomorphism.

(ii) Let $f:(X,£_x) \to (Y,£_y)$ be a continuous function and if A is a Connected subset of X, then f (A) is a Connected subset of Y.

(iii) Let $f:[a,b] \to IR$ be a continuous function. If $f(a)\ f(b) < 0$, *then*$\exists$ *an* $x \in [a,b]$ such that f(x) = 0.

(c) (i) Show that x = 2 is a limit point for the set B, where

$B = \left\{ x : x = 2 \text{ or } x = 2 - \frac{1}{n}, n \in J \right\}$, with the usual metric on R.

(ii) Let $f(x) = 1 - |x|$, is f continuous? Justify your answer.

UNIVERSITY OF ZAMBIA
DEPARTMENT OF MATHEMATICS AND STATISTICS
2005 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

M411 – THEORY OF FUNCTIONS OF A COMPLEX VARIABLE I

TIME : THREE (3) HOURS

ATTEMPT ANY FOUR (4) QUESTIONS

Q1. (a) Find the principal value of $(-1 + i\sqrt{3})^i$

(b) Find the center and the radius of the circle $|z - i| = \frac{1}{2}|z - 1|$

(c) Let u be a continuous function in the disc $|z - z_0| < r$, and let γ_ϵ be the circle $|z - z_0| = \epsilon$. Show that:

$$\lim_{\epsilon \to 0} \frac{1}{2\pi i} \int_{\gamma_\epsilon} \frac{u(z)}{z - z_o} dz = u(z_0).$$

Q2. (a) Find the solutions of the equation $z^{1-i} = 4$

(b) Let $z = re^{i\theta}$ where $0 < r < 1$ and θ a real number. Show that:

$$\text{Re}\left(\frac{e^{it} + z}{e^{it} - z}\right) = \frac{1 - r^2}{1 - 2r\cos(\theta - t) + r^2}$$

(c) Evaluate the integral $\int_\gamma \frac{z}{z+1} dz$ where γ is any curve in the domain $\{z: \text{Im } z > 0\}$, which joins $-1 + 2i$ to $1 + 2i$.

Q3. (a) Determine the radius of covergence of the power series:

(i) $\sum_{n=0}^{\infty} 5^{(-1)^n} z^n$ (ii) $\sum_{n=0}^{\infty} \frac{z^{3n}}{2^n}$

(b) Find the power series of $\frac{z^2}{(1-z)^2}$, $|z| < |$ about $z = 0$.

(c) Suppose w is not in the interval [-R, R]. Show that the equation $z + \frac{R^2}{z} = 2w$ has one solution

z with $|z| < R$ and one solution z with $|z| > R$.

Hence show that the function $f(z) = \frac{1}{2z}(z^2 + R^2)$ is a one-to-one conformal Mapping of the region $R < |z| < \infty$ onto the exterior of the closed interval [-R, R].

Q4. (a) If w is any value of $-i \operatorname{Log}(z + \sqrt{z^2 - 1})$ Show directly that $\cos w = z$

(b) Let D be a domain on which there is a single-valued branch of logz where $z = x + iy$.
Show that logz is differentiable on D.

(c) Show that the function $u(x, y) = y^3 - 3x^2y$ is harmonic in some domain. Hence find it's harmonic conjugate V(x,y).

Q5. (a) Suppose that γ is a piecewise smooth simple closed curve and u is a continuous function on γ. Let D be domain disjoint from γ, and define a function h on D by

$h(z) = \int_\gamma \frac{u(w)}{w - z} dw$, $z \in D$ Show that h is analytic on D.

(b) Evaluate the integral

$$\frac{1}{2\pi}\int_0^{2\pi} \frac{d\theta}{1 - 2a\cos\theta + a^2}, \quad 0 < a < 1$$

Q6. (a) Let z_1, z_2, z_3 and w_1, w_2, w_3 be two triples of distinct complex numbers. Set

$$\alpha = \frac{z_2 - z_3}{z_2 - z_1} \text{ and } \beta = \frac{w_2 - w_3}{w_2 - w_1}$$

Show that the linear fractional transformation that maps zj to wj for j = 1, 2, 3 is given by

$$L(z) = \frac{z(\alpha w_3 - \beta w_1) + (\beta w_1 z_3 - \alpha z_1 w_3)}{z(\alpha - \beta) + (\beta x_3 - \alpha z_1)}$$

(b) Hence find the linear fractional transformation which maps the points $z_1 = -1$, $z_2 = 0$ and $z_3 = 1$ onto the points $w_1 = -i$, $w_2 = 1$ and $w_3 = i$

THE UNIVERSITY OF ZAMBIA

SESSIONAL UNIVERSITY EXAMINATIONS

M421: STRUCTURE AND REPRESENTATIONS ON GROUPS

ME ALLOWED: THREE (03) HOURS

STRUCTIONS: ATTEMPT FIVE (5) QUESTIONS IN ALL WITH AT LEAST TWO(2) QUESTIONS FROM EACH SECTION

CTION A - STRUCTURE OF GROUPS

tempt at least two (2) questions from this section)

Define each of the following terms:

(i) the commutator $[x, y]$ of the elements x, y in the group G.
(ii) a composition series of a group G.

(a) (i) Let N be a normal subgroup of a group G and let G' denote the commutator subgroup of G. Prove that if G' is contained in N then the factor group G/N is abelian.

(ii) Prove that every finite group has a composition series.

(b) (i) Let N and K be subgroups of a group G, and let [N, K] be the group generated by their commutators. Then by using the fact that for all x, y∈N and all z∈K, the following is an identity.

$$[xy, z] = y^{-1} [x, y] y [y, z]$$

or otherwise, show that [N, K] is normal in $< N, K >$, the group generated by N and K.

(ii) Obtain a composition series for the group G which is generated by the permutations r = (1234) and i = (24) subject to the relations $r^4 = i^2 = 1$, $ir = r^3i$.

2. Give the meaning of each of the following terms:

(i) a derived series of a group G.
(ii) the lower central series of a group G.

(a) (i) Show that if G_i denotes the i^{th} term of the solvable series of a group G and $G^{(i)}$ denotes its i^{th} derived group, then $G^{(i)} \subset Gi$.

(ii) Let L_j (G) be the j^{th} term in the lower central series of a group G and let $Z_j(G)$ denote its j^{the} center. Then show that if $L_n(G) = \{e\}$ for some positive integer n then $L_j(G) = Z_{n-1}(G)$ for all j.

(b) Obtain a derived series for the symmetric group S_5 of degree 5 and hence confirm that S_5 is not solvable.

3. Define the terms:

(i) solvable group
(ii) nil potent group

(a) (i) Given that the solvable group G contains a normal subgroup H, prove that G/H is also a solvable group.

(ii) Given that a nil potent group G contains a normal subgroup H, Prove that G/H is also a solvable group.

(b) Show that every finite P-group is nil potent.

. Define each of the following terms:

(i) G is a group extension of group K by group Q.
(ii) A stabilizer of an element in the group S_n of permutations on n symbols.

(a) (i) Prove that the group S_3 of order 6 is an extension of the cyclic group C_3 of order 3 by the cyclic group C_2 of order 2.

(ii) The stabilizers of S_n partition group G.

(b) Obtain the left regular representation of $S_3 = \{(1), (12), (13), (23), (123), (132)\}$.
On the set $V = \{ v_1, v_2, v_3\}$

SECTION B - REPRESENTATIONS OF GROUPS

(Attempt at least two questions from this section)

5. Give the meaning of each of the following terms:

(i) the character of a representation of a group G.
(ii) the first orthogonality relations for group characters of G.

(a) Prove that a group character is a class function on G and that equivalent representations of G have the same character.

(b) Let $C_1, C_2, \ldots, C_n$ be the conjugacy classes of G of order hi (I = 1, 2, …, n) and let $X^{(j)}$ (j = 1, 2, … n) be the irreducible characters of G. Then by using the first orthogonality relations for the characters of G, show that

$$\frac{1}{|G|} \sum_{n=1}^{n} \text{hk } X_2^{(K)} \; X_{j^*}^{(K)} = \begin{cases} 1 \; if \; i = j \\ 0 \; if \; i \neq j \end{cases}$$

where $X_i^K = X^{(k)}$ for each $g_i \in C_j$
and $X_{j^*}^K = X^{(k)}(g_j)$, for each $g_j^{-1} \in C_j$.

6. What is the meaning of each of the following:

(i) a completely reducible representation of G.
(iii) a character table of a group G.

(a) State and prove the Maschke's theorem.
(b) (i) Let $T : G \rightarrow GL(2, R)$ be a mapping such that

$$T(a) = \begin{pmatrix} 0 & 1 \\ -1 & -1 \end{pmatrix}$$

Then show that T is an irreducible representation of G.

(ii) Show that the mapping $T^j : g \rightarrow C$ given by $T^j(g^k) = w^{ik}$, j = 0, 1, 2, …, n – 1 where $w = e^{\frac{2\pi i}{n}}$, is a representation of G defined by $G = < g/g^n = e >$
Hence obtain a character table for the group C_4 of order 4.

7. What is the meaning of the terms:

(i) a left regular presentation of a group G.
(ii) the character of a representation.

(a) Let $\theta : G \rightarrow S_n$ be a mapping from a finite group G to the symmetric group S_n of degree n given by

$$\theta(g) = \begin{pmatrix} x_1 & x_2 & \ldots\ldots x_n \\ \theta x_1 & \theta x_2 & \theta x_n \end{pmatrix}$$

where $x_i \in G$ and $\theta \in S_n$. Then prove that θ is a representation of G.

(b) Give the left regular representation of the group D_3 defined by $D_3 = < a, b : a^3 = b^2 = e, b_a = a^2b >$

Hence give the character values of this representation for each element of the group.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATION – JUNE/JULY, 2005

MSE 441/451/461

BIOLOGY, PHYSICS AND CHEMISTRY TEACHING METHODS III

TIME: **THREE (3) HOURS**

INFORMATION

1. There are six (6) questions in this paper.
2. Each question has possible maximum marks of 20.

INSTRUCTIONS

1. Answer question **one** and
2. Any other **four (4)** questions.

---

1. Stock-taking is important in the proper management of materials in a science department.

   (a) What do you understand by 'stock-taking'? [3]

   (b) What is the significance of stock-taking? [3]

   (c) Design a form you would use for stock-taking of apparatus in the science department. [6]

   (d) At one high school, there was an argument among science teachers as to whether or not it would be appropriate to invite a laboratory Assistant to some of the departmental meetings. What is your view over this issue? Justify your view. [5]

   (e) Describe a system you would put in place to ensure that apparatus are not misplaced in the department. [3]

2. (a) What issues should a head of science department consider when allocating classes to teachers? [4]

(b) Explain why each variable/issue you have indicated above is important to consider. [4]

(c) Describe four (4) approaches a head of science can use to allocate classes to teachers. [8]

(d) Identify a weakness associated with each approach you have given. [4]

3. Graduate science teachers are not expected to teach science only but also to perform other responsibilities in the school such as being a class teacher.

(a) Describe at least 6 responsibilities a class teacher is expected to perform. [6]

(b) Identify 6 responsibilities a head of science department in a high school is expected to perform. [6]

(c) Discuss qualities a head of science is expected to have in order to run the department well. [12]

4. There are various management styles a head of science department may employ in the running of the department.

(a) Identify and describe each of the management styles. [9]

(b) State one strength and one weakness of each management style you have given. [6]

(c) What factors influence the choice of management style a head may adopt? [5]

5. (a) Distinguish between the following:
(i) Syllabus and curriculum [3]
(ii) Co-curriculum and core-curriculum [2]
(iii) Needs assessment and curriculum evaluation [2]

(b) Discuss the role of objectives in the curriculum development process.[5]

(c) Discuss the part played by the science section of the Curriculum Development Centre in science education in Zambia. [8]

6. (a) In what ways do public examinations promote teaching and learning of science in Zambia? [6]

(b) How do public examinations hinder effective teaching and learning of science in Zambia? [5]

(c) Discuss the role played by the Examination Council of Zambia in the professional growth of science teachers. [3]

(d) Why should graduate science teachers engage in continuing professional growth and what avenues are available for the same at departmental level? [6]

END OF EXAMINATION

The University of Zambia
School of Natural Sciences
Department of Physics
2005 Academic Year First Semester
Final Examinations
P-191 : Introductory Physics - I

uestion 1 is <u>compulsory</u>. Attempt only <u>four more</u> questions. Clearly dicate on the answer script which questions you have attempted. All estions carry equal marks. The marks are shown in brackets.

me : Three Hours. **Maximum Marks : 100.**

<u>rite your computer number clearly on the answer script</u> !!

---

herever necessary use :

= 6.67×10^{-11} N.m^2/kg^2 : g = 9.8m/s^2 : $P_A = 1.01 \times 10^5$ N/m^2 : ρ_{water} = 1000kg/m^3 : ecific heat capacity of water = 4200J/kg.K : 1 pascal = 1 N/m^2 : 1 cal. = 4.2 J : = 8314 J/kmol.K :

me equations you may find useful :

= $v_o + at$: $v_f^2 = v_o^2 + 2ax$: $x = v_o t + (½)at^2$: $f = \mu.F_N$: work = F.s.cos θ

= $m(v_f - v_o)$: kin. energy = $(½)mv^2$: grav. pot. energy = mgh : W = mg

= $v_{avg}.t$: **Ft** = Δ**p** = $m(v_f - v_o)$: $\Delta PE + \Delta KE + \Delta TE = 0$: power = work/time

g. = $(½)(v_o + v_f)$: $\omega_f = \omega_o + \alpha t$: $\omega_f^2 = \omega_o^2 + 2\alpha\theta$: $\theta = \omega_o t + (½)\alpha t^2$: P = Fv

= **mv** : $a_T = \alpha r$: $L = I\omega$: $\tau = I\alpha = Fr$: $[\text{kin. energy}]_{total} = (½)mv^2 + (½)I\omega^2$

ev = 360° = 2π radians : $F_c = (mv^2)/r$: $I = \Sigma mr^2 = mk^2$: $F = (Gm_1m_2)/r^2$:

= $(F/A)/(\Delta L/L_o)$: $B = -\Delta P/(\Delta V/V_o)$: $W_{app.} = mg$ - B.F. : $P = \rho gh$: $v_T = \omega r$

pp. = $W[1 - (\rho_f/\rho)]$: $[(½)mv^2]_{avg.} = (3/2)kT$: $\Delta Q = mc\Delta T = nC\Delta T$: $\Delta Q = mH_f$

= $\alpha L\Delta T$: $\Delta V = \gamma V\Delta T$: $\Delta W = P\Delta V$: $P_1V_1^\gamma = P_2V_2^\gamma$: $PV = nRT = (m/M)RT$:

= $\Delta U + \Delta W$: $\Delta W = nRT.\ln(V_f/V_i)$: $R = (2u^2 \sin\theta \cos\theta)/g$: $t = (2u \sin\theta)/g$

)kx^2 + $(½)mv^2 = (½)kx_o^2$: $\omega = \sqrt{(k/m)}$: $v = \pm\sqrt{[(k/m)(x_o^2 - x^2)]}$: $v_T = \omega r$:

= $\sqrt{(Y/\rho)}$: $f = (1/2\pi)\sqrt{(k/m)}$: $f = (1/2\pi)\sqrt{(g/L)}$: $v = \sqrt{[T/(m/L)]}$: $v = \sqrt{(B/\rho)}$

= $\sqrt{(\gamma RT/M)}$: $f = 1/\tau$: $\omega = 2\pi f$: $I_1\omega_1 = I_2\omega_2$: ΔT.E. = f.s : a = - kx/m

ea of a sphere = $4\pi r^2$: volume of a right cylinder = $\pi r^2 h$: 0K = 273°C : F = -kx

ax. = kx_o/m : $a_c = \omega^2 x_o$: P.E. = $(½)kx^2$: 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) An engine block is supported by a rope hoist attached to an overhead beam. When the block is pulled to one side by a horizontal force exerted by another rope, the tension in the rope hoist :

(a) is less than before
(b) is unchanged
(c) is greater than before
(a) may be any of the above, depending on the magnitude of the horizontal force.

(B) A car has an initial velocity of 10m/s and an acceleration of $-1m/s^2$. In the first 15s after the acceleration began, the car travels :

(a) 37.5m (b) 50.5m
(c) 100.5m (d) 150m.

(C) A brick has the dimensions 8cm x 16cm x 32cm. The force of static friction between the brick and a wooden floor is :

(a) greatest when the brick rests on the 8cm x 32cm face
(b) the same regardless of which face it rests on
(c) greatest when the brick rests on the 8cm x 16cm face
(d) greatest when the brick rests on the 16cm x 32cm face.

(D) A 60kg woman whose average power is 30 watts can climb a mountain 2km high in :

(a) 1.1 hour (b) 5.4 hours
(c) 11 hours ✓ (d) 1 hour.

(E) A shell initially at rest explodes into two pieces of equal mass. The two pieces will :

(a) be at rest
(b) move with different velocities in different directions
(c) move with the same velocity in the same direction
(d) move with the same velocity in opposite directions

(F) To have an earth satellite synchronous with the rotation of the earth, it must be launched at a proper height :

(a) from west to east in equatorial plane
(b) from south to north in polar plane
(c) from east to west in equatorial plane
(d) from north to south in polar plane

(G) When the torque acting on a system is zero, what is conserved :

(a) force
(b) linear momentum
(c) angular momentum
(d) angular impulse.

(H) The centre of gravity of an object :

(a) is always in the interior of the object
(b) is sometimes arbitrary
(c) is always at its geometrical centre
(d) may be outside the object.

(I) Compressibility of a substance is :

(a) the same as its bulk modulus
(b) the same as its shear modulus
(c) the reciprocal of its bulk modulus
(d) the reciprocal of its shear modulus.

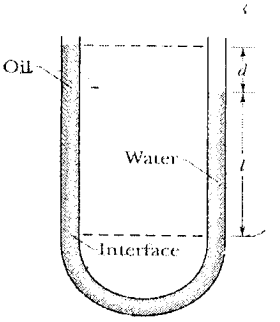
(J) Which of the following statements is not correct?

(a) matter is composed of tiny particles called molecules
(b) all molecules have the same size and mass
(c) the molecules are in constant motion
(d) the differences between the three states of matter can be attributed to the relative freedom of motion of their respective molecules.

Attempt any four questions from below :

Q 2 (a) (a) Two forces ($\mathbf{F_1}$ = 10N, θ_1= 37°; $\mathbf{F_2}$ = 8N, θ_2 = 330° act on a 5kg object. Find the magnitude and direction of the acceleration produced by these forces. [10]

(b) The U-tube in the figure contains two liquids in static equilibrium; water (of density 1000kg.m^{-3}) is in the right arm, and oil (of density ρ_{oil}) is in the left arm. If l = 135mm and d = 12.3mm, what is the density of the oil ? [8]



(c) Define "the impulse of a force". [2]

3 (a) The gauge pressure of a certain quantity of a gas kept in a cylinder is 1.30 x 10^6 Pa. After some of the gas has been used up, the new gauge pressure is 2 x 10^5 . The cylinder has a height of 1m and internal radius of 6cm. The gas is aintained at a temperature of 22^0 C. [9]

nd the mass of the gas that has been used up. Given, molar mass M of the gas = kg/kmol.

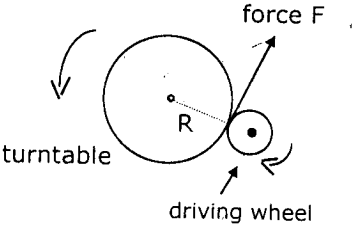
) A fish at the depth of 10m in a freshwater lake exhales an air bubble of volume If the volume of the bubble just before it reaches the surface is 2V, find the mperature of water at the surface. Given, temperature of water at 10m depth is 20 [9]

) Define the mole and explain its relation with Avogadro's number. [2]

4 (a) A ball is thrown upward from the ground at an angle of 60^0 with the rizontal with a velocity of 6m/s.

(i) Find its vertical position with respect to the ground when it has traveled a distance of 2m horizontally.
(ii) Find its vertical velocity (upward or downward) at this point. [9]

) A phonograph turntable driven by an electric otor accelerates at a constant rate from 0 to .3rev/minute in a time of 2.0s. The turntable a uniform metal disk of mass 1.5kg and a meter of 26cm.

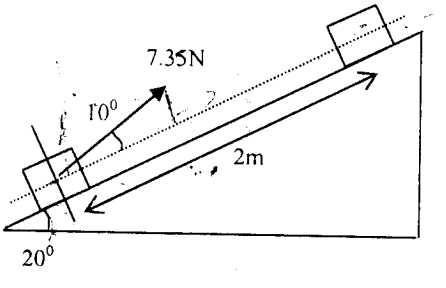


Calculate the torque required to drive the ntable.

If the driving wheel makes contact with the ntable at its outer rim, what is the tangential ce F the driving wheel must exert on the ntable ?
oment of inertia of a disk = (½)MR^2] [9]

State Hooke's law in terms of stress and strain. [2]

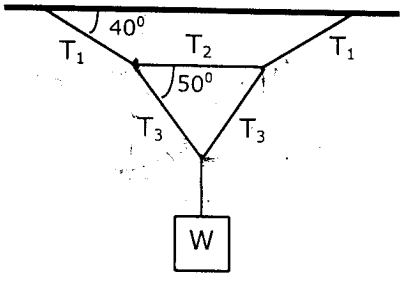
5 (a) A steel block weighing 12N is pulled an inclined plane by a constant force of 5N which makes an angle of 10^0 with pect to the surface of the plane. The block rts from rest and is pulled 2m along the ined plane whose angle is 20^0 with pect to the horizontal. The coefficient of tion between the block and the inclined ne is 0.2.



Determine :

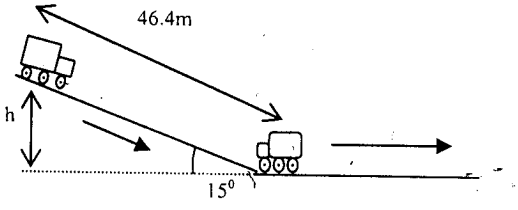
(i) the work done on the block by the force,
(ii) the increase in potential energy of the block,
(iii) the increase in kinetic energy of the block, and
(iv) the amount of work required to overcome the frictional force. [10]

(b) If the tension T_1 is given to be 60N, find the value of T_2 , T_3 and W. Assume the ropes to be massless. [8]



(c) State Archimedes's principle. [2]

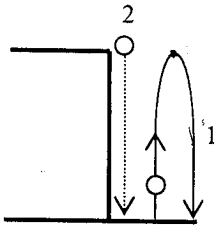
Q 6 (a) A truck of mass 3500kg is parked on a hill; its brakes fail and it crashes into another vehicle of mass 920kg parked at the bottom of the hill. The two vehicles lock together during the collision and skid a distance of 48m before being brought to rest by the locked wheels of the car. The truck travelled 46.4m downhill, which is elevated 15^0 above the horizontal.



Find the coefficient of kinetic friction between the tires of the car and the road. [11]

(b) A ball (1) is thrown straight up from the ground next to a building at a speed of 19.2m/s. Another ball (2) is dropped from the roof two seconds later.

Find the height of the building so that both balls reach the ground at the same time. [6]



(c) Define the "radius of gyration" of a rotating object. [3]

Q 7 (a) A gun of mass 4kg recoils with a speed of 0.5m/s when it fires a bullet of mass 10g horizontally.

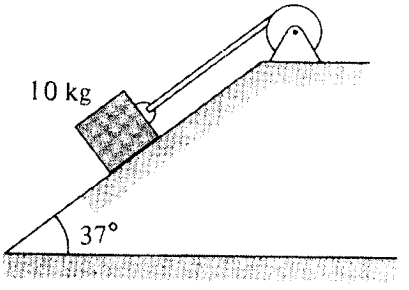
(i) find the speed with which the bullet is fired,

(ii) if the bullet embeds itself in a 1.990kg block of wood at rest on a horizontal table, with what velocity does the block begin to move ?

(iii) If the block (+bullet) stops after 10cm, what is the coefficient of sliding friction between the block and the table ? [10]

(b) The wheel has a radius of 40cm. When the mass of 10kg is released, it moves downwards with an acceleration of 0.48 m/s^2. The friction force between the block and the incline is 30N.

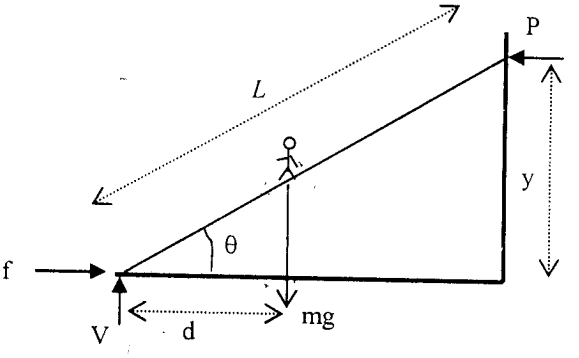
Find the moment of inertia of the wheel. [7]



(c) Define moment of inertia of a body and lever arm of a force. [3]

Q 8 (a) A uniform massless ladder of length L leans against a smooth (frictionless) wall. The ladder is placed on the ground and makes an angle of θ with the horizontal. The coefficient of static friction between the ground and the ladder is μ.

Show that the horizontal distance d which a person can move in climbing up the ladder before the ladder starts to slip is $d = \mu L \sin\theta$ [8]



(b) A composite wire of uniform diameter 3mm consisting of a copper wire of length 2.2m joined to a steel wire of length 1.6m stretches under a certain load by 0.7mm.

Calculate the load (force), given that Young modulus for copper is 1.1×10^{11} N.m^{-2} and that for steel is 2×10^{11} N.m^{-2}. [10]

(c) State the law of conservation of angular momentum. [2]

== End of P-191 Examination==

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF PHYSICS

2005 ACADEMIC YEAR FIRST SEMESTER

FINAL EXAMINATIONS

P251: CLASSICAL MECHANICS I

TIME: THREE (3) HOURS

ANSWER ANY FIVE QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

MAXIMUM MARK: 100

Universal gravitational constant, $G = 6.67\times10^{-11}\ \mathrm{m^3kg^{-1}s^{-2}}$

Acceleration due to the earth's gravity, $g = 9.8\ \mathrm{ms^{-2}}$

Speed of light in free space, $c = 3.0 \times 10^8\ \mathrm{ms^{-1}}$

The earth's planetary year, $T = 3.15 \times 10^7$ s.

Mass of the earth, $m_e = 5.95\times10^{24}$ kg

Mass of the sun, $m_s = 1.989\times10^{30}$ kg

Radius of the earth $r = 6.4 \times10^6$ m

Radius of the sun $R = 7.0 \times10^8$ m

$(\vec{A}\times\vec{B})\times\vec{C} = (\vec{C}\bullet\vec{A})\vec{B} - (\vec{C}\bullet\vec{B})\vec{A}$

Q1 (a) An object of mass m falls vertically downwards under a constant gravitational acceleration g from the top of a building. The resistive force acting on the object is mkv, where v is the velocity at any time t and k=0.10 s^{-1}.

(i) Derive an expression for the velocity v at any time t in terms of the constants g and k. [6]

(ii) Find an expression for the distance y travelled by the object in any time t. [6]

(b) If the object hits the ground after two seconds, calculate the velocity of the object as it strikes the ground and the height of the building above the ground. [8]

Q2 (a) A particle of mass m is subjected to a force

$$F = k\left(-x + \frac{x^3}{4}\right)$$

where k and d are constants, with k positive.

At t = 0 the potential $V(x)$ = 0 and the position $x = 2\frac{(1-e)}{(1+e)}$. Obtain x explicitly as a function of time for the case $E = k$. [10]

(b) Find the gravitational **potential energy** of a particle placed outside a spherically symmetric distribution of matter and hence find the gravitational force. [10]

Q3 (a) Show that the motion of a particle under the action of a central force $F(r) = -\lambda/r^2$ is characterised by a constant vector

$$\vec{k} = \dot{\vec{r}} \times \vec{L} - \frac{\lambda \vec{r}}{r} \quad ,$$

where $\vec{L}$ is the angular momentum of the particle about the origin. [8]

(b) Show that this vector is perpendicular to $\vec{L}$, and therefore lies in the plane of motion of the particle. [4]

(c) Hence otherwise, show that the general orbit of the particle is the conic

$$\frac{1}{r} = \frac{1}{l}(1 + e\cos(\theta - \delta)).$$ [8]

Q4 (a) What characterises a conservative force field? [3]

(b) Prove that the gravitational force field is conservative [8]

(c) Perihelion and aphelion of the planet Jupiter occur at distances of 7.409×10^{11} m and 8.157×10^{11} m from the sun respectively. Find;

(i) The length of the semi-major and semi-minor axis of Jupiter's orbit. [5]

(ii) The length of Jupiter's planetary year in terms of the year on earth. [4]

Q5 (a) State Kepler's laws of planetary motion. [3]

(b) Find the ratio of the escape velocity on the sun to the escape velocity on the earth. [2]

(c) What is a Hohmann orbit? At their perihelion the planets earth and Jupiter are at distances of 14.71×10^{10} m, 74.09×10^{10} m, while at their aphelion the two planets are at distances of 15.21×10^{10} m, 81.57×10^{10} m from the sun respectively. For both, find

(i) the eccentricity [3]

(ii) the semilatus rectum [3]

(iii) the orbital period [3]

(d) Assuming both planets in (c) move in circular orbits with a radius equal to the average of the semi-major and semi-minor axes, find the angle ψ between the lines joining the planetary positions to the sun at lift off for a spaceship from earth to follow a Hohmann orbit between these planets. [6]

Q6 (a) Show that the centre of mass of a system of particles is a unique point which is independent of the choice of origin. Also show that this point moves as if all the mass of the system was concentrated there and moving under the action of a single force equal to the total external force acting on the system. [6]

(b) One smooth sphere collides with another, the second one being at rest. After the collision, both of them move at an angle of ~~60~~ 45 degrees with the initial direction of motion of the first sphere. Assuming the collision is elastic, show that the spheres are of equal masses. [4]

(c) Particles of mass m_1 are scattered elastically by stationary particles of mass m_2. One wishes to count, experimentally, only those particles which have lost 30% of their initial linear momentum.

(i) At what angle with the incident beam should his counter be placed? [7]

(ii)It is found that when placed at this angle the counter gives a zero reading. What can be deduced about the masses of the particles? [3]

Q7 (a) Show that the kinetic energy of a rigid body of mass m relative to some frame of reference S is equal to the sum of the kinetic energy of the body relative to its centre of mass and the kinetic energy relative to S of a particle of mass m located at, and moving with, the centre of mass. [9]

(b) Four masses 0.03 kg, 0.05 kg, 0.02 kg and 0.1 kg are placed in the XY plane and have coordinates (4,-1), (5, 2), (-3, -4) and (-2, 4) respectively. Find the coordinates of their centre of mass. [6]

(c) The linear mass density of a 2 m long rod is given by

$$\mu = 0.4 + 4x \text{ kg/m}$$

where x is the distance measured from one end of the rod. What is the distance of the centre of mass from that end? [5]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS
FIRST SEMESTER UNIVERSITY EXAMINATIONS, 2005

P-261: ELECTRICITY AND MAGNETISM.

Instructions: Answer five questions only. Time: three hours

Wherever required, the following formulae can be used:

$$\oint B.dl = \mu_o i \quad \iint E.dS = \frac{\sum q}{\varepsilon_o}, \quad dB = \frac{\mu_o i dl \sin\theta}{4\pi r^2}, \quad \Phi = B.A \quad \varepsilon = -L\frac{di}{dt}, \quad F = BIL$$

$$B = \frac{\mu_o i}{2\pi r}$$

Q1 (a) (i) A thin disk of radius a carries a charge q. The charge density is given by $\sigma = \sigma_o + kr$ where k is a constant. Find the total charge on the disk. [7]

(ii) A long, thin straight non-conducting rod carries a charge with linear density λ uniformly distributed about its length, figure 1. Find the force the distribution will exert on a small charge of magnitude q placed 50 cm away from the rod. [6]

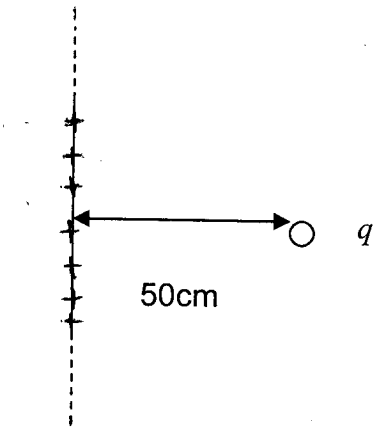


Figure 1

(b) Figure 2 shows a ring of radius a with charge q uniformly distributed over it. If the charge density is λ, show that the electric field $\vec{E}$ for points on the axis of the ring a distance x from its center is given by

$$\vec{E} = \frac{1}{4\pi\varepsilon_o}\left[\frac{\lambda x a}{(a^2 + x^2)^{\frac{3}{2}}}\right]$$ [7]

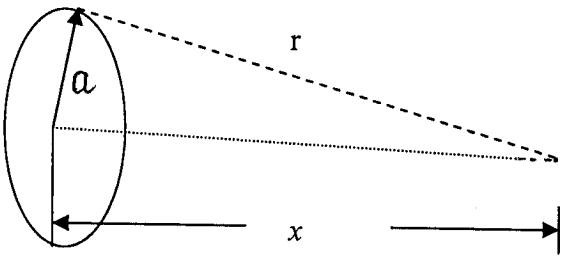


Figure 2

Q2 (a) Figure 3 shows a thick spherical shell of inner radius a and outer radius b carrying a charge q uniformly distributed over it.

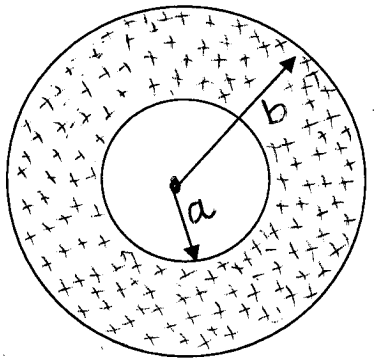


Figure 3

(i) Using Gauss's law or otherwise, show that the electric field for points inside the smaller sphere radius, i.e. $r < a$, is zero. [3]

(ii) Find an expression for the electric field for points inside and outside the solid part of the sphere, i.e. in the regions $a < r < b$ and $r > b$. Make a rough sketch of these variations. [10]

(ii) Find the potential in the hollow part of the cylinder [7]

Q3 (a) Calculate the drift velocity of electrons in a copper conductor. Take the density and average molecular mass for copper as 8.9 gram/cm^3 and 63.5 gram/mole respectively. Avogadro's constant, N_A = 6.022 X10^{23} particles/mole [6]

(b) A capacitor C_1 of capacitance 5μF is charged with a charge of 10μC to a potential difference V_o whereupon it is connected in parallel to another capacitor C_2 of capacitance 20μF. After equilibrium is established, find

(i) the value of the potential V_o [2]

(ii) the charges Q_1 and Q_2 stored by C_1 and C_2 respectively. [6]

(iii) the potentials V_1 and V_2 across each capacitor.

(iv) the energy stored in each capacitor. Is energy conserved? If not, state a reason for the difference. [5]

Q4. (a) The current density in a conductor of radius a varies as $j = j_o r$. Find the total current. [5]

(b) A galvanometer of internal resistance $R_i = 10\Omega$ gives full scale deflection when a current of 1 mA flows through its coil. It is desired to convert the galvanometer into a voltmeter giving full-scale deflection at 10volts. With the help of a clearly labeled diagram, calculate the value of the series resistor required for this conversion. [4]

(c) Using the laws of series and parallel combinations for the electrical network in figure 4, find

(i) the current flowing in branch *AF*;
(ii) the potential difference across branch *CD*. } [11]

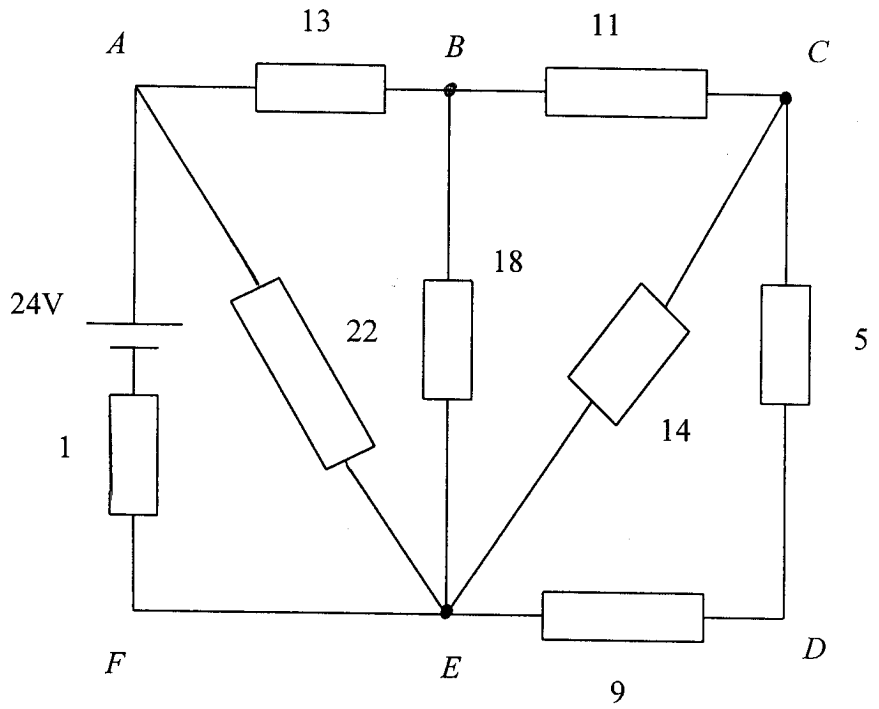


Figure 4

5 (a) Explain the physical meaning of the equation $\int \vec{B}.\vec{dS} = 0$ where $\vec{B}$ is the magnetic field intensity over a closed surface that contains no magnetic objects. [2]

(b) (i) Ampere's law is formally stated as $\oint \vec{B}.\vec{dl} = \mu_o \int \vec{j}.\vec{dS}$. Explain the meaning of this equation. [3]

(ii) Figure 5 shows a thick, hollow cylindrical conductor of inner and outer radii of a and b respectively. It carries a current i_o uniformly distributed over its cross-section.

- Show that the magnetic field B for points inside the body of the conductor (i.e. $a < r < b$) is given by the expression

$$\vec{B} = \frac{\mu_o i_o}{2\pi(b^2 - a^2)} \frac{r^2 - a^2}{r}$$ [6]

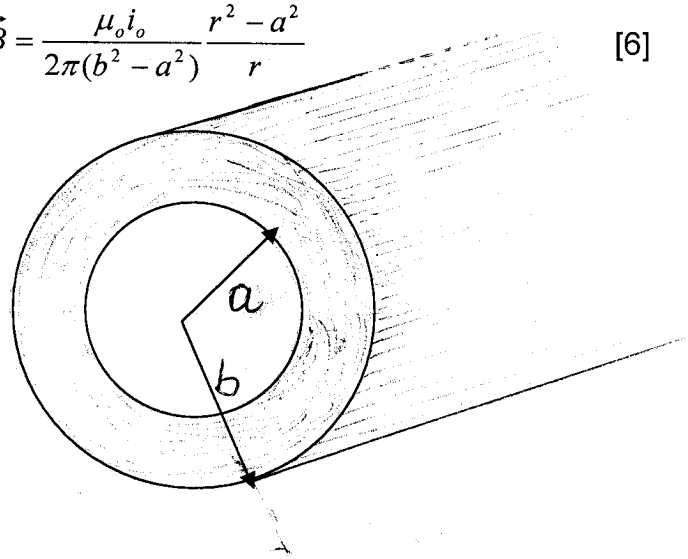


Figure 5

(c) (i)The wire shown in figure 6 carries a current i. Find an expression for the magnetic field $\vec{B}$ at the center C of the semi-circle arising from the semi-circular segment of radius R. [5]

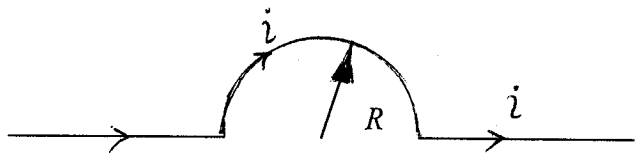


Figure 6

(ii) Two circular coils of N closely wound turns of radius a are co-axial and are separated by a distance b. Find the force between the two coils when a current i passes through each coil. [4]

6 (a)(i) Use Lenz's law to derive the direction of the induced current in the conducting loop as the magnet is brought towards the loop as shown in figure 7. [3]

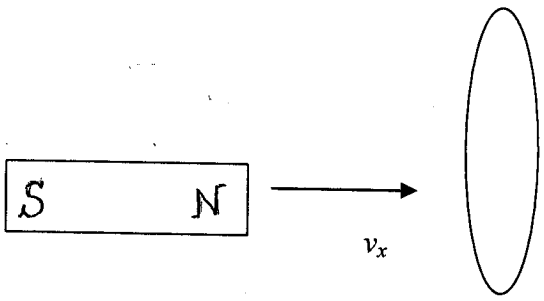


Figure 7

(ii) The field coils of a 6-pole d.c. generator, each with 500 turns, are connected in series. When the field is switched on, there is a magnetic flux of 0.02 Weber per pole. If the field circuit is opened in 0.02 seconds and residual magnetism is 0.002 Weber per pole, calculate the average voltage that is induced across the field terminals. [5]

(b) (i) A conducting loop of 20 closely wound turns measuring 20 cm by 10 cm is placed in a region where there is a uniform magnetic field B = 0.4T oriented at an angle of 30° to the plane of the loop.

A Calculate the magnetic flux threading the loop. [3]

B If the loop is suddenly removed from this region in 0.1 sec. of a second, find the average current induced in the loop given its resistance R as 10Ω [0.1]

(c) Three inductances L_1, L_2 and L_3 are connected in series and are separated by a large distance.

(i) Show that their equivalent inductance L_{eq} is given by $L_1 + L_2 + L_3$. [4]

(ii) Why is it necessary for the separation distance to be large for this equation to be valid? [1]

7 (a) Distinguish between "impedance" and "resistance" [2]

(b) The applied voltage in a circuit is given by the expression: $v = V_m \sin(\omega t)$.

(i) Show that the current i_L passing through a pure inductance L is given by the expression $i = -\frac{V_m}{\omega L}\cos\omega t$. Hence prove that the current and voltage are out of phase by $\frac{\pi}{2}$. [4]

(ii) A resistance $R = 20\Omega$, an inductance $L = 0.2H$ and a capacitance $C = 100\mu$F are connected in series across a $220V$, 50 Hz power supply. Determine the following:

A the impedance of circuit;

B the current in circuit

C the voltages across R, L and C. Do they add up to the value of the original voltage. If not, what must be done to remedy this seeming anormally?

D the phase angle between circuit current and voltage [12]

(c) Discuss reasons why pure inductive and capacitive circuits cannot be used for electrical heating whereas resistances can. [2]

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

DEPARTMENT OF PHYSICS

2005 FIRST SEMESTER UNIVERSITY EXAMINATIONS

P351
QUANTUM MECHANICS I

URATION:	Three hours.
NSTRUCTIONS:	Answer any four questions from the six given. *Each question carries 25 marks with the division of marks within each question indicated by the numbers in parenthesis next to the question.*
AXIMUM MARKS:	100
ATE:	Monday, 20th June 2005.

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rmulae that may be needed:

$$\sum_{n=0}^{\infty} e^{-nx} = \frac{1}{1-e^{-x}}$$

$$\int \sin^2 x \, dx = \frac{x}{2} - \frac{\sin 2x}{4}$$

Normalized eigenfunctions of L_z:

$$\frac{1}{\sqrt{2\pi}} e^{im\phi}$$

$$[x, p_x] = [y, p_y] = [z, p_z] = i\hbar$$

QUESTION 1

(i) Derive Planck's spectral distribution law starting from the expression for the average energy $\bar{\mathcal{E}}$ of a collection of modes of the electromagnetic field,

$$\bar{\mathcal{E}} = \frac{\sum_{n=0}^{\infty} n\epsilon_0 e^{-\beta n\epsilon_0}}{\sum_{n=0}^{\infty} e^{-\beta n\epsilon_0}},$$

derived on the assumption that electromagnetic energy is absorbed and emitted in discrete units. (20 marks)

ii) Draw the graph of the spectral distribution function (monochromatic energy density) $\rho(\lambda, T)$ according to Planck's formula and according to the Rayleigh-Jeans formula.

(5 marks)

UESTION 2

(i) Give the definition of a hermitian operator. (4 marks)

ii) Explain why hermitian operators are so important in quantum mechanics. (2 marks)

ii) Prove that the eigenvalues of a hermitian operator are real. (9 marks)

v) Prove that the eigenfunctions of a hermitian operator are orthogonal. (6 marks)

v) During the measurement of a dynamical variable A, explain what happens to (a) a general state, and (b) an eigenstate of A. For both part (a) and part (b) state whether or not the measured value of A is the same as its value before measurement. (4 marks)

UESTION 3

i) Draw a diagram of the particle in a box potential. Write down, and solve by the auxiliary equation method the Schrödinger equation inside the (one dimensional) box. Use the boundary conditions to find the allowed values of k and from these find the allowed energy eigenvalues. (12 marks)

i) Normalize the negative parity solutions. (5 marks)

i) Find the expectation value of the square of the momentum operator $\langle p^2 \rangle$ for the negative parity solutions. (6 marks)

v) How do the energy eigenvalues differ from the classical case. (2 marks)

QUESTION 4

(i) Draw a diagram of and write down the simple harmonic oscillator potential. Write down the corresponding time-independent Schrödinger equation.

(3 marks)

(ii) The following change of variables

$$\lambda = \frac{2E}{\hbar\omega}, \qquad \omega = \left(\frac{k}{m}\right)^{\frac{1}{2}}, \qquad \alpha = \left(\frac{m\omega}{\hbar}\right)^{\frac{1}{2}}, \qquad \xi = \alpha x$$

in the Schrödinger equation gives the Hermite equation:

$$\frac{d^2H(\xi)}{d\xi^2} - 2\xi\frac{dH(\xi)}{d\xi} + (\lambda - 1)H(\xi) = 0$$

Find the recursion relation for the even solutions, and state how this relation gives the even solutions of the Hermite equation. (12 marks)

(iii) Explain why the values of λ are restricted only to integer values. (2 marks)

(iv) Given that $\lambda = 4N + 1$ for even states and $\lambda = 4N + 3$ for odd states, with $N = 0, 1, 2, ...$, determine the energy eigenvalues. (3 marks)

(v) The first two eigenfunctions are $\psi_0 = e^{-\alpha^2x^2/2}$, and $\psi_1 = 2\alpha x e^{-\alpha^2x^2/2}$. Plot $|\psi_0|^2$ and $|\psi_1|^2$ together with the corresponding classical probability density.

(3 marks)

QUESTION 5

(i) The eigenvalue equation for $\boldsymbol{L}^2$ in terms $\omega = \cos\theta$ is,

$$\left[(1-\omega^2)\frac{d^2}{d\omega^2} - 2\omega\frac{d}{d\omega} + l(l+1) - \frac{m^2}{1-\omega^2}\right] F_{lm}(\omega) = 0.$$

Solve this equation for the case $m = 0$ by the power series method. (14 marks)

(ii) Explain why the values of l are restricted to integer values. What are the solutions corresponding to these integer values called?

(5 marks)

(iii) Write down the general form of the spherical harmonics in terms of the solutions of parts (i) and (ii) and the eigenfunctions of L_z. (3 marks)

(iv) The first four spherical harmonics are given by

$$Y_{00} = \frac{1}{(4\pi)^{\frac{1}{2}}}, \qquad Y_{10} = \left(\frac{3}{4\pi}\right)^{\frac{1}{2}}\cos\theta, \qquad Y_{1,\pm1}\sin\theta e^{im\phi}.$$

Draw the polar plots of the probability density $|Y_{00}|^2$, $|Y_{10}|^2$, $|Y_{\pm1}|^2$, and briefly explain what they show.

(3 marks)

QUESTION 6

(i) From the definition of angular momentum $\boldsymbol{L} = \boldsymbol{r} \times \boldsymbol{p}$ determine $\boldsymbol{L}$ in component form. (3 marks)

(ii) Prove that

$$[L_x, L_y] = i\hbar L_z,$$

and write down the other two commutation relations for the components of $\boldsymbol{L}$. (10 marks)

(iii) Using the vector model, determine the magnitude and allowed orientations of the orbital angular momentum vector $\boldsymbol{L}$ for when the orbital angular momentum quantum number is $l = 2$. Repeat for the general angular momentum vector $\boldsymbol{J}$, when the quantum number $j = \frac{3}{2}$. Show your results in a diagram. (4 marks)

(iv) Find the allowed magnitudes and orientations of the total angular momentum vector $\boldsymbol{J} = \boldsymbol{L} + \boldsymbol{S}$ when $l = 2$ and $s = \frac{1}{2}$. Show your results in a diagram. (4 marks)

(v) For the hydrogen atom probability density,

$$|\psi_{nlm}(r, \theta\phi)|^2 = |R_{nl}(r)|^2 |Y_{lm}(\theta, \phi)|^2 = R_{nl}(r)|^2 |\frac{1}{2\pi}|\theta_{lm}(\theta)|^2,$$

explain what is given by

$$|\psi_{nlm}(r, \theta\phi)|^2 d\boldsymbol{r},$$

where $d\boldsymbol{r}$ is a volume element. Integrate over θ and ϕ to obtain the radial probability density (radial distribution function) times the volume element $d\boldsymbol{r}$, and state its meaning. (4 marks)

END

The University of Zambia
School of Natural Sciences
Department of Physics
2005 Academic Year First Semester
Final Examinations
P-411 : Nuclear Experimental Techniques

Attempt <u>any four</u> questions. All questions carry equal marks. The marks are shown in brackets.

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 =	9.1×10^{-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 :

$$h\upsilon' = \frac{h\upsilon}{1+\frac{h\upsilon}{m_0 c^2}(1-\cos\theta)} \qquad \Omega = \frac{\pi a^2}{d^2} \qquad N = N_0 e^{-\Sigma_t x} \qquad m = \frac{n}{1+n\tau}$$

$$n - m = n m \tau$$

Q1.(a) (i) Derive from first principles the radioactive decay law and obtain the expressions relating the decay constant λ, half-life T, and the mean life τ of a given radioactive nuclide. (ii) Explain the terms "secular equilibrium" and "transient equilibrium". (iii) Under what conditions do they exist ? [12]

(b) The activity of 20g of element X is four times the activity of 10g of element Y. Element Y has a half-life of 20,000 years. (i) What is the half-life of X ? (ii) How much of each will remain after 40,000 years ? (iii) How long will it be before equal amounts of X and Y remain ? [8]

(c) Define 'mass defect' and 'binding energy' of an atom. Write an equation relating mass defect and binding energy giving energy in MeV. [5]

Q2. (a) Distinguish between ionizing and radiative processes in the collision of fast electrons with matter. Indicate how the importance of each process depends on the electron energy and the nature of the absorber. [8]

(b) A gold foil 0.02 cm thick and 1 cm^2 in cross section is irradiated for 5 minutes with a beam of thermal neutrons with a flux of 10^{12} neutrons per cm^2 per second. The nuclide ^{198}Au with a half-life of 2.7 days is produced by the reaction $^{197}Au(n,\gamma)^{198}Au$. The density of gold is 19.3 g per cm^3 and the cross section for the reaction is 98.7 barns.

(i) how many atoms of ^{198}Au are produced per cm^2 of the foil ?

(ii) what is the activity of the foil in milli-Curies per cm^2 ? Given, 1 Curie = 3.7 x 10^{10} d/sec. [8]

(c) The nuclide $^{222}_{86}Rn$ emits three groups of alpha particles, with kinetic energies of 5.847, 5.779, and 5.613 MeV respectively. Associated with the alpha particles are gamma rays of energies 0.0687, 0.169, and 0.238 MeV. Construct a decay scheme based on this data. [9]

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]

Q4.(a) Gamma rays of energy *3.5* MeV are incident on an "intermediate" sized *NaI(Tl)* detector. Draw the idealised response function; explain its various features. Name the types of interactions that take place in the detector. [9]

(b) Counters *A* and *B* are "non-paralysable" with dead times of 30μs 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* ? [10]

(c) Write short notes on "full-energy peak efficiency" "relative efficiency", and "intrinsic efficiency" of a radiation detector. [6]

Q5.(a) Explain the role of the activator in the NaI(Tl) scintillator. [5]

(b) Write a short note on pulse shape discrimination using a scintillation detector. Name one scintillator suitable for use in pulse shape discrimination. [5]

(c) Draw a block diagram of the basic components of a scintillation spectrometer. Explain briefly the function of each component. [3]

(d) 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 δ = 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]

Q6. (a) Define (i) radiation exposure, (ii) absorbed dose, and (iii) dose equivalent. Define the unit for each. [6]

(b) What are the types of potential hazard to humans due to radiation exposure? [5]

(c) Draw the dose response curve for threshold and non-threshold hypotheses of biological radiation damage; briefly discuss the rationale of each hypothesis. [4]

(d) Describe the types of biological effects of radiation on man. [6]

(e) Describe the most important functions of a health physicist. [4]

== End of P-411 Examination ==

UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS
2005 FIRST SEMESTER UNIVERSITY EXAMINATIONS

P415
MATHEMATICAL METHODS FOR PHYSICISTS

DURATION: Three hours.

INSTRUCTIONS: Answer any four questions from the six given. *Each question carries 25 marks with the division of marks within each question indicated by the numbers in parenthesis next to the question.*

MAXIMUM MARKS: 100

DATE: Monday 20th June 2005.

Formulae that may be needed:

. The Cauchy-Riemann equations:

$$u_x = v_y, \qquad u_y = -v_x$$

. Multiplication in polar form:

$$z_1 z_2 = r_1 r_2[\cos(\theta_1 + \theta_2) + i\sin(\theta_1 + \theta_2)]$$

. Roots:

$$\sqrt[n]{z} = \sqrt[n]{r}\left(\cos\frac{\theta + 2k\pi}{n} + i\ \sin\frac{\theta + 2k\pi}{n}\right), \qquad k = 0, 1, 2, 3, \ldots, (n-1)$$

$$\sqrt{z} = \pm\left[\sqrt{\frac{1}{2}(|z| + x)} + (\text{sign } y)i\sqrt{\frac{1}{2}(|z| - x)}\right]$$

Integration by use of the path:

$$\int_C f(z)\, dz = \int_a^b f[z(t)]\dot{z}(t)\, dt.$$

5. Cauchy's integral formula:

$$\oint_C \frac{f(z)}{z - z_0}\, dz = 2\pi i f(z_0).$$

6. Derivative of an analytic function:

$$f^{(n)}(z_0) = \frac{n!}{2\pi i} \oint_C \frac{f(z)}{(z - z_0)^{n+1}}\, dz \qquad (n = 1, 2, \ldots).$$

7. Ratio test 1: Series converges if $|\frac{z_{n+1}}{z_n}| \leq q < 1$, and diverges if $|\frac{z_{n+1}}{z_n}| \geq 1$ for n greater than some N.

8. Ratio test 2:

$$\lim_{n\to\infty} \left|\frac{z_{n+1}}{z_n}\right| = L.$$

9. Root test 1: Series converges if $\sqrt[n]{|z_n|} \leq q < 1$, and diverges if $\sqrt[n]{|z_n|} \geq 1$.

10. Root test 2:

$$\lim_{n\to\infty} \sqrt[n]{|z_n|} = L.$$

11. Radius of convergence of a power series:

$$R = \lim_{n\to\infty} \left|\frac{a_n}{a_{n+1}}\right|$$

12.

$$\cos z = \frac{1}{2}\left(e^{iz} + e^{-iz}\right)$$

13.

$$\cosh z = \frac{1}{2}\left(e^{z} + e^{-z}\right)$$

14.

$$e^z = \sum_{n=0}^{\infty} \frac{z^n}{n!} = 1 + z + \frac{z^2}{2!} + \ldots.$$

15.

$$\cos z = \sum_{n=0}^{\infty} (-1)^n \frac{z^{2n}}{(2n)!} = 1 - \frac{z^2}{2!} + \frac{z^4}{4!} - + \ldots$$

16.

$$\cosh = \sum_{n=0}^{\infty} \frac{z^{2n}}{(2n)!} = 1 + \frac{z^2}{2!} + \frac{z^4}{4!} - + \ldots$$

17. Formula 1 for residue at a simple pole:

$$\operatorname*{Res}_{z=z_0} f(z) = \lim_{z\to z_0} (z - z_0) f(z).$$

18. Formula 2 for the residue at a simple pole:

$$\operatorname*{Res}_{z=z_0} \frac{p(z)}{q(z)} = \frac{p(z_0)}{q'(z_0)}.$$

rmula for residues of any order:

$$\operatorname*{Res}_{z=z_0} f(z) = \frac{1}{(m-1)!} \lim_{z \to z_0} \left\{ \frac{d^{m-1}}{dz^{m-1}} [(z-z_0)^m f(z)] \right\}.$$

sidue theorem:

$$\oint_C f(z)\, dz = 2\pi i \sum_{j=1}^{k} \operatorname*{Res}_{z=z_j} f(z).$$

proper integrals of rational functions:

$$\int_{-\infty}^{\infty} f(x)\, dx = 2\pi i \sum \operatorname{Res} f(z).$$

benius method:

. Distinct roots not differing by an integer

$$\begin{aligned} y_1(x) &= x^{r_1}(a_0 + a_1 x + a_2 x^2 + ...) \\ y_2(x) &= x^{r_2}(A_0 + A_1 x + A_2 x^2 + ...) \end{aligned}$$

. Double root

$$\begin{aligned} y_1(x) &= x^r(a_0 + a_1 x + a_2 x^2 + ...) \\ y_2(x) &= y_1(x) \ln x + x^r(A_0 + A_1 x + A_2 x^2 + ...), \qquad (x > 0) \end{aligned}$$

. Roots differing by an integer

$$\begin{aligned} {}_1(x) &= x^{r_1}(a_0 + a_1 x + a_2 x^2 + ...) \\ {}_2(x) &= k y_1(x) \ln x + x^{r_2}(A_0 + A_1 x + A_2 x^2 + ...), \qquad (x > 0), \qquad r_1 > r_2 \end{aligned}$$

TION 1

Convert the complex numbers $z_1 = 3 + 4i$ and $z_2 = 5 - 3i$ into polar form, and hen multiply them using the formula for multiplication in polar form.

(4 marks)

ive the definition of an analytic function. (2 marks)

se the Cauchy-Riemann equations to test whether or not

$$f(z) = e^x(\cos y + i \sin y)$$

analytic. (4 marks)

tegrate the integral (using indefinite integration formula)

$$\int_{8+i\pi}^{8-i3\pi} e^{z/2} dz.$$

(5 marks)

(v) Integrate

$$\int_C \frac{ze^z}{(4z+i\pi)^2}\,dz,$$

around path C counterclockwise, where the path C is the unit circle.

(10 marks)

QUESTION 2

(i) Is the series

$$\sum_{n=0}^{\infty} n\left(\frac{i}{2}\right)^n$$

convergent or divergent?

(6 marks)

(ii) Find the center and radius of convergence of

$$\sum_{n=0}^{\infty} n\left(\frac{z}{3}\right)^n.$$

(6 marks)

(iii) Expand the function

$$f(z) = z\cos\frac{1}{z}$$

as a Laurent series that converges for $0 < |z| < R$ and determine the precise region of convergence.

(7 marks)

(iv) Determine the value and type of singularity of the function

$$f(z) = \frac{z^3+3z}{z^2+1}.$$

(6 marks)

QUESTION 3

(i) Evaluate the integral

$$\int_0^{\pi} \frac{1}{k+\cos\theta}\,d\theta, \qquad k > 1.$$

(15 marks)

(ii) Evaluate the improper integral

$$\int_{-\infty}^{\infty} \frac{1}{1+x^2}\,dx.$$

(10 marks)

QUESTION 4

Find the eigenvalues and eigenvectors of

$$\begin{bmatrix} 2 & 0 & 0 \\ 0 & 4 & 0 \\ 0 & 0 & 3 \end{bmatrix}.$$

(25 marks)

QUESTION 5

Find the basis of solutions of the differential equation

$$x(x-1)y'' + (3x-1)y' + y = 0.$$

(25 marks)

QUESTION 6

(i) Derive the Euler-Lagrange equation. (13 marks)

(ii) Determine the shortest distance (geodesic) between two points in a plane. (12 marks)

END

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF PHYSICS

2005 ACADEMIC YEAR FIRST SEMESTER

FINAL EXAMINATIONS

P421: SOLID STATE PHYSICS I

TIME: THREE (3) HOURS

ANSWER ANY FOUR QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

MAXIMUM MARK: 100

Electron rest mass $m_e = 9.11 \times 10^{-31}$ kg

Proton rest mass $m_p = 1.67 \times 10^{-27}$ kg

Planck's constant $h = 6.626 \times 10^{-34}$ Js^{-1}

Boltzmann constant $k_B = 1.38 \times 10^{-23}$ JK^{-1}

Avogadro's Number $N = 6.022 \times 10^{23}$ mol^{-1}

$(\boldsymbol{c} \times \boldsymbol{a}) \times (\boldsymbol{a} \times \boldsymbol{b}) = (\boldsymbol{c} \bullet \boldsymbol{a} \times \boldsymbol{b})\boldsymbol{a}$

Q1 (a) Name three main wave-particles which are used in crystal diffraction. [3]

(b) What is the minimum condition for diffraction of incident radiation of wave length λ at an angle θ from the (hkl) planes in a crystal? Derive this condition. [6]

(c) Show that the volume of the first Brillouin zone is $(2\pi)^3/V_c$, where V_c is the volume of a crystal primitive cell. Hint: The volume of a Brillouin zone is equal to the volume of the primitive parallelepiped in Fourier space. [7]

(d) How does the knowledge of the Brillouin zone assist in determining the allowed wave vectors which can be diffracted by a crystal? [3]

(e) Determine the structure factor of the hexagonal close-packed (hcp) lattice. [6]

Q2 (a) What is an ionic bond? State the various interactions involved, their contributions to the overall bond strength and the favoured arrangements of ions in the crystal. [8]

(b) Consider a line of $2Z$ ions of alternating charge $\pm q$ with a repulsive potential energy λ/R^x between nearest neighbours. Show that at equilibrium separation.

$$U(R_0) = -\frac{2Zq^2 \ln 2}{R_0}\left(1 - \frac{1}{x}\right) \qquad [17]$$

Q3 (a) Describe the source of the Van der Waals binding mechanism in crystals. [3]

(b) The cohesive energy of inert gas crystals is frequently approximated by the Lennard-Jones (L-J) potential, which can be expressed as

$$U = 2N\varepsilon(\sigma/R)^6\left\{(\sigma/R)^6 S_{12} - S_6\right\}$$

where R is the atomic nearest neighbour separation, $S_{12} = 12.13$ and $S_6 = 14.45$ are the structural summation constants, ε and σ are L-J parameters. Show that the equilibrium value of U may be given by

$$U_0 = -\frac{1}{2}N\varepsilon(S_6^2/S_{12}). \qquad [9]$$

(c) From the results of (b) calculate the crystal binding energy per mole of argon for which $\varepsilon = 1.67\times10^{-21}$ J. [4]

(d) The repulsive term Br^{-n} in the lattice energy expressions

$$U(r) = -N(Aq^2r^{-1}-Br^{-n})$$

is often replaced by the term $C\exp(-r/L)$, where A, B and L are constants, and r is the nearest neighbour separation. At what **equilibrium** nearest neighbour distance R_0 do the two repulsive potentials energies give rise to the same lattice energy? [9]

Q4 (a) Explain the differences between the Debye and Einstein models of heat capacity. [5]

(b) In the low frequency continuum limit the phonon dispersion relation is $\omega = vk$ where v is the velocity of sound in the crystal lattice. Derive an expression for the density of states $g(\omega)$ for a 3-D lattice under this limit. [6]

(c) Derive general expressions for Debye frequency, temperature and wave vector. Determine these values for copper which has an atomic mass of 63.5, density of 8.9 g/cm^3 and v=3.88 km/s. [14]

Q5 (a) Construct a diagram in k-space which describe the normal (N) and Umklapp (U) processes between phonons in a crystal lattice. Write down the conservation laws appropriate for each process. [8]

(b) Consider the normal modes of a linear chain in which the force constants between nearest-neighbor atoms are alternately $2C$ and $4C$. Let the masses be equal, and let the nearest-neighbor separation be $a/4$.

(i) Find $\omega(K)$ at K=0 and $K=\pi/a$. [12]

(ii) Sketch the shape of the dispersion relation. [5]

Q6 (a) Consider the dynamics of an electron in a conductor in a static magnetic field. Show that the electron moves in k-space on a surface of constant energy. Give an example of such a surface. [6]

(b) Calculate the free-electron mean free path of copper if the electrical resistivity is $\rho = 1.7\times10^{-8}$ Ωm and Hall coefficient is $R_H = -05.4 \times 10^{-11}$ m^3c^{-1}.

[9]

(c) Derive an expression for the effective mass of an electron and discuss the physical significance of the concept of effective mass. [6]

(d) Describe the phonon absorption processes in direct and indirect gap semiconductors and explain how the band gap can be determined through these processes. [4]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

P441: ANALOG ELECTRONICS II

TIME: THREE HOURS MAXIMUM MARKS = 100

INSTRUCTIONS:

Answer any four questions.
All questions carry equal marks.
The marks are shown in brackets.

Q1. (a) Derive an expression for the output resistance of a voltage series feedback amplifier. [7]

(b) Design a first order high pass Butterworth filter at a cut off frequency of 1 kHz with a passband gain of 2. Prepare the frequency response data for the following frequencies. The frequencies are given in Hz. [18]

100 200 400 700 1000 3000 7000 10,000 30,000 100,000

Q2. (a) The 741C operational amplifier having the following parameters is connected as a voltage follower with ~~R_1=1 kΩ, R_F=10 kΩ,~~ A=200,000, R_i=2 MΩ, R_o=75 Ω, f_o=5Hz, supply voltages = ± 15V, output voltage swing = ± 13 V. Compute the values of [6]

(i) voltage gain
(ii) input resistance
(iii) output resistance
(iv) bandwidth
(v) total output offset voltage.

(b) For the LM307 operational amplifier, R_F=10 kΩ, R_1=1 kΩ, V_{io}=10 mVdc and supply voltages = ± 10V. What is the maximum possible output offset voltage (V_{oo}), caused by the input offset voltage (V_{io}) if it is to be used as a non inverting amplifier? Design a compensating network for the LM307 operational amplifier. [15]

(c) Explain why open loop operational amplifier configurations are unsuitable for linear applications. [4]

Q3.(a) Derive an expression for the gain of a differential amplifier with one operational amplifier. [10]

(b) Design a square wave generator to operate at a frequency of 2 kHz. [6]

(c) Design a narrow band pass filter so that f_c=2 kHz, Q=20 and A_F=10. What modifications are necessary in the filter circuit to change the centre frequency f_c to 2.5 kHz, keeping the gain and bandwidth constant? [9]

Q4.(a) An amplifier has a differential gain of 300 and a CMRR of 60dB, V_{in1}=40 mV, V_{in2}=60 mV and V_{noise}=5mV. Determine the differential output and noise output. [6]

(b) Design a Wien bridge oscillator that will oscillate at 2 kHz. [7]

(c) Derive an expression for output voltage of an integrator. Sketch the waveforms and explain the circuit operation. [12]

Q5. (a) Find the closed loop gain A_F for the amplifier given below. Given R_1=10 kΩ and R_F=20 kΩ, how does A_F change if a third resistance R_2=10 kΩ is connected in series with R_1? In parallel with R_1? [5]

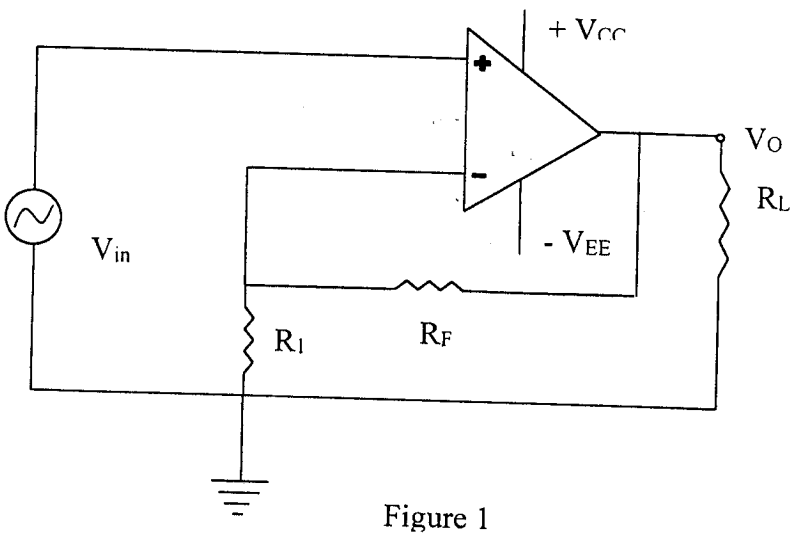

Figure 1

(b) Design a second order low pass Butterworth filter at a cut off frequency of 1.2 kHz. Using the frequency scaling technique, convert the above filter to a cut off frequency of 1.6 kHz. [11]

(c) What causes the gain of an operational amplifier to roll off after a certain frequency is reached? How do we account for this in the high frequency model of the operational amplifier? Draw the circuit diagram. [9]

Q6.(a) The following specifications apply to the differential amplifier circuit of figure 2. $R_2 = R_F = 2.2$ kΩ, $R_3 = R_1 = 1$ kΩ, $V_x = 700$ mV pp and $V_y = 500$ mV pp sine waves at 500 Hz. The operational amplifier is a 741C with A = 200, 000, $R_i = 2$ MΩ, R_o=75 Ω and f_0=5 Hz. Assume that the output is initially nulled. Calculate [10]

(i) the voltage gain

(ii) the bandwidth

(iii) the input resistance seen by each signal source

(iv) the output resistance

(v) the output voltage of the amplifier.