THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS 2001

FIRST SEMESTER AND SECOND SEMESTER

SCHOOL OF NATURAL SCIENCES

1.	BS	111	Cell Biology and Genetics – Theory paper
2.	BS	211	Cell Molecular biology and genetics theory paper
3.	BS	221	Form, function and diversity of plants theory paper
4.	BS	319	Biostatistics theory
5.	BS	321	Ethology and Evolution
6.	BS	331	plant physiology – theory paper
7.	BS	341	Microbiology – paper II practical
8.	BS	342	Mycology
9.	BS	351	Entomology – practical paper
10.	BS	375	Invertebrate Zoology
11.	BS	411	Insect behaviour and Ecology-Theory: paper I
12.	BS	425	Immunology – theory paper I
13.	Bs	431	Advanced parasitology I paper I
14.	BS	441	Advanced molecular biology – theory paper I
15.	BS	475	Population Ecology – paper I
16.	BS	491	Freshr water Biology – Theory paper
17.	BS	915	Biology of Seed plants – Theory paper
18.	BS	935	Plant pathology – theory paper
19.	C	101	Introductory Chemistry
20.	C	205	Deferred/Supplementary examination
21	C	225	Analytical Chemistry
22	C.	245	Introduction to Inorganic Chemistry
23.	C	251	Organic Chemistry
24.	C	311	Biochemistry I
25.	C	341	Inorganic Chemistry II
26.	C	342	Inorganic Chemistry
27	C	351	Organic Chemistry
28.	C	361	Chemical kinetics and Nuclear Chemistry
29.	C	445	Bio-Inorganic Chemistry
30.	C	451	Advanced organic Chemistry
31.	C	481	Inorganic industrial Chemistry
32	C	491	Organic industrial Chemistry
33.	CAV	251	Analytical/Physical/Organic Chemistry
34.	CST	2021	Introduction to Computer Systems
35.	EM	211	Engineering Mathematics I
36.	EM	311	Engineering Mathematics III
37.	EM	431	Engineering Mathematics V
38	GEO	111	Introduction to Human Geography I

39.	GEO	175	Introduction to Mapping Techniques in Geography paper II
40.	GEO	211	The Geography of Africa
41.	GEO	212	The geography of Zambia
42.	GEO	271	Quantitative Techniques in Geography I
43.	GEO	381	Environment and Development
44.	GEO	451	Land Resources Survey
45.	GEO	481	Environment and Development II
46.	GEO	911	Population Geography
47.	GEO	931	Rural Geography
48.	GEO	955	Geomorphology
49.	GEO	961	Soils Geography
50.	GEO	971	Aerial photographs and interpretation paper II
51.	M	111	Mathematical methods I
52.	M	112	Mathematical methods II
53.	M	161	Introduction to mathematics, probability Methods III
54.	M	211	Mathematics methods III
55.	M	221	Linear Algebra I
56.	M	225	Introduction to Mathematical logic
57.	M	231	Real Analysis I
58.	M	261	Introduction to Statistics
59.	M	331	Real Analysis III
60.	M	335	Point set Topology
61.	M	361	Mathematical statistics
62.	M	411	Theory of functions of a Complex Variable I
63.	M	431	Real Analysis V
64.	M	461	Multivariate Analysis
65.	M	465	Non - parametric statistics
66.	M	911	Mathematical methods V
67.	M	941	Structured Computer Organisation
68.	M	981	Numerical Analysis I
69.	P	191	Introductory physics I
70.	P	251	Classical Mechanics I
71.	P	261	Electricity and magnetism
72.	P	341	Introduction to Quantum Mechanics
73.	P	421	Solid State Physics I
74.	P	441	Electronics 2

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS
FIRST SEMESTER EXAMINATIONS – JANUARY 2001

BS 111
CELL BIOLOGY AND GENETICS
THEORY PAPER

TIME: THREE HOURS

ANSWER: ALL QUESTIONS

MARKS:

CORRECT ANSWER	= + 4
INCORRECT ANSWER	= -1
I DO NOT KNOW	= 0

DO NOT GUESS!

NOTE:

1. The paper has two sections.
   Section A: Cell Biology and Biochemistry (Q1 – Q50)
   Section B: Genetics (Q51 – Q100)

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

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

SECTION A: CELL BIOLOGY

1. Which of the following statements is CORRECT?

1. Both plant and animal cells have vacuoles at some stage in their life cycle.
2. Both plant and animal cells have lysosomes.
3. Ribosomes are peculiar to plant cells only.
4. An amoeba is an example of an organelle.
5. The nucleoplasm is completely separated from the cytoplasm.
6. I do not know.

2. Which of the following word(s) is/are associated with the nucleus?

1. Chromatin
2. Genes
3. Nucleolus
4. DNA
5. All, 1, 2, 3, and 4 above.
6. I do not know.

3. Which of the following statements is NOT TRUE about ribosomes?

1. They are usually attached to the rough endoplasmic reticulum.
2. Ribosomes can also be free floating in the cytoplasm.
3. Ribosomes have been found in mitochondria and chloroplasts.
4. Ribosomes are made up of protein alone.
5. There are different types of ribosomes, but all serve to synthesise protein.
6. I do not know.

4. Which of the following statements is NOT CORRECT?

1. Plants and bacteria have a cell wall.
2. The plasma membrane is alive while the cell wall is dead.
3. Water molecules can pass through the plasma membrane.
4. The plasma membrane protects the cell from excessive intake of substances.
5. The plasma membrane is absent in the bacteria.
6. I do not know.

5. Which of the following organelles is NOT CORRECTLY matched with its function?

1. Chloroplast - Photosynthesis.
2. Amyloplast - Storage of starch.
3. Chromoplast - Storage of plant pigments.
4. Lysosome - Protein synthesis.
5. Nucleus - Control centre of the cell.
6. I do not know.

6. Which part of the plasma membrane has affinity for water?

1. The fatty acid part.
2. The lipid part.
3. The phosphoric component.
4. The non polar part
5. The protein and carbohydrate part.
6. I do not know.

7. Who proposed the fluid mosaic model of the plasma membrane and when?

1. Napoleon (1891).
2. Singer and Nicholson (1972)
3. Sagel (1820)
4. Patterson and Wilsons (1915)
5. Mendel (1875)
6. I do not know.

8. Chemical analysis reveals that the plasma membrane has ...

1. more carbohydrate than protein.
2. more phospholipid than protein
3. more protein than carbohydrate.
4. very little of protein and more of carbohydrate
5. equal amounts of protein and lipids.
6. I do not know.

9. In the plasma membrane, ...

1. the lipids serve as the carrier of substances.
2. the proteins act as a chemical barrier to substances.
3. there are no permanent openings through it.
4. there are both temporal and permanent openings through it.
5. there are no chemical receptors.
6. I do not know.

10. Which of the following statements is CORRECT?

1. Polar substances cannot cross the plasma membrane.
2. Non-polar substances cannot move freely through the plasma membrane.
3. Organic substances cannot pass through the plasma membrane.
4. The plasma membrane allows carbon dioxide to pass freely through it.
5. Oxygen needs to be aided to cross the plasma membrane.
6. I do not know.

11. The cell takes in water, swells and becomes turgid.

1. The cell is in a hypertonic solution.
2. The cell is in an isoelectric medium.
3. The cell is in a hypotonic solution.
4. The isotonic solution makes the cell swell.
5. The solute diffuses into the cell and makes the cell swell.
6. I do not know.

12. Choose the CORRECT definition of the following items.

1. Dynamic equilibrium: The movement of substances into a cell is constant.
2. Isotonic: The movement of water molecules across the plasma membrane is zero.
3. Hypertonic: The movement of solute from a region of high concentration to one of low concentration across the plasma membrane.
4. Hypotonic: The movement of dissolved substances from the region of less water to the one with more water across the plasma membrane.
5. Osmotic pressure: The tendency for water to resist movement into a cell
6. I do not know.

13. Which of the following definitions of the given terms is CORRECT?

1. Endocytosis: Food substances are taken into the cell.
2. Pinocytosis: The cell ingests large substances.
3. Phagocytosis: The cell takes in ~~dissolved~~ materials.
4. Exocytosis: The cell ingests toxic substances
5. Exocytosis: The cell ingests valuable substances.
6. I do not know.

14. When bacteria are stained with crystal violet solution and washed in alcohol, the following happens.

1. Gram-negative bacteria do not stain.
2. Gram-positive bacteria lose the stain.
3. Gram-positive bacteria become purple.
4. Gram-negative bacteria become pink.
5. There is no reaction between bacteria and crystal violet.
6. I do not know.

15. Viruses differ from living cells in that they ...

1. they have one type of nucleic acid (RNA or DNA).
2. can reproduce independently.
3. they are cellular.
4. they do not have a nucleus.
5. are highly infectious.
6. I do not know.

16. Which of the following is a CORRECT representation of organelles in the given cells and the vurus? (+ = present, - = absent)

	viruses	plant cell	animal cell
1. membrane	-	+	-
2. nucleus	+	+	+
3. mitochondria	-	+	+
4. chloroplast	-	-	-
5. golgi body	+	+	+

6. I do not know.

17. Water is a liquid at normal temperature and pressure because ...

1. of the covalent bond between hydrogen and oxygen.
2. water molecules repel one another.
3. of the ionic bond between hydrogen of one molecule and the oxygen of another molecule.
4. water is a non polar substance,
5. water wets surfaces.
6. I do not know.

18. Which of the following substances DOES NOT dissolve in water and why?

1. Organic compounds like sugar because they are polar.
2. Lipid compounds because they are polar.
3. Cooking oil because it is polar.
4. Butter because it is non polar.
5. Table salt because it is polar.
6. I do not know.

19. A water body in a pond evaporates very slowly because ...

1. it requires a lot of energy to separate water molecules.
2. the specific heat of water is very low.
3. it is easy to raise the temperature of water.
4. water freezes at zero degrees celcius.
5. water dries up when it is in the form of ice.
6. I do not know.

20. Which of the following definitions is CORRECT?

1. Acidic solutions have a higher concentration of free protons than pure water.
2. Alkaline solutions have a higher concentration of hydrogen ions than water.
3. The pH scale ranges from 0 – 7.
4. The pH scale is a measure of the alkalinity of a solution.
5. Acidic solutions have a high concentration of hydroxide ions than water.
6. I do not know.

21. Rain water with a very low pH ...

1. destroys life forms both on land and water systems.
2. makes the soil more fertile.
3. enriches the growth of forest trees.
4. makes agricultural soils easier to till.
5. enhances the action of fertilisers.
6. I do not know.

22. Which of the following descriptions is TRUE for a buffer?

1. … readily changes the pH of a solution.
2. … resists change in pH of a solution.
3. … assists to maintain an acidic medium.
4. … binds to hydroxyl ions to maintain the pH of a solution.
5. … donates hydroxyl ions to sustain the pH of a solution.
6. I do not know.

23. In the blood system, water combines with carbon dioxide to form a buffer called …

1. carbonic acid
2. bicarbonate
3. hydrogen carbon
4. haemoglobin buffer
5. carbonated acid.
6. I do not know.

24. Which of the following statements DOES NOT describe a functional group?

1. A compound, which readily participates in a chemical reaction.
2. A compound that determines the type of reaction an organic compound participates.
3. A carboxyl group is an example of a functional group.
4. An aldehyde is an example of a functional group.
5. Glucose is a good example of a functional group.
6. I do not know.

25. What are carbohydrates?

1. Compounds with a carbon atom in them.
2. All organic compounds.
3. Organic compounds with carbon, oxygen and hydrogen in them.
4. $C_5H_{10}O_5$ is an example of a carbohydrate.
5. $C_7H_{14}O_5$ is an example of a carbohydrate.
6. I do not know.

26. Which of the following terms has been given a CORRECT example?

1. Monosaccharide: glyceraldehyde
2. Disaccharide: dihydroxyacetone
3. Polysaccharide: lactose
4. Co-enzyme maltase
5. Reducing agent NAD
6. I do not know.

27. Which of the following groups of sugars play an important role in the glycolysis metabolic pathway, following the break down of glucose.

1. Tetroses
2. Hexoses
3. Hexokinases
4. Adenines
5. Trioses
6. I do not know.

28. Choose from the following, the CORRECT combination of residues for a given disaccharide.

1. Glucose + Glucose = Sucrose
2. Glucose + Galactose = Maltose
3. Fructose + Glucose = Sucrose
4. Fructose + Galactose = Maltose
5. Galactose + Galactose = Lactose
6. I do not know.

29. Why do some sportsmen develop rheumatic pain in their limbs after a prolonged activity?

1. ... because the substrate for respiration runs out.
2. ... because the enzymes get denatured under the high body temperature.
3. ... because the oxygen debt is too high to support respiration.
4. ... because pyruvic acid gets converted into oxaloacetic acid.
5. ... because glucose conversion into its respective products is too fast.
6. I do not know.

30. How many double bonds are in pyruvic acid?

1. None
2. One
3. Two
4. Three
5. Four
6. I do not know.

31. The following is a hypothetical chemical reaction, in which 'H' represents hydrogen.

$MB + CH \Rightarrow \overline{MH} + C + B$

Which statement is CORRECT?

1. Compound MB has been reduced to MH.
2. Substrate CH has been reduced to compound C.
3. Product MH has been oxidised.
4. B is the reduced form of MB.
5. Product B has been reduced.
6. I do not know.

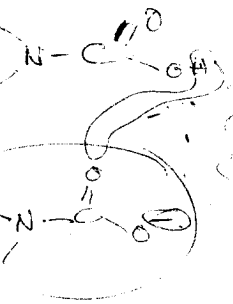
32. Which of the following statements about proteins is CORRECT?

1. The albumen of eggs is a defence protein in the developing embryo.
2. Blood antibodies in the mammalian blood are a storage protein.
3. Haemoglobin is a protein responsible for nutritional transport in the blood.
4. Tubulin protein is a carrier molecule in the plasma membrane.
5. Proteins are exclusively for defence against malnutrition.
6. I do not know.

33. What determines the chemical characteristics of an amino acid?

1. Amino group
2. Carboxyl group
3. Hydrogen atom
4. Positively charged amino group
5. Alkyl group
6. I do not know.

34. When a zwiterion ion of amino acid is placed in an alkaline solution the ...



1. amino group becomes positively charged.
2. amino group loses a hydrogen atom to the solution.
3. carboxyl group becomes negatively charged.
4. amino acid becomes electrically neutral.
5. amino acid develops both positive and negative charges.
6. I do not know.

35. Why do proteins go into a colloidal solution in cytoplasm with a pH of 6 (the isoelectric point of the amino acid is pH8)?

1. ... because they are all negatively charged and therefore repel.
2. ... because they are all positively charged and therefore repel.
3. ... because they are all electrically neutral and therefore attract.
4. ... because they all denature and therefore dissolve.
5. ... because at a pH of 8 all proteins dissolve.
6. I do not know.

36. Which of the following sets of words are complementary?

1. Protein = ester bond
2. Disaccharides = peptide bond
3. Condensation = removal of water
4. Amylose = sucrase
5. Synthesis = addition of water
6. I do not know.

37. On the shelf of groceries in a shop, fats are in ... form.

1. vapour
2. solid
3. liquid
4. solution
5. watery
6. I do not know.

38. Which of the following organic compounds yields the most energy?

1. Carbohydrates
2. Proteins
3. Organic compounds
4. Lipids
5. DNA and RNA
6. I do not know.

39. What are the building units of a lipid?

1. Fatty acids and glucose
2. Amino acids and proteins
3. Glucose and galactose
4. Fatty acids and organic compounds
5. Glycerol and fatty acids
6. I do not know.

40. In the synthesis of one molecule of triglyceride, how many molecules of water are given out?

1. None
2. One
3. Two
4. Three
5. Four
6. I do not know.

41. What is the difference between DNA and RNA?

1. DNA is one oxygen less in its structure.
2. DNA has more functional groups.
3. DNA is a nucleic acid whereas RNA is not.
4. DNA has bases in it whereas RNA does not.
5. DNA and RNA are the same, its just a difference in name.
6. I do not know.

42. What are the building units of a nucleotide?

1. Phosphoric acid, glycerol and an amide.
2. A base, glycerol and a pentose sugar.
3. Just fatty acids.
4. A pentose sugar, a base and phosphoric acid.
5. An amino acid, a sugar and a base.
6. I do not know.

43. Who was awarded the Nobel Prize for explaining the DNA structure?

1. Watson and Crick
2. Watson, Crick and Wilkins
3. Watson
4. Crick
5. Wilkins
6. I do not know.

44. In which year was the Nobel Prize discussed in question 43. above given?

1. 1817
2. 1953
3. 1956
4. 1962
5. 1980
6. I do not know.

45. Which of the following base pairs is NOT CORRECTLY matched using the DNA molecule?

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

46. Which of the following statements is TRUE about histones?

1. DNA is alkaline and histones help to neutralise it.
2. Histones help DNA to stretch out.
3. DNA is acidic and histones help to neutralise it.
4. Each nucleosome is made up of twelve histones
5. In a nucleosome, two histones are used for locking the DNA strand.
6. I do not know.

47. Which of the following compounds is an enzyme?

1. Hexokinase
2. Purine
3. Aldehyde
4. Enolpyruvate
5. Succinic acid
6. I do not know.

48. During which period of meiosis does crossing over of chromosomes take place?

1. Prophase I
2. Metaphase
3. Telophase
4. Leptotene stage
5. Pachytene stage
6. I do not know.

from here

49. Which molecule marks the end of glycolysis?

1. Carbon dioxide and water
2. Phosphoglycerate
3. Acetyl-CoA
4. Pyruvic acid
5. The acetyl group
6. I do not know.

50. The final electron acceptor in respiration is ...

1. FAD in the cytochrome system.
2. Hydrogen in glycolysis.
3. Carbon dioxide in the Krebs cycle.
4. Oxygen in the electron chain.
5. Water.
6. I do not know.

SECTION B: GENETICS

Questions 51-55 refer to the list of terminology below

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

Which of the above terms fit the following definitions most accurately?

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

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

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

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

53. Describes a cell that has two sets of homozygous chromosomes

1. 2
2. 4
3. 5
4. 7
5. 8
6. I do not know

54. Describes a cell with a single set of chromosomes

1. 1
2. 3
3. 6
4. 8
5. None of the above
6. I do not know

55. A description of an organism in terms of certain of its genes

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

56. What is the sex chromosome content of a human egg

1. XX
2. XY
3. X
4. Y
5. YY
6. I do not know

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

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

58. Chromosomes align themselves at the equatorial plane of the spindle fibre attached to the spindles by the centromeres. Which stage (s) of cell division does this statement refer to?

1. Metaphase I only
2. Metaphase II of only
3. Anaphase I and II only
4. Metaphase I and II
5. Metaphase of both mitosis and meiosis
6. I do not know

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

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

60. In rabbits , full colour(C), Chinchilla albino (c^{ch}), Himalayan albino (c^h), and albinism (c^a) form a series of multiple alleles with dominance in the order given. What are the genotypes of the parents in the following cross: wild type x himalayan, giving ½ wild type: ¼ himalayan: ¼ albino.

1. $Cc^{ch} \times c^hc^h$
2. $Cc^a \times c^hc^h$
3. $Cc^{ch} \times c^hc^h$
4. $Cc^h \times Cc^{ch}$
5. $Cc^a \times c^hc^a$
6. I do not know

61. A blood test for Mr. Banda gave the reactions indicated below.

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

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

1. $I^BiirhrhMM$
2. $I^AiRhRhNN$
3. $I^BI^BRhRhMM$
4. I^AI^A RhRhNN
5. I^BI^BrhrhNN
6. I do not know

62. What are the probable genotypes of Mr Banda's parents

	Mother	Father
1.	$I^AirhrhMN$	I^AI^B hrrhMM
2.	$I^AiRhrhMN$	I^AI^B hrrhMM
3.	$I^AirhrhNN$	I^BI^A hrRhMN
4.	I^AI^ArhrhMN	I^BI^B hrrhMM
5.	iirhrhMN	I^BI^A hrrhNN
6.	I do not know	

63. Which blood group individuals can receive blood donation from Mr. Banda

1. Blood groups A and M individuals only
2. Blood groups B, AB and M individuals only
3. Blood groups B and N individuals only
4. Blood groups B and M individuals only
5. Blood groups B and M individuals only
6. I do not know

64. The disease hemophilia is sex-linked and recessive. A normal man marries a woman who is haemophiliac. What phenotypes will the children probably have?

1. all the children are haemophiliac
2. all the children are normal but carriers
3. all male children are haemophiliac
4. ½ the sons and ½ the daughters are affected
5. ¾ of the children are carriers
6. I do not know

65. How many genotypes can a gene with 4 alleles produce?

1. 6
2. 10
3. 9
4. 8
5. 15
6. 12

66. Which of the following chromosomal complements represent Klinefelter's syndrome

1. 47AAXYY
2. 47AAXXXX
3. 47AAXXY
4. 45AAX0
5. 48AAXXXX
6. I do not know

67. Klinefelter's individuals can also be distinguished from others through the examination of the number of barr bodies in their cells. How many barr bodies do Klinefelter's syndrome fetuses have in their cells?

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

68. Short hair in rabbits is governed by a dominant gene (L) and long hair by its recessive allele (l). Black hair results from the action of its dominant gene (B) and brown from the recessive genotype (bb). What are the expected genotypic ratios from the cross LLBb x LlBb

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

69. **The trait ocular albinism (almost complete absence of eye pigment) is inherited as a sex-linked recessive. A man with ocular albinism marries a woman who is normally pigmented but her father was an albino. Which one of the following is the best prediction concerning their offspring?**

1. All their sons will have ocular albinism, and all their daughters will be carriers.
2. About 50 percent of their male children will have ocular albinism, and all other children will be carriers.
3. About 50 percent of all their daughters will have ocular albinism, but all their sons will have normal eyes.
4. None of their children will have ocular albinism, but all their daughters will be carriers.
5. 50% of their children will have ocular albinism
6. I do not know

70. **At the end of meiosis II each haploid daughter cell has one chromatid, which eventually is replicated to form a chromosome with two chromatids. At which stage of cell division does replication of the chromatid take place?**

1. at interphase
2. at late telophase II
3. early propphase I
4. Just before end of telophase
5. None of the above
6. I do not know

71. **What is the phenotypic ratio of the cross SsDd x ssdd**

1. 9:3:3:1
2. 1:1:1:1
3. 12:3:1
4. 1:2:1:4:1:2:2:1:2
5. 1:2:1
6. I do not know

72. **What name is given to the special cross executed in question 71?**

1. Dihybrid back cross
2. Dihybrid cross
3. Dihybrid test cross
4. F1 intercross
5. Monohybrid cross
6. I do not know

73. **If a trait which is not evident in the parents appears in their offspring, the parental genotypes are most likely**

1. pure recessive
2. homogametic
3. homozygous
4. heterogametic
5. heterozygous
6. I do not know

74. **A condition in the heterozygote where both members of an allelic pair express themselves is called**
1. Partial dominance
2. Dominance
3. Incomplete dominance
4. Co-dominance
5. Multiple allelesm
6. I do not now

75. **It has been observed that some individuals have a 6th finger on one hand and not the other and they also have extra toes on both feet. However, the growth of one of the extra toes is incomplete. This rare condition in humans can be explained by the concept of**
1. genotype interaction with environment
2. variable expressivity
3. incomplete penetrance
4. hypostatisis
5. polygenes
6. I do not know

76. **It has been observed that there is no significant difference in the number of hairs per unit skin surface area between males and females and yet only males express beards. What is the plausible explanation for this observation?**
1. beard development is a Y linked trait hence only expressed in males
2. genes for beard development are dominant in males and recessive in females
3. beard development is a sex influenced trait
4. beard development is a sex limited trait
5. females have suppressor genes
6. I do not know

77. **Which of the following statements is FALSE?**
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 have B antibodies in their serum
3. Blood group AB individuals are universal recipients
4. Heterozygous yellow mice do not exist.
5. A boy cannot inherit his mother's sex-linked characters
6. I do not know

78. **Which of the following statements is TRUE about qualitative inheritance?**
1. environment has a greater influence on the phenotype
2. the traits are produced by the joint action of many pairs of genes
3. traits which cannot be easily classified into distinct phenotypic classes
4. traits under the genetic control of one or two genes
5. traits which show various kinds of intermediates
6. I do not know

79. Which of the following traits is an example of a pleiotropic gene

1. Rhesus factor
2. Hypertrichosis
3. Red flower gene in the 4'Oclock plant
4. Yellow fur gene in mice
5. Night blindness
6. I do not know

80. What would be the F2 phenotypic ratio of the cross BBcc x bbCC

1. BC3 : Bc1 : bc1
2. BC9:Bc3:bC3:bc1
3. BC3:bc1
4. BC3:Bc3:bC1:bc1
5. BC1:Bc1:bC1:bc1
6. I do not know

81. Which of the following statements reflect Mendel's Second Law?

1. alleles assort from each other in equal numbers
2. independent assorting alleles occur in same numbers
3. different segregating alleles assort equally
4. different segregating alleles assort independently
5. dominant alleles express themselves in the presence of recessive ones
6. I do not know

82. Consider a trihybrid FfGgHh. How many gamete genotypes can it produce during meiosis?

1. 8
2. 12
3. 6
4. 9
5. 18
6. I do not know

83. If the trihybrid in question 82 was test crossed, what would be the number of zygote genotypes?

1. 8
2. 12
3. 64
4. 6
5. 27
6. I do not know

84. Which of the following is not a function of meiosis?

1. provision of new cells for growth and replacement
2. production of haploid number of chromosomes
3. maintaining genetic variability
4. maintaining a constant number of chromosomes for every species
5. 1 and 4 above
6. I do not know

85. **A sex-linked dominant allele causes hypophosphatemia in humans. A man with hypophosphatemia marries a normal woman. What proportions of their daughters will have hypophosphatemia?**

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

86. **Which of the following represents a phenotypic ratio for a monohybrid cross?**

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

87. **Which of the following chromosomal aberrations leads to a syndrome called 'cri-du chat'?**

1. Translocation
2. non-disjunction
3. deletion
4. trisomy
5. monosomy
6. I do not know

88. **Which set of symptoms best describes 'cri-du chat' sydrome**

1. males, fertile or infertile, very tall and vicious
2. myelocetic leukemia (cancer of the borne marrow)
3. moon face, low birth weight and malformed low-set ears
4. mentally retarded, short, abnormalities of hand and finger prints, eyelids like mongoloids
5. sterile females, broad chest, underdeveloped breasts, short, impared intelligence
6. I do not know

89. **A gardener found that when white pentunias and purple pentunias were crossed, only blue pentunias were produced. From which of the following crosses would the gardener most probably obtain the greatest percentage of white petunias?**

1. white and blue petunias
2. purple and purple petunias
3. blue and blue pertunias
4. purple and blue pertunias
5. two of the above give the same result
6. I do not know

90. What phenomenon is illustrated in question 89?

1. dominance
2. independent assortment of alleles
3. co-dominance
4. variable expressivity
5. incomplete dominance
6. I do not know

91. A student tossed 2 coins at the same time and recorded the following results, both tails 46; one head and one tail 100; both heads 41. Which genotypes represent a cross resulting in approximately the same ratio?

1. AA x aa
2. Aa x aa
3. Aa x AA
4. Aa x Aa
5. AA x AA
6. I do not know

92. If asked to compare whether or not the results in question 84 fit with the expectations, what would be the Chi-square (X^2) value for these data?

1. 0.012
2. 0.045
3. 0.071
4. 0.527
5. 1.234
6. I do not know

93. What is the degree of freedom (d.o.f) for the chi square computed in question 92?

1. 1
2. 2
3. 3
4. 4
5. 2.5
6. I do not know

94. Which of the following characteristics is controlled by a single pair of alleles?

1. Intelligence as measured in an IQ test
2. Sickle cell anaemia
3. Skin colour
4. Height
5. Yield
6. I do not know

95. Which of the following 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. none of the above.
6. I do not know

End

96. **X-rays cause damage to individuals and this damage can sometimes be inherited. This is due to the fact that...**

1. X rays cause damage to the germplasm tissue
2. X rays cause damage to the somatic tissue
3. there is continuity of somatoplasm between descendant generations
4. acquired characters can be inherited
5. two of the above
6. I do not know

97. **The absence of legs in cattle (amputated) has been attributed to a recessive lethal gene. A phenotypically normal bull is mated with a phenotypically normal cow and they produce an amputated calf. The same parents are mated again. What is the chance of the next calf being normal.**

1. 10%
2. 25%
3. 50%
4. 75%
5. 100%
6. I do not know

98. **Baldness is as sex-influenced trait. If heterozygous parents produce four girls what will be the ratio of the bald and normal children?**

1. 1 bald to 3 normal
2. 0 bald to 4 normal
3. 4 bald to 0 normal
4. 3 bald to 1 normal
5. 1 bald to 1 normal

99. **A genetic disorder caused by a homozygous combination of recessive mutant genes that may result in mental retardation is**

1. colour-blindness
2. haemophilia
3. ganglio lipidosis
4. phenylketonuria
5. sickle cell anaemia
6. I do not know

100. **Which one of the following crosses give the same F2 phenotypic ratio as the cross CCDD x ccdd**

1. CcDd x CCdd
2. CCDD x CCDD
3. CcDd x CcDd
4. CCdd x ccDD
5. CcDd CCDD
6. I do not know

END OF BS111 EXAMINATION QUESTIONS

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS
FIRST SEMESTER EXAMINATION – JANUARY 2001

BS 11: CELL BIOLOGY AND GENETICS

ANSWER SHEET

COMPUTER NUMBER..... **TUTORIAL GROUP**.....

1		21		41		61		81	
2		22		42		62		82	
3		23		43		63		83	
4		24		44		64		84	
5		25		45		65		85	
6		26		46		66		86	
7		27		47		67		87	
8		28		48		68		88	
9		29		49		69		89	
10		30		50		70		90	
11		31		51		71		91	
12		32		52		72		92	
13		33		53		73		93	
14		34		54		74		94	
15		35		55		75		95	
16		36		56		76		96	
17		37		57		77		97	
18		38		58		78		98	
19		39		59		79		99	
20		40		60		80		100	

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER DEFERRED AND SUPPLEMENTARY EXAMINATIONS MARCH 2001

BS 211 CELL MOLECULAR BIOLOGY AND GENETICS
THEORY PAPER

TIME: THREE HOURS

ANSWER: 1) TWO QUESTIONS FROM SECTION A
TWO QUESTIONS FROM SECTION B
ONE QUESTION FROM EITHER SECTION A OR SECTION B.
2) SECTION A AND SECTION B SHOULD BE ANSWERED IN SEPARATE ANSWER BOOKLETS.

SECTION A: CELL MOLECULAR BIOLOGY

1. Explain in detail the following statement: "Photosynthesis may involve different electron donors and different electron acceptors, depending on the species of photosynthetic organism."

2. a) Discuss briefly the various biochemical routes used by plants to fix carbon dioxide.
   b) In your discussion, indicate which route is the most efficient and state reasons for your choice.

3. Carbohydrate, proteins, and fats are all sources of energy for the cell.
   a) Construct a simplified and combined catabolic route for these compounds.
   b) Explain the points of junction of the separate catabolic routes into a common one.

4. Discuss the various factors which bring about the denaturation of an enzyme, and how they operate to cause such a condition.

5. With the help of a clear and clearly labelled diagram, explain how the biological Membrane is suitably structured for its most significant functions.

SECTION B: GENETICS

1. Discuss the chromosome theory of inheritance.
2. Discuss the role of mutations in gene evolution.
3. Describe gene regulation in prokaryotes.
4. Discuss the pros and cons of the Human Genome Project.
5. "Human off-springs are usually more 'beautiful' or 'handsome' than their parents. In a sense, this may be evidence for evolution, at least on a shorter time scale". Discuss.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER UNIVERSITY EXAMINATIONS

JANUARY 2001

BS 221

FORM, FUNCTION AND DIVERSITY OF PLANTS

THEORY PAPER

TIME: ***Three Hours***

INSTRUCTIONS:

1. Answer ***FIVE Questions***, at least two to be attempted from each Section.
2. Write questions of each Section in separate answer books.
3. Tie-up all the answer books in a single bundle.

SECTION A: THE LOWER PLANTS

1. Compare the thallus morphology and cell structure in Ulotrichales and Chaetophorales, and describe in detail sexual reproduction in *Coleochaete*.

2. Discuss structure and replication in viruses and explain their importance to living organisms.

3. Describe structure, reproduction and the agricultural importance of *Phytophthora* and *Perenospora*. Give an illustrated account of the common reproductive structures of the two organisms.

4. Write short notes on any FOUR of the following:
    i. Thallus structure of bryophytes
    ii. Coenobial structure in *Scenedesmus* and *Pediastrum*
    iii. Oogamy in *Fucus* and *Sargassum*
    iv. Heterocysts
    v. Zooids of *Oedogonium*
    vi. *Ulva*
    vii. Conjugation in *Rhizopus.*

SECTION B: THE HIGHER PLANTS

5. Explain why the genus *Pinus* tends to exhibit xeromorphic features when the plants are known to occur in cold temperate regions of the world that receive relatively high precipitation.

6. Describe the vegetative and reproductive features that characterize plants belonging to the genus *Marsilea.*

7. Give an illustrated account on the anatomical features of the angiosperm leaves that provide a correlation to hydrophytic, mesophytic and xerophytic ecological conditions.

8. Describe the morphology and anatomy of the vegetative and reproductive organs considered unique to *Equisetum.*

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY FIRST SEMESTER SUPPLEMENTARY AND DEFFERED EXAMINATIONS

MARCH 2001

BS 321

ETHOLOGY AND EVOLUTION

PAPER I - THEORY

TIME: THREE HOURS

INSTRUCTION: ANSWER FIVE (5) QUESTIONS.

QUESTION **ONE** IS COMPULSORY. ANSWER QUESTION ONE, AND TWO OTHERS FROM EACH SECTION. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY. ALL QUESTIONS CARRY EQUAL MARKS.

---

1 Define the following terms as used in this course:

(i) Genetic Drift (ii) A Species Territory (iii) Hypothalamus
(iv) Character Displacement

SECTION A: ETHOLOGY

2. Define altruism and discuss its significance to animal breeding.

3. Explain the concept of imprinting in species, and apply this principle to show difference between group selection and kin selection as they relate to species fitness.

4. Discuss the main advantages of cooperative breeding among the vertebrate species.

SECTION B: EVOLUTION

5 Trace the origins of modern Man *Homo sapiens sapiens* from its remote ancestor *Australopithecus*.

6 What is speciation? Outline the full process of speciation

7 Discuss the mechanism of reproductive isolation and its significance to the species concept

---

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - JANUARY, 1999/2001

BS 331 PLANT PHYSIOLOGY

THEORY PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS

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1. Discuss the Ohm's Law analogue of water movement in plants.

2. Write on active transport of inorganic ions in plant cells, distinguishing between primary and secondary active transport.

3. Apply the concept of electrochemical potential to explain why ions can be driven passively into plant cells against their concentration gradient.

4. Discuss the role of cytosolic Ca^{2+} in guard cell physiology.

5. Compare and contrast CO_2 assimilation in a C4 plant and a CAM plant.

6. (a) What is partitioning of photoassimilates within the plant?

   (b) Discuss the factors influencing partitioning of photoassimilates between the source leaves on one hand and developing fruits, buds and young leaves.

7. Discuss the mechanism of phototropic responses in gramineceous coleoptiles.

8. How do phytochrome mediated plant responses differ in terms of the amount and quality of light required to induce them?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - JANUARY, 1999/2001

BS 341 MICROBIOLOGY

PAPER II PRACTICAL

TIME: **THREE (3) HOURS**

INSTRUCTIONS: **Reagents; Stains and equipment required to answer the questions are provided. Label all your work clearly ANSWER ALL QUESTIONS**

---

1. Culture A is a mixture of organisms growing in Nutrient broth.

    1. Perform Gram stain of this culture and describe the reaction of organisms in this culture. **LABEL YOUR SLIDE WITH YOUR NAME, CULTURE NO. AND HAND IN YOUR SLIDE.**

    2. Describe the shapes and arrangements of the organisms - illustrate your observations.

    3. How would you go about obtaining a pure culture of any of the organisms in the culture?

    4. Based on the Gram reaction; place the organisms in the broad morphological groupings.

2. Culture B is a pure culture of Escherichia coli growing on nutrient agar. Describe the colonial morphology and growth characteristics of E. coli on this medium.

3. Culture C is a mixed culture growing on blood agar. Differentiate the two organisms based on:

    1. growth characteristics (e.g. hemolysis if present)

    2. Cell morphology (you may use simple stains or Gram stain)

    Would blood agar be referred to as selective or enrichment medium? Explain.

4. In your laboratory exercises you used both differential and special stains. Explain giving 2 examples of each. What stain is commonly used in Microbiology to group bacteria?

5. Name and explain 2 methods you would use to estimate the population of a turbid culture of E. coli growing in nutrient broth.

THE UNIVERSITY OF ZAMBIA
SECOND SEMESTER UNIVERSITY EXAMINATIONS, MAY 2000

BS 342 –MYCOLOGY

THEORY PAPER

ANSWER: ANY FIVE QUESTIONS

TIME ALLOWED: THREE HOURS

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1. What is a fungal hormone? Explain in detail the significance of hormones in the sexual reproduction of *Allomyces, Achyla* and *Mucor.*

2. What is extra-cellular digestion? Explain fully how crystalline cellulose is made available fungi as a carbon source. Comment on the significance of carbon and nitrogen as sources nutrition in fungi.

3. Discuss the four types of structural movements associated with cytoplasmic streaming. Explain in detail the mechanism of movement of one of the structures you have discussed.

4. Distinguish between spore dispersal and spore liberation. Using a named example describe how fungi are adapted to spore dispersal by insects.

5. What is mycology? What are some of the industrial/technological benefits of fungi?

6. How do hyphal branches form? Using explained experimental evidence, discuss the branching pattern commonly observed in a fungal colony.

7. Write illustrated but descriptive notes on any TWO of the following:

   (a) Passive spore liberation
   (b) Active spore liberation
   (c) The significance of spore dispersal

8. Write detailed notes on TWO of the following:

   (a) Sclerotia
   (b) Appressorium formation
   (c) Rhizomorphs
   (d) Catabolic repression

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS
JANUARY, 2001

BS 351 : ENTOMOLOGY

PRACTICAL PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS.

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1. **Identify specimen A-J to Order and list four taxonomic features that distinguish each specimen from other insects.**

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

3. **Using the equipment and chemicals provided, conduct a dissection of the grasshopper provided to expose the alimentary canal.**

    a. **Make a large and neat diagram of this system labeling all parts and explain the functions of the different sub-anatomical divisions.**

    b. **How many gastric caeca are present on your specimen? What is their function and how is it controlled? How many malpighian tubules are there and what is the equivalent of these structures in man?**

    c. **Excise one gastric caecum and the rectum from the alimentary canal, bisect these organs to expose their lumens and then describe the internal appearance of each organ.**

END OF EXAMINATION

The University of Zambia
School of Natural Sciences
Department of Biological Sciences

First Semester Supplementary/Deferred Examinations
March 2001

BS 375
Invertebrate Zoology

Time: **Three (3) Hours**

Instructions: Answer Q1 and Four other Questions

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Q1. Describe, in tabular form and with examples, the key distinguishing features of the following invertebrate orders. Ensure to identify the phylum and class to which each particular order belongs:

i. Protomonadina
ii. Haemosporidia
iii. Opisthopora
iv. Monogenea
v. Stylommatophora
vi. Siphonoptera
vii. Diptera
viii. Acarina
ix. Scolopendromorpha
x. Limacomorpha

Q2. write brief notes on <u>four</u> of the following topics:

(a) The skeletal system of invertebrates
(b) Evolution of the blood sucking habit in invertebrates
(c) Evolution, Structure and Function of the cuticle
(d) Sources of Energy in invertebrate locomotion
(e) Evolution, structure and function of the Hydrostatic Skeleton
(f) Flight in insects

Q3. Give illustrated descriptions of the life histories of Schistosoma haematobium and <u>plasmodium vivax</u>.

Q4. (a) What is cephalization?
(b) Review the structures of the nervous systems in invertebrates, highlighting the development of sense organs.

Q5. (a) Define respiration.
(b) Compare and construct respiratory mechanisms in aquatic and terrestrial invertebrates.

Q6. Discuss the various types of asexual and sexual reproduction seen in invertebrates. In evolutionary terms, what would be the strengths and weaknesses of each of these reproductive modalities.

Q7. discuss the relationship between the form and function of invertebrates and their living environments.

Q8. Compare the feeding mechanisms of mosquitoes and ticks. How are the two groups behaviourally and structurally adapted to their feeding habits?

END OF EXAMINATION
& GOOD LUCK!

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS
JANUARY, 2001

BS 411 : INSECT BEHABIOUR AND ECOLOGY

THEORY : PAPER I.

TIME: THREE (3) HOURS

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

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1. Discuss the roles of ocelli and the sub-oesophageal ganglion in the nocturnal diel rhythm of cockroaches.

2. Can insects be taught or can they learn? Compare and contrast learning in insects and man.

3. One entomologist at one annual general meeting of the Entomological Society of Zambia was heard saying, "It is about time that man revised his theories about thinking in insects, because in my view, some insect activities are so complex that there is no doubt in my mind that thinking is somehow involved". Argue for or against this statement.

4. Distinguish between transverse and primary orientation in insect behaviour and using a specific example, explain how the former enables an ant like, *Lasius niger* to navigate correctly in its environment.

5. Discuss escape and defense mechanisms exhibited by insects and explain why "Faining death" observed in many insect species across insect orders, can be considered as a defensive mechanism.

6. Write short notes on five of the following:

    a. Bombycol.
    b. Strigilation in insects.
    c. Dance language of bees.
    d. Batesian mimicry.
    e. Cold light production in named insects.

f. **Social hormone production in insects.**
g. **Eusociality in insects.**

7. **Distinguish between token stimulant and phago-stimulant in insect behaviour. Using a named insect group or species explain how these two types of stimulants enhance its survival.**

8. **Discuss factors that lead to insect gregarious behaviour. How does this type of behaviour differ from that of members of a full –fledged insect society?**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS

1999/2001 ACADEMIC YEAR-- JANUARY 2001 EXAMINATIONS

BS 425

IMMUNOLOGY

THEORY PAPER I

TIME: THREE (3) HOURS
INSTRUCTIONS: ANSWER ALL FIVE (5) QUESTIONS.

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1. "Laughter and good thoughts keep you healthy". Propose a model or mechanism for this phenomenon.

2. (a) "All immunogens are antigens but not all antigens are immunogens". Discuss.

   (b) Describe an experiment that demonstrated the role of effector cells and helper cells in antibody formation. How are the results of this experiment important in the design of subunit vaccines?

3. Do you think that Interleukin-6 (IL-6) promotes the growth of Kaposi's Sarcoma (KS) cells *in vitro*? If your answer is "yes", suggest a mechanism of how the IL-6 pathway modulates the clinical diversity of KS. If your answer is "no", explain whether IL-6 can be a candidate treatment for KS?

4. (a) Name and discuss three effects of HIV nef on the immune system.

   (b) Chinsembu and colleagues at the University Teaching Hospital have recently found that in about 10% of couples having unprotected sex, either the husband is HIV sero-positive and the wife is sero-negative, or the husband is HIV sero-negative while the wife is sero-positive. Explain the cyto-immunological basis of this discordancy?

(c) Explain how (i) African trypanosomes, and (ii) *Neisseria gonorrhoeae*, evade the immune system.

(d) Describe the immunological basis of asthma. What group of drugs are used for the treatment of this condition?

5. Effector cells are redundant once antigen is cleared. In fact, there is wide-scale T cell elimination at the end of the primary response.

(a) Suggest two reasons why prolonged survival of effector cells would be potentially dangerous?

(b) Despite the extensive elimination of lymphocytes at the end of the primary response, a proportion of antigen-reactive cells survive. Discuss.

--END OF EXAMINATION--

THE UNIVERSITY OF ZAMBIA

First Semester Examinations
January, 2001

BS 431 : Advanced Parasitology I Paper I (Theory)

Time: Three (3) Hours

INSTRUCTIONS: Answer five (5) questions. All questions carry equal marks.

---

1. Discuss the factors in location of host by parasite dispersive stages. Using *Wuncheria banerofti* as an example, relate mode of transmission to behaviour of parasites.

2. Parasitism is an essential relationship which has regulatory effect on the equilibrium of a natural community. Which are the two sides of this equation and explain how man's influence impacts on this state.

3. Define susceptibility in host-parasite relationship. What is the difference between natural and acquired immunity. With brief explanation, give two factors which affect natural immunity of a host.

4. Abnormal tissue growth result in some parasitic infection. Giving an example of a specific named parasite, explain (i) type of growth, (ii) how it results, (iii) and reasons for the condition, what are the different forms of cancerous growths?

5. In parasite reproduction, explain the advantages of hermaphrodism in success of parasite species and also in expression of survival genes. Briefly describe asexual reproductive in metazoan parasites.

6. Using schistosomes as an example, explain mechanisms of entry into host, survival in the host, and the transformation from larval to adult stages.

7. Describe three of the main endoparasite feeding mechanisms.

8. Explain how knowledge of disease epidemiology can be used in disease control. Giving explanation, what disease measurements are used in monitoring infections in a community.

End of Examination – Good Luck (No. of pages = 1)

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - JANUARY 2001

BS441 ADVANCED MOLECULAR BIOLOGY I

THEORY EXAMINATION PAPER 2

TIME ALLOWED : 3 HOURS

SECTION A

Answer all questions

---

1. **Briefly explain the recombination events which take place during meiosis.**

2. **Draw the molecular structure of the A-T pair of the DNA molecule, clearly showing the hydrogen bonding .**

3. **Differentiate between nonsense and missense mutations giving one example in each case.**

4. **Write brief notes on each of the following :**

   a) **the gene**
   b) **Z-DNA**
   c) **transduction**
   d) **mismatch repair of DNA**
   e) **DNA glycosylase repair**

5. **Mention one suicidal protein and briefly explain how it functions.**

SECTION B

Write a short essay on any THREE of the following

---

6. Chromosomal abberations

7. The structure of DNA

8. The Holliday model of genetic recombination

9. Mutagens and their effects on DNA structure

END OF EXAMINATION – BEST WISHES IN THE NEW YEAR !

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - JANUARY 2001

BS441 ADVANCED MOLECULAR BIOLOGY I

THEORY EXAMINATION PAPER 2

TIME ALLOWED : 3 HOURS

SECTION A

Answer all questions

---

1. **Briefly explain the recombination events which take place during meiosis.**

2. **Draw the molecular structure of the A-T pair of the DNA molecule, clearly showing the hydrogen bonding .**

3. **Differentiate between nonsense and missense mutations giving one example in each case.**

4. **Write brief notes on each of the following :**

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5. **Mention one suicidal protein and briefly explain how it functions.**

SECTION B

Write a short essay on any THREE of the following

6. Chromosomal abberations

7. The structure of DNA

8. The Holliday model of genetic recombination

9. Mutagens and their effects on DNA structure

END OF EXAMINATION – BEST WISHES IN THE NEW YEAR !

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – JANUARY 2001

BS475

POPULATION ECOLOGY

(PAPER I)

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS AND USE ILLUSTRATIONS WHEREVER POSSIBLE.

---

1. How would you study and analyse the life table of an annual grass.

2. The development and maintenance of soil seed banks involves a number of processes. Discuss these processes using an appropriate model framework.

3. How can you study the presence of dormancy in plant seeds.

4. Develop a life table for a cohort of an annual herb using the following data:

Age of cohort in days	Cohort members alive
0	97
10	54
20	40
30	29
70	4
120	3
150	2

What survivorship curve do the data approximate.

5. A plant species with overlapping generations had 20 adults at time t. Eighty percent of the adults produced 40 seeds per individual, with a germination rate of 10% and a recruitment rate of 80%. The adults have an inter-generation survival rate of 60%. What was the new adult population at time t+1.

6. Calculate and discuss reproductive allocation in a plant given the following parameters:

   i. Vegetative biomass per flowering plant of 10g
   ii. Seed mass per plant of 4g
   iii. Nitrogen content in vegetative biomass of 0.5%
   iv. Nitrogen content in seed of 5%
   v. Phosphorus content in vegetative biomass of 0.2%
   vi. Phosphorus content in seed of 1%

7. What processes result in clumped and non-clumped distributions in plants.

8. Contrast the life-history attributes of a herbaceous weed and a primary tropical forest tree.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGICAL SCIENCES

BS 491 Freshwater Biology **Theory Paper**

First Semester Examinations **January 2001**

Instructions

Attempt both questions in **Section A** and **two** questions in **Section B**. At the end of the examination, please had in all the answer booklets and question papers.

SECTION A

1. Briefly describe classifications of aquatic ecosystems based on following characteristics of water bodies:

   i) nature and type of currents;
   ii) methods of origin;
   iii) the annual thermal regime;
   iv) Salinity; and
   v) Level of nutrients.

   (10 Marks)

2. A well known freshwater biologist is reported to have suggested that 'a perceptive limnologist can determine the relative productivity of a lake simply by measuring the oxygen concentration throughout the depth profile during summer stratification.' Assess the validity and accuracy of this statement and explain in detail the rational for such an observation

   (10 Marks)

SECTION B

3. Discuss the relationship between pH and alkalinity or acidity in freshwater environments demonstrating the variation in the proportions of inorganic carbon compounds with changes in the pH.

   (5 Marks)

4. Discuss: (i) the dynamics of Silica in freshwater ecosystems; and (ii) evaluate the contribution of silicon compounds in the seasonal succession of the phytoplankton in monomictic lakes of temperate regions.

   (5 Marks)

5. Discuss in detail the dynamics and circulation of nitrogenous compounds in freshwater ecosystems.

   (5 Marks)

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER UNIVERSITY EXAMINATIONS

JANUARY 2001

BS 915

BIOLOGY OF SEED PLANTS

THEORY PAPER

TIME: ***Three Hours***

INSTRUCTIONS:

1. Answer ***One question*** from Section A and any ***Four questions*** from Section B.
2. Write your answers in any order, but clearly indicating the question numbers.
3. Tie-up all the answer books in a single bundle.

SECTION A:

1. Describe the different methods of plant propagation used in food production with the merits and demerits of each method.

2. Identify five herbs and five condiments with complete botanical name in each case. Describe the comparative importance of herbs and condiments in human diet.

3. Crop improvement is the main emphasis placed on current crop production. Discuss this phenomenon with relevant examples and supporting evidence.

SECTION B

4. Describe the physiognomic status and the flora that characterize the Miombo woodland in southern Africa. Comment on the factors that maintains the structure and floristic composition of this vegetation type.

5. Discuss some taxonomic features that can be employed to differentiate members of the sub-family Caesalpinioideae from members of the sub-family Papilionoideae.

6. Write short notes on any FIVE of the following:
   (a) Monotypic taxon
   (b) Monophyletic origin
   (c) Climatic climax
   (d) Pollination chamber
   (e) Pycnoxylic wood
   (f) Synthetic characters

7. Explain the significance of the "Maule Test" as applied in the field of plant systematics. Support your answer with relevant examples.

8. Outline the variants of symbiotic associations that are considered to have evolved along with some groups of vascular plants. Stress the biological significance of such associations in tropical ecosystems.

9. Discuss endemism and explain why this phenomenon is of interest to both taxonomists and phytogeographers.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER DEFERRED/SUPPLEMENTARY EXAMINATIONS

MARCH 2001

BS 935- PLANT PATHOLOGY

THEORY PAPER

TIME: **THREE HOURS**

ANSWER: **ANY FIVE QUESTIONS**

---

1. Discuss plant viruses with regard to characteristics, disease symptoms and control. Explain why viruses are considered as devastating agents of disease.

2. Discuss merits and demerits of plant disease control through cultural, chemical and plant resistance. Explain which of these methods would you prefer and why?

3. Define microbial toxins and explain their types and role in plant disease.

4. Distinguish between vertical and horizontal resistance of plants and explain which type of resistance would you choose. Give reasons in support of your choice.

5. "As agents of plant disease fungi surpass all other pathogen types". Give evidence in favour of this observation and list five most economically important diseases of plants.

6. Identify phenolics and discuss their role in plant defence.

7. Identify the causal organism of late blight of potatoes and describe how it reoccurs annually and spreads in fields during the growing season in Zambia. Describe disease symptoms and control of late blight of potato and tomato.

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

   i. Vascular wilts
   ii. Downy mildews
   iii. Rusts
   iv. Leaf spot diseases

END OF EXAMINATION

The University Of Zambia

UNIVERSITY EXAMINATIONS-JANUARY 2001
INTRODUCTORY CHEMISTRY-C101

INSTRUCTIONS

THE PAPER CONSISTS OF TWO SECTIONS
Section **A** has 10 questions answer **ALL (40 marks)**
Section **B** has 5 questions answer **FOUR. (60 marks)**

SHOW YOUR WORKING CLEARLY

DURATION: 3Hours

USEFUL DATA

Physical Constants

Rydberg constant	= 109 678 cm^{-1} or 2.18 x 10^{-18} J
Speed of light, c	= 2.998 x 10^{8} m/s
Universal Gas constant, R	= 8.314 J/K.mol or 0.08206atm.dm^3/K.mol
Avogadro constant, N_A	= 6.02 x 10^{23} per mol
Molar volume of gas at STP	= 22.4 dm^3
Planck's constant, h	= 6.63 x 10^{-34}J-s
Faraday's constant, F	= 96 485 C/mol

1atm = 760 mmHg = 760 torr = 101 325 Nm^{-2} = 101 325 Pa

Relative Atomic Masses (A_r) and mass number (Z)

$_1$H = 1.0	$_2$He = 4.0	$_3$Li = 6.9	$_4$Be = 9.0	$_5$B = 10.8	$_6$C = 12.01
$_7$N = 14.0	$_8$O = 16.0	$_9$F = 19.0	$_{10}$Ne = 20.0	$_{11}$Na = 23.0	$_{12}$Mg = 24.3
$_{13}$Al = 27.0	$_{14}$Si = 28.1	$_{15}$P = 31.5	$_{16}$S = 32.7	$_{17}$Cl = 35.5	$_{18}$Ar = 40.0
$_{19}$K = 39.1	$_{20}$Ca = 40.1	$_{24}$Cr = 52.0	$_{25}$Mn = 54.9	$_{26}$Fe = 55.9	$_{28}$Ni = 58.7
$_{29}$Cu = 63.6	$_{30}$Zn = 65.4	$_{36}$Kr = 83.8	$_{53}$I = 126.9	$_{54}$Xe = 131.3	

Electronegativity numbers

H = 2.1	N = 3.0	F = 4.0

Standard Reduction Potentials

					E°-volts
$Cl_2(g)$	+	2e	$\longrightarrow$	$2Cl^-(aq)$	+1.36
$Hg^{2+}(aq)$	+	2e	$\longrightarrow$	$Hg(l)$	+0.85
$HgO(s)$	+	$H_2O(l)$ + 2e	$\longrightarrow$	$Hg(l) + 2OH^-$	+0.10
$2H^+(aq)$	+	2e	$\longrightarrow$	$H_2(g)$(1atm), SHE	0.000
$Ni^{2+}(aq)$	+	2e	$\longrightarrow$	$Ni(s)$	-0.25
$Fe^{2+}(aq)$	+	2e	$\longrightarrow$	$Fe(s)$	-0.44
$Zn^{2+}(aq)$	+	2e	$\longrightarrow$	$Zn(s)$	-0.76
$Zn(OH)_2(s)$	+	2e	$\longrightarrow$	$Zn(s) + 2OH^-(aq)$	-1.25
$Al^{3+}(aq)$	+	3e	$\longrightarrow$	$Al(s)$	-1.66

SECTION A

ANSWER ALL

A1. $5.2cm^3$ of a gaseous hydrocarbon were exploded with an excess of oxygen. After cooling to the original room temperature and pressure, a contraction in volume of $15.6cm^3$ was observed. A further contraction of $10.4cm^3$ was noted after treatment with concentrated KOH. What is the molecular formula of the hydrocarbon?

A2. A student was asked to determine the formula of a hydrate. He intended to heat the hydrate in a crucible in order to dehydrate the compound. The difference in mass of the crucible + contents before and after heating would allow him to calculate the mass percentage of water in the hydrate. Before adding some hydrate to the crucible, the student heated the empty crucible first for a few minutes and allowed it to cool to room temperature in a dessicator.

(i) Why did the student heat the empty crucible for a few minutes?

(ii) Why would you, in general, allow a hot crucible to cool to room temperature in a dessicator?

A3. The mercury cell is an alkaline zinc/mercury cell that is very widely used to power transistors, radios, watches, hearing aids, etc. It can be represented as

$$Zn(Hg)(s)\left|Zn(OH)_2(s)\right|KOH(sat'd),Zn(OH)_4^{2-}(sat'd)\left|HgO(s)\right|Hg(l)$$

Write the cathode reaction and determine the voltage of the mercury cell.

A4. The percentage of copper in a sample of brass was determined *iodometrically*. 2.0g of the brass was converted to $200cm^3$ of a solution of $Cu(NO_3)_2$ and acidified with ethanoic acid, $20cm^3$ of the solution liberated sufficient iodine from potassium iodide solution to react with $25.0cm^3$ of 0.10M $Na_2S_2O_3$ solution. The reaction between $Cu^{2+}(aq)$ and $I^-(aq)$ is

$$2Cu^{2+}(aq) + 4I^-(aq) \longrightarrow 2CuI(s) + I_2(aq)$$

The *unbalanced* reaction between I_2 and $S_2O_3^{2-}$ is

$$I_2 + S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + I^-$$

What is the percentage by mass of copper in the brass?

A5. Predict the nature of corrosion that would take place if an iron gutter were nailed to a house using aluminium nails.

A6. Aluminium and manganese oxide react according to the equation;

$$2Al + 3MnO \longrightarrow Al_2O_3 + 3Mn$$

A mixture containing 100g Al and 200g MnO was heated to initiate the reaction. Determine the percentage yield if 83.5g of Al_2O_3 were produced. Comment on why the percent yield is less than 100%.

A7. (a) What is the maximum number of electrons in an orbital that has quantum numbers $n = 3, l = 0$?

(b) State whether the following sets of quantum numbers are wrong or correct. Explain.

	n	l	m_l	m_s
(i)	3	2	2	½
(ii)	3	0	-1	½
(iii)	2	0	0	-½

A8. (a) What is the wavelength and frequency of a particle of sand that has a mass of 1.00×10^{-5}g and is moving at a speed of 0.0100m/s?

(b) Calculate the energy required to ionise a mole of hydrogen atoms given that the wavelength for the ionisation of one atom is 9.14×10^{-9}m.

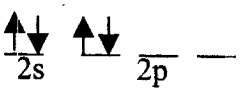
A9. (a) State whether the following electron configuration of a neutral atom is ground state or excited state.

(i) $1s^2 2s^2 2p^6 3s^1$

(ii) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^1$

(iii) $1s^2 2s^2 2p^5 3s^2$

(b) What rule does the following orbital diagram violate and what does it state?



(c) Write the electron configuration and determine the number of valency electrons for the following atoms

(i) Silicon, Si

(ii) Magnesium, Mg

A10. (a) What quantum numbers for an electron in an atom denotes the

(i) shape of its atomic orbital

(ii) orientation of its atomic orbital about the nucleus

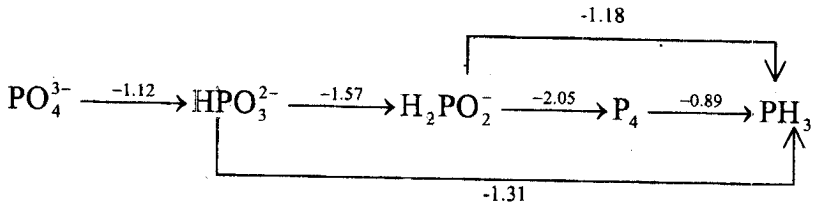
(iii) the energy of atomic orbitals

(b) Sketch the shapes and orientation of the following atomic orbitals

(i) d_{xy} (ii) $d_{x^2-y^2}$

SECTION B: **ANSWER ANY FOUR QUESTIONS**

B1. (a) The reduction potential, in volts, for species containing phosphorus in basic solution are shown below:



(i) State the oxidation state of P in $H_2PO_2^-$ and in PH_3.

(ii) Which species is unstable towards disproportionation? Write the equation and cell potential for this disproportionation?

(b) Determine the mass of calcium hydrogen phosphate, $CaHPO_4$, which contains as much phosphorus as 1kg of $(NH_4)_2HPO_4$ does.

B2. (a)

Bulb A Bulb B

Bulb A of volume $50cm^3$ contains a gas under conditions of 27°C and 300mmHg, and is separated from bulb B, of volume $50cm^3$ containing a gas at 177°C and 600mmHg by a closed tap. When the tap is opened and the gases allowed to mix the final pressure and temperature are 455mmHg and 129°C. Are the gases behaving ***ideally*** on mixing? Justify your answer

(b) (i) Convert 375torr to kPa

(ii) Calculate the concentration (in mol/dm^3) and the density (in g/dm^3) of a sample of sulfur dioxide, SO_2 at 500K and a pressure of 200mmHg assuming it to behave as an ideal gas under these conditions.

B3 (a) What is meant by the term "electrolysis"?
What species enter into reactions and where during electrolysis?

(b) Sketch a cell for the electrolysis of a molten $NiCl_2$ using inert electrodes. Indicate the directions in which the ions and electrons move, electrode reactions and the electrode polarity.

(c) What will be mass of magnesium produced on a large scale by electrolysis of molten $MgCl_2$ by a current of 90,000A flowing for 16hours if the cell is 50% efficient?

B4. (a) What is a chemical bond? Describe clearly, and give one example, what is meant by

(i) ionic bond

(ii) covalent bond

(iii) coordinate bond

(b) Account for the following observations

(i) The second ionisation energy (IE_2) of magnesium is about twice that of its first ionisation (IE_1) whereas the third ionisation energy (IE_3) is about 11times that of the first ionisation energy (IE_1).

(ii) The dipole moment of NH_3 is 1.49 D whereas the dipole moment of NF_3 has a magnitude of 0.21 D.

(c) Calculate the frequency and wavelength associated with an electron of mass 9.11×10^{-28}g travelling at a speed of 1.20×10^{7}m/s

(d) Draw the resonance structures of SO_2.

B5. (a) (i) What do understand by the terms "hybridisation and hybrid orbitals"?

(ii) How many unhybridised p atom orbitals are there on an sp-hybridised carbon atom?

(b) Draw and name the shapes of the following chemical species and state the type of hybridisation around the central atom.

(i) BF_3

(ii) ClF_4^-

(b) Draw Lewis structures, indicating formal charges, for the following molecules. Use the VSEPR theory to predict their shapes and comment on their polarity.

(i) ICl_2^-

(ii) XeF_5^+

(c) Which of the following molecules do not obey the octet rule, explain.

(i) NO_2

(ii) CO_2

THE END

A

THE UNIVERSITY OF ZAMBIA

C205 DEFERRED/SUPPLEMENTARY EXAM

SEMESTER 1 2001

TIME ALLOWED : THREE (3) HOURS

ANSWER : ANY TWO QUESTIONS FROM EACH SECTION

ALL QUESTIONS CARRY EQUAL MARKS

SECTION A
(ANALYTICAL CHEMISTRY)

1. a) Define the following terms
   - i) Accuracy and precision
   - ii) Relative error and absolute error
   - iii) Standard deviation of the mean (s_x) and coefficient of variation (s_r)
   - iv) Confidence limit and confidence level
   - v) Arrhenius theory and Bronstad Lowry theory of acids and baser

   b) The following data was obtained for phosphorus in urine. Determine the linear least-squases line and make the plot. Calculate the concentration of phosphorus in the urine if its absorbance reading is 0.625.

Standards (ppm P)	**Absorbance reading**
1.00	0.205
2.00	0.410
3.00	0.615
4.00	0.820

2. a) Derive the α_0 expression for H_2S hence calculate the concentration of all the species in a 0.100M solution of H_2S at pH = 6.00, $Ka_1 = 9.1 \times 10^{-8}$, $Ka_2 = 1.2 \times 10^{-15}$.

   b) Calculate the concentration of all the species in a 0.100M solution of H_2SO_4. Assume the first ionization step proceeds to completion and the second ionization step has $Ka_2 = 0.012$.

3. a) Calculate the pH of 1.00×10^{-7} M HCl.

b) How many moles of potassium hydroxide must be added to a 250ml solution containing 0.100M each of C_6H_5COOH and C_6H_5COOK in order to give a solution whose pH is 4.60? Assume no volume change. $Ka(C_6H_5COOH) = 6.3 \times 10^{-5}$.

c) Calculate the pH of 0.200M NaH_2PO_4

For H_3PO_4:
$Ka_1 = 1.1 \times 10^{-2}$
$Ka_2 = 7.5 \times 10^{-8}$
$Ka_3 = 4.8 \times 10^{-13}$

SECTION B
(INORGANIC CHEMISTRY)

1. a) One of the rules governing hybridisation is that the resultant hybrid orbital assume the direction (in shape) characteristic of the dominating atomic orbital (in terms of energy). Name the other four rules.

b) Predict the hybridization on the central atom of the following molecules and hence determine the shape of each molecule.

i) ClF_3,
ii) I_3
iii) SO_2

c) The trend in ionization energy is generally an increase across a period. Explain why the opposite is true when you move from

i) Be ⟶ B or Mg ⟶ Al
ii) N ⟶ O or P ⟶ S.

2. a) Use molecular orbital theory to determine which molecule has the stronger bond in the following pairs.

i) O_2^+ and O_2^-

ii) N_2^+ and N_2^-

Which molecules are paramagnetic and which are diamagnetic?

b) Name four factors that affect ionization energy and briefly explain any two.

3. a) Name three properties of photoelectric emissions.

b) Calculate the wavelength of an electron that drops from infinite to

i) Lyman series
ii) Balmer series
iii) Brackett series

Which wavelength would correspond to the ionization energy of a hydrogen atom?

$R = 1.10 \times 10^{7} m^{-1}$

c) i) Define all the four quantum numbers that describe an electron and state how they are related to each other.

ii) Give the electronic configuration for:

As (Atomic No. 33)
Cu^{+} (Atomic No. 30)

c) What is electronegativity? What is its observed trend with regard to the periodic table. Explain briefly why this trend is observed.

END OF EXAM

THE UNIVERSITY OF ZAMBIA

C205 DEFERRED/SUPPLEMENTARY EXAM

SEMESTER 1 2001

TIME ALLOWED : THREE (3) HOURS

ANSWER : ANY TWO QUESTIONS FROM EACH SECTION

ALL QUESTIONS CARRY EQUAL MARKS

SECTION A
(ANALYTICAL CHEMISTRY)

1. a) Define the following terms
   - i) Accuracy and precision
   - ii) Relative error and absolute error
   - iii) Standard deviation of the mean (s_x) and coefficient of variation (s_r)
   - iv) Confidence limit and confidence level
   - v) Arrhenius theory and Bronstad Lowry theory of acids and baser

   b) The following data was obtained for phosphorus in urine. Determine the linear least-squases line and make the plot. Calculate the concentration of phosphorus in the urine if its absorbance reading is 0.625.

Standards (ppm P)	**Absorbance reading**
1.00	0.205
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2. a) Derive the α_0 expression for H_2S hence calculate the concentration of all the species in a 0.100M solution of H_2S at pH = 6.00, $Ka_1 = 9.1 \times 10^{-8}$, $Ka_2 = 1.2 \times 10^{-15}$.

   b) Calculate the concentration of all the species in a 0.100M solution of H_2SO_4. Assume the first ionization step proceeds to completion and the second ionization step has $Ka_2 = 0.012$.

3. a) Calculate the pH of 1.00×10^{-7} M HCl.

b) How many moles of potassium hydroxide must be added to a 250ml solution containing 0.100M each of C_6H_5COOH and C_6H_5COOK in order to give a solution whose pH is 4.60? Assume no volume change. $Ka(C_6H_5COOH) = 6.3 \times 10^{-5}$.

c) Calculate the pH of 0.200M NaH_2PO_4

For H_3PO_4:
$Ka_1 = 1.1 \times 10^{-2}$
$Ka_2 = 7.5 \times 10^{-8}$
$Ka_3 = 4.8 \times 10^{-13}$

SECTION B
(INORGANIC CHEMISTRY)

1. a) One of the rules governing hybridisation is that the resultant hybrid orbital assume the direction (in shape) characteristic of the dominating atomic orbital (in terms of energy). Name the other four rules.

b) Predict the hybridization on the central atom of the following molecules and hence determine the shape of each molecule.

i) $Cl F_3$,
ii) I_3
iii) SO_2

c) The trend in ionization energy is generally an increase across a period. Explain why the opposite is true when you move from

i) Be ⟶ B or Mg ⟶ Al
ii) N ⟶ O or P ⟶ S.

2. a) Use molecular orbital theory to determine which molecule has the stronger bond in the following pairs.

i) O_2^+ and O_2^-

ii) N_2^+ and N_2^-

Which molecules are paramagnetic and which are diamagnetic?

b) Name four factors that affect ionization energy and briefly explain any two.

3. a) Name three properties of photoelectric emissions.

b) Calculate the wavelength of an electron that drops from infinite to

i) Lyman series
ii) Balmer series
iii) Brackett series

Which wavelength would correspond to the ionization energy of a hydrogen atom?

$R = 1.10 \times 10^{7} m^{-1}$

c) i) Define all the four quantum numbers that describe an electron and state how they are related to each other.

ii) Give the electronic configuration for:

As (Atomic No. 33)
Cu^{+} (Atomic No. 30)

c) What is electronegativity? What is its observed trend with regard to the periodic table. Explain briefly why this trend is observed.

END OF EXAM

University of Zambia
University Examinations-March 2001

Analytical Chemistry
C225 Deferred/Supplementary Examination

1. (a) It is desired to perform 99 % complete separation of 0.01M Pb^{2+} from 0.01 M Hg_2^{2+} by precipitation with oxalate (I^-). Given the solubility products below, decide whether this is feasible.

$$PbI_2 \quad K_{sp} = 7.9 \times 10^{-9}$$
$$Hg_2I_2 \quad K_{sp} = 1.1 \times 10^{-28}$$

(b) Write the solubility product expression for AgCl in terms of x where x is the solubility of AgCl.

2. (a) Outline the steps involved in a typical analytical method of quantitative analysis.

(b) How many grams of perchloric acid, $HClO_4$, are contained in 37.6 g of 75% by weight aqueous perchloric acid?

(c) How many grams of water are in the solution in (b) above?

3. (a) What is the relationship between the standard deviation of a procedure and the precision of a procedure?

(b) It is found from a reliable assay that ATP (Adenosine Triphosphate) content of a certain type of cell is 111 mmole/100 mL. You have developed a new assay which gave the following values for replicate analyses. 117, 119, 111, 115, 120 mmole/100 mL. The average value is 116 and the standard deviation is 3.578. Can you be 95 % confident that your method produces a result different from the "unknown" value?

(c) The percentage of an additive in gasoline was measured six times with the following results: 0.13, 0.12, 0.16, 0.17, 0.20, 0.11%. Find the 99 % confidence interval.

4. (a) Write mass balance equations for a solution of a $CH_3COO^-Na^+$.

(b) Consider the diprotic acid H_2A with $K_1 = 1.23 \times 10^{-2}$ and $K_2 = 4.66 \times 10^{-7}$. Calculate α_0, α_1 and α_2 at pH 1.00.

(c) Calculate α_0, α_1, α_2 and α_3 for phosphoric acid at pH = 7.00. For phosphoric acid, $K_1 = 7.11 \times 10^{-3}$, $K_2 = 6.32 \times 10^{-8}$, $K_3 = 7.1 \times 10^{-13}$.

(d) Use the systematic approach to calculate the pH of a 0.5 M solution of NaCN. (Ka HCN = 1.8×10^{-5})

5. (a) Write the Nernst equation for the following half reaction:

$$ClO_3^-(aq) + 6H^+ + 5e^- \rightleftharpoons \frac{1}{2}H_2(g) + 3H_2O$$

(b) (i) Write a balanced half reaction for $ClO_3^- \rightarrow Cl^-$.
(ii)Using just the information below, find E° for the ClO_3^- half reaction.

$$ClO_3^-(aq) + 6H^+ + 5e^- \rightleftharpoons \frac{1}{2}H_2(g) + 3H_2O \quad E^\circ = 1.458\ V$$
$$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^- \quad E^\circ = 1.360\ V$$

(b) Consider the titration of 100.0 mL of 0.0100 M Ce^{4+} in 1 M $HClO_4$ by 0.0400 M Cu^+ to give Ce^{3+} and Cu^{2+}, using a pt and saturated Ag | AgCl electrodes to find the end point. (Formal potentials in 1 M $HClO_4$ $Ce^{4+}/Ce^{3+} = +1.70$ and $Cu^{2+}/Cu^+ = 0.521$ V)

(a) Write a balanced titration reaction.
(b) Write two different half reactions for the indicator electrode.
(c) Write two different Nernst equations for the net cell reaction.
(d) Calculate E at the following volumes of Cu^+: 1.00, 24.5, 25.0, 30 and 50.0 mL. Sketch the titration curve.

DEPARTMENT OF CHEMISTRY, UNIVERSITY OF ZAMBIA.
INTRODUCTION TO INORGANIC CHEMISTRY COURSE, C245.
SEMESTER I, EXAMINATION, JANUARY, 2001.

ANSWER ANY FIVE QUESTIONS.

1. (a) Derive the relationship between the energy of a photon and the kinetic energy of a photoelectron.
   (b) Show that the second ionization energy of helium atom is equal or very close to 5.25 MJ mol^{-1} .
2. (a) Give a simple expression of Schrödinger wave equation and define its symbols.
   (b) Outline the major results that are obtained when the equation is solved.
   (c) Sketch the shapes (angular wave functions) of the d atomic orbitals.

3. (a) Briefly discuss the expected variation of the first ionization energy across the elements of period 3.
   (b) Draw the ideal geometries (ignoring the influence of VSEPR) of
   i. BF_3 ii. CF_3^+ iii. ClF_3 iv. ClF_4^-

4. (a) Give a balanced equation and propose a possible mechanism of the reaction between diborane and water.
   (b) Draw a molecular orbital energy level diagram of a nitric oxide (NO) molecule. Using the diagram, deduce the magnetic properties and the bond orders for NO, NO^+, and NO^- species.

5. The complex, $[FeF_6]^{4-}$ is paramagnetic whereas $[Fe(CN)_6]^{4-}$ is diamagnetic.
   i. Using valency bond theory, account for the above observations.
   ii. Calculate the magnetic moment and the crystal field stabilization energies (CFSE)of the complexes in terms of their Dq parameters. Given 10Dq for $[FeF_6]^{4-}$ is 25,000 cm^{-1} , evaluate its CFSE in cm^{-1}.

6. The electronic spectra of $[Ni(OH_2)_6]^{2+}$ shows three peaks in the UV spectrum at 8700, 14500 and 25300 cm^- . Account for the origin of these peaks.

Given:	RS Term	Octahedral Ligand Field Terms
	S	A_{1g}
	P	T_{1g}
	D	$E_g + T_{2g}$
	F	$A_{2g} + T_{1g} + T_{2g}$

$N_A = 6.022 \times 10^{23}$ mol^- ; $R = 2.18 \times 10^{-18}$ J ; $c = 3.0 \times 10^{10}$ cm s^{-1}

END OF EXAM. GOOD LUCK!

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
JANUARY 2001.

C251
ORGANIC CHEMISTRY

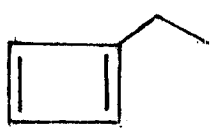
Time: **Three (03) Hours**

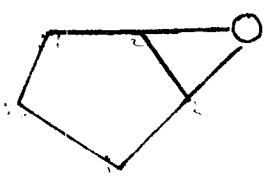
Instructions:

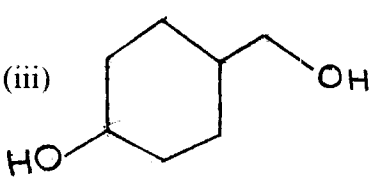
1. **Answer any FOUR questions.**
2. **All questions carry equal marks.**
3. **Marks allocation for each question is shown.**
4. **Maximum marks = 100**

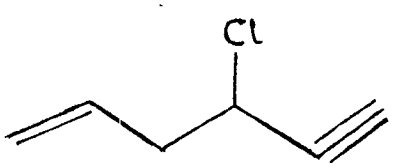
QUESTION ONE

a) Give the **IUPAC** names corresponding to each of the following structures.

(i) 

(ii) 

(iii) 

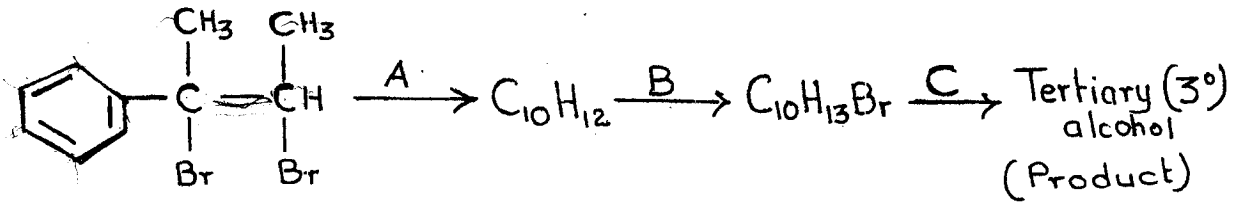
(iv) 

(04 marks)

b) When 2-bromo-2-methylpropane (t-butylbromide), is allowed to stand at room temperature for a long time, it becomes contaminated with 1-bromo-2-methylpropane (iso- butylbromide), because of long exposure to atmospheric oxygen. Write a reasonable reaction mechanism to account for the formation of 1-bromo-2-methylpropane.

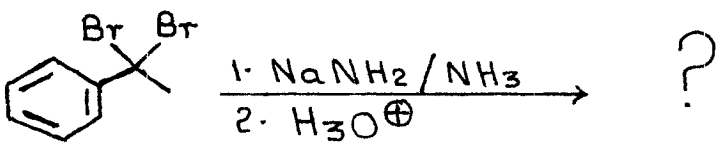
(10 marks)

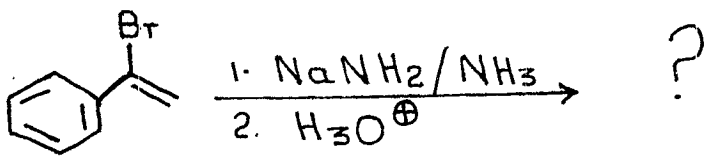
c) In the multi-step synthetic route given below, identify reagents **A**, **B**, **C**, and the product, the tertiary (3^0) alcohol, and give a reaction mechanism for the transformation of $C_{10}H_{12}$ to $C_{10}H_{13}Br$ using reagent **B**



(06 marks)

d) Write the mechanisms for each of the following reactions and briefly comment on the expected product of each reaction.

(i) 

(ii) 

(05 marks)

QUESTION TWO

a) Draw the most favoured conformations for the following pairs of compounds and identify, stating your reasons, which isomer in each pair is the most stable.

(i) cis-1,3-Dibromocyclobutane and trans-1,3-dibromocyclobutane.

(ii) cis-1,3-Dibromocyclohexane and trans-1,3-dibromocyclohexane.

(05 marks)

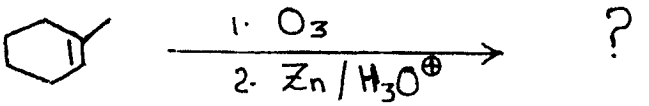
b) Write a synthetic route to show how you would carry out each of the following transformations using any necessary reagents.

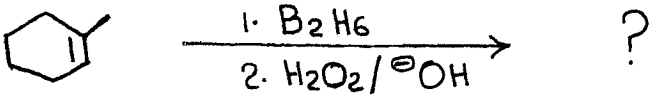
(i) n-Propanol into iso-propanol.

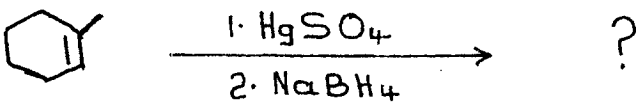
(ii) Iso-Propanol into 3-methyl-1-butanol

(08 marks)

c) Suggest the mechanisms and show the products(s) of each of the following reactions, indicating clearly the regiochemistry and stereochemistry of each of the reactions.

(i) 

(ii) 

(iii) 

(12 marks)

QUESTION THREE

a) Suggest a mechanism for the reaction between bromine and (+)-3-methyl-1-penten-4-one. Provide the **IUPAC** names and show the Fischer projection formulas for the products obtained in this reaction.

(09 marks)

b) (i) Using a reaction mechanism, show how 3-methyl-1-hexene would isomerise by the action of $\mathbf{H_2SO_4}$ and name all the isomers you would expect to be formed.

(2½ marks)

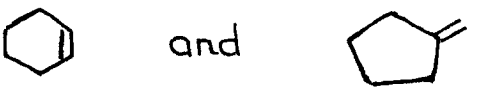
(ii) If 3-methyl-1-hexene in 3(b)(i) above, were treated with $\mathbf{KMnO_4}$ before addition of $\mathbf{H_2SO_4}$, what product would you expect to obtain?

(02 marks)

c) Explain briefly how the application of a simple analytical procedure or a simple chemical test will enable you to distinguish between the following pairs of compounds.

(i) 1-Propene and cyclopropane

(02 marks)

(ii)  and

(02 marks)

(iii) 2-Butanol and 3-butanol, and show the mechanism for **ONLY** this analytical procedure or chemical test you have given.

(07½ marks)

QUESTION FOUR

a) Explain briefly what is meant by each of the following terms.

(i) Molecular conformation

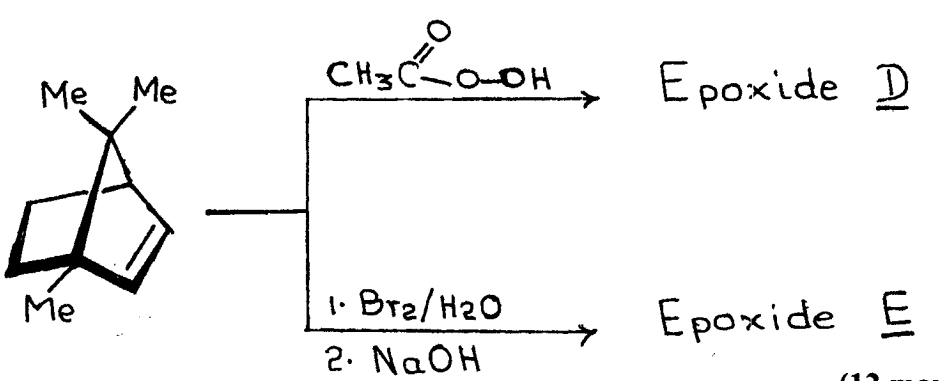
(ii) Molecular configuration

(iii) Optical activity

(iv) Diastereomer

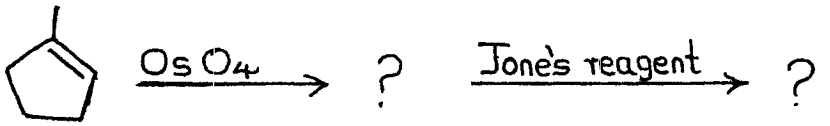
(04 marks)

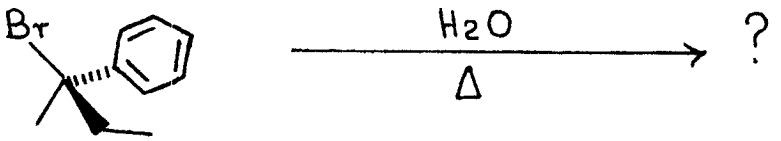
b) When bornene, structure is shown below, is treated with peroxyacetic acid, **CH_3COOOH,** an epoxide **D** is obtained, but when the same bornene is reacted with aqueous bromine, followed by base treatment, a different epoxide **E** is obtained. Propose a suitable mechanism for each reaction and suggest structures for epoxides **D** and **E.**



(12 marks)

c) Suggest the mechanisms for the following reactions and comment briefly on their products.

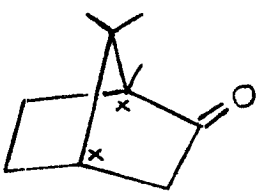
(i) 

(ii) 

(09 marks)

QUESTION FIVE

(a) Camphor, structure is shown below, has two asymmetric carbon atoms as shown, but only two optical isomers are known. Give an explanation for this observation.



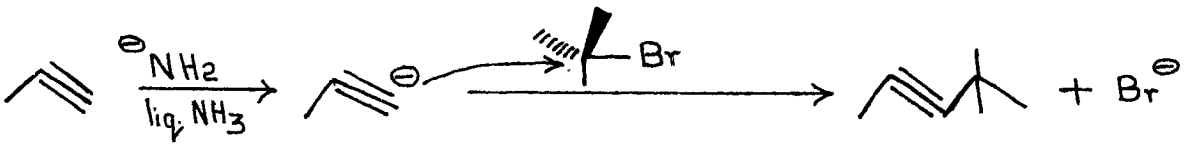
Camphor

(03 marks)

b) An unknown hydrocarbon **F**, with formula C_6H_{12}, reacts with one mole of hydrogen in the presence of a palladium (**Pd**) catalyst. Hydrocarbon **A** also reacts with OsO_4 to give a diol **G** When oxidised with $KMnO_4$ in an acidic solution, hydrocarbon **F** yields two fragments; one fragment is carboxylic acid **H**, containing three (03) carbon atoms, and the other fragment is a ketone **I**. Write all the reactions clearly showing your reasoning and suggest the structure of a hydrocarbon **F**, the structure of diol **G**, the structure of carboxylic acid **H**, and the structure of ketone **I**.

(12 marks)

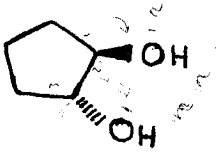
c) A second year organic chemistry student attempted to prepare 4,4-dimethyl-2-pentyne using the following reaction scheme.

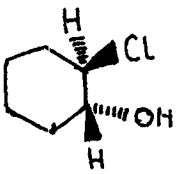


Upon working-up the reaction mixture, propyne was isolated and one other compound, which was not an alkyne. Provide a reaction mechanism to show how this other compound was formed.

(06 marks)

d) Name the following compounds by the **R/S** system of nomenclature.

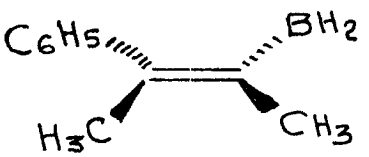
(i) 

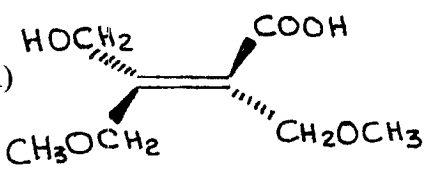
(ii) 

(04 marks)

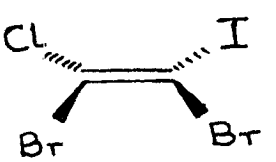
QUESTION SIX

a) Assign **E** or **Z** configuration to the following alkenes.

(i) 

(ii) 

(iii) 

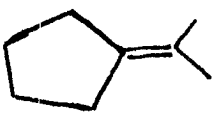
(iv) 

(04 marks)

b) When cis-2-butene is reacted with acidified **HOCl**, a mixture of products is obtained which shows no optical activity. Write a reaction mechanism to account for the observed optical inactivity and provide the general name for the compounds in the mixture.

(10 marks)

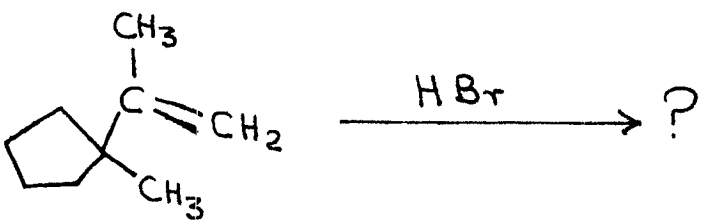
c) Dehydration of 2,2-dimethylcyclohexanol using sulphuric acid as a catalyst yields a mixture of 1,2-dimethylcyclohexene and iso-propylidenecyclopentane, structure is shown below. Propose a reaction mechanism to show the formation of the two compounds.



Iso-propylidenecyclopentane

(08 marks)

d) Write a mechanism and predict the product of the reaction shown below and suggest the major laboratory application of this reaction in organic synthesis.



(03 marks)

END OF EXAM

The University of Zambia
University Examination - January 2001 Examinations

C311 Biochemistry I

Instructions

Time: **Three** (3) hours

Answer **ALL** questions in section A and any **THREE** questions in section B

Useful information

FARADAY CONSTANT 23060 cal/mol/volt

GAS CONSTANT 1.987cal/mol/K

Section A

[40 marks]

1. a) The $\Delta G'_0$ for the hydrolysis of ATP to ADP is -8.0Kclal/mol. **Calculate** the equilibrium constant for this reaction at 310K. **Is** this reaction at equilibrium in cells? **Explain**.

   b) If at 298K and pH7, E'_0 of NAD^+/NADH redox couple is -0.320Vand E'_0 of the OAA^{2-}/Mal^{2-}couple is -0.166V, **what** is the equilibrium constant at this temperature and pH of malate oxidation by NAD^+? **Is** the reverse reaction spontaneous? **Explain**.

[8 marks]

2. a) The average volume of a red blood cell is 87 μm^3. The mean concentration of hemoglobin in red blood cells is 34g/100ml. **What** is the weight of the hemoglobin contained in a red cell? **How** many hemoglobin molecules are in a red blood cell? (MW of Hemoglobin = 64 500g/mol, $N_A = 6.023 \times 10^{23}$)

b) The equilibrium constant K for the binding of oxygen to myoglobin is 10^{-6}M, where K is defined as:

$K = [Mb][O_2]/[MbO_2]$

The rate constant for the combination of oxygen with myoglobin is $2 \times 10^7 M^{-1} sec^{-1}$. **What** is the rate constant for the dissociation of oxygen from oxymyoglobin? **What** is the mean duration of the oxymyoglobin complex?

[8 marks]

3. **Where** in the cell does the pentose phosphate pathway take place, and **what** is its purpose?

[8 marks]

4. In thermodynamic terms, briefly **discuss** the feasibility of the reactions between 1,3 bisphosphoglycerate and fructose 6-phosphate during gluconeogenesis.

[4 marks]

5. Given the following information about a decapeptide:

a) Amino acid composition after hydrolysis is:
(arg, asx, gly, glx, leu, lys, met, ser, pro, tyr)

b) Treatment of the peptide with

i) dinitrofluorobenzene yields DNP-gly

ii) trypsin yields three fragments having the following compositions:

T-1: (asx, glx, leu, lys, pro)
T-2: (arg, gly, ser)
T-3: (met, tyr)

iii) CNBr results in no cleavage.

iv) Edman degradation (using a sequencer) on fragment T-1 yields pro, leu, and asn after cycles 1, 2, and 3. Because of a malfunction after cycle 3, it is necessary to shut down the sequencer.

Based on the above information, **what** is the probable sequence of the decapeptide?

[12 marks]

Section B

[60 marks]

6. i) Glycophorin A is a glycoprotein that extends across the red blood cell membrane. The portion of the polypeptide that extends across the membrane bilayer contains nineteen amino acid residues and is folded into an α-helix. **What** is the width of the bilayer that would be spanned by this helix? The interior of the bilayer includes long acyl chains that are non-polar. **Which** of the twenty L-amino acids would you expect to find among those in the portion of the polypeptide that transverse the bilayer?

ii) The absorbance of a protein solution containing 1 mg/ml albumin was measured using a 1 cm light path and was found to be 0.550 and 0.199 absorbance units at 279 nm and 290 nm respectively. Assuming that tyrosine and tryptophan are the only amino acids which absorb appreciably at these wave lengths, **calculate** the number of these two amino acids in a molecule of the protein given that:

(a) MW of albumin is 65 000 Dalton.
(b) The molar extinction coefficient of tyrosine is 1.1×10^3 l/mol.cm at 279 nm and 0.28×10^3 l/mol.cm at 290 nm.
(c) The molar extinction coefficient of trptophan is 5.2×10^3 l/mol.cm at 279 nm and 4.3×10^3 l/mol.cm at 290 nm.

[20 marks]

7. a) **Explain** in detail how enzymes speed up biochemical reactions. (hint: start with equation: $\Delta G^* = \Delta H^* - T\Delta S^*$)

b) In an experiment the activity of a sample of 10μg of enzyme (MW = 10 000g/mol) each in 1 cm of solution was tested at various substrate concebtrations and in the presence of two substances, **A** and **B**. the results are shown below:

[S] mM	1.00	2.00	5.00	10.0	20.0
product with **A** present μmole/min	0.77	1.25	2.00	2.50	2.86
product with **B** present μmole/min	1.17	2.10	4.00	5.70	7.70
product with neither A nor **B** present μmole/min	1.50	4.00	6.30	7.60	9.00

(i) On the same pair of axes, **graph** these results in an appropriate way.
(ii) **Calculate** Vmax, and Km for the enzyme, in the presence of substrate alone.
(iii) **Calculate** the turnover number for the enzyme

(iv) **What** conclusions can you draw about **A** and **B**? **Explain** their effects.

[20 marks]

8. a) **Discuss** in detail how the oxidation of $FADH_2$ is coupled to the phosphorylation of ADP in mitochondria.

   b) Briefly **discuss** how it is that the NADH generated in glycolysis does not produce the same amount of ATP as the NADH produced in the TCA cycle.

[20 marks]

9. Aufinsen carried out experiments on refolding of ribonuclease enzyme. It was apparent from his results that refolding of ribonuclease into its characteristic 3-D structure was an automatic process, that is, ribonuclease refolded on its own when the denaturing agents were removed. **Discuss** one reason why ribonuclease refolded on its own. **What** have been results of this kind of experiments on other proteins? Briefly **discuss** what is currently known about protein folding? What does this current information suggest about the nature of science in general and biochemistry in particular?

[20 marks]

End of C311 y2k examination.....Cheers!

UNIVERSITY OF ZAMBIA

SEMESTER I EXAMINATIONS JANUARY 2001

C341

INORGANIC CHEMISTRY II

TIME: THREE HOURS

Instructions:

1. This examination has **SIX (6)** questions.
2. Answer any **FOUR (4)** questions.
3. A tidy and orderly presentation is a must.
4. Each question carries **25** marks.

1(a) Write balanced reactions, when

(i) Perchloric acid undergoes dehydration process in presence of phosphorous pentaoxide at -10^0C.
(ii) Barium perchlorate reacts with conc. Sulphuric acid.
(iii) Thiocyanogen reacts with ethene.
(iv) Xenon tetrafluoride reacts with boron trichloride.
(v) Xenondioxy difluoride reacts with water.

(b) Draw the structures of the following species.

(i) Br_2O (ii) Cl_2O_6 (iii) ClF_5 (iv) XeO_4

(c) Write balanced chemical reactions between silica and

(i) XeF_6 (ii) XeO_4 (iii) XeO_2F_2

(d) Name the following co-ordination compound.

(i) $[Zn(NH_3)_4]Cl_2$
(ii) $[Co(NH_3)_3NO_2ClCN]$
(iii) $[Cr(EDTA)]^-$

2(a) When the four co-ordinate square planar complex $[IrCl(PMe_3)_3]$, where PMe_3 is trimethyl phosphane, reacts with chlorine, two six co-orditnate products of the formula $[IrCl_3(PMe_3)_3]$ are formed by oxidative addition reaction . Name and draw all possible isomers for the compound.

(b) Account for the following:

(i) $[Fe(CN)_6]^{3-}$ is an inner orbital complex while FeF_6^{3-} is an outer orbital complex.
(ii) $[Ni(CO)_4]$ is a tetrahedral complex.

(c) Describe laboratory method for the preparation of hydrogen peroxide using sodium peroxide. How does it react with
(i) Acidified potassium iodide (ii) Moist silver oxide
(iii) Alkaline potassium ferrocyanide solution.

3(a) Describe the extraction of titanium metal from its ore ileminite. Mention clearly all chemical reactions involved in the process.

(b) Describe by using a suitable diagram and the chemical reactions in the industrial production of nitric acid by Ostwald Process.

(c) What happens when
(i) Carbon monoxide reacts with hydrogen in presence of zinc oxide catalyst at 150^0C.
(ii) A mixture of mercuric cyanide and mercuric chloride is heated.
(iii) Calcium phosphate is heated with dilute hydrochloric acid.
(iv) Phosphorous pentachloride reacts with conc. Sulphuric caid.
(v) Antimony trioxide reacts with conc. Nitric acid.

4 (a) State Jahn-Teller distortion theorem.

(b) Show by means of diagram, how the pattern of 'd' orbital splitting changes as an octahedral complex undergoes tetragonal distortion and eventually becomes a square planar complex.

(c) Write the structures of the following.

(i) N_2O_4 (ii) $(P_3O_{10})^{5-}$ (iii) $H_2S_2O_7$

5(a) Draw a labelled molecular energy level diagram for $[Co(NH_3)_6]^{3+}$ complex and determine its bond order.

(b) Write balanced reactions between silicoethane and
(i) Aqueous potassium hydroxide (ii) Chloroform (iii) Water.

(c) Carbon and silicon are the members of group IVA in the periodic table. Explain, why silicon cab form complex compounds whereas carbon is not able to form such compounds.

(d) Write three commercial uses of each of the following
(i) Sulphuric acid (ii) Phosphates

6(a) Nitrogen, a group V element forms more than one hydride. Give their formula. Describe Haber's process for the manufacture of ammonia on a large scale. How does it react with
(i) Iodine (ii) Copper(II)oxide (iii) sodium metal.

(b) Derive ground state spectroscopic R-S terms for a d^8 ion and determine crystal field stabilisation energy (CFSE) in a weak tetrahedral ligand field in terms of Dq.

(c) Complete and balance the following reactions

(i) $Cl_2O_7 + I_2 \longrightarrow$

(ii) $XeF_2 + NH_3 \longrightarrow$

(iii) $XeO_4 + H_2 \longrightarrow$

(iv) $KClO_4 + H_2SO_4 \longrightarrow$

(v) $Br_2 + 3F_2 \longrightarrow$

USEFUL INFORMATION:

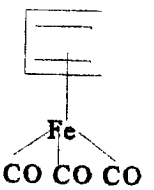
Atomic number: C=6 ; Si= 14 ; Fe=26 ; Co=27 ; Ni = 28

END OF C341 EXAMINATION

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ZAMBIA
C 342 : INORGANIC CHEMISTRY - SEMESTER II EXAMINATION, 2000.
ANSWER ANY **FOUR** QUESTIONS.

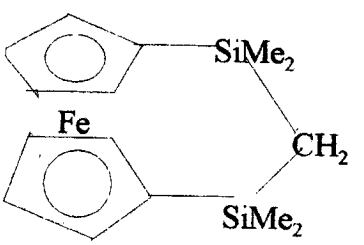
1. Suggest a plausible synthetic route to obtain each of the following organometallic complexes:

(i) $[TiMe_4]$
(ii) $[\ Cr(C_6H_6)_2\ ]$
(iii) $[\ (C_4H_4)Fe\ (\ CO\ )_3\ ]$
(iv)



(v) $[\ Fe\ (C_5H_5)\ (C_5H_4Br\ )\ ]$

(vi)



2. The ligand group orbitals (LGOs) of C_6H_6 have the following expressions:
(1) $\Psi(A) \rightarrow [\ \phi_1 + \phi_2 + \phi_3 + \phi_4 + \phi_5 + \phi_6]$
(2) $\Psi(B) \rightarrow [\ \phi_1 - \phi_2 + \phi_3 - \phi_4 + \phi_5 - \phi_6]$
(3) $\Psi(C) \rightarrow [\ \phi_1 + \phi_2 - \phi_3 - \phi_4 - \phi_5 + \phi_6]$
(4) $\Psi(D) \rightarrow [\ \phi_2 + \phi_3 - \phi_5 - \phi_6]$
(5) $\Psi(E) \rightarrow [\ \phi_1 - \phi_2 - \phi_3 + \phi_4 - \phi_5 - \phi_6]$
(6) $\Psi(F) \rightarrow [\ \phi_2 - \phi_3 + \phi_5 - \phi_6]$

Sketch the shapes of the LGOs showing the nodal planes where present. Hence deduce the atomic orbitals on the metal suitable for overlap with each of the LGOs.

3. The following catalytic reactions are of great industrial importance.

(a) $n\ C_2H_4 \xrightarrow{TiCl_4/Et_3Al} -(-CH_2CH_2-)_n Et$

(b)

$$RCH{=}CH_2 \xrightarrow[H_2]{RhH(CO)(PPh_3)_3} RCH_2CH_3$$

(c)

$$RCH{=}CH_2 \xrightarrow[H_2\ /\ CO]{Rh\ H(CO)(PPh_3)_3} RCH_2CHO$$

(d)

$$CH_3OH \xrightarrow[H_2\ /\ CO]{RhI_2(CO)_2} CH_3COOH$$

Give a plausible mechanism for the formation of each of the above product.

4. (a) Write a concise account on each of

(i) Lanthanide contraction and its consequences.

(ii) Extraction of lanthanide ions from a mineral rock.

(b) Complete and balance the following reactions

(i) $Gd(s) + S_8(l) \rightarrow$

(ii) $Gd(s) + N_2(g) \rightarrow$

(iii) $Gd(s) + F_2(g) \rightarrow$

(iv) $Gd(s) + HCl(aq) \rightarrow$

(v) $Gd(s) + H_2O(l) \rightarrow$

(c) (i) Compare and contrast the electronic spectra of transition metal ions with those of lanthanide ions.

(ii) Derive the RS terms of an f^4 configuration of the promethium ion, Pm^{3+} (yellow solution) with the help of the following partial terms

Electron configuration	Partial Term
f^1	F
f^2	HFD
f^3	IGFDS

5. Discuss the possible mechanism and observation for the formatiom of the products in each of the following reactions.

(a) $[Ru(phen)_3]^{2+} + [RhCl_6]^{2-} \rightarrow [Ru(phen)_3]^{3+} + [RhCl_6]^{3-}$

(b) The aquation reaction of cis-$[Co(en)_2Cl_2]^+$ gives a mixture of cis and trans-$[Co(en)_2Cl(OH_2)]^{2+}$.

(c) The base hydrolysis cis-$[Co(en)_2Cl_2]^+$ also gives a mixture of cis and trans-$[Co(en)_2Cl(OH)]^+$ with a rate 10^6 times that of the corresponding aquation reaction.

(d) $[PtCl_4]^{2-} + NH_3 \rightarrow [PtCl_3(NH_3)]^- + Cl^-$

6. (a) Write a short account on
   (i) Group Displacement Laws.
   (ii) Naturally occurring radioactive series.
   (b) Convert one atomic mass unit (amu) into million electron volt (mev).

   (c) Define nuclear binding energy per nucleon. The atomic mass of $_{35}I^{127}$ is 126.9004 amu , Calculate the nuclear binding energy for this nucleus and the corresponding energy per nucleon.
   (d) One gram of a radioactive isotope of lithium decays to 0.35 grams in two days. How much time will it take for the radioactivity to fall to one-fifteenth(1/15) of its original value?

PHYSICAL CONSTANTS

amu = 1.66×10^{-27} kg ;
1ev = 1.60×10^{-19} J
1 J = 6.25×10^{12} mev ;
mass of one proton = 1.0078 amu
mass of one neutron = 1.0087 amu;
speed of light = 3.0×10^{8} m . sec^{-1}

UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS: SEMESTER II

JANUARY 2001

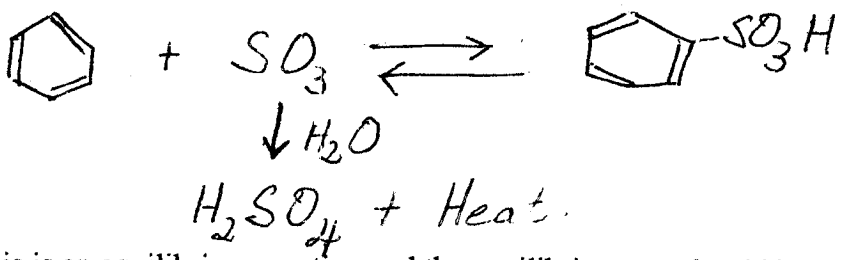
C351-ORGANIC CHEMISTRY

TIME: THREE (3) HOURS

INSTRUCTIONS

1. ANSWER ALL THE FOUR (4) QUESTIONS
2. ALL QUESTIONS CARRY EQUAL MARKS
3. INDICATE CLEARLY ALL THE DETAILS MEANT TO CLARIFY YOUR ANSWER

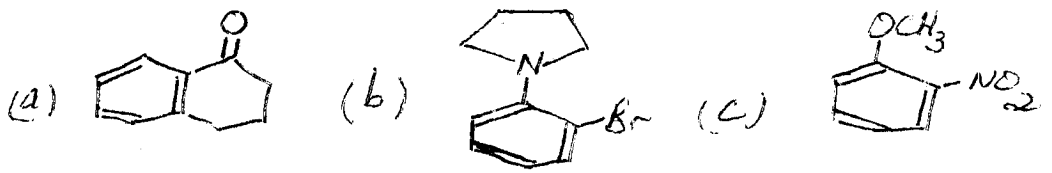
1.(a) The aromatic sulfonation reaction is an example of the electrophilic aromatic substitution reaction.



This is an equilibrium reaction and the equilibrium may be shifted to the side of the starting materials by removing the sulfur trioxide with water to give the sulfuric acid and heat.

Give the mechanism of the reverse sulfonation reaction.

(b) Predict the site of electrophilic aromatic substitution in

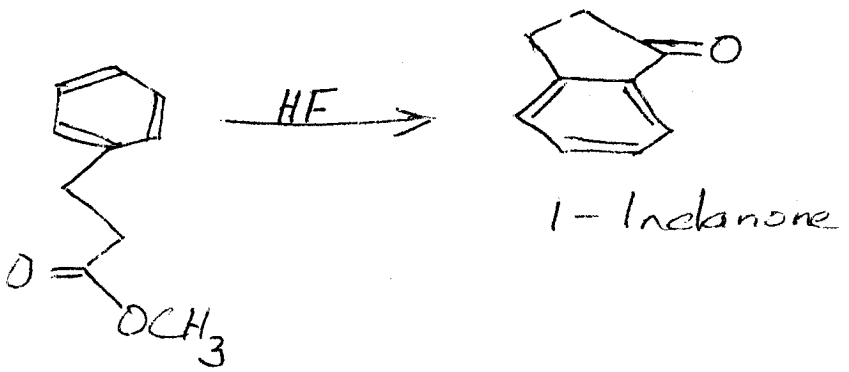


(c) Professor G. Olah and his colleagues exposed benezene to the especially strong acid system HF-SbF_5 in the nonnucleophilic solvent SO_2ClF – SO_2F_2 in an NMR tube and observed a new H NMR spectrum with absorption at δ = 5.69 (2H) 8.22 (2H), 9.42 (1H) and 9.58 (2H) ppm. Propose a structure for this species.

2(a) Treatment of benzene with chloromethane in the presence of $AlCl_3$ results in a complex mixture of tri-, tetra- and pentamethylbenzenes. One of the components in this mixture crystallizes out selectively; m.p. = 80°C; mass m/z = 134 $(M)^+$; ^{1}H NMR δ = 2.27 (b, 12 H) and 7.15 (b, 2H) ppm; ^{13}C NMR δ = 19.2, 131.2 and 133.8 ppm. Give the structure of this product.

(b) Electrophilic bromination of an equimolar mixture of methylbenzene (toulene) and (trifluoromethyl) benzene with one equivalent of bromine gives only 2- and 4-bromo-1-methylbenzene. Explain.

(c) Explain the following transformation by a mechanism. Propose a free energy profile for this reaction.

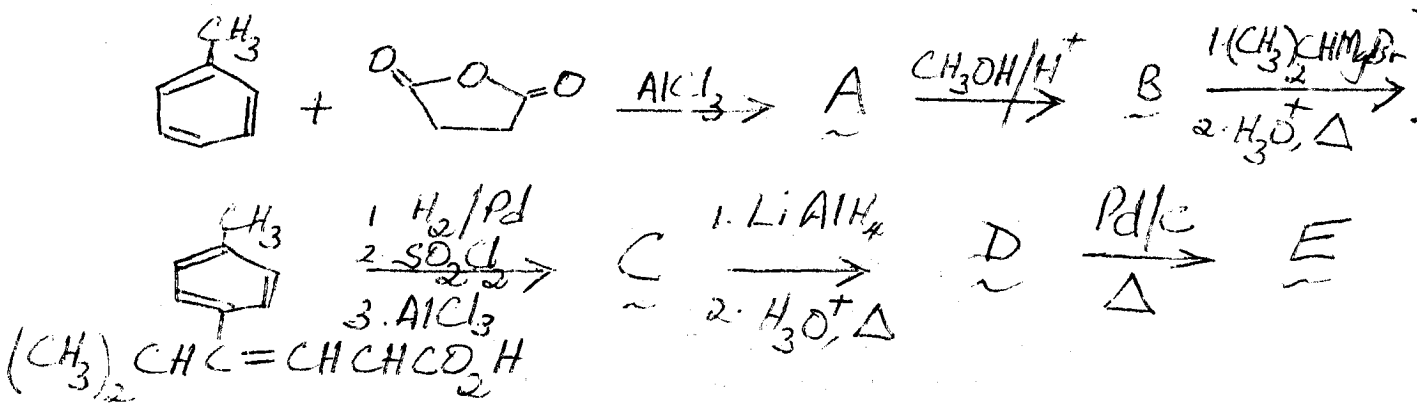


3.a. For the following pair, give at least one example in which one compound can undergo a reaction and the other one can not.

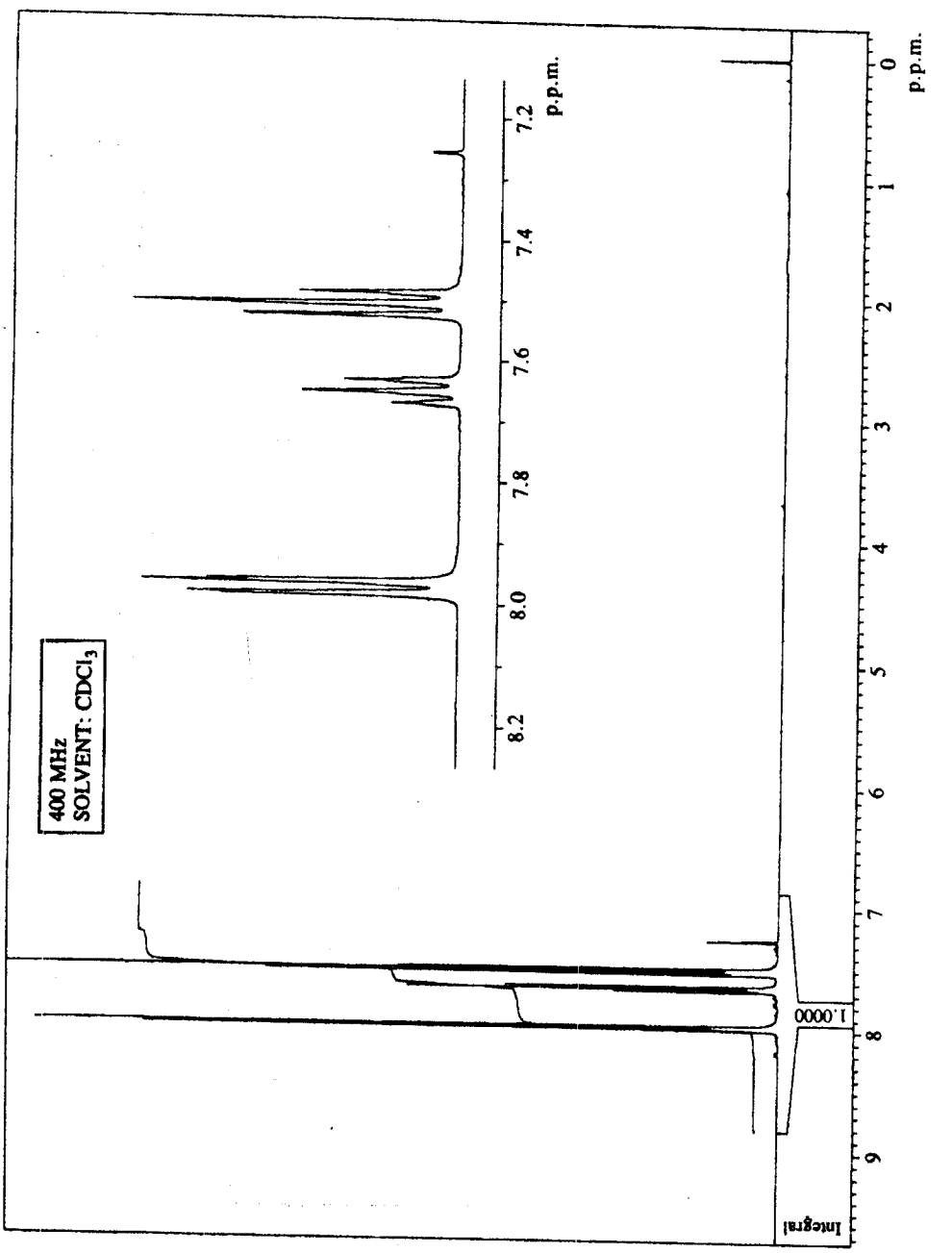
i. Cyclohexanol and cis-1, 2-cyclohexanediol.
ii. Propanal and propenal

b. Account for the observation that an ortho-para-directing substituent on the 1 position of naphthalene directs substitution to the 2 and 4 positions whereas the same substituent on the 2 position directs substitution almost exclusively to the 1 position in the electrophilic substitution reaction.

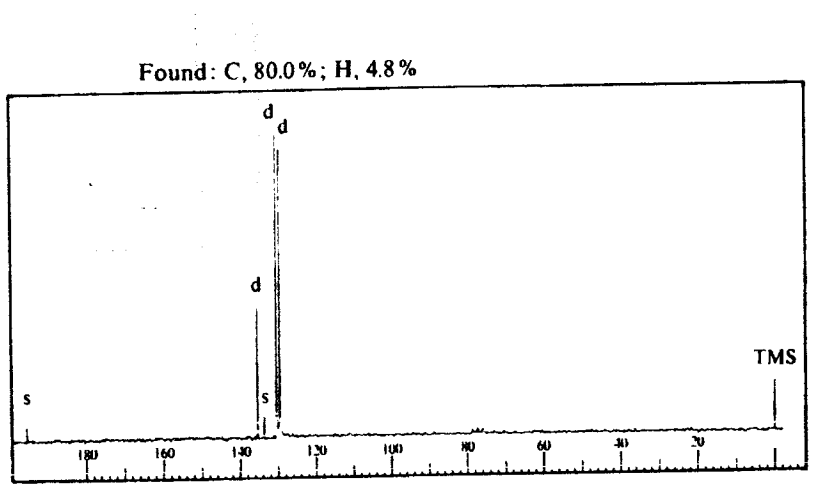
c. Identify the lettered compounds in the following reaction sequence

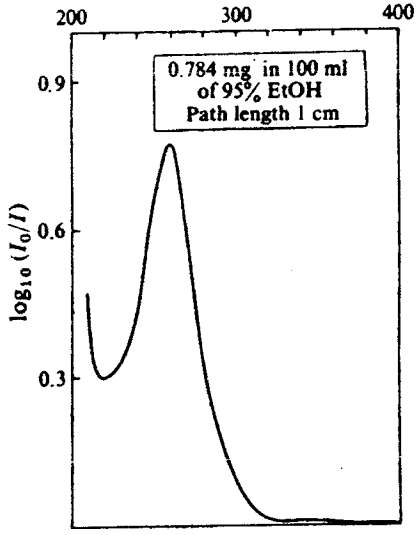


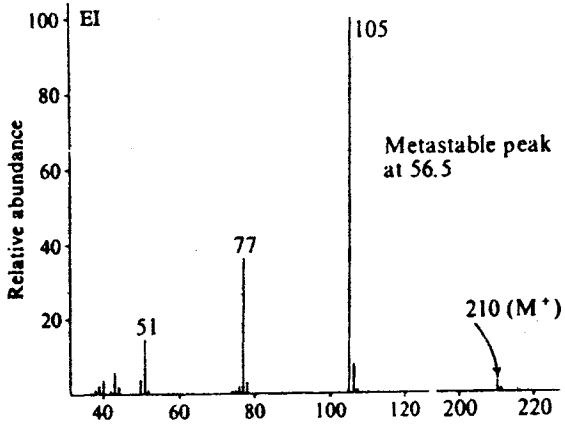
Compound P

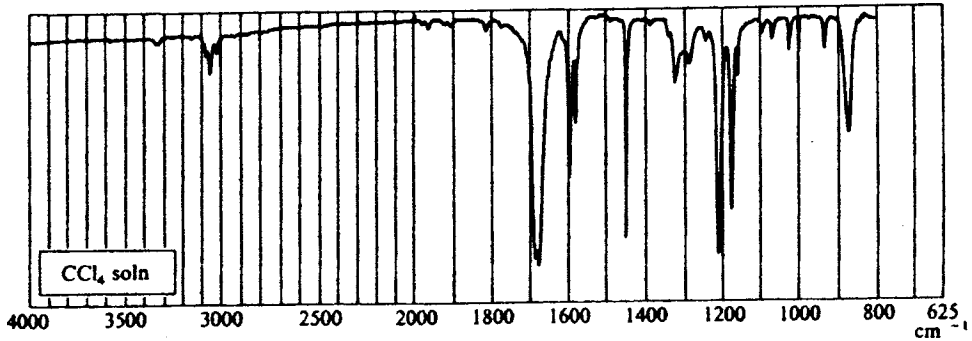

400 MHz
SOLVENT: $CDCl_3$
8.2
8.0
7.8
7.6
7.4
7.2
p.p.m.
Integral
1.0000
0
1
2
3
4
5
6
7
8
9
p.p.m.

COMPOUND P

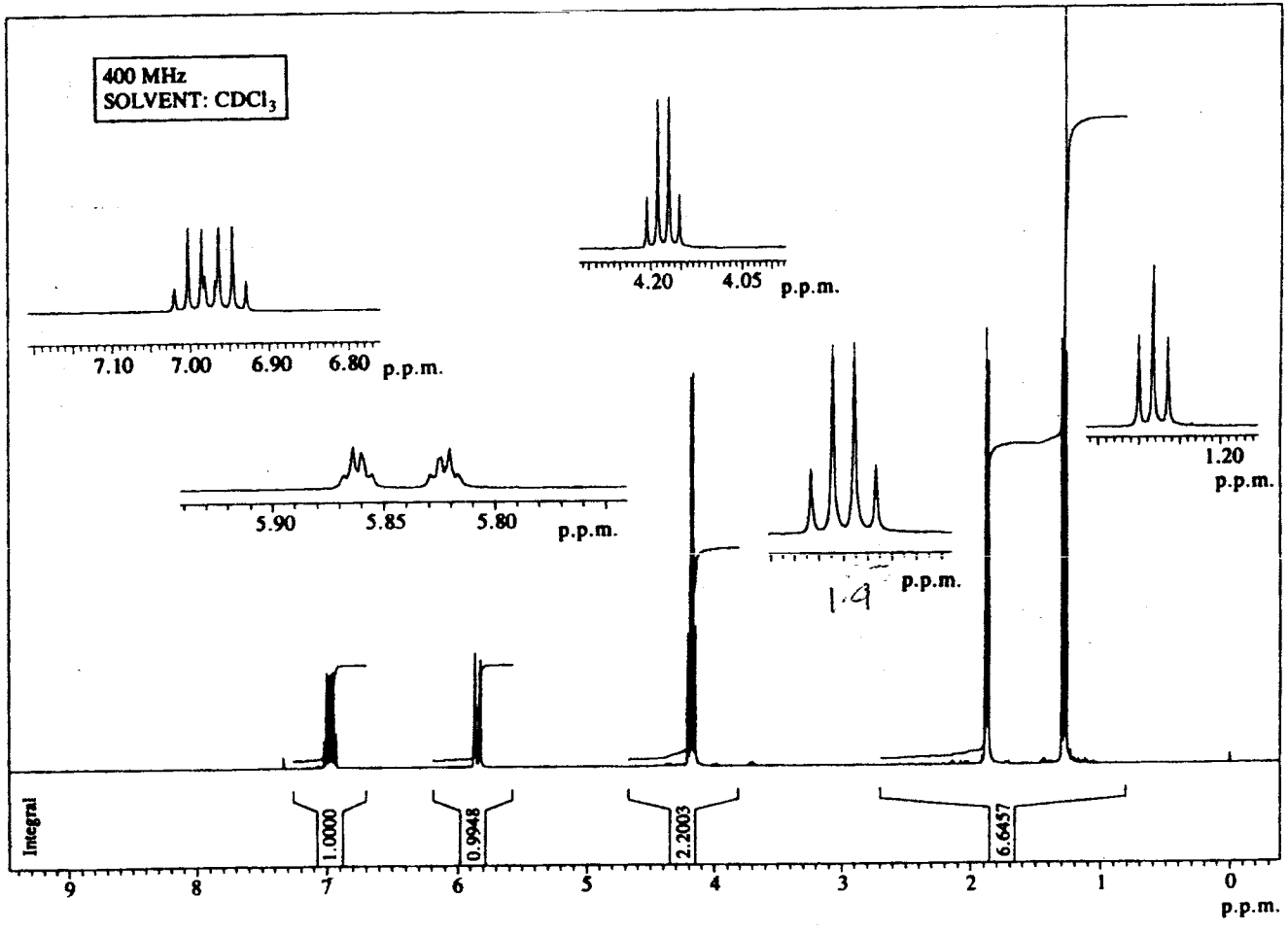

Found: C, 80.0%; H, 4.8%
d
d
d
s
s
TMS
180
160
140
120
100
80
60
40
20

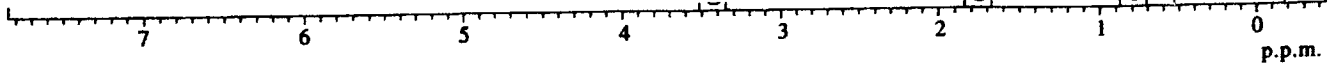

200
300
400
0.784 mg in 100 ml
of 95% EtOH
Path length 1 cm
0.9
0.6
0.3
$\log_{10}(I_0/I)$


EI
105
77
51
210 (M^+)
Metastable peak
at 56.5
Relative abundance
100
80
60
40
20
40
60
80
100
120
200
220


CCl_4 soln
4000
3500
3000
2500
2000
1800
1600
1400
1200
1000
800
625
cm^{-1}

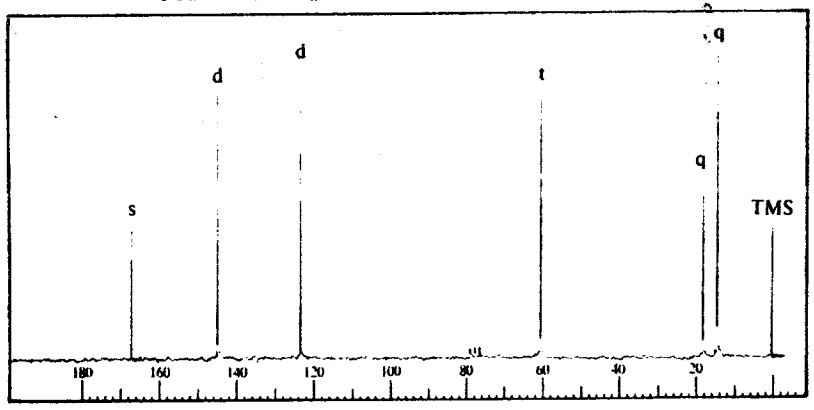
COMPOUND 4

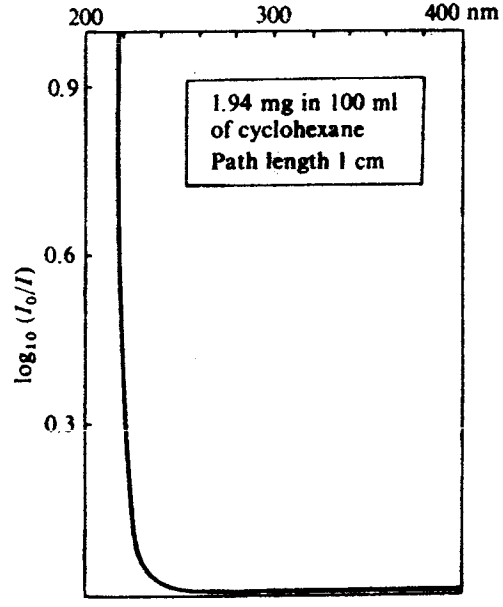

400 MHz
SOLVENT: $CDCl_3$
7.10 7.00 6.90 6.80 p.p.m.
4.20 4.05 p.p.m.
5.90 5.85 5.80 p.p.m.
p.p.m.
1.9
1.20 p.p.m.
Integral
1.0000
0.9948
2.2003
6.6457
9 8 7 6 5 4 3 2 1 0
p.p.m.

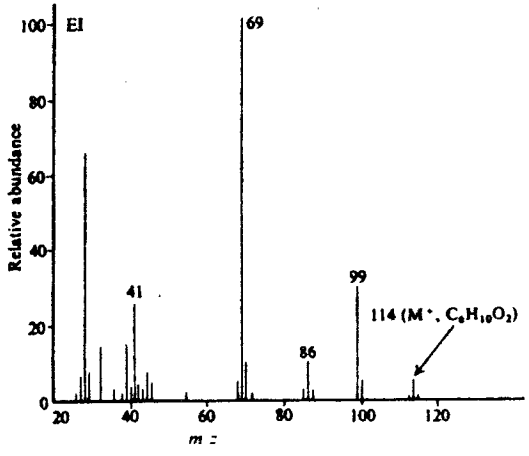


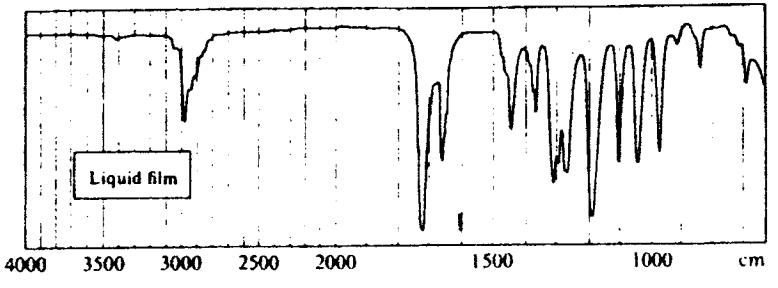
COMPOUND Q

Found: C, 64.3%; H, 8.8%



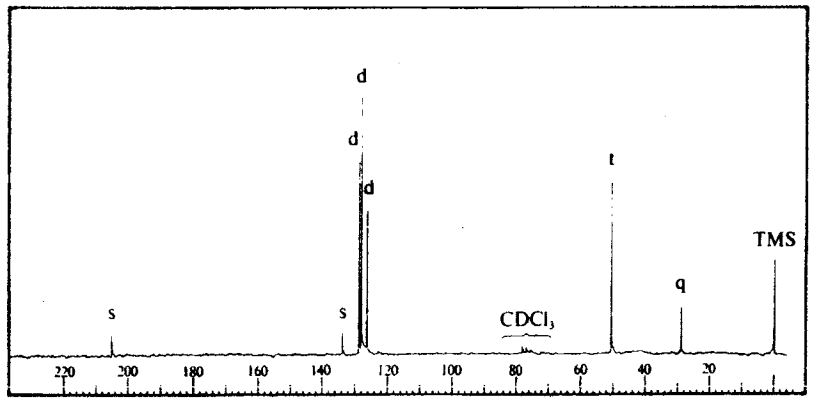


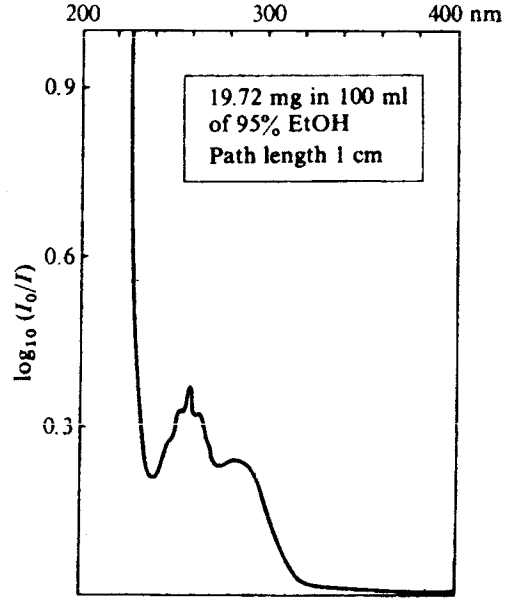


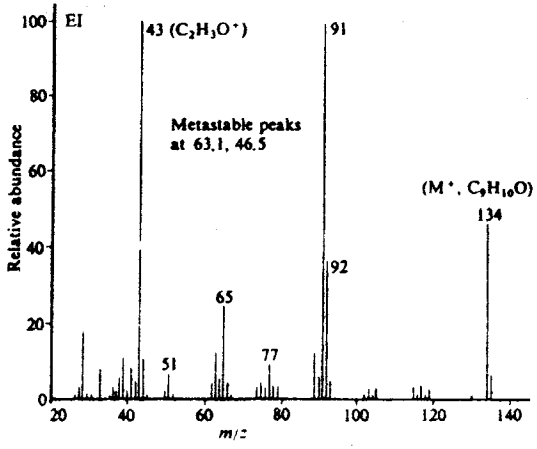


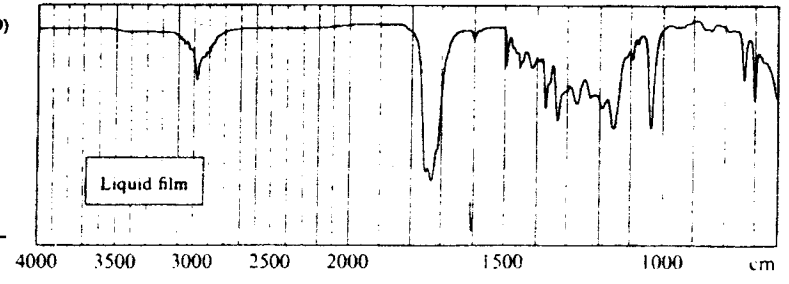
COMPOUND R

Found: C, 80.7%; H, 7.6%

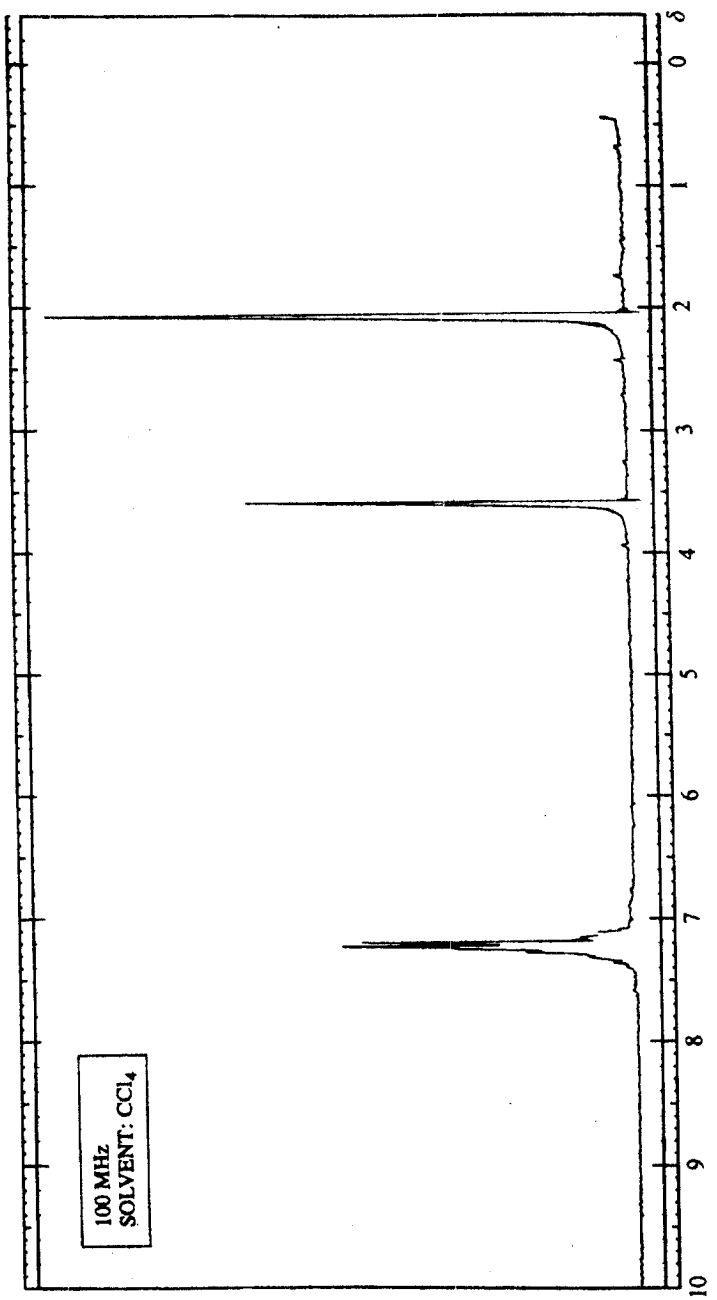








Compound R



THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS
JANUARY 2001.

C451
ADVANCED ORGANIC CHEMISTRY

Time: **Three (3) Hours**

Instructions:

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

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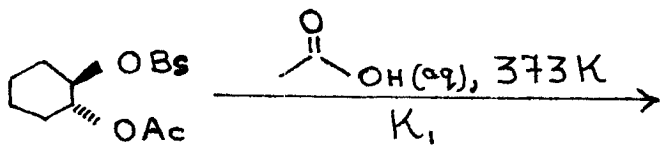
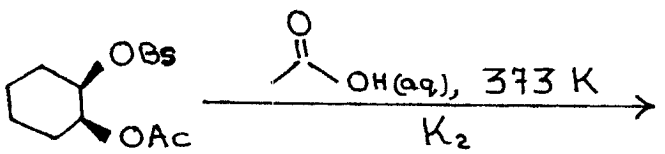
1. a) Solvolysis of syn- and anti-brosylates **A** and **B** at 373K, structures shown below, was found to proceed as follows:



A (Optically active) — Racemic mixture



B (Optically active) — Optically active

Kinetic data:

$K_1 = 1.9 \times 10^{-4}$

$K_2 = 2.9 \times 10^{-7}$

(i) Give a mechanistic explanation for the above experimental results.

(8 marks)

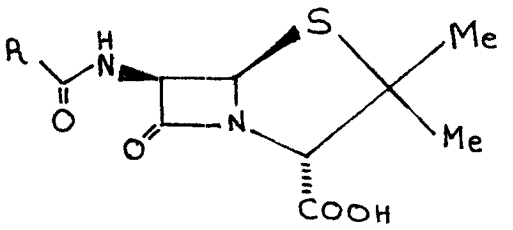
(ii) What product or products could be isolated that would support your explanation if the reactions were run in aqueous ethanol.

(5 marks)

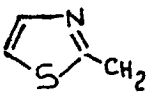
b) (i) Briefly, explain how the beta-lactam anti-biotics are inactivated by several Gram-positive and Gram-negative cocci.

(6 marks)

(ii) A penicillin **D**, structure shown below, was designed to overcome the problem of bacterial inactivation of penicillins. Suggest a stepwise synthesis of compound **D** from naturally occurring penicillin **C**.

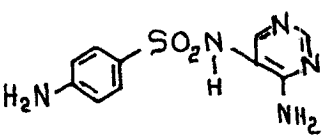


Compound C: R = $C_6H_5OCH_2$

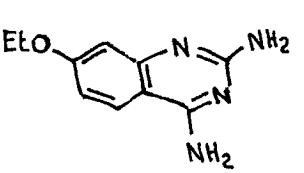
Compound D: R = 

(6 marks)

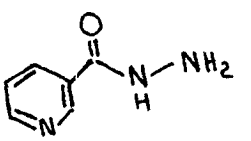
2. a) Identify the pharmacophore in the following anti-bacterial agents, **E** - **G** and give systematic names for compounds **E** - **G**.



E



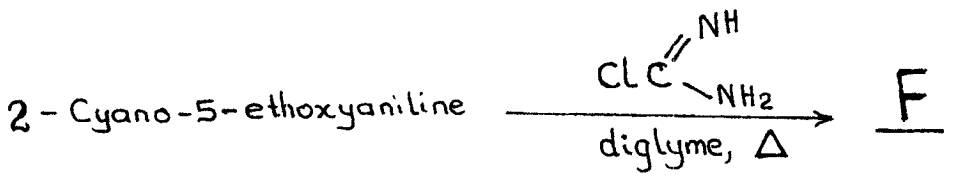
F



G

(7½ marks)

b) Suggest the mechanism of the reaction involved in the following synthesis of compound **F**, structure shown in 2(a) (i) above.



(5½ marks)

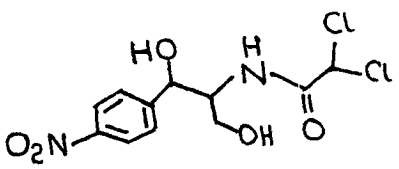
c) Explain the mode of anti-bacterial action of compound **E**, structure shown in 2(a) (i) above.

(8 marks)

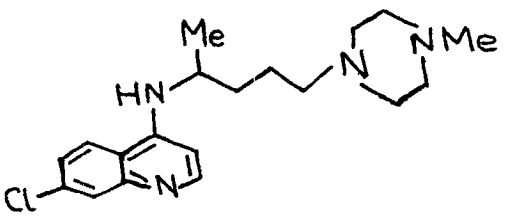
d) Suggest a synthesis of compound **G** from 2-methylpyridine.

(4 marks)

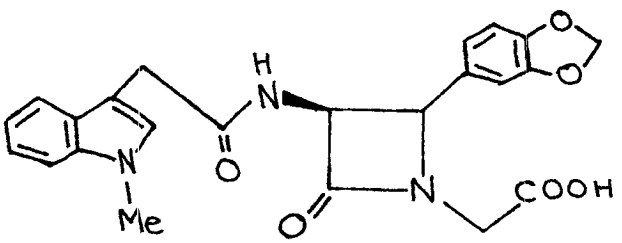
3. a) Propose an efficient synthesis of **any TWO** of the following biologically active compounds, from readily available non-heterocyclic starting materials and any other needed reagents. Show the logic of your proposal.



H



I



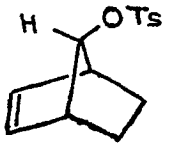
J

(22 marks)

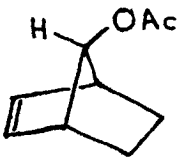
b) State the principal pharmacological action(s) of the compounds **H**, **I** and **J**, structures shown in (a) above.

(3 marks)

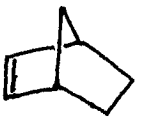
4. a) anti-7-Norbonylene tosylate **K** reacts with ethanoic acid 10^{11} times as fast as the saturated analog, and yields anti-7-norbonylene acetate **L** with retention of configuration. Solvolysis of **K** in presence of sodium borohydride gives **M** and **N**



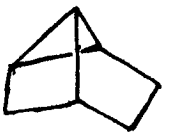
K



L



M

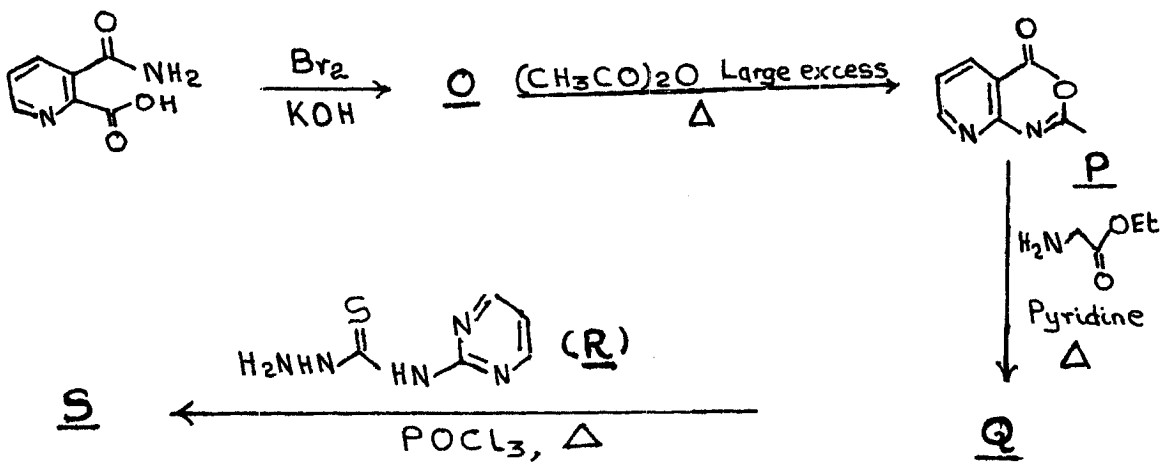


N

Account in detail for the above observations.

(8 marks)

b) Synthetic pathway for a potent anti-bacterial agent is shown below.



(i) Identify compounds **O**, **Q** and **S** in the above synthesis.

(9 marks)

(ii) Suggest mechanisms of the reactions involved in the transformation of **O** into **P**

(5 marks)

(iii) Suggest a synthesis of compound **R** used in the last step of the above synthetic pathway from non-heterocyclic starting materials.

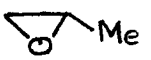
(3 marks)

5. Give the structures of major organic products of the following reactions.

a) trans-2-pentene + CH_2N_2 $\xrightarrow[\text{gas phase}]{h\nu}$? + ? **(5 marks)**

(With inert gas diluent)

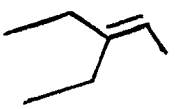
b) $(CH_3O)_3P$ $\xrightarrow[2.\ n\text{-BuLi/THF}]{1.\ ClCH_2COOMe/ether}$? **(4 marks)**

3. 

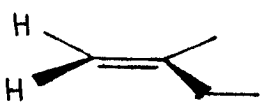
c) $C_6H_{13}C{\equiv}CH$ $\xrightarrow[2.\ H_2O_2/NaOH]{1.\ Sia_2BH}$? **(3 marks)**

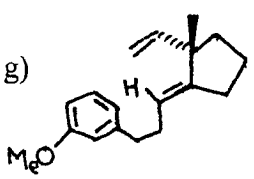
d)  $\xrightarrow[2.\ CO/HO\diagup\diagdown OH]{1.\ H_3B.THF}$? **(3 marks)**

3. $H_2O_2/NaOH$

e)  $\xrightarrow[2.\ \Delta]{1.\ NaBH_4/BF_3}$? **(4 marks)**

3. C_8H_{17} 

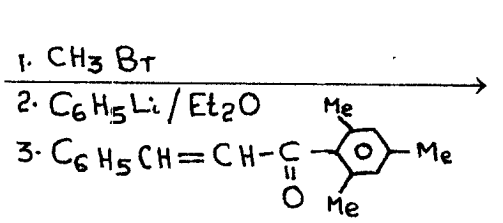
f)  $\xrightarrow[2.\ H_2O_2/NaOH]{1.\ (+)\text{-}Ipc_2BH}$? **(3 marks)**

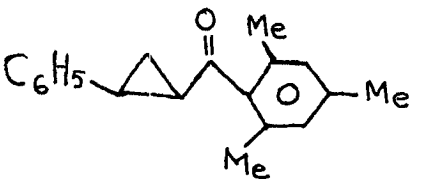
g)  $\xrightarrow[2.\ CO/H_2O]{1.\ \text{thexylborane}}$? **(3 marks)**

3. $H_2O_2/NaOAc$

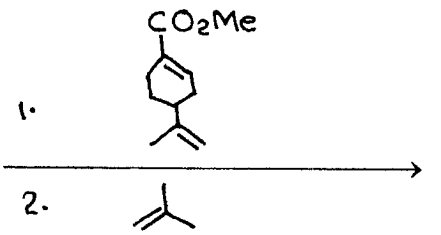
4. HCl/Zn

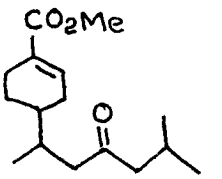
6. Propose mechanisms to account for the indicated products of the following reactions.

a) Ph_3P 

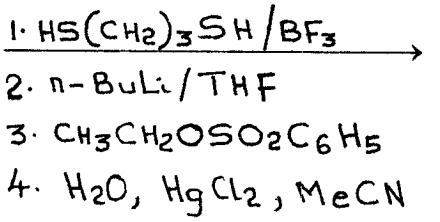


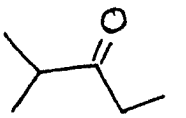
(6 marks)

b) thexylborane 



(7 marks)

c) $(CH_3)_2CHCHO$ 



(12 marks)

END OF EXAM

The University Of Zambia

UNIVERSITY EXAMINATIONS-JANUARY 2001

SEMESTER I

CHEMICAL KINETICS AND NUCLEAR CHEMISTRY - C361

INSTRUCTIONS

THE PAPER CONSISTS OF TWO SECTIONS

Section **A** has 3 questions

ANSWER A1 and either A2 or A3 (40 marks)

Section **B** has 4 questions

ANSWER B1 and ANY Two (2) others (60 marks)

SHOW YOUR WORKING CLEARLY

ANSWER EACH SECTION IN SEPARATE ANSWER BOOKLETS

DURATION: 3Hours

SECTION A **Answer question A1 and either A2 or A3**

A1. (a) (i) What is meant by the term "*half-life period*"

(ii) The half-life of a reaction of a compound A to give compounds D and E is 8.5 min when the initial concentration of A is 0.150mol L^{-1}. How long will it take for the concentration to drop to 0.0300mol L^{-1} if the reaction is second order with respect to A?

(b) (i) Define the terms "*chain reaction, intermediate and the steady-state approximation*".

(ii) The thermal decomposition of acetone is given by the following reaction

$$CH_3COCH_3 \longrightarrow CH_4 + CH_2CO$$

The proposed mechanism is given below. Develop a simplified rate expression corresponding to it - *let A stand for CH_3COCH_3*

$$A \xrightarrow{k_1} CH_3 + CH_3CO$$
$$CH_3 + A \xrightarrow{k_2} CH_4 + CH_3COCH_2$$
$$CH_3COCH_2 \xrightarrow{k_3} CH_3 + CH_2CO$$
$$CH_3 + CH_3COCH_2 \xrightarrow{k_4} CH_3COC_2H_5$$

Assume at some point that k_3 is much greater than k_4 $[CH_3]$, that is, the rate of termination is much smaller than the rate of propagation

A2. (a) (i) Chemical reactions occur when reactants collide. Give two reasons why a collision may fail to produce a chemical reaction.

(ii) The rate constant for the decomposition at 45°C of dinitrogen pentoxide, N_2O_5, is dissolved in chloroform, $CHCl_3$, is $6.2 \times 10^{-4} min^{-1}$

$$2N_2O_5 \longrightarrow 4NO_2 + O_2$$

What is the rate of decomposition when $[N_2O_5] = 0.40M$?
What are the rates of formation of NO_2 and of O_2 when $[N_2O_5] = 0.40M$?

(b) (i) What do you understand by the term "*second order reaction*"

(ii) Derive an integrated rate law for a second order reaction whose reactants, A and B have different initial concentration.

(iii) From (ii) above, calculate the concentration of A remaining after 100s if the initial concentration of A was 0.100M and that of B was 0.200M. The rate constant, k_2 being $1.0 \times 10^{-3} M^{-1}s^{-1}$.

A3. (a) The hydrolysis of the sugar sucrose to the sugars glucose and fructose

$$C_{12}H_{22}O_{11} + H_2O \longrightarrow C_6H_{12}O_6 + C_6H_{12}O_6$$

Follows a first order rate equation for the disappearance of sucrose:

$$\text{Rate} = k\,[C_{12}H_{22}O_6]$$

(i) In neutral solution, $k = 2.1 \times 10^{-11} s^{-1}$ at 27°C and $k = 8.5 \times 10^{-11} s^{-1}$ at 37°C. Determine the activation energy, the frequency factor, and the rate constant for this reaction at 47°C.

(ii) When a solution of sucrose with an initial concentration of 0.150M reaches equilibrium, the concentration of sucrose is 1.65×10^{-7}M. How long will it take the solution to reach equilibrium at 27°C in the absence of a catalyst? *Because the concentration of sucrose at equilibrium is so slow, assume that the reaction is irreversible.*

(iii) Why does assuming that the reaction is irreversible simplify the calculation in (ii)

(b) The hydrolysis of ethyl nitrobenzene by aqueous sodium hydroxide was followed at 25°C by titration of the hydroxide against standard acid at different stages in the reaction, from the following data, show that the reaction is of second order.

Time (s)	0	95	140	222	335	805	1364
ml of acid used	10	9.3	9.0	8.5	7.8	6.1	4.8

(c) Define the following terms and give a hypothetical example of each

(i) Parallel reaction

(ii) Consecutive reaction

SECTION B

INSTRUCTIONS : 1. ANSWER QUESTION B1 AND ANY TWO(2) OTHERS
2. USE A SEPARATE ANSWER BOOK.

DATA

$c = 2.998 \times 10^{8}\ m\ s^{-1}$; $R = 8.314\ J\ K^{-1}\ mol.^{-1}$; $J \equiv kg\ m^2\ s^{-2}$; $1\ eV = 1.602 \times 10^{-19}\ J$;
$N_A = 6.02 \times 10^{23}\ mol.^{-1}$; $^{12}_{6}C = 12.00000.$; $m_P = 1.67262 \times 10^{-27}\ kg$; $m_N = 1.67493 \times 10^{-27}\ kg$

B 1. (30 %)

a) On a clearly labeled diagram, show how the observed rate constant varies with pH for a specific base catalyzed reaction.

b) The adsorption of carbon monoxide on the surface of an $Fe/A\ell_2O_3$ catalyst obeys the BET isotherm. On a clearly labeled diagram, show how the amount of gas adsorbed varies with pressure.

c) Complete the following reactions by identifying the missing species given in each equation as a letter: A, B, C, E, F, and G :

(i) $^{1}_{1}p \rightarrow {}^{1}_{0}n + A + B$

(ii) $^{2}_{1}H + C \rightarrow {}^{3}_{2}He + {}^{1}_{0}n$

(iii) $^{31}_{15}P + {}^{1}_{0}n \rightarrow {}^{4}_{2}He + E$

(iv) $^{238}_{92}U + {}^{16}_{8}O \rightarrow {}^{250}_{100}Fm + F$

(v) $^{27}_{13}A\ell \rightarrow {}^{27}_{13}A\ell + G$

d) Calculate the amount of energy (in eV) released in the following reaction:

$$6\,^{1}_{1}H + 6\,^{1}_{0}n \rightarrow {}^{12}_{6}C$$

e) The average time for which an oxygen atom remains adsorbed to a tungsten surface is 0.36 s at 2548 K and 3.49 s at 2362 K. Calculate:

(i) the activation energy of desorption;

(ii) the pre-exponential factor.

f) Is the following statement True (T) or False (F). Briefly explain your answer. "In the primary kinetic salt effect, salts which do not react in the solution affect the ionic strength but not the rate constant".

g) The following equation is of great importance in physical chemistry. Identify the equation and the letters in the equation:

$$k_2 = \chi\, kT/h\, K^{\neq}\, \gamma_A \gamma_B / \gamma_{(AB)^{\neq}}$$

h) The decay of the radioactive family : $^{239}U \xrightarrow{23.5\ min} {}^{239}Np \xrightarrow{2.35\ day} {}^{239}Pu$ is unimolecular (the times are half lives). On a clearly labeled diagram, indicate the variation of the concentrations of the reactants and products as functions of time t.

B 2 (15 %)

The water gas reaction, which is used in the commercial production of hydrogen gas, is catalyzed by chromium (III) oxide. The overall reaction is given by the equation :

$$H_2O + CO \rightarrow H_2 + CO_2$$

a) (i) Write the formula for chromium (III) oxide

(ii) Is the reaction homogeneous, enzymatic or heterogeneous. Explain your answer.

b) Outline a simplified and most plausible two step mechanism for the reaction to illustrate the principles of catalysis.

c) On the basis of the catalytic mechanism in part b) above, discuss the reaction in terms of:

(i) the energetics of the reaction (i.e. the variation of energy with reaction path)

(ii) the thermodynamic equilibrium of the reaction and the enthalpy of the reaction, $\Delta H^{o}_{reaction}$.

(iii) consumption or production of the catalyst

(iv) the Arrhenius or van't Hoff intermediate

d) On a clearly labeled diagram, summarize your results in part c) indicating the reaction paths for the thermal and catalytic reactions and $\Delta H^{o}_{reaction}$

(From S. Ted Oyama and Gabor A. Somorjai; *Journal of Chemical Education* 65 (9), 765 - 769 ; 1988)

B 3 (15 %)

a) (i) What are nuclear isobars?

(ii) Arrange the following isomers in order of increasing energy : Sb ($t_{½}$ = 90 s) Sb ($t_{½}$ = 21 min.); and Sb ($t_{½}$ = 60 days).

b) Explain: (i) K capture

(ii) Pair production and annihilation

c) (i) What do the letters bepn stand for?

(ii) Calculate the bepn of the nuclide $^{60}_{28}Ni$ whose binding energy is 522 MeV.

d) Consider the reaction $^{14}_{7}N$ (α, p) ^{17}O - 1.19 MeV

(i) Write the complete reaction

(ii) calculate the energy (in J) required to convert 1 g of $^{14}_{7}N$ into ^{17}O.

B 4 (15 %).

a) Discuss the Eley - Rideal Mechanism for surface catalyzed reactions . In your discussion outline the main features of the mechanism, including any assumptions. Derive the rate equations of the mechanism in both the high and low pressure limits.

b) Nitrous oxide is weakly adsorbed on Au but very strongly adsorbed on Pt. On the basis of your results in part (a), derive the order of the decomposition reaction on each of the two metal surfaces.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER I EXAMINATIONS, JANUARY 2001

C481 — Inorganic Industrial Chemistry

Time : 3 hours
Instructions : Answer any five questions

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1. Describe the apparatus for the measurement of fluids and gas flows: orifices, Pitot tubes, Rotameters, Weirs.

2. Explain the CO and H_2 production processes.

3. Describe the absorbers used for gas purification: packed columns, fluidized packing columns, columns with bubble cap plates and sieves.

4. State the composition and production process of Portland cement.

5. Describe the flowsheet diagram for the purification of a gas mixture from CO_2 with monoethanolamine solution (Flowsheet is attached).

6. Discuss the production of carbon: lampblack, carbon black, activated carbon and state when each one is used.

7. Write down the reactions and technology of production of sodium compounds: NaCl, Na_2SO_4 and "Antichlor" compounds.

End of Examination

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER I EXAMINATIONS, JANUARY 2001

C491 – Organic Industrial Chemistry

Time : 3 hours
Instructions : Answer question 1 and any other four questions
Detach and submit relevant flowcharts

1. (i) By means of a reaction equation show how soap is prepared through saponification of fats and oils. Explain the difference in product properties between potassium and sodium soaps.

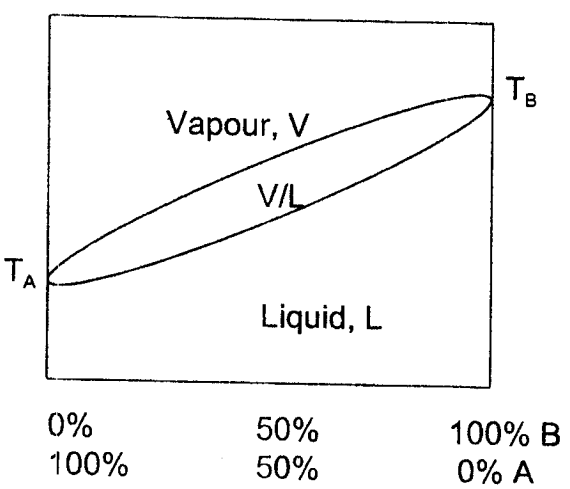
(ii) What do you understand by the terms proximate and ultimate analysis of coal?

(iii) Give two methods by which sulfur preparations used as fungicides may be produced in colloidal form. What problems are associated with storage and transportation in these products and how are they alleviated?

(iv) Explain how colour can be removed from paper pulp? Give two examples of materials that may be used in the colour removal process.

(v) (a) Explain why the temperature remains constant through out the distillation of a pure liquid

(b) Below is the vapor-liquid composition diagram of a binary mixture (two-component system). Why do the two curves meet at either 100% A or 100% B at T_A or T_B, respectively?



2. (a) Draw a schematic diagram showing the production of paper using the Fourdrinier machine.

(b) Explain what is involved in stock preparation during paper manufacturing and suggest the advantage(s) to be gained from these operations.

(c) Additives in paper making are added to impart or improve various properties of paper. Explain the function of titanium oxide and starch in the manufacture of paper.

(d) Outline environmental problems associated with the pulp and paper industry.

3. (a) Explain the formation of curd and how the soap and detergent industry attempts to minimise its formation. How does curd formation affect the cleansing action of soap?

(b) The flowchart for the production of detergent granules (Procter & Gamble) is attached to the examination paper. Label the diagram in full and indicate the functions of the units A, B, C and D.

Some materials used in the production of granules are added after the unit labelled C. Explain why it is undesirable to add certain additives before the unit C.

4. (a) What problems are associated with the purification of organophosphorous insecticides in industrial preparations?

(b) The laboratory and industrial routes to the preparation of dimefox (an organophosphorous insecticide) is shown in the Table below.

Laboratory anhydrous	Industrial aqueous
$POCl + 4(CH_3)_2NH$ in inert solvent	$POCl_3$ run into mixture of 2NaOH in water
↓	and $2(CH_3)_2NH$ in chloroform
$((CH_3)_2N)_2POCl + 2(CH_3)_2\overset{+}{N}H_2\overset{-}{Cl}$	↓
solid filtered off →	$((CH_3)_2N)_2POCl$ in chloroform
↓	2NaCl in water separated off →
NaF suspended	↓
↓	agitated with KF in water solution
$((CH_3)_2N)_2POF + NaCl$	↓
solid filtered off →	$((CH_3)_2N)_2POF$ in chloroform
	KCl in water separated →
	↓
	chlorform distilled off

(i) Comment on the economics of the two processes shown above.

(ii) What is the significance of using water in the preparation of organophosphorous insecticides?

(c) Pyrethrins are toxic, non-nitrogeneous organic esters of chrysanthemic acid derived from a flower called pyrethrum. Describe a process by which pyrethrins are produced.

(d) Explain how weed control is achieved using phenoxyacetic herbicides and indicate the advantages that such herbicides have. Comment on the production of these compounds.

5. (a) In the Winkler process for gasification of coal grading of particles is not essential but the efficiency of conversion may be affected by the particle size used. Explain the effect of particles on processing in the Winkler process.

(b) The Lurgi gasification process of coal involves a counter-current flow of the gasifying medium and the coal which favours heat conservation and creates temperature zones.

(i) By means of a simple sketch show the relative positions of the various temperature zones indicating on your diagram the direction in which temperature increases.

(ii) Different processes occur preferentially in the various zones. Explain in brief processes associated with each zone.

(c) Outline the advantages of the Winkler process over the Lurgi process.

6. (a) What do understand by the term destructive distillation of coal? Describe in note form how benzene may be produced from coal giving information on the various fractions obtained from destructive distillation, which fraction gives benzene and how it is isolated from other products.

(b) By means of chemical equations show how benzene may be produced from toluene. Indicate the reaction conditions used.

(c) Separation of xylenes from petroleum fractions, coke oven gas and coal tar sources is easily achieved by column distillation. The separation of the three isomers, however, is rather difficult. Outline methods by which the isomers can be separated.

7. (a) Define the term "*octane number*"

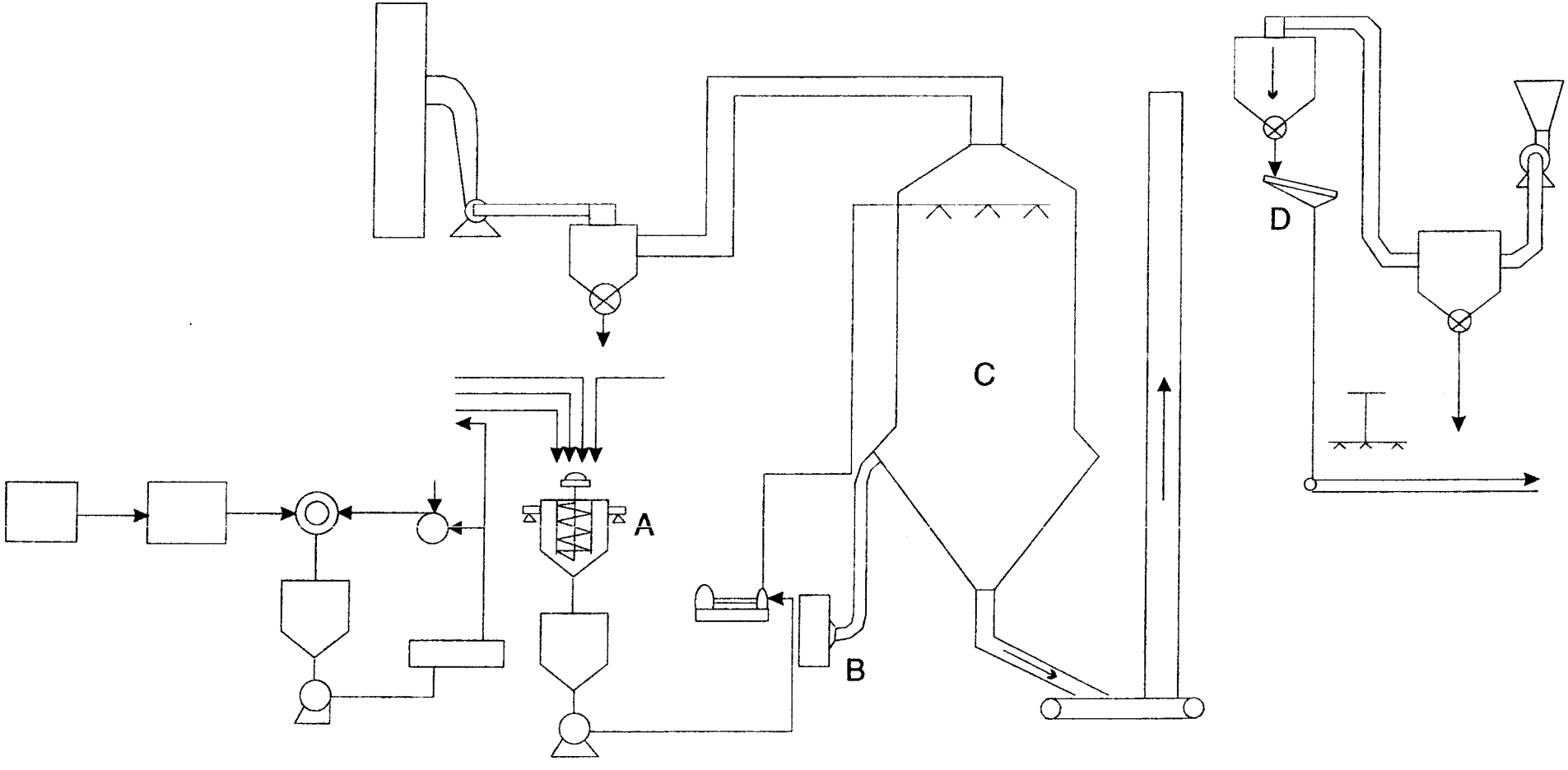
(b) Distinguish between motor octane number, MON and research octane number, RON, and which one is normally used for marketing purposes?

(c) In the laboratory determination of anti-knock value, the process is carried out using a single-cylinder engine known as the CFR engine.

(i) What do the letters CFR stand for?
(ii) Describe how you would carry out the procedure above.

(d) Define the terms *catalytic reforming* and *steam reforming*. In your answer show the type of reactions that take place, feedstock and major products obtained. What is the importance of having these processes?

(e) What do you understand by the term "*Azeotropic distillation*"? Sketch a liquid-vapour diagram, in terms of the pressure and mole fraction at constant temperature for a maximum boiling point mixture.



Simplified Continuous Flowchart for the Production
of Heavy-Detergent Granules

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER 1 SUPPLEMENTARY/DEFERRED EXAMINATIONS

MARCH 2001

CAV 251

ANALYTICAL/PHYSICAL/ORGANIC CHEMISTRY

TIME: THREE (3) HOURS.

INSTRUCTIONS

1. There are **THREE** sections in this examination paper: section A, B and C.
2. Answer **ALL** the questions in section A. Section A carries 50 marks.
3. Answer only **ONE** question in section B. Section B carries 20 marks.
4. Answer any **THREE** questions in section C. Section C carries 30 marks.
5. Show all your working and reasoning clearly.

SECTION A

Answer **ALL** the questions in this section.

1. (a) Distinguish between a gross sample and analysis sample (3marks)

   (b) Explain how you would obtain an analysis sample of soil from a 5-hectare field of farm land. (6marks)

   (c) State and explain the errors that would affect accuracy and precision of experimental results. How would you correct them? (4marks)

2. Twenty millilitres of 0.100M $AgNO_3$ were added to 100.0ml of 0.050M NaCl during titration. Calculate the chloride and silver ion concentration in the resulting solution. Ksp for AgCl $= 1.75 \times 10^{-10}$. (6marks)

3. A chemical reaction occurs in a vessel of cross-sectional area $250cm^2$ fitted with a loosely fitted seal. During the reaction the seal is pushed through 20cm against the external pressure of one atmosphere. One (1) atmosphere = $101325\ N/m^2$.

   (a) How much work does the reaction do on the outside world? (3marks)

   (b) How much work is done if the pressure of the system is replaced by a mass of 10kg acting downwards on the vertical piston? (3marks)

4. An organic compound **P** has the formula C_3H_6O.

   (a) Write four structural formulae for the compound. (4 marks)

   (b) Classify each according to its functional group. (4 marks)

   (c) Give the systematic IUPAC names for each compound. (4 marks)

5 (a) Explain, using formulas, the difference between a D- sugar and an L- sugar. (5 marks)

   (b) What is the difference in structure between D-ribose and 2-deoxy-D-ribose? (4 marks)

   (c) Write the possible dipeptide structures that can be obtained by joining alanine, $CH_3\text{-}\underset{\displaystyle NH_2}{CH}\text{-}COOH$, and glycine, $\underset{\displaystyle NH_2}{CH_2}\text{-}COOH$, by a peptide bond. (4 marks)

SECTION B

Answer only **ONE** question in this section.

1. A new method of determining nitrogen in an imported fertilizer gave 99.35% recovery (variance 0.0185). The standard method gave 99.53% recovery (variance 0.152). In each case three replicate measurements were made. Test whether the two means differ significantly at the 95% confidence level. (20marks)

2 (a) Define the **Zeroth** law of Thermodynamics and give an example of its application. (6 marks)

   (b) What is a reversible process? (2 marks)

(c) The hydrolysis of adenosine triphosphate (ATP) which liberates its terminal phosphate group is a reaction of considerable biochemical significance, and many attempts have been made to measure the values of ΔH, ΔS and ΔG for this reaction at " physiological" temperature and pH values. In one such determination at 309K ($36^{o}C$) and pH 7 in the presence of Mg^{2+} ions, it was calculated that when ΔH was -20.68kJ/mol, ΔS was +35.68J/K-mol.

(i) Calculate the corresponding value of ΔG of the reaction. (6marks)

(ii) Deduce whether or not the reaction will be spontaneous at 309K. (6marks)

SECTION C

Answer **THREE** questions in this section.

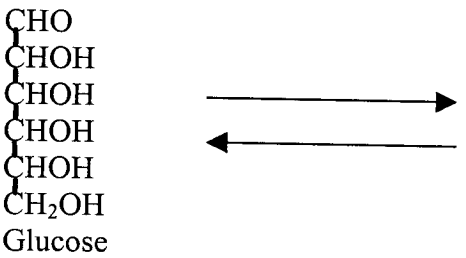
1. Compound **A** ($C_5H_{12}O$) does not give a yellow precipitate with 2,4-dinitrophenylhydrazine. Oxidation of A with potassium dichromate gives **B** ($C_5H_{10}O$). Compound **B** reacts with 2,4-dinitrophenylhydrazine but does not give a precipitate with silver nitrate in ammonia. Acid- catalyzed dehydration of compound **A** gives hydrocarbon **C** (C_5H_{10}). Ozonolysis of hydrocarbon C gives propanone (acetone) and ethanal (acetaldehyde). Propose structural formulas for compounds **A**, **B** and **C**. (10 marks)

2. (a) Give an account of the mechanism of nitration and Friedel Craft's alkylation reactions of benzene. (7marks)

(b) How would you convert 1-butanol into the following compounds? (3marks)

(i) $CH_3CH_2CH_2CHO$
(ii) $CH_3CH_2CH_2CO_2H$
(iii) $CH_3CH_2CH_2CH_2CN$.

3. Glucose, a polyhydroxylaldehyde, forms a six-membered cyclic hemiacetal in which the oxygen on carbon-5 of the chain reacts with the aldehyde on carbon-1



Glucose

A cyclic hemiacetal

(a) (i) How many chiral carbon atoms are there in glucose? (1mark)

(ii) How many stereoisomers are possible for a molecule of this structure? (3marks)

(b) Draw a structural formula for the cyclic hemiacetal of glucose. (4marks)

(c) (i) How many chiral carbon atoms are there in the cyclic hemiacetal formed by glucose? (1mark)

(ii) How many stereoisomers are possible for the cyclic hemiacetal? (1mark)

4. (a) The amino acid L- leucine rotates the plane polarized light to the left.

(i) In which direction does D-leucine rotate the light? (1mark)

(ii) Can you predict in which direction L-valine (another amino acid) rotates the plane of the light? (1mark)

(b) Glycine can be obtained in three forms:

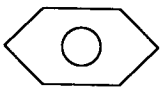
(i) Glycine hydrochloride
(ii) Isoelectric glycine and
(iii) Sodium glycinate.

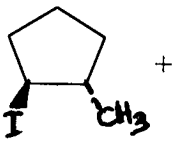
Draw the structures of these three forms.(8marks)

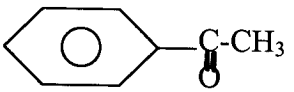
5. (a) Three possible products can be formed in the bromination of methyl benzene (toluene). Draw the three structures. (3marks)

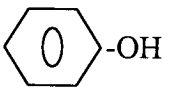
(b) Predict the results of the following reactions. (7marks)

(i) $CH_3\text{-}\underset{Br}{CH}\text{-}\underset{Br}{CH}\text{-}CH_2\text{-}CH_3 + Zn \longrightarrow$

(ii)  $+ 3H_2$ $\xrightarrow{\text{Raney Ni, } 160^\circ C}$

(iii)  $+ CN^- \longrightarrow$

(iv)  $\xrightarrow[\text{(ii) } H_2O, H^+]{\text{(i) } LiAlH_4}$

(v)  $+ CH_3\text{-}\overset{O}{\overset{\|}{C}}\text{-}Cl \xrightarrow[\text{(ii) } H_2O]{\text{(i) } AlCl_3 \text{ / heat}}$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF COMPUTER STUDIES
CST2021 – INTRODUCTION TO COMPUTER SYSTEMS
SEMESTER ONE (1) EXAMINATION 2001

INSTRUCTIONS : Answer Any Five (5) Questions.
TIME ALLOWED : Three (3) Hours.

Q1. (a) Suppose that you were going to store logical records on a magnetic tape, with a density of x characters per cm, and inter-record gaps of half a cm each. If each logical record consists of 100 characters and you want to use a blocking factor of n so as to waste not more than one-fifth of the tape to inter-record gaps, show that $n \geq f(x)$ for some function f.

(b) Hence, determine the possible values of n if $x = 2000$.

(c) If the tape described above has a total length of 2505cm, determine the minimum possible number of logical records that can be stored on the tape.

Q2. (a) Devise the Huffman Codes for the digits 1-9 based upon the following frequencies (use the conversion: 1 for the middle branch taken, and 0 for either the left or the right branch taken):

DIGIT	FREQUENCY	DIGIT	FREQUENCY
1	0.345	6	0.08
2	0.145	7	0.02
3	0.03	8	0.06
4	0.178	9	0.067
5	0.075		

(b) Using the codes devised in (a) above, which digit/s
(i) can be decoded?
(ii) may or may not be decoded?
(iii) cannot be decoded?

(c) Suppose that a memory word consists of m Data Bits to which we add r Check Bits. Let the total length for the Codeword be n, i,e $n = m + r$. Determine the general formula for n if

(i) $2 \leq m \leq 4$ (ii) $5 \leq m \leq 11$

Q3. (a) Give one difference between

(i) Translation and Interpretation.

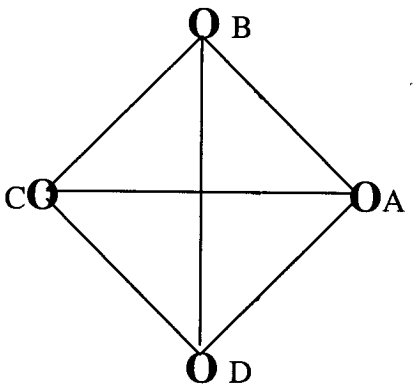
(ii) An Assembler and a Compiler.

(b) List down the six (6) main levels of a modern computer.

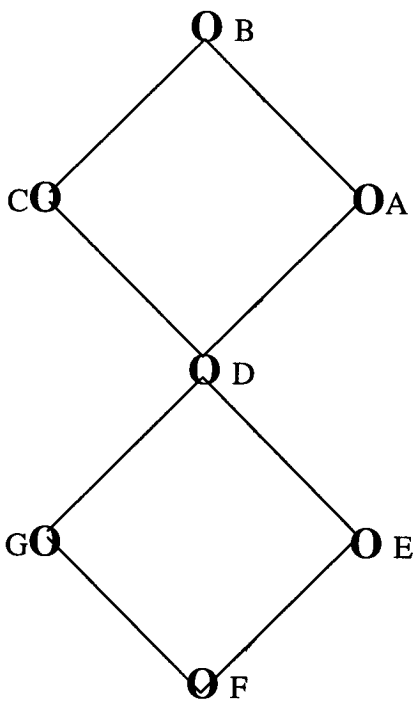
(d) Consider a multilevel computer in which levels 4 and 5 have interpreters which are 10 times as powerful as those of level 3, and levels 1 and 2 have interpreters which are 20 times as powerful as those of level 3. Assume that 5 level 1 instructions are required to interpret a single level 2 instruction, 5 level 2 instructions are required to interpret a single level 3 instruction, 5 level 3 instructions are required to interpret a single level 4 instruction, and 5 level 4 instructions are required to interpret a single level 5 instruction. If a program takes 100 microseconds to run at level 3, how long does it take the program (or an equivalent program) to run at level

(i) 1? (ii) 2? (iii) 3? (iv) 4? (v) 5?

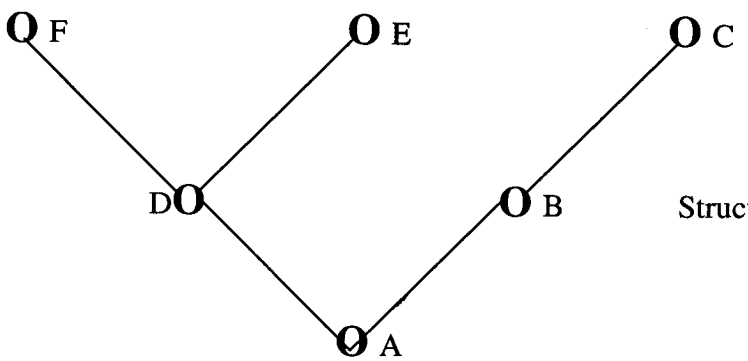
Q4. (a) Consider the following three Network Structures:



Structure 1



Structure 2



Structure 3

(i) Name the above Network Structures (preceding page).

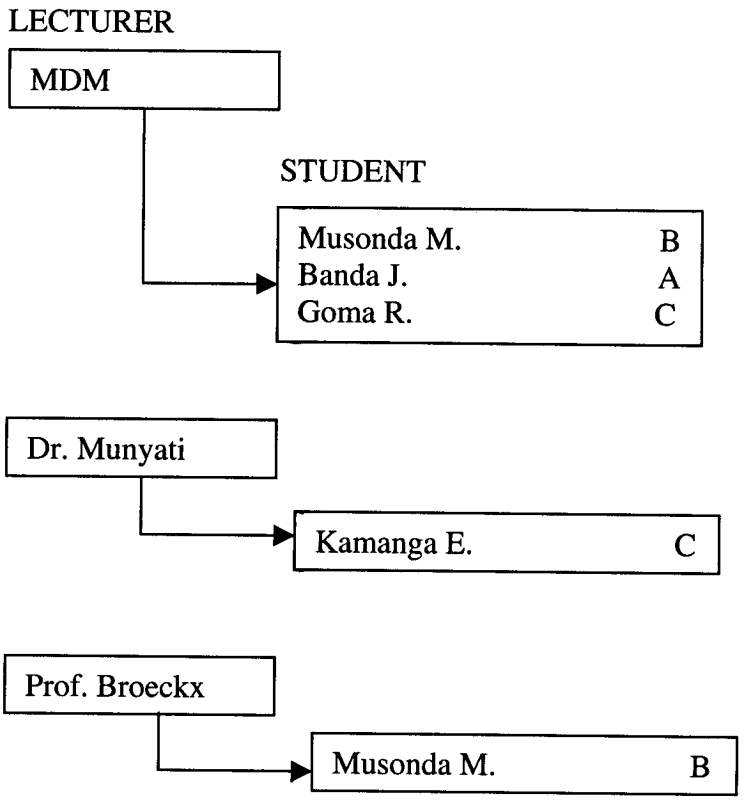
(ii) Draw clearly labeled diagrams for the other three common Network Structures.

(b) Which one of the three Network Structures in (a) (i) above is the best? Give three reasons in support of your answer.

(c) What sequence/s of letters should data flow follow for structure 2 in (a) (i) above? Give two reasons in support of your answer?

Q5. (a) Hierarchical, Network and Relational Data Models are the three main types of logically structured Databases. Give two reasons why the Relational Model is the best.

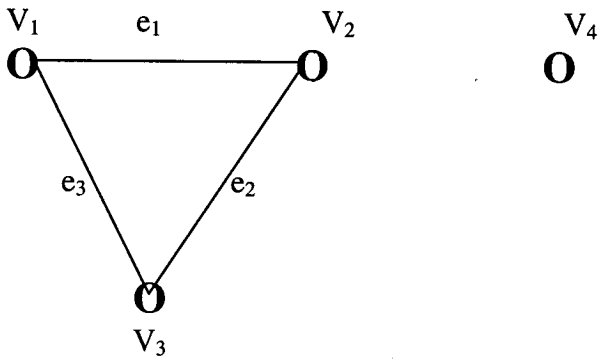
(b) The user view below is an example of Hierarchical Data Structure showing some student grades:



Draw a Network Data Structure for the above user view.

(c) Draw a Relational Data Structure for the user view given in (b) above.

Q6. (a) Consider the following graph G representing some Network:

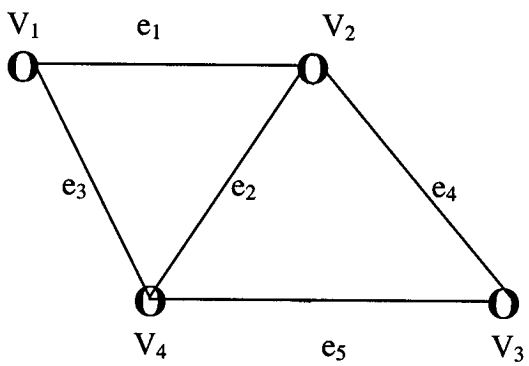


Determine

(i) the Node Connectivity $C_N(G)$ of G, and

(ii) the Edge Connectivity $C_E(G)$ of G.

(b) Determine the Cutsets C(i), $0 \leq i \leq 5$, for the graph G below:



(c) Calculate the Network Reliability R(p) for the graph G in (b) above, given that each link has a probability p = 0.1 of failing.

END(MDM)

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS - SEMESTER I, 2000/01

EM211 - ENGINEERING MATHEMATICS (I)

INSTRUCTIONS: There are six(6) questions in this paper. Candidates must attempt any five(5) questions of their choice.

TIME ALLOWED: Three (3) hours.

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1. a) (i) Show that

$$\frac{dF}{dx} = (2s\cos s^2)j + \frac{s}{\sqrt{s^2-1}}k$$

given that

$F(t) = i + \sin(t+1)j + \sqrt{t}k$
with $t = (s+1)(s-1)$

(ii) Find parametric equations for the line through the point (-2,0,4) parallel to the vector

$v = 2i + 4j - 2k$

b) Prove the absolute convergence of the following series:-

(i) $\sum_{n=1}^{\infty}(-1)^{n+1}\ 1/n^2$ (ii) $\sum_{n=1}^{\infty}\frac{\sin(n)}{n^2}$

2. a) By using the new equation

$A^*X^2 + B^*XY + C^*Y^2 + D^*X + E^*Y + F^* = 0$

when the axes are rotated; where the coefficient

$B^* = B\cos 2\alpha + (C-A)\sin 2\alpha$

i) Show that

$$\tan 2\alpha = \frac{B}{A - C}$$

ii) The coordinate axes are to be rotated through an angle α to eliminate the cross product term and give out a new equation for the curve

$x^2 + xy + y^2 - 6 = 0$

Find α and the new equation.

iii) Sketch the curve in its rotated form.

b) i) State Taylor's formula about the point of expansion $x = a$.

ii) Write down the first four terms of the Taylor series generated by $f(x) = \frac{1}{x}$ about $x = 2$.

3. a) Find an equation for the set of points p(x,y) that are equidistant from the origin 'O' and the line L: $x = 4$ and sketch the graph. Given that PQ is the horizontal line joining P(x,y) to Q(x,y) on L; prove that

$OP = PQ$.

b) Find the centre, vertices, foci and asymptotes of the hyperbola

$4x^2 - y^2 + 8x + 2y - 1 = 0$.

Sketch the graph, clearly showing all its features.

Write down <u>any</u> two applications of the hyperbola.

4. a) Show that

$v(t) = (\sin t)i + (\cos t)j + \sqrt{3}\ k$ has a constant length and is orthogonal to its derivative

b) Find some of the terms in the maclaurin series, for tanx by dividing the series for sinx by the series for cosx.

c) A projectile is fired from the origin with an initial velocity of 500m/sec at an angle of 60° relative to the x-axis. Find its velocity, speed and direction at 10 seconds later.

5. Define the following terms:-

i) An ellipse

ii) the eccentricity $e = \frac{c}{a} = \frac{\sqrt{a^2 - b^2}}{a}$

Discuss what happens if we keep 'a' fixed and vary the focal distance 'c' over the interval $0 \leq c \leq a$.

a) i) Given the foci at $F_1(-c,0)$ and $F_2(c,o)$ and the sum of the distances $PF_1 + PF_2 = 2a$ where 'a' is the semi-major axis and 'b' is the semi-minor axis, derive clearly the equation for an ellipse.

ii) Find the centre, vertices and foci of the ellipse

$$9x^2 + 4y^2 + 36x - 8y + 4 = 0$$

b) The vector $R(t) = (3\cos t)i + (3\sin t)j + t^2k$ gives the position of a moving body at time t. Find the body's speed and direction when $t = 2$. At what times, if any, are the body's velocity and acceleration peperdicular?

6. a) Show that

$$\frac{3}{4}+\frac{5}{9}+\frac{7}{16}+\frac{9}{25}+\ldots=\sum_{n=1}^{\infty}\frac{2n+1}{(n+1)^2}$$

diverges.

b) For what values of x does the series

$$x+\frac{x^3}{3}+\frac{x^5}{5}+\frac{x^7}{7}+\ldots+\frac{x^{2n-1}}{2n-1}+\ldots$$

converge?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS SUPPLEMENTARY/DEFFERED
SEMESTER ONE 2000/2001

EM311 – ENGINEERING MATHEMATICS III

INSTRUCTIONS: **Attempt any five(5) questions, showing necessary working. All questions carry equal marks.**

TIME ALLOWED: Three (3) hours.

1. (a) Sketch the graph of the function

$$f(t) = \begin{cases} t^2, & 0 < t < 2 \\ t-1, & 2 < t < 3 \\ 7, & t > 3 \end{cases}$$

(b) Find the inverse Laplace transform of

$$\frac{3s-5}{s(s-2)(s+3)}$$

(c) Solve the equation $\frac{d^2y}{dt^2} + y = F(t)$

Where $F(t) = n + 1$ for $\pi n < t < (n+1)\pi$, with $n = 0,1,2,\ldots$ and given that $\frac{dy}{dt} = 0 = y$, when $t = 0$.

2. (a) Show that the function $H(t-1) - H(t-3)$ is of exponential order.

(b) Solve the differential equation

$$x^2y'' + 10xy' + 8y = x^2$$

(c) Find the Fourier Series Expansion of the Periodic Function whose definition in one period is

$$f(x) = \begin{cases} 0, & -\pi < x < 0 \\ \sin x, & 0 < x < \pi \end{cases}$$

3. (a) Evaluate $\int_0^1 x^{3/2}(1-x)^2 dx$

(b) Classify the PDE

$$X^2 U_{xx} - U_{xy} = x^2 U$$

defined over $-\infty < x,y < \infty$ as elliptic, parabolic or hyperbolic.

(c) Given that the fourier transform is

$\hat{f}(w) = [H(w+1) - H(w-1)]|w|$, find its inverse fourier transform f(x).

4. (a) Determine the singular points of the differential equation

$x(3 - x)y'' + (x+1)y' - 2y = 0$, and determine if they are regular or irregular.

(b) Evaluate $\int_0^\infty \frac{x^c}{c^x} dx$ where c is a constant.

(c) Find a series solution in powers of x of $y'' - xy = 0$

5. (a) Given that $P_n(x) = \frac{1}{2^n n!} \frac{d^n}{dx^n}\left[(x^2-1)^n\right]$
express x^3 in terms of Legendre Polynomials.

(b) Show whether the PDE

$U_t + UU_x = \lambda U_{xx}$ is linear or nonlinear.

(c) Derive the fourier integral representation of the function

$$F(x) = \begin{cases} e^{-x}, x \geq 0 \\ 0 \quad x < 0 \end{cases}.$$ Evaluate the fourier integral of f at $x = 0$, and compare its value with $f(0)$.

6. (a) Sketch the graph of the function

$$f(x) = \begin{cases} x, & -2 < x \leq -1 \\ 0, & -1 < x < 0 \\ 5, & x = 0 \\ 10, & 0 < x \leq 1. \end{cases}$$

Hence find the left-hand and right-hand derivatives at $x = -1$.

(b) Solve the PDE $3\frac{\partial u}{\partial x} + 2\frac{\partial u}{\partial y} = 0$
When $u(x,0) = 4e^{-x}$.

(c) Find, the indicial roots of the differential equation $2x^2y'' - xy' + (1+x)y = 0$.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCE

UNIVERSITY DEFERRED/SUPPLEMENTARY SEMESTER I EXAMINATIONS
2000/2001
EM 411 ENGINEERING MATHEMATICS V

INSTRUCTIONS: (i) Attempt any **five** (5) questions only.
(ii) Indicate the question attempted on your main answer book.

TIME ALLOWED: Three (3) hour.

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1. (a) If x_1, x_2 are used to approximate X_1 and X_2, with absolute errors of magnitude e_1, e_2 respectively, prove that the maximum relative error in the expression $\frac{X_1^{\,m}}{X_2^{\,n}}$ (where m and n are exact) is approximately $\frac{me_1}{x_1} + \frac{ne_2}{x_2}$.

   (b) If correct to 2 decimal places, $x_1 = 4.00$ and $x_2 = 10.00$, find the approximate maximum relative and absolute errors in the evaluation of $\frac{X_1^{\,4}}{X_2^{\,3}}$.

2. (a) The equation $x^2 + ax + b = 0$ has two real roots α and β. Show that the iteration method

$$x_{k+1} = -(ax_k + b)/x_k$$

   is convergent near $x = \alpha$ if $|\alpha| > |\beta|$.

   Hence find, correct to 2 decimal places, the root near x = -6, of

$$x^2 + 7x + 5 = 0.$$

   (b) Use the Aitken's Δ^2 – process to find the root of the equation

$$2x = \cos x + 3,$$

   correct to three decimal places, taking the initial value to be 1.5.

3. (a) It was found using Kirchoff's laws that equations governing the current flows in one circuit are

$$I_1 + I_2 - I_3 = 0$$
$$2I_1 \quad + 5I_3 = 6$$
$$2I_1 - 4I_2 \quad = 4.$$

Use the Jacobi method to find the current flows in the circuit, giving your answer correct to 1 decimal place.

(b) Given that the matrix

$$A = \begin{bmatrix} 2 & 0 & 1 \\ -1 & 2 & 3 \\ 1 & 0 & 2 \end{bmatrix}.$$

(i) Find the eigenvalues of A.
Hence state the spectral norm (radius) $\rho(A)$ of A.

(ii) Determine the eigenvector $\underline{x}$ corresponding to $\rho(A)$ such that $\|\underline{x}\|_2 = 1$, ($\|.\|_2$ is the Euclidean norm).

4. (a) Using the data

$$y(0) = 1, \quad y(1) = 0, \quad y(2) = 1 \text{ and } y(3) = 10,$$

compute the finite difference table.
Hence or otherwise obtain the value y(4).

(b) Using Lagrange's interpolation formula, find the interpolation polynomial f(x) from the following table.

x	0	1	3	4
f(x)	-12	0	12	24

Hence, estimate the value of f(2).

5. (a) For the data in the given table, using the finite difference method, find f '(6.0), error = O(h) and f "(6.3), error = $O(h^2)$.

x	6.0	6.1	6.2	6.3	6.4
f(x)	0.1750	-0.1998	-0.2223	-0.2422	-0.2596

(b) The area A inside the closed curve $y^2 + x^2 = \cos x$ is given by

$$A = 4\int_0^{\alpha} (\cos x - x^2)^{\frac{1}{2}} dx$$

where α° is the positive root of the equation $\cos x = x^2$.

(i) compute α to three decimal places using the Newton - Raphson method.

(ii) Use the Simpson's rule to compute the area A with an absolute error less than 0.05.

6. (a) In and electrical circuit, the relationship between the current I and the time t is described by the differential equation

$$L\frac{dI}{dt} + RI = E, \text{ such that } I = 0 \text{ at } t = 0,$$

where E is a constant voltage source, R is the resistance and L is the inductance. Taking L = 10 henries, E = 6 volts, R = 3 ohms, and $\Delta t = 1$ second, find, using Euler's method , the current after 5 seconds.

(b) Given

$$(1 + x^2)\frac{dy}{dx} - xy = 0, \quad y(0) = 2,$$

using Runge-Kutta Fourth order formula with step size 0.5, find y(2).

7. (a) Write down the finite - difference analogue of the parabolic equation

$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2}.$$

Hence,

(b) given that u = 1 when t = 0 and u = 0 at x = 0 and x = 1, compute the solution of the above equation at x = 0.1 and t = 0.01, using Gauss - Seidel's method.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATION – JANUARY 2001

GEO 111
INTRODUCTION TO HUMAN GEOGRAPHY I

TIME: Three hours
ANSWER: Question 1 (40%) and any other three questions
NOTE: Credit will be given for use of relevant illustrations.
Use of electronic calculators and an approved atlas is allowed

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1. Figure 1 illustrates the Kafubu river Basin Settlements with names and dots representing village locations for two areas marked as A,B,C,D and A,B,E,F.

   a) Calculate the nearest neighbour measure (RN) for each area.

   b) Explain the distribution pattern of each area.

2. Explain the current trends in the development of human geography.

3. 'Zambia's rapid urbanization is problematic'. Discuss.

4. Give a critical account of Central Place Theory.

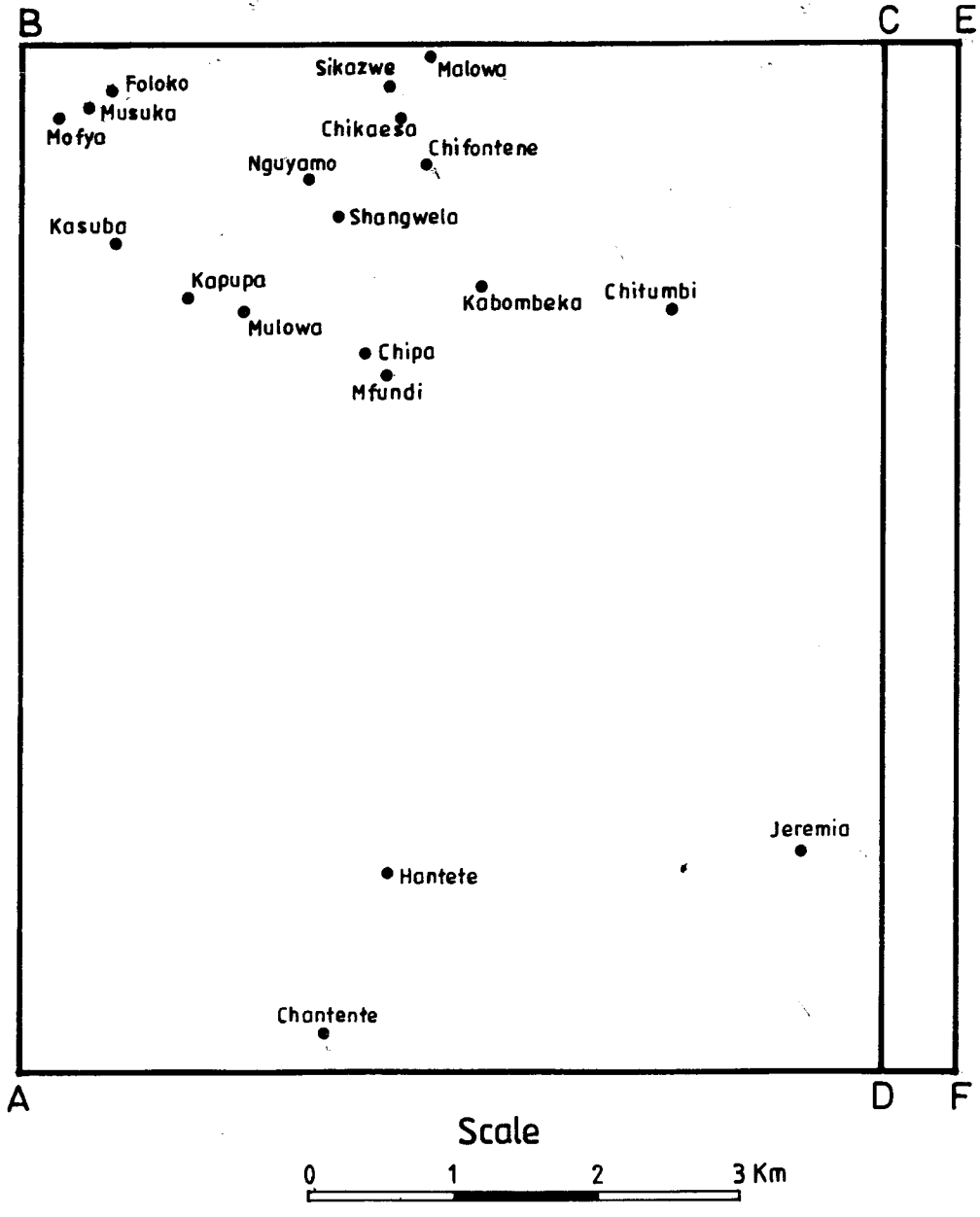
5. Write an account of the distribution of rural settlements in Zambia.

6. Write short explanatory notes on each of the following:

   a) Hagerstrand's contribution to Innovation Diffusion
   b) Von Thünen's Model
   c) Weber's Industrial location Model
   d) Jacob's Model of Cultural Development
   e) Rank Size Rule

END OF EXAMINATION

Fig. 1 Kafubu River Basin Settlements



THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER DEFERRED/SUPPLEMENTARY EXAMINATIONS – MARCH 2001

GEO175
INTRODUCTION TO MAPPING TECHNIQUES IN GEOGRAPHY
PAPER 11

TIME: THREE HOURS

ANSWER: Any four questions

NOTE: The use of an approved atlas and calculators is allowed

Candidates are encouraged to use illustrations wherever appropriate.

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1. A sample comprises 86 observations, each recorded to the nearest tenth of a unit ranging in value from 5.1 to 15.4. It is decided to use ten classes of width 1.1 units and to begin the first one at 4.85. Find the class boundaries, limits and marks of the ten classes.

2. Examine the data given in Table 1 below and then answer all the questions that follow:

Table 1: Zambia's population by Province in 1990

Province	Area ('000km^2)	Population ('000)		
		Female	Male	Total
Central	94	370	360	730
Copperbelt	31	780	800	1,580
Eastern	69	500	470	970
Luapula	51	270	260	530
Lusaka	22	600	610	1,210
Northern	148	450	420	870
North-western	126	200	180	380
Southern	85	480	470	950
Western	126	330	280	610
Zambia	752	3,980	3,850	7,830

Source: 1990 Census

a) Identify and name the most appropriate statistical mapping technique that you would use to show the data in table 1 above.

b) On the outline map of Zambia provided, use the technique you have identified in part (a) to show the data in Table 1 diagrammatically.

c) Discuss the merits and limitations of the technique that you have used.

3. Study the Island map provided (Fig 1) very carefully. Spot heights are marked and rivers and streams are also marked to help you. You should also remember that rivers and streams are found in the lowest parts of the valleys and that they do not flow uphill.

a) What statistical mapping technique would you use to show the changes in altitude on the Island map provided?

b) Explain how you would construct a map using the technique you have identified in part (a) of this question.

c) Interpolate contours on the Island map provided at a 200 metre interval.

d) What are the advantages and disadvantages of the technique that you have used.

4. Table 2 below shows the number of road traffic casualties from 1990 to 1996. Present the data diagrammatically using the most appropriate method.

Table 2: Road traffic casualties from 1990 – 1996

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Fatalities	954	864	899	830	912	893	928
Serious injuries	1785	1566	2096	2191	244	2882	2473
Slight injuries	3424	2934	3511	3183	3633	3637	3191

Source: Zambian Transport & communication Vol. 1. No.3 p 52.

5. Table 3 below shows the direction of wind recorded at the UNZA weather station over a period of one year.

Table 3: Wind Direction Frequency

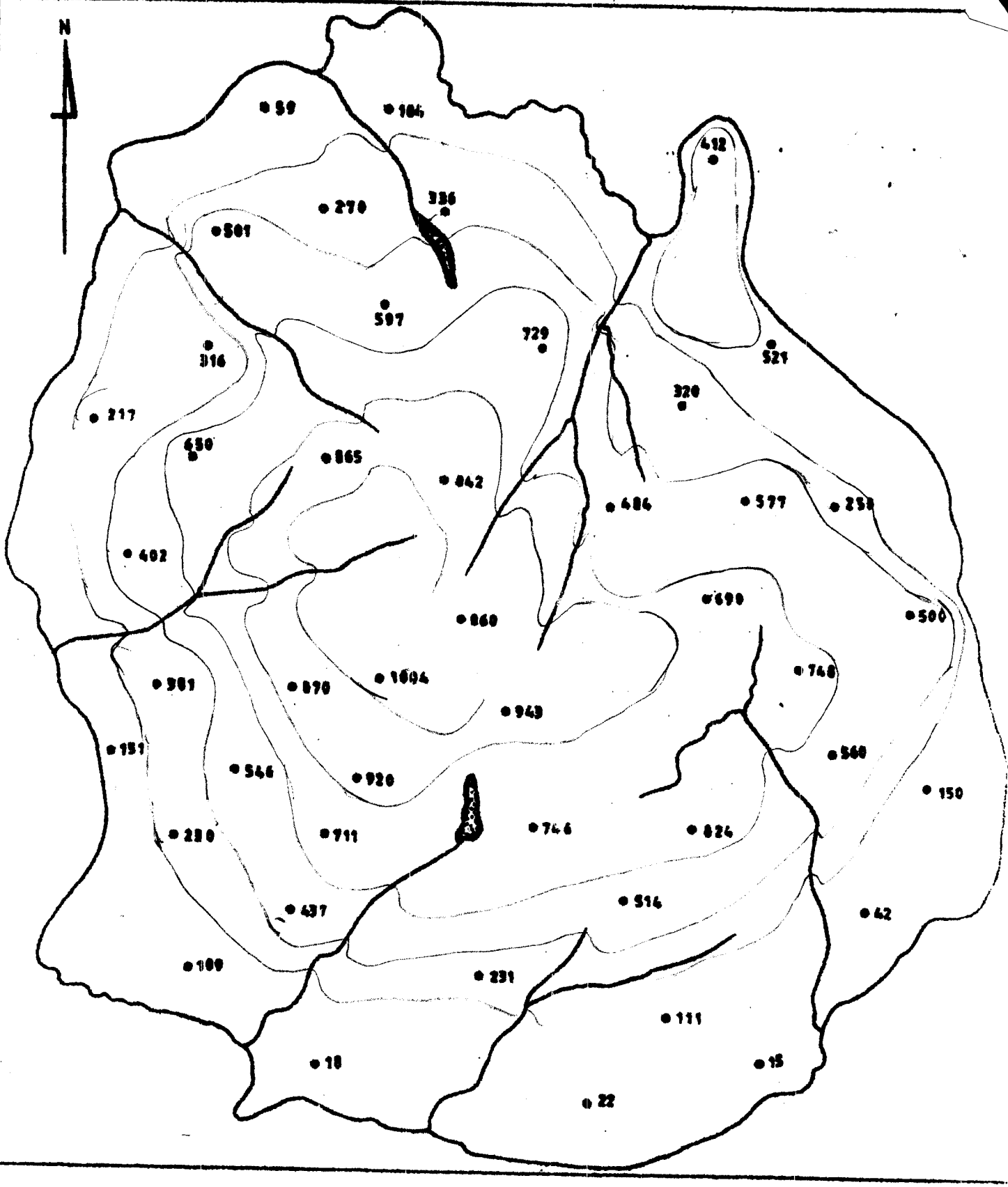
Direction	**N**	**NE**	**SE**	**S**	**SW**	**W**	**NW**	**CALM**
No. of days	36	41	30	31	58	59	57	29

Source: Imaginary data

Use the most appropriate technique to show these data diagrammatically.

6.a) With the help of a diagram, describe any diagrammatic technique, which shows how the whole is divided into component parts.

b) Discuss the merits and limitations of the technique you have selected.



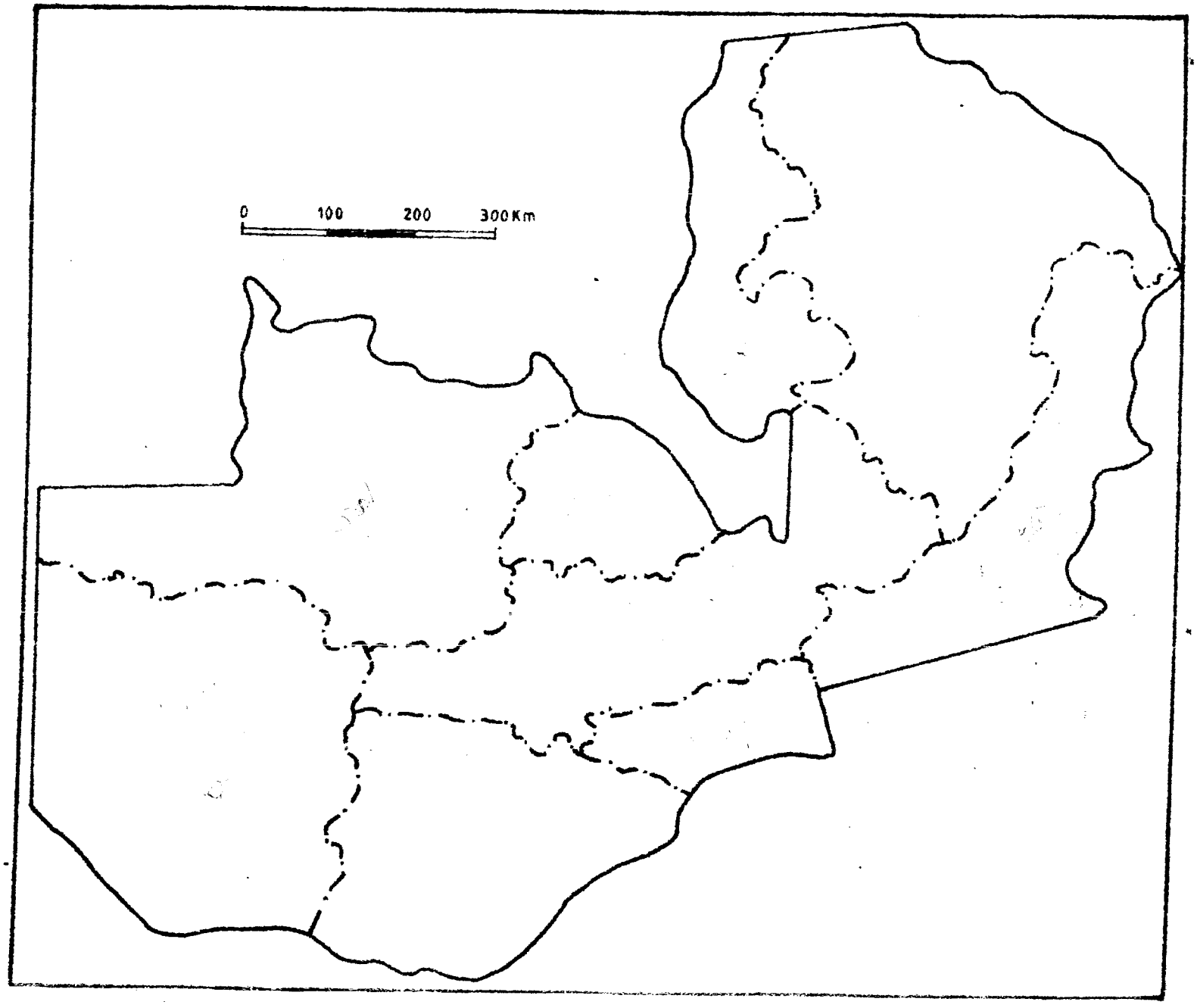
Scale 1:200,000

● 55..... Spot height (in metres)

..... River

..... Lake

Fig. 1.


0 100 200 300 Km

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER DEFERRED/SUPPLEMENTARY EXAMINATIONS – MARCH 2001

GEO211

THE GEOGRAPHY OF AFRICA

TIME: THREE HOURS

ANSWER: Any four questions

NOTE: Candidates are advised to make use of illustrations and examples wherever appropriate. Use of an approved atlas is allowed.

---

1. In what ways can Rivers, Vegetation and soils in Africa contribute to socio-economic development?

2. How can the divisions caused by liguistic and religious diversity be overcome in Africa?

3. Explain the causes of regional inequality in the space-economy of Ghana, and suggest ways of overcoming it.

4. What is the role of Tourism in the socio-economic development of Kenya?

5. Outline the causes of environmental degradation in the Sahel region and suggest solutions to the problem.

6. Why has the contribution to the Neolithic Revolution in Africa been neglected by modern scholars?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY DISTANCE EDUCATION EXAMINATION – JULY 2000

GEO 212
THE GEOGRAPHY OF ZAMBIA

TIME: Three hours
ANSWER: Any four questions
NOTE: All questions carry equal marks
Candidates are encouraged to use illustrations wherever appropriate

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Q1 'The Copperbelt and Lusaka provinces which constitute only 7.1% of the Zambia's total area accommodate more than one third of the total population in the country'. Discuss.

Q2. Outline and explain the major factors that affect the drainage and hydrology of Zambia.

Q3. Describe and explain the distribution pattern of rainfall in Zambia.

Q4. In what ways and to what extent has drought affected small-scale farmers in Zambia in the 1990s?

Q5. Discuss the major constraints to tourism development in Zambia and suggest possible solutions.

Q6. Write short explanatory notes on all of the following:

a) Barotse sands
b) Karoo rock system
c) Itigi forest
d) Primary and secondary infertility
e) Disadvantages of Zambia's landlockedness

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER DEFERRED/SUPPLEMENTARY EXAMINATIONS – FEBRUARY/MARCH 2001

GEO271

QUANTITATIVE TECHNIQUES IN GEOGRAPHY I

TIME: THREE HOURS

ANSWER: Question 1 and three others.

NOTE: Tables of random numbers are provided. Use of a calculator is allowed.

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1. Suppose you, as a researcher, wanted to conduct research to investigate the relationship between overcrowding (house density) and human health in Lusaka. You obtain the list of residential areas in Table 1, from which you decide to select 30 residential areas to use in the study. Proceed with the following tasks:

   i. State your research hypothesis.
   ii. Select the 30 residential areas using each of the following techniques:

      a) Simple random sampling.
      b) Quota sampling.
      c) Stratified random sampling.
      d) Accidental (availability) sampling.

   iii. Which of the samples in 1(ii) would be best and why?
   iv. Having selected the 30 residential areas, what would you do with them?
   v. For the activity you stated in 1(iv), why would sampling be advantageous compared to using all the residential areas?

2. 'A research proposal is an outline of planned research'. Elucidate this statement using the example of research on whether Weber's Theory on Industrial Location is applicable in Zambia.

3. Design a questionnaire that would help you establish the preferred mode(s) of transport used by Lusaka residents, the reasons for the popularity of the method(s), as well as the variety of modes of transport that are available in Lusaka.

4. Using geographical examples explain descriptive, correlational and explanatory research.

5. Suppose you were conducting research to establish whether or not banning fishing in the fish breeding season (November to March) is effective at maintaining fish abundance.

   i. State what the 'treatment' is in this research, as well as the dependent variable.

   ii. Explain how you would conduct the research using each of the following designs:

      a) Pre-test/post-test control group design.
      b) Intact group comparison design.
      c) Contrasted group design.

   iii. Comment on the reliability of conclusions from each of the designs in 5(ii).

6. Write short explanatory notes on all of the following:

   i. Cross-sectional *versus* longitudinal time dimensions in research.
   ii. The sampling process.
   iii. Possible sources of ideas for developing a research problem.
   iv. Secondary *versus* primary sources of data.
   v. Non-scheduled, structured interview.

END OF EXAMINATION

Table 1 Residential Areas in Lusaka

High Density Areas	Medium Density Areas	Low Density Areas
Mandevu	Chilenje	Avondale
Chipata	Kabwata	Fairview
Chaisa	Kamwala	Northmead
Chunga	Matero	Chainama
Ng'ombe	Libala	Chudleigh
Kamanga	Helen Kaunda	Jesmondine
Kaunda Square	Lilanda	Munali
Chainda		Handsworth Park
Mtendere		Kalundu
George		Roma
Kalikiliki		Rhodes Park
Bauleni		Long Acres
Chawama		Woodlands
Misisi		Kabulonga
Kanyama		Madras
Garden		Nyumba Yanga
John Laing		Emmasdale
Marapodi		Villa Wanga
Kalingalinga		Villa Elizabetha
Chinika		Thornpark
Kabanana		Olympia Park

Table A–1
Random Numbers

08210	32973	08003	54512	64863	78634	36344	73293	77660	90199
56822	81546	04735	15228	37475	79057	48749	89898	95554	39734
89182	97110	37211	11688	69132	97318	83419	82573	72506	55631
72674	35938	58483	08612	23129	95675	47142	74290	97894	17531
90431	35286	24567	05594	75288	52097	07687	25548	36274	59709
26899	07988	28526	97601	03588	46466	55143	65558	25847	59878
18345	22317	08035	94062	39380	80045	80231	29109	50908	15304
59231	50655	21753	70621	91045	11318	73098	42457	45905	58889
25446	92080	34212	70395	64493	86192	96633	11311	62422	32794
64825	37691	90465	51579	83918	22217	55262	47065	36168	65350
56902	23614	90057	12880	89522	81453	41294	14603	39279	54730
94781	64586	97431	01310	04978	25833	61253	48959	53841	12864
55140	32776	03346	61125	91434	84200	73664	45914	90551	83073
71284	19521	04812	76028	20044	78244	58015	05867	53847	04736
12938	37575	74532	60769	26928	29666	84318	21283	17537	31834
74888	92697	43016	56171	27506	72769	60939	50508	37332	77234
92592	82165	90227	88560	86908	32283	83958	92590	97910	40983
13741	37073	04809	23138	34852	45986	73823	08534	45867	18800
84984	54147	59332	70137	24535	17957	21012	51279	67206	63087
60528	16871	20195	14420	27684	35554	90414	80832	86089	61328
74340	27455	43144	85543	85639	91044	58951	85251	69761	57118
22071	81837	14952	50079	08851	56337	76769	83059	23254	73901
46002	37283	12700	60802	93248	12585	88835	97516	69585	78330
08389	69818	88126	63220	09217	89809	41827	63143	94194	69001
80520	76260	83873	30245	69153	36222	71188	50184	69731	00382
86956	16358	66811	24846	57071	40649	92444	63235	89322	99933
53138	21244	18794	69981	67197	20656	01157	43212	71717	36254
36225	08162	77121	36757	48280	01627	42182	90286	33607	39507
94504	39905	37479	59621	90903	25258	02601	40884	18925	19143
62903	81216	82151	05623	29557	17355	75959	26697	92117	50471
49684	94165	26723	59644	97156	95754	14613	62639	19567	24652
74368	66450	66013	32765	29673	05637	18535	59269	40732	90216
65947	65189	25064	99907	41696	83361	05711	44600	31021	34714
48562	64985	78945	43273	93601	41398	47898	87513	71023	77141
56879	44941	45205	84341	92222	50193	34172	63957	65014	93068
56352	13144	30800	60403	84654	28738	48297	30614	71784	23440
02272	93016	25229	43692	36151	96505	73151	82126	30327	15817
33209	67546	92428	91522	75736	59065	00668	43097	75282	81904
04042	27494	05204	86656	04755	03880	91082	33651	63806	19334
06255	03873	64275	81962	00650	39269	73457	07644	21562	67255
02637	88632	65996	41115	33863	95116	66522	55347	30163	50594
66788	56790	14606	63123	05831	14117	04288	63610	48924	01827
75185	54242	23276	86228	68663	31051	10832	72330	70330	01769
97678	41209	34692	03790	01489	45480	18809	16099	52339	41146
98264	76970	35868	18540	25973	28110	52129	77706	18505	89583
85483	81260	62113	64994	60821	40518	94273	64432	48779	05310
11364	56369	72114	94681	74135	49670	21072	78489	39630	89270
52663	97730	76199	52766	34479	03055	92954	43490	39790	46437
86276	71122	87556	29504	32565	48447	08719	83014	23615	14317
92295	34604	61004	19707	97387	90740	48369	57337	76910	82215

Reproduced from "A Million Random Digits with 100,000 Normal Deviates," by the RAND

Table A–1 (continued)

91225	47297	05208	09509	83287	98993	04792	82551	59606	88054
48832	04241	71986	08556	40419	69537	86871	54707	41149	16991
83516	35332	54964	28304	46934	61746	09772	20208	36456	51403
55814	15346	17425	41510	13329	09591	71725	31094	34654	45090
85716	12864	61976	24101	23601	62813	47996	57362	30232	35867
77799	89902	53499	34027	44773	91246	93487	85827	35988	31423
89346	94359	64580	88245	21215	78937	18180	62989	17247	96211
22821	26700	43247	48748	35591	77935	97016	92278	91298	23566
19651	46588	74048	25245	88242	89392	74849	23163	74727	89559
21738	10422	44197	57245	23564	05076	18267	27692	18681	49264
14439	16349	58690	24767	66401	63240	44038	15142	81338	70308
25482	05354	72238	80246	75754	88446	87496	92774	28165	06299
14606	94425	14315	64213	96364	29901	94156	13008	34784	34997
47291	66501	04111	98604	76249	16047	95252	69177	23764	57974
00097	39513	26145	50286	37804	95165	97489	83770	80511	71298
44474	18685	83439	63916	76277	87092	43999	65474	45455	17684
80188	55310	74084	41674	80282	46222	74965	69025	10428	30224
99909	70398	88267	96784	22232	74548	18681	71053	49820	54954
58968	12199	67836	95022	67725	67527	86541	97150	74569	90047
19893	22171	37003	03270	40464	39309	71950	31827	28303	62957
31180	66582	07814	48192	79581	82781	59678	20881	03922	96690
55358	46206	28790	27657	47210	39684	69566	95109	17541	67975
45265	25613	50103	93017	49489	63137	42899	46824	55305	68436
78752	50062	52099	49755	47455	85377	13404	12583	42142	94438
77026	65887	30936	69948	52651	44038	14192	65084	94240	30663
39276	97558	34925	86347	06528	94788	98409	12127	61672	09999
47532	77074	39717	09655	69029	12061	62872	18773	11799	42629
99298	62008	14744	81394	50813	60959	17941	99294	68438	54384
23713	29543	20617	02525	49301	62333	84918	38377	45095	89424
70125	93654	46311	61173	48844	38937	03812	05838	34285	08267
74948	69730	38268	45877	74220	17727	68357	92038	16486	72612
01975	51053	74679	33939	04308	29308	00031	52498	46210	21401
19636	08802	65859	83454	29762	95675	80618	46154	81250	49413
37063	11564	68775	32383	78364	35447	70729	31821	41957	96850
06570	48472	76950	25543	37661	13124	05752	28250	06892	32216
67187	70029	32276	51020	16715	26725	00374	24518	85007	95592
74318	16668	14616	51147	63823	28920	63506	67422	21521	62018
84658	32328	48257	69420	57437	18892	88152	43925	07585	13485
43578	54413	29390	82628	06420	48451	80697	68097	22577	12231
65336	91369	07765	92143	34215	96303	03353	71515	55424	68205
12297	99455	36506	53575	42859	03056	54436	72004	90550	24695
07592	19189	36976	54389	52519	88593	12640	63742	52863	57294
72348	55701	98604	75531	73266	45496	74386	51293	20682	99981
70909	48599	36829	27150	21839	05236	20499	47538	84775	44543
16013	75265	65054	51584	65837	44116	49457	46055	92802	10073
39954	51272	93372	19705	20047	81087	62993	40227	95610	75971
61131	59612	43759	27369	68613	88117	88168	62985	01794	51874
01608	31737	72572	47112	73336	86842	54882	81541	97497	42052
59312	10832	96622	32093	71354	71923	25833	55831	35692	71534
90697	91454	99243	74995	80926	93834	49471	55910	09853	12529

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATION – JANUARY 2001

GEO 381
ENVIRONMENT AND DEVELOPMENT

TIME: Three hours
ANSWER: Any four questions
NOTE: All questions carry equal marks
Illustrations and examples should be used wherever appropriate

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Q1. Write short explanatory notes on all of the following:

a) Global Environmental Facility (GEF)
b) Land evaluation
c) Conservation of biodiversity
d) Concept of sustainable development
e) Traditional comparative theory

Q2. Outline and explain the principles underlying the logical framework approach to planning and management of a sustainable environmental programme.

Q3. 'Economic development and sound environmental management are complementary aspects of the development process of a country'. Discuss.

Q4. "The gap in the availability, quality, coherence, standardization and accessibility of data between the developed and developing world has been increasing, seriously impairing the capacities of countries to make informed decisions concerning environment and development" (UNCED, 1992). Discuss.

Q5. Explain how 'Land titling is likely to improve productivity of the land and conservation of resources in Africa'.

Q6. To what extent do Ecological processes, by their nature, place some fundamental limits on human activities?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - JANUARY 2001

GEO451

LAND RESOURCES SURVEY

TIME: THREE HOURS
ANSWER: Question 1 and three others.

1. Imagine the piece of land sketched in Figure 1 has been donated to the Wildlife and Environmental Conservation Society of Zambia (WECSZ) by a farmer. The land is approximately 900m long at its widest. Before WECSZ puts it to a use of their choice, it is required that a chain survey of the land be carried out so that a plan of the land at 1:2000 can be produced. Suppose WECSZ hires you to carry out the survey, since no map or aerial photograph of this land at this scale exists. Proceed with the tasks below.

   i. What equipment will you need?

   ii. Show on Figure 1 the framework of chain lines you will use for the survey. Remember to detach Figure 1 and attach it to your answer booklet.

   iii. Explain how you would go about with the survey, including both field and office work procedures.

2. a) Outline the main features of the process of land evaluation.
   b) State and explain the principles of land evaluation.
   c) How does land evaluation differ from land use planning?

3. Outline the main components of a land use system and, using examples, explain the following:

   i. Single, multiple purpose and compound land utilization types.
   ii. Key attributes for describing land utilization types.

4. What are land qualities and how do they relate to land characteristics? Explain your answer using the following land qualities:

   i. Soil moisture availability
   ii. Drainage
   iii. Length of the growing season
   iv. Accessibility
   v. Risk of flooding

5. Describe the main features of the FAO land suitability classification system and those of the Land Use System (LUS) used for land capability classification at the Zambian Soil Survey. How does the Zambian system compare with the FAO system?

6. Write short explanatory notes on ALL of the following:

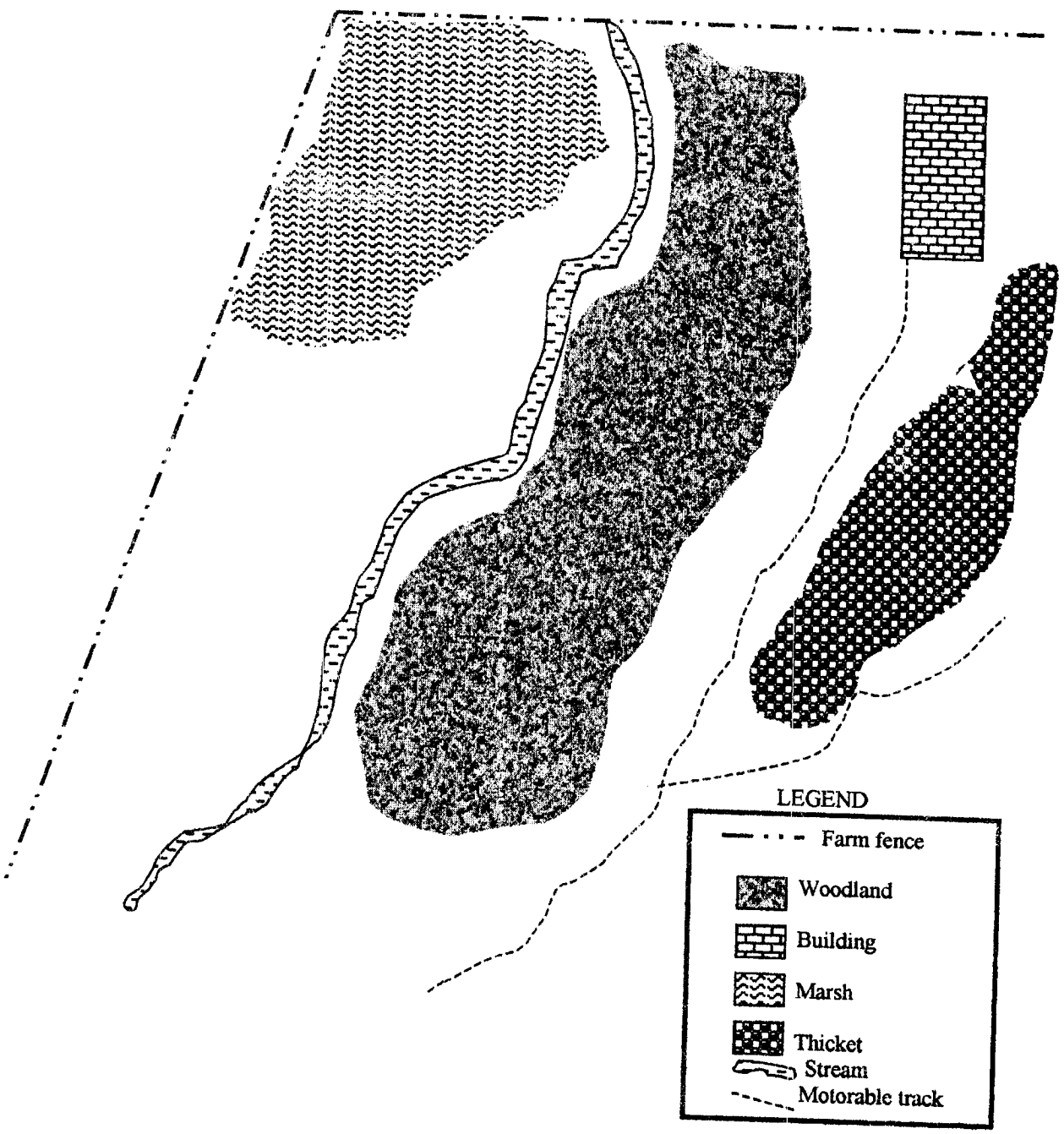
   i. The purpose of the FAO Soils Bulletins.
   ii. Major *versus* minor land improvements.
   iii. Human resource considerations in land evaluation.
   iv. Guidelines on delineation of land mapping units.
   v. Permanently unsuitable land *versus* currently unsuitable land.

END OF EXAMINATION

GEO451 Examination - January 2001

Computer Number: _____ **Examination Centre**_____

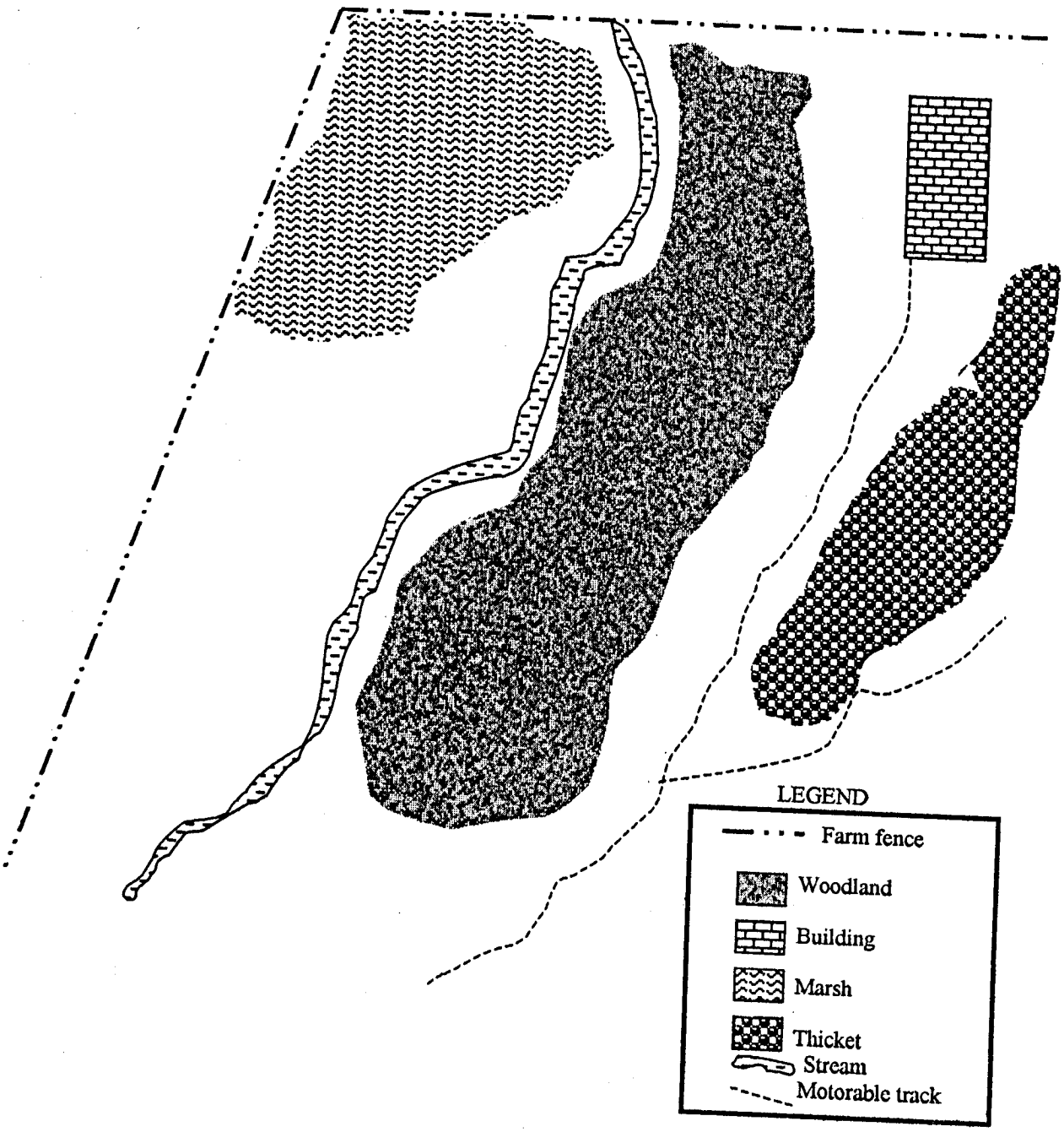
Figure 1 - Sketch of Land to be Surveyed (not to scale)



GEO451 Examination - January 2001

Computer Number: _____ **Examination Centre**_____

Figure 1 - Sketch of Land to be Surveyed (not to scale)



THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - JAN. 2001

GEO 481

ENVIRONMENT AND DEVELOPMENT II

Time: Three Hours
Answer: Any four questions
Note: All questions carry equal marks
The use of calculators and approved atlas atlas is allowed

1. The table below shows some of the important reports and activities in environmental matters.

Year	Report/Activity
1980	World Conservation Strategy, IUCN
1984	World Bank Annual Report
1985	World Bank Annual Report
1985	National Conservation Strategy of Zambia
1987	World Commission on Environment and Development Report (*Our Common Future*, Brundtland Commission)
1991	Third Republic in Zambia
1992	United Conference on Environment and Development, Rio de Janeiro
1992	The establishment of Environmental Council of Zambia
1994	The National Environmental Action Plan, MENR/GRZ

Using this table as indicators to the importance of mainstreaming environment into development, discuss the factors that have led to realization of mainstreaming environmental issues in development. Highlight some developments in Zambia on how the environment is being incorporated into political and economic development.

2. Discuss the problems and causes of urban transport on the environment and suggest solutions to minimise these problems.

3. Discuss the problems of water resource management in Zambia. What is being done to solve these problems?

4. (a) Give a appropriate definition of sustainable agriculture and explain the important aspects of this definition.

(b) Discuss the measures that can be taken to promote sustainable agriculture.

5. Petroleum prices worldwide have risen sharply over the past eight months. In Zambia prices of gasoline, diesel and kerosene have risen by almost 60% in the same period. Imagine that you have been hired to advise the government of Zambia on the strategies that can be taken to cushion the impact of petroleum price increases. Write a report to the government highlighting the strategies that can be taken bearing in mind the alternative energy sources which Zambia is endowed with.

6. 'Complexities of many forest revenue systems in Africa and other developing countries make them unmanageable, generate inefficiencies and open up opportunities for abuse' Discuss these complexities and how they can be abused.

End of Examination

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATION – JANUARY 2001

GEO 911
POPULATION GEOGRAPHY

TIME: Three hours
ANSWER: Question 1 and any other three questions
NOTE: Use of calculator and an approved atlas is allowed

Q1. Write short explanatory notes on all of the following:

a) Implicit as opposed to explicit population policies.

b) The exponential method for projecting population.

c) The rhythm method of regulating births.

d) Caldwell (1982) on family sizes.

e) Crude Death Rates (CDRs) and Infant Mortality Rates (IMRs) as measures of a nation's welfare.

Q2. Examine China's antinatalist policy while paying particular attention to its objectives, successes and failures.

Q3. Discuss what determines mortality levels when a country is in the first stage of Demographic Transition as compared to when it is in the second stage.

Q4. Review any migration theory of your choice and discuss how it has been applicable to the Zambian situation during the colonial and post colonial periods.

Q5. Argue for or against high population growth rates and high population densities vis-a-vis the physical environment.

Q6. Assess the necessary preparations the Zambian government was expected to make before executing the 2000 census of population, housing and agriculture.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATION – JANUARY 2001

GEO 931
RURAL GEOGRAPHY

TIME: Three hours
ANSWER: Any four questions
NOTE: Candidates are advised to make use of illustrations and examples wherever appropriate. Use of an approved atlas is allowed

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1. Outline the steps followed in undertaking research based on the Participatory Rural Appraisal (PRA) methodology, and comment on the popularity of this approach in rural research.

2. Comment on the view that the African cash cropping peasantries are still in the making and have not yet been 'captured'.

3. Show how the perception of 'common property resources' has undergone change in rural Africa since the introduction of a cash economy.

4. How can women be best integrated in rural development programmes in Africa?

5. To what extent will the policy measures and strategies for rural water supply and sanitation benefit rural dwellers in Zambia?

6. What factors account for the current rural settlement types and their distribution in Zambia?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATION – JANUARY 2001

GEO 955
GEOMORPHOLOGY

TIME: Three hours
ANSWER: Any four questions
NOTE: Use of an approved atlas is allowed
Candidates are encouraged to use illustrations wherever appropriate

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Q1. Write short explanatory notes on all of the following:

a) The different facets of a slope
b) Theory of Isostasy
c) The hypsographic curve
d) The effects of earthquakes on topography
e) The geographical significance of faulting

Q2. "The eruption of volcanoes and lava flows are environmental hazards of the severest sort" (Strahler and Strahler, 1997:317). Discuss

Q3. Describe the three main stages in the life-cycle of a stream and discuss the factors that may upset this 'normal' pattern of development.

Q4. Define anthropogeomorphology and discuss the major processes associated with it.

Q5. Distinguish between initial and sequential landforms and explain how they represent the balance of power between internal and external earth forces of denudation agents.

Q6. Distinguish the part played by a) gravity and b) water in the development of slopes.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - JANUARY 2001

GEO 961

SOILS GEOGRAPHY

Time: Three Hours
Answer: Any four questions
Note: All questions carry equal marks
The use of calculators and an approved atlas is allowed

1. Write short notes on all of the following

   (a) Differences between montimorillonite and kaolinite clays
   (b) The Revised Universal Soil Loss Equation
   (c) Development of salinity in soil
   (d) Endopedons formed from accumulation of solubilised substances
   (e) Mycorrhizal fungi

2. Describe the characteristics that are unique with Vertisols and comment on special management problems which exist with this soil type.

3. Discuss the importance of organic matter and autotrophic bacteria in the development of low input agricultural systems.

4. Discuss the damages of soil erosion from the point of view of quality of soil lost and rates of loss versus the rate of soil formation.

5. Explain how inorganic fertilizers, pesticides, manure, and land fills can be pollutants to soil and suggest possible solutions to the problem?

6. Describe the activities and information that is analyzed in the office before undertaking field a soil survey.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATION – JANUARY 2001

GEO 971:
AERIAL PHOTOGRAPS AND INTERPRETATION PART II

TIME: Three hours
ANSWER: All questions
NOTE: Use of a calculator is allowed

Q1. Explain the procedure of establishing an 'effective area'.

Q2. In what respect is photo reading different from photo interpretation?

Q3(a) Explain the following:

i) The nature of flying errors that may occur during aerial photo acquisition.
ii) Ways in which flying errors would affect aerial photo interpretation
iii) How the flying errors would be corrected.

(b) A set of 1:25 000 aerial photographs is required of an area (400km x 400km) which is at an average altitude of 2150m above sea level. A 150 mm lens is used. Assume that the photo format is 23 x 23cm, forward and lateral overlaps are 60% and 20% respectively.

i) What should be the average flying height of the aircraft above the average terrain?
ii) What is the total number of photographs for the area?

Q4(a) Aerial photographs of a plantation consisting of two classes of trees at different growth stages are undertaken at a scale of 1:20 000 using a narrow angle (300mm) camera.

The height difference between the two classes is found to be about 1.5m. Explain whether you would be able to make a distinction between these classes when the photographs are examined under a stereoscope.

(b) A set of 1:25 000 vertical aerial photographs were acquired for a forest plantation at sea level. A superwide angle lens of 83mm was used. What would be the relief displacement for a 30m Eucalyptus tree if it is 150mm away from the photo centre?

(c) Two overlapping vertical aerial photographs covering an industrial area have been aligned in the flight direction and fastened after obtaining a stereo model. Using a parallax bar, the parallax of the base of the tallest chimney is found to be 70.2mm and that of the top is 69.5mm. The photo base is found to be 90.2mm. Calculate the height of the chimney if the scale of the 230mm x 230mm photographs taken with a 152mm focal length camera is 1:5 000 and the forward overlap is 60%.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS - SEMESTER I -2000/01

M111- MATHEMATICAL METHODS I

INSTRUCTIONS: (i) Attempt any **five(5)** questions only.
(ii) Show all necessary working for full marks.
(iii) Write down your **computer number** on all answer booklets used.
(iv) Indicate the number of each question attempted on your main answer booklet.

TIME ALLOWED: Three (3) hours

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1. (a) For any two set A and B, simplify

$$[A' \cap (A' \cap B)']'$$

(b) Given A={0,5} , B=[-2,2] and C=(-3,2) find

(i) $A \cap B$
(ii) $A' \cap B$.
(iii) $B \cup C$

(c) (i) Express $\dfrac{2i}{(1-i)^2}$

in the form a + ib where a and b are rational numbers.

(ii) Express $2.\overline{13}$ in the form p/q where p and q are integers and $q \neq 0$.

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2. (a) Let $f(x) = 3x^2 - (p-4)x - (2p+1)$

(i) If α and β are roots of f(x) = 0, find the equation whose roots are $\alpha+2$ and $\beta+2$.
(ii) Find the value(s) of p for which f(x) = 0 has equal roots.

(b) Complete the square of the quadratic function $f(x) = -2x^2 + x + 5$.
Hence
(i) find the turning point, the x- and y-intercepts.
Sketch the graph of y = f(x).

(ii) On the same diagram sketch the graph of y = |f(x)|.

---

3. (a) Prove the following trigonometric identities

(i) $\operatorname{cosec}\theta + \tan\theta \sec\theta = \operatorname{cosec}\theta \sec^2\theta$

(ii) $\dfrac{1}{\operatorname{cosec}\theta + \cot\theta} = \dfrac{1-\cos\theta}{\sin\theta}$

(b) Find the general solution of

$$2\sin^2\theta + \cos\theta - 1 = 0.$$

(c) Given that

$$f(x) = \sin(2x + \pi) \text{ where } 0 \le x \le 2\pi.$$

State the
(i) amplitude
(ii) period and
(iii) phase shift of y = f(x).
Hence, sketch the graph of y = f(x).

---

4. (a) (i) Given that

$$f(x) = \frac{ax + b}{x + c}$$

where a, b, c are real and $x \neq \pm c$ show that if f is **even** then $ac = b$.

(iii) Given that $g(x) = \sqrt{x}$, simplify

$$\frac{g(x+k) - g(x)}{k}$$

in such a way that there are no radicals in the numerator.

(b) For the real valued function h defined by

$$h(x) = \frac{2x}{5 - x}$$

(i) Find the range of h.
(ii) Determine whether the function is one-one.
(iii) Find (hoh)(x)

(c) Given that

$$f(x) = x^3 + kx^2 - 2x + 1$$

gives a remainder k when divided by x - k, find all possible values of k.

---

5. (a) Solve for x in each of the following:

(i) $\log_{16} x + \log_{16}(10x+3) = \frac{1}{2}$

(ii) $x^{\log_x x} = \frac{x^3}{100}$.

(b) (i) Find the **integer** value of the product yz given that

$$y = \log_a(x^3)$$
$$z = \log_x a$$

(ii) simplify $3^{\log_9 x}$

(c) On the same axes, sketch the three graphs:

$f(x) = e^x$; $g(x) = e^{-x}$; $h(x) = \frac{1}{2}(e^{-x} + e^x)$.

Hence or otherwise

(i) state the range of h

(ii) find the value of x for which h(x) = 1.

---

6. (a) Compute the limits

(i) $\lim_{x\to 9} \frac{x-9}{\sqrt{x}-3}$ (ii) $\lim_{x\to\infty} \frac{x}{2x+3}$

(b) Using **first principles**, find $\frac{dy}{dx}$ given $y = \frac{1}{\sqrt{x}}$.

(c) Find the derivative dy/dx of each of the following

(i) $y = \frac{1}{1+x}$ (ii) $y = (3x^2+1)^2$.

---

7. (a) Resolve into partial fractions

$$\frac{5x}{(x+2)(x^2+1)}$$

(b) Solve each of the following inequalities

(i) $\frac{1}{x+1} > \frac{2}{3-x}$ (ii) $|x+2| < 1 - \frac{x}{2}$

(c) Solve for x given that

$$\sqrt{3+2x} + \sqrt{2-2x} = 3.$$

END OF EXAMINATIONS

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER EXAMINATIONS

MAY 2000

M112-MATHEMATICAL METHODS II

INSTRUCTIONS: -Attempt *any* five (5) questions

-Show all essential working clearly

-Write the number of questions attempted on the main answer book

TIME ALLOWED: Three (3) hours.

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1. a) State the binomial theorem for ***any real*** number indicating clearly the condition(s) under which the expansion is valid.

   b) Find ***the coefficient*** of the term independent of x in the expansion

$$\left(\sqrt{x}-\frac{2}{x}\right)^{36}$$

   c) Using the *binomial expansion*, computer the approximate value of $(15)^{1/4}$.

2. a) ***Without*** using a calculator, evaluate

   i) $\log_{0.5}(16)$ ii) $\log_{10}(0.001)$

   b) Obtain the ***value of x*** given that

   i) $27^{4x^2}=\left(\frac{1}{9}\right)^{x-1}$ ii) $\ln\left(\frac{1}{x}\right)+\ln(2x^3)=\ln 8$

   c) In a medical treatment the function

$$f(t)=500e^{-\frac{t}{5}}$$

   represents the amount of drug in mg remaining in a patient after t hours of being administered.

   i) How many mg of drug where present ***initially***?

   ii) After ***how many hours*** will 200mg remain?

   iii) Find the ***rate of decrease*** when the amount of drug remaining in the body is 200mg.

3. a) Let $\mathbf{a} = 2\mathbf{i} + \mathbf{j} - 3\mathbf{k}$ and $\mathbf{b} = \mathbf{i} - 2\mathbf{j} + \mathbf{k}$.

i) Find a vector of magnitude 5 perpendicular to ***both*** vectors **a** and **b**

ii) The *cosine of the* ***angle*** between **a** and **b**

iii) The ***area*** of a triangle with adjacent sides **a** and **b**

b) Let A be a (3x3) matrix

$$A = \begin{pmatrix} 1 & 2 & -3 \\ 3 & 0 & -1 \\ 2 & -3 & 5 \end{pmatrix}$$

i) Compute the ***inverse*** A^{-1}

ii) ***Hence*** solve the system of equations

$$x + 2y - 3z = 2$$
$$3x - z = -8$$
$$2x - 3y + 5z = -9$$

4. a) Let P(10,3) be a point on the curve

$$y^2 - x + 1 = 0$$

i) Find equations of ***normal*** and ***tangent*** the curve at point P.

ii) Let Q(-2,1), find the ***co-ordinate*** of a point R dividing QP *externally* in the ratio 2:3

b) Consider the curve

$$4y^2 - 9x^2 + 16y + 18x - 29 = 0$$

Find

i) co-ordinates of the ***Centre***

ii)co-ordinates of the ***foci***

iii) co-ordinates of the ***vertices***

iv) equation of ***asymptotes*** and ***sketch the curve*** using above facts.

5. For the curve

$$y = 2x^3 - 3x^2$$

a) Find i) *stationary* (or turning) points

ii)*maximum/minimum* points

iii) *inflexion* points

b) Sketch the curve.

c) Find the ***area*** under the curve between the points –1 and 2.

6. a) Find $\frac{dy}{dx}$ for each of the following functions

i) $y = x\cos y$ ii) $y = \frac{1}{\sqrt{\cos(x^3)}}$ iii) $y = \ln(1 - xe^{-x})$

b) Let $y = x^2 \ln x$. Find

i) $\frac{dy}{dx}$ and

ii) $\frac{d^2y}{dx^2}$.

Hence find the value of

$$x^2\frac{d^2y}{dx^2} - 3x\frac{dy}{dx} + 4y$$

c) A girl flies a kite at a height of 30m. If the kite moves horizontally away from the girl at 4m/s, how *fast* is the string being paid out when the kite is 50m from her?

7. a) i)Resolve *into partial* fractions

$$\frac{4 - 2x^2}{(2x-1)(x^2+1)}$$

ii) Hence evaluate the indefinite integral

$$\int \frac{4 - 2x^2}{(2x-1)(x^2+1)}\,dx$$

b) Using a method of *your choice* evaluate each of the following

i) $\int x^2 \ln x\,dx$ ii) $\int \frac{x^2}{\sqrt{x^3+2}}\,dx$ iii) $\int x^2 e^{-2x}\,dx$

END OF EXAMINATION.

UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – DEFERRED/SUPPLEMENTARY SEMESTER ONE 2000/01

M161- INTRODUCTION TO MATHEMATICS, PROBABILITY AND STATISTICS

INSTRUCTIONS:

1. Attempt ANY **Five (5)** questions.
2. Show all your work to earn full marks.
3. You may use calculators.

TIME ALLOWED: Three (3) Hours

Q[1] (a) Let $f(x) = x^3 - 4x^2 - x + 4$.

(i) Factorize f(x).

(ii) Solve the inequality $x^3 - 4x^2 - x + 4 \leq 0$ and present your answer on the number line.

(b) Given the equation $\sqrt{6x+7} - \sqrt{2x+2} = 1$,

(i) let $y = 2x + 2$, express the equation in terms of y

(ii) hence, or otherwise solve the equation. Express your answer in terms of x.

Q[2] (a) Determine the set of values of k for which the quadratic equation

$kx^2 + 3x + k = 0$

(i) has two distinct real roots.
(ii) has the same real roots.
(iii) has complex roots.

(b) Find the values of a in the expressions below when the following conditions are satisfied:

(i) $x^3 + ax^2 + 3x - 5$ has remainder – 3 when divided by $x - 1$.
(ii) $x^3 + x^2 + ax + 8$ is divisible by $x - 1$.
(iii) $x^3 + x^2 - 2ax + a^2$ has remainder 8 when divided by $x - 2$.

(c) use synthetic division to show that $x + 2$ and $3x - 2$ are factors of $3x^4 - 20x^3 + 80x - 48$.

Q[3] (a) You are given $z_1 = a + 3i$ and $z_2 = 16 + bi$, where a and b are real numbers.

(i) Obtain the values of a and b if $z_2 = \overline{z}_1$.

(ii) Obtain the values of a and b if $z_2 = z_1\overline{z}_1$.

(iii) Obtain the values of a and b if $z_2 = z_1^2$.

(b) Find the modulus of the following complex numbers

(i) $(3 - 4i)(1 + i)$

(ii) $(6 + 3i)^2$

(iii) $1 - \sqrt{3}i$

(c) Solve the following equation $z^2 + 2z + 2 = 0$, and write the solution in the form $a + bi$

Q[4] (a) Mention one property of **rational** numbers.

(b) Perform the indicated operations for the real numbers given below

(i) Rationalize denominator $\dfrac{2}{\sqrt{x-2} - \sqrt{x+1}}$.

(ii) Express $3.7\overline{428}$ in the form $\dfrac{a}{b}$, where a and b are integers.

(iii) Express the real number $\dfrac{10}{3}$ as a repeating decimal.

(c) A binary operation * on the set of **positive numbers** is given by $a*b = \dfrac{a}{b}$

(i) Show that * is **not** commutative.

(ii) Find the value of $\left[\dfrac{1}{2} * 2\right] * 3$.

(iii) Find the value of $\dfrac{1}{2} * [2 * 3]$.

Q[5] (a) (i) A personnel director for a chain-store has hired ten new sales-persons, six are male and four are female. Three (distinctly different) positions are open at one of the branches. In how many ways can she fill the positions if the first position is to be occupied by a female and last two positions by males?

(ii) Students who registered at the University of Zambia last year were given computer numbers which began with 99 followed by six digits. How many computer numbers starting with 99 are possible if digits are allowed to repeat?

(b) Find the indicated term and simplify:

(i) The term free of x in the expansion of $\left(\frac{2}{x^{1/2}} - \frac{x^{1/4}}{4}\right)^9$.

(ii) 7^{th} term of $\left(xy^{1/6} - y^{-2/3}\right)^{15}$.

(c) (i) Expand $\left(x^{3/2} + y^{2/3}\right)^4$ by the binomial theorem and simplify.

(ii) The coefficients of 6^{th} and 16^{th} terms in the expansion of $(a + b)^n$ are equal. Find n.

Q[6] (a) Solve the following systems of equations:

$$\begin{aligned} 2x - y + 3z &= -9 \\ x + 3y - z &= 10 \\ 3x + y - z &= 8 \end{aligned}$$

(b) Solve the given pair of equation algebraically and then plot the graph of the two lines, showing the **intercepts** and the **point of intersection**.

$$\begin{aligned} 4x - y &= 5 \\ x + 2y &= 8 \end{aligned}$$

END OF EXAM

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS - SEMESTER I, 2000/01

M211 - MATHEMATICS METHODS III

INSTRUCTIONS : Answer any five questions. All working must be shown. Calculators and mathematical tables are not allowed.

TIME ALLOWED: Three (3) hours.

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1. a) Find the equation of a hyperbola with foci at (1,1) and (1,11) and vertices at (1,3) and (1,9).

   b) Find the directrices and coordinates of the foci and vertices of the conic which is represented by the equation

   $$9x^2 - 16y^2 + 54x + 64y - 127 = 0$$

   Hence sketch the conic and its directrices.

2. a) From the following equation, eliminate the cross product term by a suitable rotation of axes. Hence graph the equation showing the rotated axes.

   $$x^2 - 3xy + y^2 = 5$$

   b) Find the polar equation of an ellipse with one focus at the origin, the other at (2,0) and a vertex at (4,0).

3. a) State the Mean Value Theorem. Show that there is no number c in the interval (-8,27) for the function $f(x) = x^{2/3}$, guaranteed by the Mean Value Theorem and state the reason why the conclusion of the Mean Value Theorem fails in this case.

   b) Find the Taylor polynomial of order four at base point a = 1 for the function $f(x) = \ln x$ and use it to approximate ln(0.9).
   Determine a bound on the error of approximation.

4. a) Compute the following limits:

i) $\lim_{x\to 0} \frac{\tan 2x}{\ln(1+x)}$

ii) $\lim_{x\to 0^+} (x+1)^{\cot x}$

iii) $\lim_{x\to \infty} \frac{\ln x^{1000}}{x}$

b) Evaluate the improper integral

$$\int_{-\infty}^{-1} xe^{-x^2}\,dx$$

5. a) Evaluate the following integrals

i) $\int \frac{7}{x^2 - 6x + 25}\,dx$

ii) $\int_2^5 t\sqrt{t^2 - 4}\,dt$

iii) $\int \tan^5 x\,dx$

b) If m and n are positive integers, show that

$$\int_{-\pi}^{\pi} \sin mx \sin nx\,dx = \begin{cases} 0 & \text{if } n \neq m \\ \pi & \text{if } n = m \end{cases}$$

6 a) Sketch the region R bounded by the curves $y = x^2 - 2x$ and $y = -x^2$ and find the area of R.

b) Show that the volume of a sphere of radius a units is $\frac{4}{3}\pi a^3$. .

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS SUPPLEMENTARY/DEFFERED
SEMESTER ONE 2000/2001

M221 - LINEAR ALGEBRA(I)

INSTRUCTIONS: **Attempt any five(5) questions of your choice.**

TIME ALLOWED: Three (3) hours.

Q1. (a) Let T: v_3 ® $\rightarrow$ v_2® be a linear transformation defined by
$T(\alpha, \beta,\gamma) = (\alpha+\beta - \gamma,\ 2\alpha + \gamma)$ for all $(\alpha, \beta,\gamma) \in v_3$®

(i) Find the matrix of a linear transformation T relative to the standard R-bases for v_3® and v_2®.

(ii) Let **B** = $\{v_1 = (1,0,-1);\ v_2 = (1,1,1);\ v_3 = (1,0,0)\}$ and

W = $\{w_1 = (1,1),\ w_2 = (1,0)\}$ be R-bases for v_3® and v_2® respectively, determine the matrix of the linear transformation T relative to B and W.

(b) Prove that Ker T is a subspace of V, where Ker T is the kernel of the linear transformation

T: V $\rightarrow$ V.

Q2. a) Prove that $\{(1,1,0,-1), (4,-2,1,0)\}$ is linearly independent over the field Q and give an example of a Q-basis for $V_4(Q)$ containing these two vectors.

b) Let V be a subspace of V_4® generated by $\{v_1, = (1,1,2,4);$
$v_2 = (2,-1,-5,2),\ v_3 = (1,-1,-4,0),\ v_4 = (2,1,1,6)\}$. Find an R-basis for V.

c) An example of the dimensions of the vector space V_3® over R(where R is the set of real numbers) is three (3) denoted by $(V_3$® :R) = 3; copy and complete the following:-

(i) $(V_n(\mathbf{C})R) = \ldots$

(ii) $(M_n(K):K) = \ldots$

(iii) $(Mn©:R) = \ldots$

Q3. (a) Show that $\begin{vmatrix} 1 & 1 & 1 \\ x & y & z \\ x^2 & y^2 & z^2 \end{vmatrix} = (y - x)(z-x)(z-y)$

(b) Find the inverse of

$$A = \begin{pmatrix} 1 & -1 & 2 \\ 3 & 2 & 4 \\ 0 & 1 & -2 \end{pmatrix}$$

Using <u>any other</u> method.

Q4. (i) If B and C are inverses of a matrix A, show that $B = C$

(ii) Determine the values of λ for which the systems of equations is consistent.

$$\begin{aligned} 5x + 2t - z &= 1 \\ 2x + 3y + 4z &= 7 \\ 4x - 5y + \lambda z &= \lambda - 5 \end{aligned}$$

(iv) Find the reduced echelon form of :-

$$\begin{pmatrix} 1 & -1 & 2 & 1 \\ 2 & 1 & -1 & 1 \\ 1 & -2 & 1 & 1 \end{pmatrix}$$

Q5. (i) Determine whether the following mappings are linear transformation defined by the following:-

(a) $T(f(x)) = f'(x)$

(b) $T(\alpha,\beta,\gamma) = (\alpha\beta, \beta\alpha)$

(iii) For what values of x will the matrix be non-invertible?

$$\begin{pmatrix} 1 & x & 0 \\ 0 & 1 & -1 \\ x & 0 & 1 \end{pmatrix}$$

Q6. (i) Find the solution space for the differential equation

$$\frac{d^2y}{dx^2} + y = 0$$

(ii) Solve completely the following systems of linear homogeneous equations;

$$\begin{aligned} x_1 - x_2 + x_3 &= 0 \\ x_1 + x_2 + 2x_3 &= 0 \\ x_1 + 2x_2 - x_3 &= 0 \end{aligned}$$

Q7. Find all the solutions of the linear equations:-

(i) $$\begin{aligned} x_1 - 2x_2 + x_2 &= 1 \\ 2x_1 - x_2 + x_3 &= 2 \\ 4x_1 + x_2 - x3 &= 1 \end{aligned}$$

(ii) $$\begin{aligned} x_1 + x_2 &= 2 \\ 2x_1 + 2x_2 &= 3 \end{aligned}$$

(iii) $$\begin{aligned} x_1 - 2x_2 + x_2 &= 1 \\ 2x_1 - x_2 + x_3 &= 2 \end{aligned}$$

Discuss your conclusions!

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS - SEMESTER I, 2000/01

M225 - INTRODUCTION TO MATHEMATICAL LOGIC

INSTRUCTIONS: Attempt any five(5) questions.

TIME ALLOWED: Three (3) hours.

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1. a) i) Define a statement frame.

   ii) The universal quantifier is written in many ways. Give three of these.

   iii) The existential quantifier is written in many ways. Given three of these.

   b) Let $\{x_n\}_{n=1}^{\infty}$ be any sequence of real numbers and x be a real number. Let $P\left(\{x_n\}_{n=1}^{\infty}, x\right)$ be the frame "$\{x_n\}_{n=1}^{\infty}$ converges to x". Obtain two statements from this frame using both the universal and existential quantifiers in each statement.

   c) Given the truth-functional form

   " $\forall x \exists y \ni (A(y,x) \,\&\, \forall y C(y)) \Rightarrow B(x,y)$",

   identify the free and bound occurrences of each variable.

2. a) Define a connective.

   b) Name a relation that partitions a set and give the properties of this relation.

   c) Let $f: U \to V$ he a function and $\{A_i\}_{i \in I} \subset P(U)$.

   Prove that $f\left(\bigcap_{i \in I} A_i\right) \subset \bigcap_{i \in I} f[A_i]$.

3. a) Define E[A], the image of a set A under the relation E.

b) If a function has domain N, the set of natural numbers, give two ways of designating its range set.

c) Let $f \subset A \times B$. Prove that f^{-1} is a function if and only if f is a bijection

4. a) Let A and B be truth-functional forms. When is A said to be logically equivalent to B?

b) Let A and B be truth-functional forms. Prove that A is logically equivalent to B if and only if "$A \Leftrightarrow B$" is a tautology.

c) Show that $p \Leftrightarrow q$ is logically equivalent to $(p \,\&\, q)$ or $(\neg p \,\&\, \neg q)$

5. a) Let $A_1, A_2, \ldots, A_n$ be a finite sequence of truth-functional forms and B be a truth-functional form.

i) When is B said to be a logical consequence of $A_1, A_2, \ldots, A_n$?

ii) Prove that B is a logical consequence of $A_1, A_2, \ldots, A_n$ if and only if $A_1 \,\&\, A_2 \,\&\ldots\&\, A_n \Rightarrow B$ is a tautology.

b) Let $A_1 = p \Rightarrow q$,, $A_2 = q \Rightarrow r$ and $B = p \Rightarrow r$.
Show that B is a logical consequence of A_1, A_2.

6. a) State the three axioms used in the procedure of forming new strings of symbols from given strings.

b) Define a theorem and a proof of such a theorem.

c) Prove that $(\neg p \Rightarrow p) \Rightarrow p)$ is a theorem.

7. a) State the deduction theorem for truth-functional forms.

b) Taking as hypotheses $q \Rightarrow r$, $p \Rightarrow q$ and p,
prove that $(q \Rightarrow r) \Rightarrow ((p \Rightarrow q) \Rightarrow (p \Rightarrow r))$ is a theorem.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS - SEMESTER I, 2000/01

M231 - REAL ANALYSIS I

INSTRUCTIONS : Answer any five (5) questions
TIME ALLOWED: Three (3) hours.

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1. Let $f: X \to Y$ be a function. Let A and B be subsets of Y. Prove that

   i) $f^{-1}(A \cup B) = f^{-1}(A) \cup f^{-1}(B)$
   ii) $f^{-1}(A \cap B) = f^{-1}(A) \cap f^{-1}(B)$
   iii) $f^{-1}(A') = [f^{-1}(A)]'$.

2. a) Let S be any set of real numbers. Define least upper bond of S and greatest lower bound of S.

   b) Prove the following:

   i) If M is the least upper bound of S, then for every $\varepsilon > 0$, there exists $x \in S$ such that

   $$M - \varepsilon < x \leq M.$$

   ii) If m is the greatest lower bound of S, then for every $\varepsilon > 0$, there exists $x \in S$ such that

   $$m \leq x < m + \varepsilon .$$

3. a) Prove that if x and y are real numbers and if $y > 0$, then there exists a natural number n such that $ny > x$.
   b) Prove that if $a, b \in R$, then

   i) $|a + b| \leq |a| + |b|$
   ii) $-|a - b| \leq |a| - |b|$

4. a) Prove that if $\lim_{n\to\infty} s_n$ exists, then it is unique.

b) Prove that if (s_n) converges to l, then $(|s_n|)$ converges to $|l|$.

c) Prove that $\left(\log\frac{1}{n}\right)$ diverges to minus infinity.

5. a) If the sequence of real numbers (x_n) converges to real number x and the sequence of real numbers (y_n) converges to real number y, then prove that $(x_n.y_n)$ convergent to xy.

b) If (s_n) is a sequence of real numbers converging to L, prove that $\left(s_n^2\right)$ converges to L^2.

6. a) i) Define cauchy sequence.

ii) Prove that if a sequence (s_n) of real numbers is convergent, then it is a cauchy sequence.

b) Prove that the sequence (s_n) defined by

$$s_n = 1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \ldots + \frac{(-1)^{n-1}}{n}$$

is convergent.

7. a) Define limit superior and limit inferior of a sequence of real numbers.

b) If (s_n) and (t_n) are bounded sequences of real numbers, then prove that

i) $\limsup_{n\to\infty}(s_n + t_n) \le \lim_{n\to\infty} \sup s_n + \lim_{n\to\infty} \sup t_n$

ii) $\lim_{n\to\infty} \inf(s_n + t_n) \ge \lim_{n\to\infty} \inf s_n + \lim_{n\to\infty} \inf t_n$.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS - SEMESTER I, 2000/01

M261 - INTRODUCTION TO STATISTICS.

INSTRUCTIONS : Answer any five(5) questions. Use of mathematical tables and calculators is allowed.

TIME ALLOWED: Three (3) hours.

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1. a) The following data shows the marks obtained by fifty students in M261 test 1. The marks are in percentages.

60	22	51	60	37	34	76	47	28	58
11	41	25	36	58	42	51	67	45	43
50	59	20	81	36	33	91	07	32	28
24	64	33	32	40	53	32	50	50	23
61	53	48	40	55	28	77	68	40	47

i) Present the distribution using stem-and-leaf plot and Box-and-Whisker plot.

ii) Identify any value(s) which may be considered outlier(s).

iii) Comment on the performance of the students in this test.

b) i) State the central limit theorem.

ii) A random sample of size 100 is taken from a population having a mean of 20 and standard deviation of 5.

The shape of the distribution is unknown.

α). Find the mean and standard deviation of the sample mean $\overline{X}$.

β) Find the probability that the sample mean $\overline{X}$ will exceed 20.75.

2. You are given the following data:

$n_1 = 15 \qquad \bar{x} = 20 \qquad \sum(x_i - \bar{x})^2 = 28$

$n_2 = 12 \qquad \bar{y} = 17 \qquad \sum(y_i - \bar{y})^2 = 22$

a) Obtain S^2_{pooled}

b) Test $H_o: \mu_1 = \mu_2$ against

$H_1: \mu_1 > \mu_2$ with $\alpha = 0.05$

Determine the p-value and comment on its size.

c) Construct a 95% confidence interval for $\mu_1 - \mu_2$.

3. The Ministry of Transport and Communication is responsible for the enforcement of airline safety regulations and has become concerned about an apparent increase in accidents and near mishaps involving commercial aircraft. One area of concern is overloading due to passenger baggage exceeding regulated limits. Each passenger on overseas flights is allowed to carry 20kg of luggage on board. To check adherence to this regulation, Ministry officials conducted a spot check on passengers boarding both South African Airways and British Airways flights from Lusaka International Airport.

The weight of luggage for each was recorded with the following results.

	AIRLINE	
	South African Airways	British Airways
No. of passengers	137	184
Mean Weight in kg	29.48	32.67
Standard Deviation	9.45	8.03

a) Construct 95% confidence intervals for the true mean weight of passenger luggage for each airline.
Is there reason to believe that either airline is routinely violating luggage regulations?

b) Do the mean weights of luggage differ between the two airline? Support your conclusion statistically and state the p-value for your test (Test with $\alpha = 0.05$).

4. A post graduate student in the school of Education is studying the effect of alcohol on intellectual activity. The student devises two equivalent tests which entail a series of arithmetic operations. Eight undergraduate statistics students are selected to take the first test. The following day the same eight students are each given three medium sized glasses of Mosi which they promptly consume. Immediately after consuming the beer, the students took the second test.

Although there were a great many volunteers to take the second test, only eight students were also willing to take the first test.

The test results are listed below:

STUDENT ID	FIRST TEST	SECOND TEST
A	72	61
B	84	52
C	67	74
D	73	68
E	78	60
F	53	66
G	69	64
H	64	59

a) Test at 0.05 level of significance, whether alcohol affects mental performance.

b) Construct a 95% confidence interval for the difference in test result.

5. a) Game Management officials are studying the incidence of intestinal parasites in ruminants. Four species of ruminants are examined for parasites in both Kafue National Park and Luangwa National Park. The results of the study are summarised below:

		SPECIES			
PARK		Puku	Kudu	Impala	Hartbeast
KAFUE	Sampled	43	17	58	32
	parasitic	12	8	14	11
LUANGWA	Sampled	24	30	26	37
	parasitic	7	9	6	10

Does the rate of parasitic infection of ruminants differ between the two parks? (Test with $\alpha = 0.05$)

b) A sample of 400 contracts was selected from about 4000 on file and classified according to two characteristics: (1) duration of contract and (2) type of industry. Among those contracts selected in the survey, 245 contracts were in manufacturing and 155 contracts were classified as non manufacturing. The contracts, organised by duration (in years) and type of industry (manufacturing/non manufacturing) are given below:

	2 yrs or less	3yrs	4 years or more	Total
Manufacturing	10	187	48	245
Nonmanufacturing	13	107	35	155
Total	23	294	83	400

Test at 0.05 level of significance whether the duration of contract is independent of the type of industry.

6. In a study to determine the influence of training on the time required to do a complex job, 15 new employees were given amounts of training ranging from 3 to 12 hours. After the training, their time to complete the job were recorded.

Let x denote the duration of training (in hours), and let y denote the time to do the job (in minutes). The following summary statistics were obtained:

$\bar{x} = 7.2$ $\quad S_{xx} = 33.6$ $\quad S_{xy} = -57.2$
$\bar{y} = 45.6$ $\quad S_{yy} = 160.2$

a) Determine the equation of the best fitting straight line for these data.

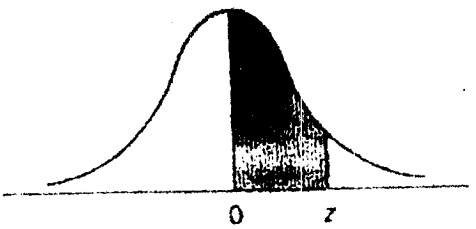
b) Do the data substantiate the claim that the job time decreases with more hours of training? (Test with $\alpha = 0.01$)

c) Estimate the mean time for 9 hours of training and construct a 95% confidence interval.

d) Predict the time to do a job y for x = 35 hours and comment on the result.

END OF EXAMINATION.

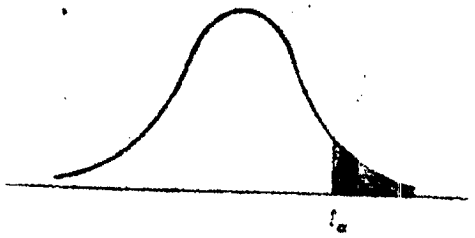
CURVE AREAS



z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0000	.0040	.0080	.0120	0160	.0199	.0239	.0279	.0319	0359
0.1	0398	.0438	.0478	0517	0557	0596	.0636	0675	0714	0753
0.2	.0793	0832	0871	.0910	0948	0987	.1026	1064	.1103	1141
0.3	1179	.1217	.1255	.1293	1331	1368	.1406	.1443	1480	1517
0.4	1554	.1591	.1628	.1664	1700	1736	1772	1808	1844	1879
0.5	1915	.1950	.1985	.2019	2054	2088	.2123	2157	2190	2224
0.6	2257	.2291	2324	.2357	2389	.2422	.2454	2486	25 7	2549
0.7	.2580	.2611	2642	.2673	2704	.2734	2764	.2794	.2823	2852
0.8	2881	.2910	2939	.2967	.2995	.3023	.3051	3078	3106	3133
0.9	3159	.3186	.3212	.3238	.3264	3289	.3315	.3340	3365	3389
1.0	3413	.3438	.3461	3485	3508	3531	3554	.3577	3599	3621
1.1	.3643	3665	.3686	.3708	.3729	.3749	.3770	.3790	3810	3830
1.2	3849	.3869	.3888	.3907	.3925	3944	3962	.3980	3997	4015
1.3	.4032	4049	.4066	.4082	.4099	.4115	.4131	.4147	4162	4177
1.4	4192	4207	.4222	.4236	.4251	.4265	.4279	.4292	4306	4319
1.5	.4332	4345	.4357	4370	.4382	4394	.4406	4418	4429	4441
1.6	.4452	4463	4474	.4484	.4495	4505	.4515	.4525	4535	4545
1.7	.4554	4564	.4575	.4582	4591	.4599	.4608	.4616	.4625	4633
1.8	.4641	4649	.4656	4664	.4671	4678	4686	4693	4699	4706
1.9	4713	4719	.4726	4732	4738	4744	4750	4756	4761	4767
2.0	4772	.4778	4783	.4788	.4793	.4798	.4803	.4808	8	4817
2.1	.4821	4826	.4830	.4834	4838	4842	.4846	4850	.4854	4857
2.2	4861	.4864	.4868	.4871	4875	4878	4881	4884	4887	4890
2.3	4893	.4896	.4898	4901	.4904	4906	4909	4911	4913	4916
2.4	.4918	4920	.4922	.4925	.4927	.4929	4931	4932	4934	4936
2.5	.4938	4940	.494	.4943	.4945	.4946	4948	4949	4951	4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	4961	4962	4963	4964
2.7	.4965	.4966	4967	.4968	.4969	4970	.4971	4972	4973	4974
2.8	4974	.4975	4976	.4977	4977	4978	4979	.4979	4980	4981
2.9	4981	.4982	4982	.4983	4984	4984	.4985	4985	4986	4986
3.0	4987	.4987	4987	.4988	4988	4989	.4989	.4989	499	

Source: Abridged from Table I of A. Hald, *Statistical Tables and Formulas* (New York: John Wiley & [illegible]). 1952. Reproduced by permission of A. Hald and the publisher.

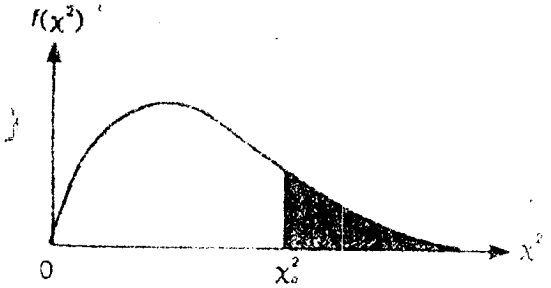
E V
CAL VALUES OF *t*



DEGREES OF FREEDOM	$t_{.100}$	$t_{.050}$	$t_{.025}$	$t_{.010}$
1	3.078	6.314	12.706	31.821
2	1.886	2.920	4.303	6.965
3	1.638	2.353	3.182	4.541
4	1.533	2.132	2.776	3.747
5	1.476	2.015	2.571	3.365
6	1.440	1.943	2.447	3.143
7	1.415	1.895	2.365	2.998
8	1.397	1.860	2.306	2.896
9	1.383	1.833	2.262	2.821
10	1.372	1.812	2.228	2.764
11	1.363	1.796	2.201	2.718
12	1.356	1.782	2.179	2.681
13	1.350	1.771	2.160	2.650
14	1.345	1.761	2.145	2.624
15	1.341	1.753	2.131	2.602
16	1.337	1.746	2.120	2.583
17	1.333	1.740	2.110	2.567
18	1.330	1.734	2.101	2.552
19	1.328	1.729	2.093	2.539
20	1.325	1.725	2.086	2.528
21	1.323	1.721	2.080	2.518
22	1.321	1.717	2.074	2.508
23	1.319	1.714	2.069	2.500
24	1.318	1.711	2.064	2.492
25	1.316	1.708	2.060	2.485
26	1.315	1.706	2.056	2.479
27	1.314	1.703	2.052	2.473
28	1.313	1.701	2.048	2.467
29	1.311	1.699	2.045	2.462
∞	1.282	1.645	1.960	2.326

Source: From M. Merrington, "Table of Percentage Points of the *t*-Distribution," *Biometrika*. Reproduced by permission of the *Biometrika* Trustees.

LE VI
ICAL VALUES OF χ^2



DEGREES OF FREEDOM	$\chi^2_{.995}$	$\chi^2_{.990}$	$\chi^2_{.975}$	$\chi^2_{.950}$
1	0.0000393	0.0001571	0.0009821	0.0039321
2	0.0100251	0.0201007	0.0506356	0.102587
3	0.0717212	0.114832	0.215795	0.351846
4	0.206990	0.297110	0.484419	0.710721
5	0.411740	0.554300	0.831211	1.145476
6	0.675727	0.872085	1.237347	1.63539
7	0.989265	1.239043	1.68987	2.16735
8	1.344419	1.646482	2.17973	2.73264
9	1.734926	2.087912	2.70039	3.32511
10	2.15585	2.55821	3.24697	3.94030
11	2.60321	3.05347	3.81575	4.57481
12	3.07382	3.57056	4.40379	5.22603
13	3.56503	4.10691	5.00874	5.89186
14	4.07468	4.66043	5.62872	6.57063
15	4.60094	5.22935	6.26214	7.26094
16	5.14224	5.81221	6.90766	7.96164
17	5.69724	6.40776	7.56418	8.67176
18	6.26481	7.01491	8.23075	9.39046
19	6.84398	7.63273	8.90655	10.1170
20	7.43386	8.26040	9.59083	10.8508
21	8.03366	8.89720	10.28293	11.5913
22	8.64272	9.54249	10.9823	12.3380
23	9.26042	10.19567	11.6885	13.0905
24	9.88623	10.8564	12.4011	13.8484
25	10.5197	11.5240	13.1197	14.6114
26	11.1603	12.1981	13.8439	15.3791
27	11.8076	12.8786	14.5733	16.1513
28	12.4613	13.5648	15.3079	16.9279
29	13.1211	14.2565	16.0471	17.7083
30	13.7867	14.9535	16.7908	18.4926
40	20.7065	22.1643	24.4331	26.5093
50	27.9907	29.7067	32.3574	34.7642
60	35.5346	37.4848	40.4817	43.1879
70	43.2752	45.4418	48.7576	51.7393
80	51.1720	53.5400	57.1532	60.3915
90	59.1963	61.7541	65.6466	69.1260
100	67.3276	70.0648	74.2219	77.9295

Source: From C. M. Thompson, "Tables of the Percentage Points of the χ^2-Distribution," *Biometrika*, Vol. 32, 188–189. Reproduced by permission of the *Biometrika* Trustees.

DEGREES OF FREEDOM	$\chi^2_{.100}$	$\chi^2_{.050}$	$\chi^2_{.025}$	$\chi^2_{.010}$	$\chi^2_{.005}$
1	2.70554	3.84146	5.02389	6.63490	7.87944
2	4.60517	5.99147	7.37776	9.21034	10.5966
3	6.25139	7.81473	9.34840	11.3449	12.8381
4	7.77944	9.48773	11.1433	13.2767	14.8602
5	9.23635	11.0705	12.8325	15.0863	16.7496
6	10.6446	12.5916	14.4494	16.8119	18.5476
7	12.0170	14.0671	16.0128	18.4753	20.2777
8	13.3616	15.5073	17.5346	20.0902	21.9550
9	14.6837	16.9190	19.0228	21.6660	23.5893
10	15.9871	18.3070	20.4831	23.2093	25.1882
11	17.2750	19.6751	21.9200	24.7250	26.7569
12	18.5494	21.0261	23.3367	26.2170	28.2995
13	19.8119	22.3621	24.7356	27.6883	29.8194
14	21.0642	23.6848	26.1190	29.1413	31.3193
15	22.3072	24.9958	27.4884	30.5779	32.8013
16	23.5418	26.2962	28.8454	31.9999	34.2672
17	24.7690	27.5871	30.1910	33.4087	35.7185
18	25.9894	28.8693	31.5264	34.8053	37.1564
19	27.2036	30.1435	32.8523	36.1908	38.5822
20	28.4120	31.4104	34.1696	37.5662	39.9968
21	29.6151	32.6705	35.4789	38.9321	41.4010
22	30.8133	33.9244	36.7807	40.2894	42.7956
23	32.0069	35.1725	38.0757	41.6384	44.1813
24	33.1963	36.4151	39.3641	42.9798	45.5585
25	34.3816	37.6525	40.6465	44.3141	46.9278
26	35.5631	38.8852	41.9232	45.6417	48.2899
27	36.7412	40.1133	43.1944	46.9630	49.6449
28	37.9159	41.3372	44.4607	48.2782	50.9933
29	39.0875	42.5569	45.7222	49.5879	52.3356
30	40.2560	43.7729	46.9792	50.8922	53.6720
40	51.8050	55.7585	59.3417	63.6907	66.7659
50	63.1671	67.5048	71.4202	76.1539	79.4900
60	74.3970	79.0819	83.2976	88.3794	91.9517
70	85.5271	90.5312	95.0231	100.425	104.215
80	96.5782	101.879	106.629	112.329	116.321
90	107.565	113.145	118.136	124.116	128.299
100	118.498	124.342	129.561	135.807	140.169

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS - SEMESTER I, 2000/01

M331 REAL ANALYSIS III

INSTRUCTIONS: Attempt any five(5) questions.

TIME ALLOWED: Three (3) hours.

---

1. a) Let f be a function with domain and range in R. What is a fixed point of f?

   b) Let $B > 0$. Show that if $f:[-B,B] \to [-B,B]$ is continuous then f has a fixed point.

   c) Let $f:[-3,3] \to [-3,3]$ be defined by $f(x) = \frac{5}{4} + 3x - x^2$. Find two fixed points of f.

2. a) Let $\{f_n\}_{n=1}^{\infty}$ be a sequence of functions defined on a subset D of R with range in R. When is $\{f_n\}_{n=1}^{\infty}$ said to be convergent on D?

   b) Let $\{f_n\}_{n=1}^{\infty}$ Let be a sequence of functions defined on a subset D of R with range in R. If for each $n \in N$ f_n is continuous on D and if $\{f_n\}_{n=1}^{\infty}$ converges uniformly on D, show that the limit is continuous on D.

   c) $\forall n \in N$ let $f_n : [0,1] \to [0,1]$ be defined by $f_n(x) = x^n$. Find $\lim_{n\to\infty} f_n$ and show that $\lim_{n\to\infty} f_n$ is not continuos on [0,1].

3. a) i) Let [a,b] be a closed interval of the real line. Define a partition of [a,b].

   ii) Define a function of bounded variation on [a,b].

b) If $f:[a,b] \to R$ is of bounded variation, show that f is bounded.

c) Let $f:[0,1] \to R$ be defined by

$$f(x) = \begin{cases} x\cos\dfrac{\pi}{2x}, & \text{if } 0 < x \leq 1 \\ 0, & \text{if } x = 0. \end{cases}$$

By considering a suitable partition of [0,1], show what f is not of bounded variation on [0,1].

4. a) Define a step function with domain and range in R.

b) Let D be a closed and bounded subset of R and $f:D \to R$ be continuous. Show that f can be uniformly approximated by step functions.

5. a) Define the total variation of a function of bounded variation on an interval [a,b].

b) Let f be of bounded variation on [a,b] and $V(x) = V_f(a,x)$, if $a < x \leq b$, $V(a) = 0$, where $V_f(a,x)$ is the total variation of f on [a,x]. Show

i) V is increasing on [a,b]
ii) V-f is increasing on [a,b].

6. a) i) Define a covering of a subset of R.

ii) Define a compact subset of R.

b) Let f be a continuous real valued function and K be a compact subset of the domain of f. Show that there is a point x^* in K such that $f(x^*) = \sup_{x \in K} f(x)$.

c) Let B = (0,1]. Let $A_1 = \left(\frac{1}{2}, 2\right)$ and for $n > 1$ set $A_n = \left(\frac{1}{n+1}, \frac{1}{n-1}\right)$. By considering the set $\{A_n : n \in N\}$ show that B is not compact.

7. a) Define a connected subset of R.

b) Let H be a connected subset of R and let f be continuous on H with values in R. If k is any real number satisfying

$$\inf\{f(x): x \in H\} < k < \sup\{f(x): x \in H\}$$

Show that there is atleast one point of H where f takes the value k.

c) Show that the set S consisting of all positive rational numbers is disconnected in R.

END OF EXAMINATION.

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS - SEMESTER I, 2000/01

M335 - POINT SET TOPOLOGY

INSTRUCTIONS : Attempt ANY Five (5) Questions.

TIME ALLOWED: Three (3) hours.

---

1. Define the following:

   i) an *equivalence relation* R on a set A;
   ii) an *injective function* $f: A \to B$.

   a) i) Let $N \times N$ be the set of ordered pairs of positive integers and let R be the relation $\sim$ in $N \times N$ defined by $(a, b) \sim (c, d)$ if and only if $ad = bc$.

   Then, show that R is an equivalence relation on $N \times N$.

   ii) A set A is said to be *equivalent* to a set B, written $A \sim B$, if there exists an injective function $f: A \to B$.

   Prove that the relation in any collection of sets defined by $A \sim B$ is an equivalence relation.

   b) Let A, B and C be non-empty sets, and let $f: A \to B$ and $g: B \to C$ be functions.

   Prove that

   (i) if f and g are surjective, then $gof: A \to C$ is surjective;

   (ii) if f and g are injective, then $gof: A \to C$ is injective, where gof is the composition of f and g.

---

2. What is meant by the following terms:

(i) a *metric* on a set X?
(ii) an *open ball* in a metric space?

(a) Let d be a metric on a non-empty set X.
Show that the d defined by

$$d(a, b) = \begin{cases} 1 & \text{if } a \neq b \\ 0 & \text{if } a = b, \end{cases}$$

where $a, b \in X$, is also a metric on X.

b) (i) Let S be an open ball with centre p and radius δ, *i.e.* $S = S(p, \delta)$. Then prove that for every point $q \in S$ there exists an open ball T centered at q such that T is contained in S.

(ii) Let S_1 and S_2 be open spheres and let $p \in S_1 \cap S_2$. Show that there exists an open sphere S_p with centre p such that $p \in S_p \subset S_1 \cap S_2$.

---

3. Define the following terms as applied to metric spaces:

(i) a *closed* set;
(ii) a *limit* point.

(a) Let X be a metric space and let $\{F_1, F_2, \text{---}F_n\}$ be any finite collection of closed sets in X. Show that the union

$$\bigcup_{i=1}^{n} F_i \text{, of the } F_i,\ i = 1,2, ..,n; \text{ is closed.}$$

(b) (i) Let R be the metric space of real numbers and let

$$A = \{x : x \in R,\ x = 1/n,\ n \in N\}$$

be a subset of R.

Show that 0 is a limit point of A which does not belong to A.

(ii) Let x_o be a limit point of a subset A of a metric space X. Prove that every neighbourhood of x_o contains infinitely many points of A.

---

4. What does the following mean:

(i) a *topology on a set X*?
(ii) a *continuous function* from one topological space to another?

(a) Let X be a non-empty set, and let τ be the collection of the null set and all subsets of X whose complements are finite. Show that τ is a topology on X.

(b) Let (X, τ_1) and (Y, τ_2) be topological spaces and let $f: X \to Y$ be a function.

Prove that
(i) f is continuous if and only if the inverse image of every open set in τ_2 is an open set in τ_1.
(ii) if X is an indiscrete topology and Y is a discrete topology, then every function $f: X \to Y$ which is *not* a constant, is discontinuous at all points of X.

---

5. Let X be a non-empty set with topology defined on it. What is meant by
(i) a *limit point* of a subset A of X?
(ii) a *relative topology* on a subset A of X?

(a) Let (X, τ) be a topological space with

$$X = \{a, b, c, d, e\},$$
$$\tau = \{X, \phi, \{a\}, \{a, b\}, \{a, c, d\}, \{a, b, e\}, \{a, b, c, d\}\},$$

and let $A = \{a, b, c\}$.

Determine
(i) the limit points of A,
(ii) the closure of A.

Hence or otherwise, determine whether A is closed.

(b) Determine the *relative topology* on A.

---

6. Define the following:

(i) a *Hausdorff space*;
(ii) a *compact topological* space.

(a) Let $X = \{a, b, c, d, e\}$ and $\tau = \{X, \phi, \{a\}, \{c, d\}, \{a, c, d\}, \{b, c, d, e\}\}$.

(i) Show that (X, τ) is a topological space.
(ii) Determine whether or not, (X, τ) is Hausdorff.

(b) Let (R, τ) be a topological space where τ is the usual topology on R.

(i) Prove that R is not compact.

(ii) Show that the set

$$E = \{x \in R : -3 \leq x < 2\}$$

is *not compact* under the usual topology on R.

---

7. What does the following mean:

(i) a *connected topological* space?
(ii) *components* of a topological space?

(a) (i) Let (X, τ) be a topological space. Prove that ϕ and X are the only subspaces of X which are both open and closed if and only if X is connected.

(ii) Let S be a connected topological space and let $f: S \to T$ be a continuous mapping. Then, prove that $f(S)$ is also connected.

(b) Let $X = \{a, b, c, d, e\}$ and $\tau = \{X, \phi, \{a\}, \{c, d\}, \{a, c, d\}, \{b, c, d, e\}\}$.

Determine

(i) whether or not X is connected;
(ii) the number of components of X.
(iii) whether $A = \{b, d, e\}$ is connected under the *relative topology* on A.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - SEMESTER ONE 2000/01

M361- MATHEMATICAL STATISTICS.

INSTRUCTIONS:

1 Attempt ANY **Five (5)** questions.
2 Show all your work to earn full marks.
3 You may use calculators and tables, tables have been provided.

TIME ALLOWED: Three (3) hours

Q1 The probability function of the random variable X

$$f_X(x) = \frac{1}{\theta} e^{-(x-\beta)/\theta} \qquad x \geq \beta, \theta > 0$$
$$= 0 \qquad \text{otherwise}$$

is known as a two-parameter exponential distribution.

(a) (i) Find the moment-generating function $M_X(t)$ of the distribution

(ii) State the range for which $M_X(t)$ exists.

(b) (i) Evaluate E(X) and Var(X) *using the moment-generating function*

(ii) Confirm your answer for E(X) using direct integration.

Q2 (a) A random sample $X_1, X_2, \ldots, X_n$ is drawn from a population with a continuous probability density function f(x) such that $X_j \sim f(x_j)$ with a CDF $F(x_j)$, j =1, 2,.., n. Let $Y_{(n)}$ = Maximum($X_1, X_2, \ldots, X_n$), show that the probability density function of $h(Y_{(n)})$ is

$$h(Y_{(n)} = y) = n(F(y))^{n-1} f(y).$$

(b) Suppose that the length of time, Y, that it takes a worker to complete a certain task has the probability density function

$$f(y) = \begin{cases} e^{-(y-\theta)}, & y > \theta \\ 0, & \text{otherwise} \end{cases}$$

where θ is a positive constant that represents the minimum time to task completion. Let $Y_1, Y_2, \ldots, Y_n$ denote a random sample of completion times from this distribution.

(i) Find the density function for $Y_{(1)}$ = Minimun($Y_1, Y_2, \ldots, Y_n$)

(ii) Find $E(Y_{(1)})$

Q3 A population of rice growers in a certain region is divided into two groups; 1 and 2. Farmers in group 1 grow an improved variety of rice and those in group 2 grow a local variety. The yield per hactare, Y_1, of the improved variety follows a normal distribution with mean μ_1 and variance σ_1^2. The yield of the local variety, Y_2, also follows a normal distribution with mean μ_2 and variance σ_2^2. The two distributions are independent. There are N_1 farmers who grow the improved variety and N_2 who grow the local variety.

The mean yield per hectare of rice grown in this region can be calculated as:

$\mu = W_1\mu_1 + W_2\mu_2$, where $W_1 = \frac{N_1}{N}$ and $W_2 = 1 - W_1 = \frac{N_2}{N}$ are weights.
$N = N_1 + N_2$, the size of the total population of rice growers.

(a) A firm contracted to estimate the yield of rice in the region takes a sample of size n_1 of yield from group 1 only. It calculates $\overline{Y}_1$ as an estimate of μ.

(i) Clearly, the estimate is biased, give **one** reason to support this assertion.

(ii) Calculate the bias of $\overline{Y}_1$

(iii) Obtain the Mean Square Error (MSE) of $\overline{Y}_1$ given that

$$\text{Var}(\overline{Y}_1) = \left(\frac{N_1 - n_1}{N_1 - 1}\right)\frac{\sigma_1^2}{n_1}$$

(iv) More data are collected from group 1 and combined with earlier data. What components of the MSE would be affected by this additional data, and in what way?

(b) Fortunately for the firm in (a), you are employed as a statistician and you insist data have to be collected from both groups. Unfortunately, all the parameters; μ_1, μ_2, σ_1^2, and σ_2^2 are unknown, their respective sample estimates; $\overline{y}_1$, $\overline{y}_2$, s_1^2, and s_2^2 have to be used instead. The data are shown below:

Parameter	Estimator	Sample Value	Sample Size
μ_1	$\overline{Y}_1$	784 kg/ha	350
μ_2	$\overline{Y}_2$	600 kg/ha	150
σ_1^2	S_1^2	135^2 kg/ha^2	350
σ_2^2	S_2^2	130^2 kg/ha^2	150

(i) In an attempt to impress donors, the firm directs you to report $\overline{y}_1$ as an estimate of μ.
Calculate an estimate of the MSE of $\overline{y}_1$ using the sample values in the table above given that $W_1 = 0.70$, $W_2 = 0.30$ and $N = 2000$.

(ii) Obtain an unbiased estimate of μ using the weights above.

Q4 A medical doctor has noticed that some of the patients passing through her private clinic seem to be hypertensive. Let X_j be the random variable describing the state of hypertension of the jth patient in the following manner:

$$X_j = \begin{cases} 1 & \text{if the jth patient is hypertensive} \\ 0 & \text{if the jth patient is not hypertensive} \end{cases}$$

Assume $X_j \sim$ Bernoulli (1, p). Suppose $X_1, X_2, \ldots, X_n$ is a random sample from this distribution:

(a) (i) State the distribution of $X = \sum_{j=1}^{n} X_j$

(ii) State the variance of X_j for any j =1, 2, . . ., n.

(b) Find the variance of X

(c) Find the Method of Moments Estimator σ^2_{MME} of the variance of X and express it in terms of n and $\hat{p} = \frac{x}{n}$ only.

(d) (i) Show that σ^2_{MME} is a biased estimator

(ii) Obtain an unbiased estimator of the variance of X.

Q5 Consider a random sample of size n from a Poisson distribution, $X_i \sim POI(\theta)$.

(a) Let $\tau(\theta) = \theta$.

(i) Find the Cramer-Rao Lower Bound (CRLB) for the variances of unbiased estimators of θ.

(ii) Find the Maximum Likelihood Estimator (MLE) $\hat{\theta}_{MLE}$ of θ.

(iii) Is $\hat{\theta}_{MLE}$ unbiased?

(iv) Find the variance of $\hat{\theta}_{MLE}$?

(v) Is $\hat{\theta}_{MLE}$ a Minimum Variance Unbiased Estimator (UMVUE) of θ?

(b) Let $\tau(\theta) = e^{-\theta}$.

(i) Find the MLE of $\tau(\theta)$

(ii) Find the CRLB for the variances of unbiased estimators of $\tau(\theta) = e^{-\theta}$.

Q6 A study was conducted to determine the effects of sleep deprivation on subject's ability to solve simple problems. The amount of sleep deprivation varied over 8, 12, 16, 20, and 24 hours without sleep. A total of 5 subjects participated in the study, one at each sleep-deprivation level. After his specific sleep-deprivation period, each subject was administered a set of simple addition problems and the number of errors recorded. The results were as follows:

Number of Errors, y	6	8	10	12	14
Number of Hours Without sleep, x	8	12	16	20	24

Assume x and y are related via the model:

$Y_j(x_j) = \alpha + \beta x_j + \varepsilon_j, \quad j = 1, 2, \ldots, 5$

where ε_j are iid normal random variables with mean 0 and variance σ^2.

(i) Write down the general expressions for the least-squares estimators of α and β

(ii) Find the least- squares estimates of α and β using the data above

(iii) Write down the fitted line $\hat{Y}(x_j) = \hat{\alpha} + \hat{\beta} x_j$, where $\hat{\alpha}$ and $\hat{\beta}$ are the estimated obtained in (i).

(iv) Obtain an estimate of the number of errors for a subject deprived of sleep for 15 hours.

END OF EXAM

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS - SEMESTER I, 2000/01

M411 - THEORY OF FUNCTIONS OF A COMPLEX VARIABLE I

INSTRUCTIONS : Attempt ANY Five (5) Questions. Showing all necessary working. All questions carry equal marks.

TIME ALLOWED: Three (3) hours.

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1. a) Prove that

$$|I_m z| + |\mathrm{Re}\, z| \le \sqrt{2}|z|$$

b) Show that $\operatorname{arctanh} z = \frac{1}{2}\ln\left(\frac{1+z}{1-z}\right), \quad z \neq \pm 1$

c) (i) Show that $v(x,y) = x^2 + 2y - y^2 + 1$ is harmonic and find it's harmonic conjugate $u(x,y)$ such that $u(0,0) = 0$.

(ii) Writing $f(z) = u(x,y) + iv(x,y)$, with $z = x+iy$, determine $f(z)$ as a function of z, hence

Evaluate $I = \frac{1}{2\pi i}\int_c \frac{f(z)}{(z+1)(z+i)}dz$

where c is the circle $|z+i| = 1$.

2. a) Sketch the curve in the complex plane defined by

$$\left|\frac{z+1+i}{z-1-i}\right| = 1.$$

b) Find the linear transformation with the fixed point 2-3i that maps $z = i$ into $w = 4$.

c) Evaluate $\int_c z^\alpha dz$ where α is an arbitrary complex number, c is the unit circle $|z| = 1$, the branch to be used is the one for which $1^\alpha = 1$, and the integration starts from $z = 1$.

3. a) Find the values and principal value of $(-4)^i$

b) Express the Cauchy-Riemann equations in polar form.

c) Find the linear fractional transformation that maps the z-plane onto the w-plane such that the points, $z = 0,1,2$ are mapped into the respective points $w = 0, 1, \infty$.

4. a) If z lies on the circle $|z| = 2$, show that

$$\left|\frac{1}{z^4 - 4z^2 + 3}\right| \leq \frac{1}{3}.$$

b) Prove that $\left|\frac{a-b}{1-b\bar{a}}\right| < 1$ if

$|a| < 1$ and $|b| < 1$.

c) State and prove the cauchy integral formula

5. a) Verify the integral inequality for the integral

$\int_c e^z dz$ where c is the straight line path joining $z = 0$ and $z = 1 + i$

b) Find the smallest upper bound for

$$\int_c \frac{|\sinh z||dz|}{|z-a||z+a|}$$ where c is the unit circle $|z| = 1$ and $|a| \neq 1$.

c) Evaluate $\int_c \frac{4z^2 + 9iz + 27}{z(z^2+9)} dz$ where is c the perimeter bounding the area common to the circles $|z-3| = 4$ and $|z+2| = 3$.

6. a) Locate the singular points of the function $f(z) = \dfrac{1}{\sinh\left(\frac{1}{z}\right)}$ and state whether they are isolated or non isolated.

b) Show that the function $x^2 + iy^3$ is not analytic anywhere. Reconcile this with the fact that the cauchy-Riemann equations are satisfied at the origin.

c) Let the rectangular region Ω in the z-plane be bounded by $x = 0$, $y = 0$, $x = 2$, $y = 1$. Determine the region Ω' of the w-plane into which Ω is mapped under the transformation $w = z + 1 - 2i$.

7. a) Evaluate $\left(\dfrac{1+\sqrt{3}i}{1-\sqrt{3}i}\right)^{10}$

b) State without proof, the cauchy-Goursat theorem,

c) Express $\dfrac{z^4-3}{z^2+2z+1}$ into partial fractions. Hence evaluate

$\int_c \dfrac{z^4-3}{z^2+2z+1}$

where c is the circle $|z - 1| = 1$.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS - SEMESTER I, 2000/01

M431 - REAL ANALYSIS V

INSTRUCTIONS : Answer any five (5) questions
TIME ALLOWED: Three (3) hours.

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1. a) Prove that the union of a countable collection of countable sets is countable.

   b) Define cantor set and prove that the sum of the lengths of the intervals removed in the construction of cantor set is 1.

   c) Prove that the set of real numbers R is uncountable.

2. (a) Define partially ordered set and chain. Explain these concepts by examples.

   b) Define maximal element in a partially ordered set.
   Explain this notion by examples.

   c) Sate Zorn's Lemma and indicate how it can be applied in a particular situation.

3. a) Let l_2 be the set of all sequences $x = (x_n)$ of all real numbers such that

$$\sum_{n=1}^{\infty} |x_n|^2 < \infty.$$

   Define a metric d on l_2 by

$$d(x,y) = \left[\sum_{n=1}^{\infty} (x_n - y_n)^2 \right]^{1/2}.$$

   Prove that l_2 is a metric space with this metric.

b) Find an example of a closed and bounded subset of l_2 which is not totally bounded.

c) Prove that the metric space c_o is a separable metric space.

4. a) Let l_∞ denote the set of all bounded sequences of real numbers. Define $d(x,y) = \sup_{1 \le n < \infty} |x_n - y_n|$.
Prove that l_∞ is a metric space.

b) Prove that l_∞ is not separable.

c) Prove that every normed linear space X is a metric space relative to the natural metric d defined by

$$d(x,y) = \|x - y\|$$

5. a) Let (X,d) be a metric space. If X is compact, then prove that it has the Heine-Borel property.

b) Find an open covering for $[a,b]$ which contains a finite subcovering in the absolute value metric of R.

6. a) If a metric space (X,d) is compact, then prove that it is complete and totally bounded.

b) If A and B are compact subsets of R, then prove that AxB is a compact subset of R^2.

7. a) If $f:X \to Y$ is uniformly continuous and (x_n) is a cauchy sequence in X, then prove that $f(x_n)$ is a cauchy sequence in Y.

b) Let (X,d_1) be a compact metric space. If f is a function from (X,d_1) to another metric space (Y,d_2) and f is continuous, then prove that f is uniformly continuous.

END OF EXAMINATION.

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS - SEMESTER I, 2000/01

M461 - MULTIVARIATE ANALYSIS

INSTRUCTIONS : Answer any five (5) questions. Calculators are allowed.
Statistical tables will be provided.
TIME ALLOWED: Three (3) hours.

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1. a) Let $\bar{X}$ be the mean of a random sample $X_1,...X_n$ from a p-variate population with mean μ and covariance Σ. Find $E(\bar{X})$ and $cov(\bar{X})$.

b) Let the realizations $x_1,...,x_n$ of the random sample $X_1,.....,X_n$ be arranged in the data matrix X, where x_i is the ith column of X.

Given (n-1) S = $\left(X - \frac{1}{n}X11'\right)\left(X - \frac{1}{n}11'\right)'$, where S is the sample covariance matrix and $1'$ is the n-dimensional row of 1's, show that

$$S = \frac{1}{n-1}X\left(I_{nxn} - \frac{1}{n}11'\right)X'.$$

c) Given the data matrix

$$X = \begin{pmatrix} 1 & 4 & 4 \\ 2 & 1 & 0 \\ 5 & 6 & 4 \end{pmatrix}$$

find S, using the derivation of S from part b.

2. a) Let Σ be a positive definite matrix. If (λ, e) is an eigen value and eigen vector pair for Σ, show that the corresponding pair for Σ^{-1} is $\left(\frac{1}{\lambda}, e\right)$.

b) Let $e_1,\ldots,e_p$ be orthonormal eigen vectors of positive definite matrix Σ corresponding to eigen values $\lambda_1,\ldots,\lambda_p$.

Write spectral decomposition of Σ^{-1}.

c) Let X be distributed as

$N_p(\mu,\Sigma)$ with $|\Sigma| > 0$.

Show that $(X - \mu)'\Sigma^{-1}(X - \mu)$

has a chi-square distribution with p degrees of freedom.

3. a) Let Y and X be subvectors, each 2x1 where

$\begin{pmatrix} Y \\ X \end{pmatrix}$ is $N_4(\mu,\Sigma)$ with

$$\mu = \begin{pmatrix} 2 \\ -1 \\ 3 \\ 1 \end{pmatrix}, \Sigma = \begin{pmatrix} 7 & 3 & -3 & 2 \\ 3 & 6 & 0 & 4 \\ -3 & 0 & 5 & -2 \\ 2 & 4 & -2 & 4 \end{pmatrix}$$

Find the conditional distribution of Y given $X = \begin{pmatrix} 4 \\ 2 \end{pmatrix}$

b) The normal varieties $X' = (X_1,,X_2,X_3)$ and $Y' = (Y_1, Y_2, Y_3)$ are distributed independently with

$$\mu_X = \begin{bmatrix} 2 \\ 2 \\ 2 \end{bmatrix}, \Sigma_x = \begin{bmatrix} 3 & 2 & 1 \\ 2 & 4 & 1 \\ 1 & 1 & 2 \end{bmatrix},$$

$$\mu_Y = \begin{bmatrix} 3 \\ 4 \\ 2 \end{bmatrix}, \sum_Y = \begin{bmatrix} 4 & 2 & 0 \\ 2 & 4 & 2 \\ 0 & 2 & 4 \end{bmatrix}$$

Determine the distribution of $\begin{pmatrix} X - Y \\ X + Y \end{pmatrix}$.

4. a) Observations were made on three subjects for each of the three variables V_1, V_2, V_3. The collected data is arranged in the following data matrix:

$$X = \begin{pmatrix} 1 & 6 & 8 \\ 4 & 2 & 3 \\ 3 & 6 & 3 \end{pmatrix}$$

The investigator is interested in linear combinations $V_1 + V_2 + V_3$ and $V_1 + 2V_2 - 3V_3$. Find the sample means, variances and covariance of the above linear combinations.

b) Measurement on stiffness (X_1) and bending strength (X_2) from a sample of 101 pieces of a particular grade of lumber were taken.
The sample statistics was computed as follows.

$$\bar{X} = \begin{pmatrix} 55.24 \\ 34.97 \end{pmatrix}$$

$$S = \begin{pmatrix} 210.54 & 126.99 \\ 126.99 & 119.68 \end{pmatrix}$$

Test at the $\alpha = 0.01$ level of significance the null hypothesis that the observations came from a population with mean vector $\mu_o = \begin{pmatrix} 60 \\ 50 \end{pmatrix}$

5. a) The joint density function of a random sample $X_1,...,X_n$ from a p-dimensional normal population with mean μ and covariance Σ is expressed as

$$\frac{1}{(2\pi)^{\frac{np}{2}}|\Sigma|^{\frac{n}{2}}} e^{\frac{-1}{2}tr\left[\Sigma^{-1}\left(\sum_{j=1}^{n}(X_j-\bar{X})(X_j-\bar{X})'+n(\bar{X}-\mu)(\bar{X}-\mu)'\right)\right]}$$

Find the maximum likelihood estimate of μ based on the observed sample $x_1,...,x_n$.

b) The results of a psychological test on 10 subjects were recorded as
2.80, 2.70, 4.38, 3.21, 2.73, 2.81, 2.88, 2.90, 3.28, 3.20

construct a Q-Q plot. Determine whether the data seem to be normally distributed.

6. a) i) Define Wishart's distribution
ii) State the sampling distribution of the sample covariance matrix S.

b) A wildlife ecologist measured tail length (in millimetres), body length (cms) and neck diameter (cms) of 20 one year old rabbits.
Computer calculations provide

$$\bar{x} = \begin{pmatrix} 4.640 \\ 45.40 \\ 9.905 \end{pmatrix}, \quad S = \begin{pmatrix} 2.879 & 10.002 & -1.81 \\ & 199.798 & -5.627 \\ & & 3.628 \end{pmatrix}$$

i) Construct one at a time 95% confidence intervals for individual means.
ii) Construct the simultaneous 95%
T^2 - intervals for the individual means.
iii) Construct simultaneous 95% Bonferroni intervals for the individual means.

iv) Compare the three sets of intervals.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY OF EXAMINATIONS - SEMESTER I, 2000/01

M465 - NON-PARAMETRIC STATISTICS

INSTRUCTIONS : Answer any five(5) questions.

TIME ALLOWED: Three (3) hours.

Q.1 a) Data on earnings per share for a random sample of 10 co-operations yielded the following information comparing 1998 and 1999

Co-operation	1	2	3	4	5	6	7	8	9	10
1998	4.6	4.5	2.6	2.9	1.6	0.1	2.5	3.1	2.4	-1.2
1999	4.4	4.1	3.1	4.7	2.3	0.7	4.1	2.5	8.4	1.5

At 0.1 level of significance test whether or not 199 earnings per share exceeded 1998 earnings, on the average.

i) Use the sign test and find the p-value
ii) Use the Wilxoxon signed rank test.

b) A certain manufacturing company has recently been experimenting with a number of new behavioural approaches to management. To determine which of three leading approaches it should adopt throughout the company, it tests each of them in one of three similar factories. The production in units per hour during each week of the experimentation period are:

Approach A	3	7	9	6	2	15					
Approach B	18	14	7	5	11	9	11	12			
Approach C	4	21	11	16	19	23	7	10	17	6	8

At 0.01 level of significance can the company conclude that all three approaches lead to the same production record on the average? If not which approaches are different?

c) Let O_{ij} = the number of observations from the jth sample that exceed the grand median.

O_{2j} = the number of observations from the jth sample that are less or equal to the grand median.

show that $$\frac{N^2}{ab}\sum_{j=1}^{k}\frac{\left(O_{ij}-\frac{n_j a}{N}\right)^2}{n_j}=\frac{N^2}{ab}\sum_{j=1}^{k}\frac{O_{ij}^2}{n_j}-\frac{Na}{b}$$

where $a=\sum_{j=1}^{k}O_{ij}$, $b=\sum_{j=1}^{k}O_{2j}$, $N=a+b$.

Q2. a) Personal income showed strong gains in 1994. The following data compare the percentage increases in personal income for a random sample of companies and organisations in the copperbelt and Lusaka provinces for the first three quarters of 1994.

Copperbelt	11.2	10.4	11.2	9.3	10.7	9.8	12.4	13.4	8.3	12.2
Lusaka	12.1	13.2	15.3	3.9	12.4	10.9	10.5	11.8		

At 0.01 level of significance do the data indicate that personal incomes increased to a greater extent in Lusaka province than in Copperbelt province?

b) Some union executives have testified that employee theft is inversely correlated with the wage rates prevailing in the employee's industry. The wage and theft records for various companies were obtained. The companies were ranked by wage rates, lowest to highest, and compared with the estimated dollar loss due to employee theft in 1996.

Wage Rate (Rank)	1	2	3	4	5	6	7	8	9	10	11	12	13
Employee theft Thousand of dollars	103	104	105	100	102	101	99	100	99	98	100	99	97

At 0.01 level of significance do the results of the study support the union executives' claim that as wage rates increase, employee theft decreases

i) Use Kendal τau
ii) Spearman mark test.

c) A consumer organisation studied the effect of age of motor vehicle owner on amount of cash offer for a used Car by utilizing nine persons in each of three age groups (young, middle elderly) who acted as the owner of a used car. A medium priced three-year old car was selected for the experiment, the offers (in hundred dollars) were:

young	23	25	21	22	21	22	20	23	19
middle	28	27	27	29	26	29	27	30	28
Elderly	23	20	25	21	22	23	21	20	19

Conduct a median test at 0.01 level of significance to find out if age of motor vehicle owner has an effect on the cash offer for a used car.

Q3. a) The inter-arrival times (times between failures) for 15 system failure times are:

5.2 8.4 0.9 0.1 5.9 17.9 3.6 2.5 1.2 1.8 6.1
1.2 3.0 7.6 2.4

Can one conclude that inter-arrival times have an exponential distribution with mean 5 at 0.01 level of significance.

b) A special field version of a laboratory instrument was developed powered by a battery. Three different designs of the battery were tested. Data on the number of operating hours in the field for 12 batteries of each type follow:

Battery Type	1	2	3	4	5	6	7	8	9	10	11	12
A	7.5	10.1	3.8	13.2	10.2	8.3	13.3	4.9	5.7	11.7	6.5	2.7
B	10.9	23.4	6.4	17.4	12.4	11.5	14.1	7.1	14.8	8.4	9.1	11.0
C	6.7	8.1	9.7	5.3	16.4	8.6	7.1	16.7	6.3	22.4	10.5	6.0

Conduct the Kruskall-Wallis rank test to test if the designs are the same at 0.1 level of significance. If the designs are not all the same, which ones are different?

Q4. a) i) Define the test statistic used in a Wilcoxon signed rank test

ii) Derive the mean and variance for the test statistic in (i) above.

iii) For the Kruskall-Wallis test show that

$$\frac{\sum_{j=1}^{k}\frac{R_j^2}{n_j}-\frac{N(N+1)^2}{4}}{\frac{1}{N-1}\left(\sum_{j=1}^{k}\sum_{i=1}^{n_j}R^2(x_{ij})-\frac{N(N+1)^2}{4}\right)}=\frac{12}{N(N+1)}\sum_{j=1}^{k}\frac{R_j^2}{n_j}-3(N+1)$$

If there are no ties.

b) The following table shows the scores made by nine randomly selected student nurses on final examinations in three course areas.

	Student								
Course Area	1	2	3	4	5	6	7	8	9
Fundamentals	98	95	76	95	83	99	82	75	88
Physiology	95	71	80	81	77	70	80	72	81
Anatomy	77	79	91	84	80	93	87	81	83

Test the null hypothesis that student nurses perform equally well in all the three subject areas.

c) In a study on factors thought to be responsible for the adverse effects of smoking on human reproduction, cadmium level determinations were made on placenta tissue of a random sample of 8 mothers who were smokers and an independent random sample of 12 non-smoking mothers. The results were as follows:

Non-smokers:	10.0	8.4	12.8	25.0	11.8	9.8	12.5	15.4	23.5	9.4
Smokers:	30.0	30.1	15.0	24.1	30.5	17.8	16.8	14.8		

Can one conclude at 0.05 level of significance that the distribution of the cadmuim level determinations are the same between smokers and non-smokers (mothers).

Q.5 a) A seed company advertises that each of its seeds has 80% chance of germinating. A detailed analysis of 50 of the company's seed packets, containing four seeds each, gives the following information.

Number of seeds that germinated	0	1	2	3	4
Number of packets	6	4	15	20	5

The company's claim of an 80% germination probability will be substantiated if the number of seeds germinated per packet has a distribution that is binomial with parameters $n = 4$ and $p = 0.80$. Is the company's claim substantiated at 0.05 level of significance.

b) The pesticide residue levels (ppb) in blood samples from two populations of human subjects were collected.

A	15	5	10	12	6	6	9	11	9	14
B	7	11	10	8	2	5	4	5	2	6

Test whether the distribution's of pesticide residue levels in blood for the two populations are the same at 0.1 level of significance.

Q6. a) A road construction company studied the wear characteristics of four different paints at eight locations. The standard, currently used (paint 1), and three experimental paints (2,3,4) were included in the study. The data on the wear follow (the higher the score, the better the wearing characteristics)

	Location							
Paint	1	2	3	4	5	6	7	8
1	11	20	8	30	14	25	43	13
2	13	28	10	35	16	27	46	14
3	10	15	8	27	13	26	41	12
4	18	30	16	41	22	33	55	20

Apply the Friedman's test and do multiple comparison if appropriate, use 0.05 level of significance.

b) The following are the fasting blood glucose levels of a sample of 10 children (ordered)

56 62 63 65 65 65 68 70 72

Can one conclude that these data come from a normal distribution at 0.05 level of significance (the sample mean and standard deviations are 65.1 and 4.43 respectively).

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS SUPPLEMENTARY/DEFFERED
SEMESTER ONE 2000/2001

M911 – MATHEMATICAL METHODS V

INSTRUCTIONS: Attempt any five(5) questions.

TIME ALLOWED: Three (3) hours.

1. Obtain parametric representation **r(u,v)** of the surface

$$4z = x^2 - y^2$$

Given P(3,1,2)

(a) Write down the *unit normal* to the surface at P

(b) Write down the equation of the *tangent plane* at P.

(c) Symmetric equation of *normal line* at P.

2. (a) Define curl of a vector field $\overline{F}$

(b) Let φ be a scalar field. Compute $\text{curl}(\nabla\varphi)$

(c) A vector field $\overline{F}$ is said to be irrotational if curl $\overline{F} = 0$. Determine whether

$$\overline{F} = 2xz\mathbf{i} + (x^2 - y)\mathbf{j} + (2z - x^2)k$$

is irrotational.

3. (a) Obtain all relative extrema of the surface

$$f(x,y) = xy - x^3 - y^2$$

and classify their nature

(b) Find the length of the curve

$$x = 4\cos t \quad y = 4\sin t \quad z = 3t$$

from point $(4,0,0)$ to $(4,0,6\pi)$

4. Consider the function

$$f(x,y) = 2x^2 - 4xy + y^4 + 2$$

defined over the square region R: $-2 \leq x \leq 2, \quad -2 \leq y \leq 2$

(a) Find (i) the relative expemum of f on each edge of R.

(ii) the relative expemum of f over R.

(b) Hence determine the maximum and minimum values(s) of f over R

5. Consider the coordinate system

$$x = uv\cos\theta \quad y = uv\sin\theta \quad z = \frac{1}{2}\left(u^2 - v^2\right)$$

(a) Compute (i) scale factors h_u, h_v, h_θ
(ii) unit vectors e_u, e_v, e_θ

(b) Write down i, j k in terms of e_u, e_v, e_θ

6. Given a surface representation

$$z = \frac{x}{a^2} + \frac{y^2}{a^2}$$

(i) Obtain parametric representation of the surface.
(ii) Compute the square, ds^2, of the linear arc element
(iii) Write down the integral (do not evaluate it) for the surface area.

END OF EXAMINATIONS

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATIONS - SEMESTER 1, 2000/01

M941 - STRUCTURED COMPUTER ORGANISATION

INSTRUCTIONS: There are six (6) questions in this paper. Attempt any five (5) questions. All questions carry equal marks.

TIME ALLOWED: 3 Hours.

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1. a) Describe and distinguish the following:-

   i) Instruction Register
   ii) Program Counter
   iii) Address Register
   iv) Data Register

   b) What is read only memory (ROM) used for?

   c) Suppose you were going to store a mailing list on magnetic tape with a density of 1600 characters per inch and inter-record gaps of one inch. If each entry (consisting of a name, address, city, state and zipcode) totals 100 characters, what blocking factor should you use to waste only half of the tape to inter-record gaps? What if you were willing to waste only one-third of the tape?

   d) In error control coding, codes can either correct or simply detect error. Explain and distinguish two commonly used approaches in error control.

2. a) Define the following terms:-

   i) Processor
   ii) ALU
   iii) Cache
   iv) Control unit

   b) Discuss the characteristics of RAM.

c) Devise a Huffman code for the symbols $x_1, x_2, \ldots x_6$ based upon the following frequencies.

x_i	$p(x_i)$
x_1	0.4
x_2	0.30
x_3	0.2
x_4	0.04
x_5	0.04
x_6	0.02

d) A bridge is designed for use between LANs that use identical protocols for the physical and link layers. Give four reasons why a bridge would be used in a situation like this instead of simply having one large LAN.

3. a) Explain the meaning of these terms:-

i) LAN
ii) OSI model
iii) Baud
iv) CSMA\CD

b) Why was the OSI model created?

c) You are a Network Administrator for Zambian Telecom Company and you wish to implement a Star LAN in your premises. What would be the advantages and disadvantages (one of each) of using each of the following:-

i) Twisted-Pair
ii) Optical Fibre
iii) Coaxial Cable
iv) Wireless infrared

d) State the nature of analogue signals and contrast then with digital signals and give an example of each.

4. a) Define the following terms:-

i) Modulation
ii) Digital Repeater
iii) Duplex
iv) Packet

b) Give two main functions of a repeater.

c) List and briefly distinguish three widely implemented LAN topologies.

d) A simplex line is capable of transmitting data in one direction. Why is this configuration rarely used by computers?

5. a) Define the following terms as applied to Operating Systems;-

i) Scheduler
ii) Processor
iii) Dispatcher
iv) Allocator

b) An operating system may be classed as a human/machine interface. Discuss.

c) Suppose you are asked to develop an operating system for a personal computer with an expected life of 5 years. What might be the relative importance of the various requirements described below. Which of these requirements would be different for an operating system for a large mainframe with a market life of 20 years?

i) Performance
ii) Protection and security
iii) Maintainability
iv) Standards
v) Small-size

d) From an editor's point of view, why is it convenient to have the computer's memory divided into cells of byte sizes?

6. a) What is the function of each of the following devices:-

i) Hub
ii) Router
iii) Modern
iv) Parity bit

b) List five(5) activities of a typical operating system.

c) Consider a family-owned-and-operated mail-order business that operates out of a converted garage where two family members fill each day's orders. The business obtains orders by running large impressive magazine adverts. It is incorporated, has its own letter-head and handles all its sales through the mail. With this arrangement, a customer's image of the business is likely to be quite different from the reality. The fact that this virtual business is not the same as the actual one is not important so long as the system continues to function like the virtual business from the customer's point of view construct a table contrasting the virtual and real characteristics of the mail-order business.

d) To keep up with user files and utility software, the operating system must keep records in files of its own. Why should these files be stored on disk instead of on tape?

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY OF EXAMINATIONS - SEMESTER I, 2000/01

M981 - NUMERICAL ANALYSIS I

INSTRUCTIONS : There are seven (7) questions in this paper. Attempt ANY (5) questio
All questions carry equal marks.

TIME ALLOWED: Three (3) hours.

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1. The amount of a particular radioactive element decreases with time according to the equation $N(t) = N_0 e^{-\lambda t}$ where N(t) is the number of atoms left at time t if the origi number at $t = 0$ is N_o. The decay constant is λ. The half-life of the decay is defin to be $T = \ln(2)/\lambda$. The data below have been measured for a particular type radioactive hydrogen atom. Fit the data to an equation of the form $N(t) = \alpha e^{\beta t}$ a determine the half-life and the original number of atoms present.

i	1	2	3	4	5
T(month)	0.0	10.0	20.0	40.0	80.0
N	1.41×10^{18}	1.35×10^{18}	1.29×10^{18}	1.17×10^{18}	9.72×10^{17}

2. a) Derive a Newton-Raphson iteration formula for finding the cube root of a positive number c.

   b) Use Newton-Raphson method to find a positive solution of $2\sin x = x$.

3. a) Find a solution of $f(x) = x^3 + x - 1$ by fixed-point theorem

   One root of the quadratic $x^2 + x - 1$ is at $x = 0.6180$. The form

   b) $$x = \frac{1}{x+1}$$

   converges to this root for $x_0 = 1$. How many iterations of the fixed-po method are required to get the root to within 10^{-5}.

4. a) Write an algorithm for the Simpson's rule for finding the value of an integral over the interval [a,b] partitioned into n subintervals (n even).

b) Evaluate $J = \int_0^1 e^{-x^2} dx$ by Simpson's rule with $2n = 10$ and find error bound for this evaluation.

5. a) For $x \in [-1,1]$, chebyshev polynomials are given by

$$T_n(x) = \cos(n \arccos x)$$

Derive the recurrence relationship $T_{n+1}(x) = 2xT_n(x) - T_{n-1}(x)$ for $n \geq 1$

b) Find the value of the integral

$$\int_0^{\pi/4} (\cos x)^2 dx$$

using Gaussian quadrature four point integration (n=4)

(Use the attached table)

6. a) Calculate the n^{th} divided difference of $f(x) = 1/x$

b) The following data has been experimentally collected:-

t	0.2	0.4	0.6	0.8	1.0
f(t)	0.9798652	0.9177710	0.8080348	0.6386093	0.384373

Use methods of $0(h^2)$ to approximate $f'(0.2)$ $f'(0.6)$, $f'(1.0)$

7. a) Determine an appropriate stepsize to use, in the construction of a table of $f(x) = (1+x)^6$ on [0,1]. The truncation error for linear interpolation is to be bounded by 5×10^{-5}.

b) Fit a cubic through the first four points to the data in the table and find the value of the function at $x = 3.0$.

x	3.2	2.7	1.0	4.8	5.6
f(x)	22.0	17.8	14.2	38.3	51.7

END OF EXAMINATION

n	Roots $r_{n,i}$	Coefficients $c_{n,i}$
2	0.5773502692	1.0000000000
	−0.5773502692	1.0000000000
3	0.7745966692	0.5555555556
	0.0000000000	0.8888888889
	−0.7745966692	0.5555555556
4	0.8611363116	0.3478548451
	0.3399810436	0.6521451549
	−0.3399810436	0.6521451549
	−0.8611363116	0.3478548451
5	0.9061798459	0.2369268850
	0.5384693101	0.4786286705
	0.0000000000	0.5688888889
	−0.5384693101	0.4786286705
	−0.9061798459	0.2369268850

The University of Zambia
Physics Department
University Examinations 2000/2001
P-191 : Introductory Physics - I

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

Time : Three Hours. **Maximum Marks : 100.**

Do not forget to write your computer number clearly on the answer script !!

Wherever necessary use :

$g = 9.8 m/s^2$: $P_A = 1.01 \times 10^5 N/m^2$: 1 cal. = 4.18 J : $\rho_{water} = 1000 kg/m^3$
specific heat of H_2O = 4180 J/kg.^{0}C : 1 Pascal = 1 N/m^2

Some equations you may find useful :

$v_f = v_o + at$: $v_f^2 = v_o^2 + 2ax$: $x = v_o t + (1/2)at^2$: $W = mg$: $x = v_{avg.} t$: $p = mv$

$f = \mu F_N$: $Ft = m(v_f - v_o)$: work = $Fs\cos\theta$: kinetic energy = $(1/2)mv^2$: $Ft = \Delta p$

gravitational potential energy = mgh : $v_{avg.} = (1/2)(v_o + v_f)$: power = work/time

$\Delta PE + \Delta KE + \Delta TE = 0$: $F = ma$: $P = Fv$: $R = (2u^2 \sin\theta \cos\theta)/g$: $t = 2u \sin\theta/g$

$v_T = \omega r$: $\omega_f = \omega_0 + \alpha t$: $\omega_f^2 = \omega_0^2 + 2\alpha\theta$: $\theta = \omega_0 t + (1/2)\alpha t^2$: $p = mv$: $F_C = mv^2/r$

$a_T = \alpha r$: $L = I\omega$: $\tau = I\alpha = Fr$: kin. $energy_{total} = (1/2)mv^2 + (1/2)I\omega^2$: $I = \Sigma mr^2$

kin. $energy_{rot.} = (1/2)I\omega^2$: $F = (Gm_1 m_2)/r^2$: $Y = (F/A)/(\Delta L/L_0)$: $B = -\Delta P/(\Delta V/V_0)$

$W_{app.} = mg - B.F.$: $P = \rho gh$: $W_{app.} = W[1 - \rho_{fl.}/\rho]$: $F = -kx$: $Q/\Delta t = (kA\Delta T)/\Delta L$

$[(1/2)mv^2]_{avg.} = (3/2)kT$: $\Delta Q = mc\Delta T = nC\Delta T$: $\Delta L = \alpha L \Delta T$: $\Delta V = \gamma V \Delta T$: $\Delta W = P.\Delta V$

$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$: $Q = \Delta U + W$: $\Delta W = nRT.\ln(V_f/V_i)$: $PV = nRT$: $f = 1/\tau$: $\omega = 2\pi f$

$I_1\omega_1 = I_2\omega_2$: $\Delta T.E. = f.s$: area of a sphere = $4\pi r^2$: area of a right cylinder = $2\pi rL$

$a_{max} = kx_0/m$: $a_c = \omega^2 x_0$: $P.E. = (1/2)kx^2$: $(1/2)kx^2 + (1/2)mv^2 = (1/2)kx_0^2$

$a = -kx/m$: $\omega = \sqrt{(k/m)}$: $v = \pm\sqrt{[(k/m)(x_0^2 - x^2)]}$: $v = \sqrt{(Y/\rho)}$: $v = \sqrt{(T/(m/L))}$

$v = \sqrt{(B/\rho)}$: $f = (1/2\pi)\sqrt{(k/m)}$: $f = (1/2\pi)\sqrt{(g/L)}$: $v = \sqrt{(\gamma RT/M)}$: 0 K = 273^{0}C

1 metric ton = 1000kg : $x = x_0 \cos(\omega t)$: 1 rev = $360^0 = 2\pi$ radians

Question 1 : Use the answer sheet provided. DO NOT guess the answer. For each correct answer, 2 marks. For each wrong answer, (2/3) will be deducted. No answer, zero mark. No deduction of marks for not attempting. Minimum total mark for Question 1 is zero. [10 × 2 = 20]

(A) The resultant of two vectors is a maximum when the angle between them is :

(a) 0^0 (b) 180^0
(c) 90^0 (d) 120^0

(B) An airplane requires 20s and 400m of runway to become airborne, starting from rest. Its velocity when it leaves the ground is :

(a) 32m/s (b) 80m/s
(c) 40m/s (d) 20m/s.

(C) A projectile is fired at an angle of 25^0 to the horizontal with a certain speed v. If another projectile is fired with the same speed v, then to have the same range as the first projectile, its angle of projection (different from the first angle) will have to be :

(a) 12.5^0 (b) 75^0
(c) 65^0 (d) it is not possible.

(D) Under conditions corresponding to its triple point, a substance :

(a) is in the solid state
(b) is in the gaseous state
(c) is in the liquid state
(d) may be in any or all of the above states.

(E) A type of process that does not need outside energy to reverse is one that takes place at constant :

(a) volume (b) pressure
(c) speed (d) temperature.

(F) A steel wire of length 2m and cross sectional area 0.80×10^{-6} m^2 has Young modulus of 2.0×10^{11} Pa. The upper end of the wire is fixed and a load of 4N is tied at the other end. The extension in mm of the wire is :

(a) 0.002 (b) 0.05
(c) 0.50 (d) 1.00.

(G) At the olympic high-diving competition, a diver from the top board curves her body in order to :

(a) increase her speed (b) spin more slowly
(c) dive cleanly into water (d) spin more.

(H) The volume of a gas is held constant while its temperature is raised. The pressure the gas exerts on the walls of its container increases because :

(a) the molecules have higher average speeds and strike the wall more often
(b) the masses of the molecules increase
(c) the molecules are in contact with the wall for a shorter time
(d) each molecule loses more kinetic energy when it strikes the wall.

(I) In the operation of a hydraulic press, it is impossible for the output piston to exceed the input piston's :

(a) force (b) displacement
(c) work (d) speed.

(J) When equal and opposite forces are exerted on an object along different lines of action, the object is said to be under :

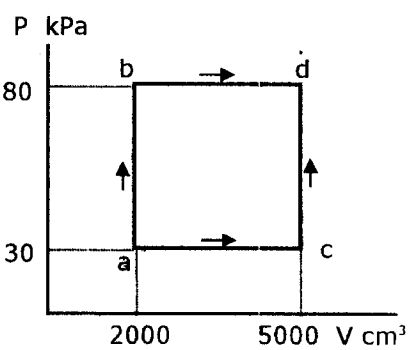
(a) compression (b) shear
(c) tension (d) elasticity.

Attempt any four questions from the following :

Q2. (a) Vector **A** of magnitude 10N makes an angle of 30^0 clockwise with the positive y-axis, while vector **B** of magnitude 15N makes an angle of 53^0 anti-clockwise with the negative x-axis. A third vector **C** of magnitude 20N makes an angle of 135^0 anti-clockwise with the positive x-axis. They all act at the same point. Find the magnitude and direction of the vector **A – B + C.** [8]

(b) Figure shows a thermodynamic process in which during the part ab, 600J of heat is added to the system, and in the part bd, 200J of heat is added. Find :

(i) The change in internal energy U in the part ab,
(ii) The change in internal energy U in going through abd, and
(iii) The total heat added in going through acd. [8]

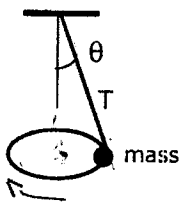


(c) Write short notes on isothermal and adiabatic processes. [4]

Q3. (a) A car moving with a constant acceleration covers the distance between two points 54m apart in 6 seconds. Its speed as it passes the second point is 13.5m/s.

(i) Find its speed at the first point.
(ii) Find its acceleration.
(iii) At what distance before the first point was the car at rest ? [9]

(b) A string of length 30cm has one end attached to a fixed point and the other to a mass of 100g which revolves in a horizontal circle 80 times per minute. Calculate (i) the angle of inclination θ of the string to the vertical, and (ii) the tension T in the string. [11]

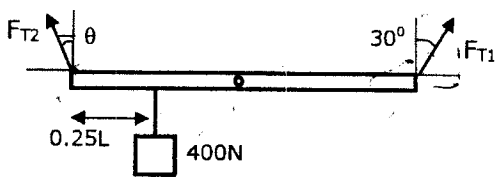


Q4.(a) A particle of mass *m*, moving with a velocity *u* makes a head-on elastic collision with a particle of mass *2m* initially at rest. Calculate the final kinetic energy of the particle of mass *m* in relation to its initial kinetic energy. What fraction of the initial kinetic energy has it lost in the collision ? [10]

(b) A glass tube is bent into a U-shape and water is poured into the tube until it stands 15cm high in each side. A 3cm column of alcohol is slowly poured into one side; the two liquids do not mix. How far will the water column in the other side rise ? Given, density of alcohol = 720kg/m^3. [7]

(c) Differentiate clearly between elastic and inelastic collisions. [3]

Q5. (a) The uniform 120N board of length L is supported by two ropes as shown. A 400N weight is suspended one-quarter of the way from the left end. Find the tensions F_{T1} , F_{T2} and the angle θ made by the left rope with the vertical. [11]



(b) A glass rod and a steel rod are of equal length at 0°C. At 100°C they differ in length by exactly 0.001m. What were the lengths at 0°C ?
(Given α_{glass} = 0.000008/°C and α_{steel} = 0.000012/°C). [7]

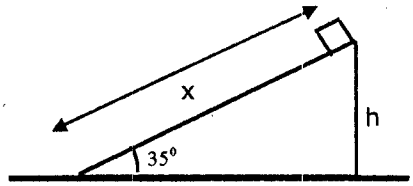
(c) Write a short note on coefficient of linear thermal expansion. [2]

Q6.(a) A wheel of moment of inertia 20kg.m^2 about its axis is rotated from rest about its centre by a constant torque τ, and the energy gained in 10 seconds is 360J. Calculate (i) the angular velocity at the end of 10 seconds, and (ii) the value of τ. (iii) If τ is removed at 10s and a constant opposing torque of 4N.m is then applied to the wheel, calculate the number of revolutions made by the wheel before coming to rest. [9]

(b) How deep is a pond if bubbles forming at the bottom triple their size in rising to the top. The temperature at the bottom is taken to be 10°C, and that at the surface to be 25°C. [7]

(c) Write short notes on moment of inertia and radius of gyration. [4]

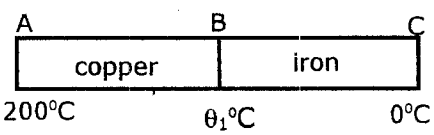
Q7. (a) A block takes twice as long to slide down an inclined plane of length x that makes an angle of 35° with the horizontal, as it does to fall freely through the same vertical distance
h. What is the coefficient of kinetic friction of the plane? [9]



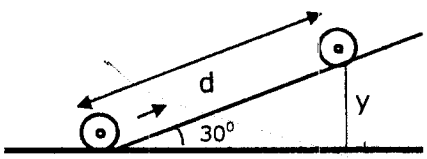
(b) A reversible heat engine takes in heat from a reservoir at 527°C and gives out heat to the sink at 127°C. How many calories per second must it take from the reservoir in order to produce useful mechanical work at the rate of 750 watts ? [7]

(c) State in a few sentences the difference between a heat engine and a refrigerator. [4]

Q8. (a) A bar of length 30cm and uniform cross section 5cm^2 consists of two halves, AB of copper, and BC of iron welded together at B. The end A is maintained at 200°C and the end C at 0°C, and the sides are thermally insulated. Find the rate of flow of heat along the bar when steady state has been reached.
(thermal conductivities are :
copper : 400W/m.K, iron : 50W/m.K) [10]



(b) A disk is made to roll without slipping up an incline making 30° with the horizontal. If the speed at the bottom of the incline was 2m/s, how high up the incline will the disk travel before rolling back down again. Neglect rolling friction. **Use the "energy method".**
Given, moment of inertia of a disk = (1/2)MR^2 [8]



(c) State the work-energy theorem. [2]

— End of Examination —

UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT

UNIVERSITY EXAMINATIONS 2000/2001

P251
CLASSICAL MECHANICS I

INSTRUCTION: Answer only four (4) questions in total. All questions carry equal marks, with the marks for each part of the question given indicated by the numbers in parentheses

DURATION: Three (3) Hours

MAXIMUM MARKS: 100%

Use, where necessary:

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

Rectangular to spherical coordinates:

$$x = r\sin\theta\cos\varphi, \quad y = r\sin\theta\sin\varphi, \quad z = r\cos\theta$$

Coefficient of restitution, $\varepsilon = \dfrac{|v_2' - v_1'|}{|v_2 - v_1|}$

Energy loss, $Q = \dfrac{1}{2}\mu v^2(1-\varepsilon^2)$ where $\mu = \dfrac{m_1 m_2}{m_1 + m_2}$ and $v = |v_2 - v_1|$

Laboratory to center of mass transformation: $\tan\phi_1 = \dfrac{\sin\theta}{\gamma + \cos\theta}$ where $\gamma = \dfrac{v_{cm}}{\bar{v}_1'}$

Q1. (a). (i) Show that if all the components of a vector are reversed in direction, then the vector itself is reversed in direction. (3 Marks)

(ii) Show that if the components of a vector product are all reversed, then the vector product is not changed. (6 Marks)

(iii) Is a vector product, then, a vector? (3 Marks)

(b). The scalar (dot) product of two vectors $\mathbf{A} \bullet \mathbf{B}$, is equal to $AB \cos \theta_{AB}$, where θ_{AB} is the angle between the vectors.

(i) By expressing the vectors in terms of their Cartesian components, show that

$$\cos\theta_{AB} = \frac{A_x B_x + A_y B_y + A_z B_z}{AB}$$ (5 Marks)

(ii) By using the relation between rectangular and spherical coordinates show that the angle θ_{12} between the radii to two points (R, θ_1, φ_1) and (R, θ_2, φ_2) on a sphere is given by

$$\cos\theta_{12} = \cos\theta_1\cos\theta_2 + \sin\theta_1\sin\theta_2 \cos(\varphi_2 - \varphi_1).$$

(10 Marks)

[*Note*: The distance between the two points as measured along the great circle that passes through them is equal to $R\theta_{12}$, where θ_{12} is expressed in radians. This can be used, for example, to calculate mileages between points on the earth's surface.]

Q2. (a). (i) Can there be motion in two dimensions with acceleration in only one dimension? Explain. (4 Marks)

(ii) What happens to our kinematic equations under the operation of time reversal, that is, replacing t by $-t$? Explain. (6 Marks)

(b). The position of a particle moving along the x-axis depends on the time according to the relation

$$x = \frac{v_{xo}}{k}(1 - e^{-kt})$$

in which v_{xo} and k are constants.

(i) Sketch a curve of x versus t, and find the total distance through which the particle moves. (5 Marks)

(ii) Show that the velocity v_x is given by

$$v_x = v_{xo} e^{-kt}$$

so that the velocity decreases exponentially with time from its initial value of v_{xo}, coming to rest only in infinite time. (4 Marks)

(iii) Show that the acceleration a_x is given by

$$a_x = -k v_x$$

so that the acceleration is directed opposite to the velocity and has a magnitude proportional to speed. (4 Marks)

(iv) This particular motion is one with variable acceleration. Give a plausible physical argument explaining how it can take an infinite time to bring to rest a particle that travels a finite distance. (2 Marks)

Q3. (a). A horizontal force acts on a mass which is free to move. Can it produce an acceleration if the force is less than the weight of the mass? (5 Marks)

(b). The resistance of the air to the motion of bodies in free fall depends on many factors, such as the size of the body and its shape, the density and temperature of the air, and the velocity of the body through the air. A useful assumption, only approximately true, is that the resisting force $\mathbf{F}_R$ is proportional to the velocity and oppositely directed; that is, $\mathbf{F}_R = -k\mathbf{v}$, where k is a constant whose value in any particular case is determined by factors other than velocity. Now consider free fall of an object from rest through the air.

(i) Show that Newton's second law gives

$$mg - kv = ma \quad \text{or} \quad mg - k\frac{dz}{dt} = m\frac{d^2z}{dt^2}.$$ (3 Marks)

(ii) Show that the body ceases to accelerate when it reaches a velocity

$$v_t = mg/k$$

called the terminal velocity. (3 Marks)

(iii) Prove that the velocity varies with time as

$$v = v_t(1 - e^{-kt/m})$$

and sketch the curve of v versus t. (7 Marks)

(iv) Sketch qualitatively curves of z versus t and a versus t for this motion, noting that the initial acceleration is g and the final acceleration is zero. (7 Marks)

Q4. (a). (i) Can a body have energy without having momentum? Explain. (4 Marks)

(ii) Can a body have momentum without having energy? Explain. (4 Marks)

(b). A particle of mass m moves according to the equations

$$x = x_o + at^2$$
$$y = bt^3$$
$$z = ct$$

(i) Find the angular momentum $\mathbf{L}$ at any time t. (6 Marks)

(ii) Find the force $\mathbf{F}$, and from it, the torque $\mathbf{N}$ acting on the particle. (8 Marks)

(iii) Verify that the angular momentum theorem ($d\mathbf{L}/dt = \mathbf{N} = \mathbf{r} \times \mathbf{F}$) is satisfied. (3 Marks)

Q5. (a). Can a satellite move in a stable orbit in a plane not passing through the earth's center? Explain. (5 Marks)

(b). The elliptic orbit of an earth satellite has major axis $2a$ and minor axis $2b$. The distance between the earth's center and the other focus is $2c$. the period is T.

(i) Verify that $b = (a^2 - c^2)^{1/2}$. (5 Marks)

(ii) Consider the satellite at perigee ($r_o = a - c$) and the apogee ($r_1 = a + c$). At these two points, its velocity vector and its radius vector are at right angles. Verify that conservation of energy implies that

$$\frac{1}{2}mv_o - \frac{GMm}{a-c} = \frac{1}{2}mv_1 - \frac{GMm}{a+c} = E$$ (5 Marks)

(iii) Verify also that conservation of angular momentum implies that

$$\frac{\pi ab}{T} = \frac{1}{2}(a-c)v_o = \frac{1}{2}(a+c)v_1$$ (5 Marks)

Q6. (a). Two clay balls of equal mass and speed strike each other head-on, stick together, and come to rest. Kinetic energy is certainly not conserved. What happened to it? Is momentum conserved? (4 Marks)

(b). A proton of mass m_p with initial velocity $\mathbf{v}_o$ collides with a helium atom, mass $4m_p$, that is initially at rest. If the proton leaves the point of impact at an angle of 45° with its original line of motion,

(i) find the final velocities of each particle, assuming that the collision is perfectly elastic. (7 Marks)

(ii) Work out the above problem for the case that the collision is inelastic and that Q is equal to 1/4 of the initial kinetic energy of the proton. (7 Marks)

(iii) Find the scattering angle of the proton in the center-of-mass system. (7 Marks)

********** THE END OF EXAM **********

Q.4 (a) Show that Kirchhoff's rules for current at a junction and voltage around a closed circuit, respectively, express

(i) Conservation of electric charge. [3]

(ii) Conservation of energy required to move charge around the circuit. [2]

(b) Find the effective resistance between points a and b of an infinitely long ladder of resistors of Figure **2** each having resistance R.

[6]

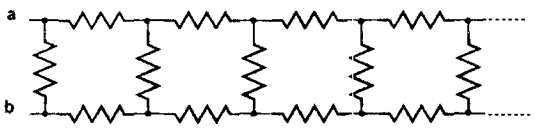


Figure 1

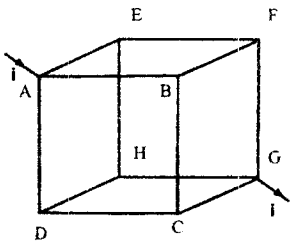


Figure 2

(c) Twelve equal wires each of resistance r are joined up to form a cubic frame. A current enters one corner and leaves at the other diagonally opposite corner as shown in Figure 2. Find

(i) the equivalent resistance of the skeletal cube. [6]

(ii) the current through the battery if a battery of 1.5 volt is connected across the points A and G and assuming each wire segment to have a resistance of 1Ω.

[3]

Q.5 A straight wire AB carries a current i (Figure 3)

(a) Prove that the magnetic field at a distance r from the wire is $H = \frac{i}{4\pi r}(\sin\alpha + \sin\beta)$ where α and β are the angles made by PA and PB, respectively, with the normal PM from P. [12]

(b) Hence deduce that for a very long wire the magnetic field at P is [3]

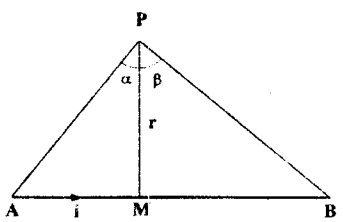


Figure 3

$$H = \frac{i}{2\pi r}$$

(c) Using the result obtained in part (a) show that the magnetic field at the centre of a square of length of side a carrying a current i is [5]

$$H = \frac{2\sqrt{2}i}{\pi a}$$

Q.6 (a) What is magnetic flux and how does it differ from the magnetic field density? [3]

(b) Explain why it is possible to induce an e.m.f. in a conductor by moving it in a magnetic field. [3]

(c) A square coil of wire of length of side l consisting of N turns is rotated at a constant angular speed ω with its axis perpendicular to a magnetic field $\vec{B}$. If the resistance of the coil is R, find,

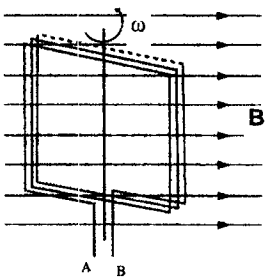


Figure 4

(i) The magnetic flux linking the coil at any time t. [5]

(ii) The induced e.m.f. measured at the terminals AB. [4]

(iii) The current circulating in the loop. [2]

(iv) Sketch a diagram, on a common axis, showing the magnetic flux and induced e.m.f as a function of time. [3]

Q.7 A circuit has a resistance R; an inductance L and a capacitance C all connected in series with a sinusoidal source of e.m.f. of amplitude V_0 and frequency f.

(a) Show that the equation governing the flow of current is

$$L\frac{d^2i}{dt^2} + R\frac{di}{dt} + \frac{i}{C} = j\omega V_0 e^{j\omega t}$$

where $j^2 = -1$, t is the time and $\omega = 2\pi f$. [6]

(b) Show that the impedance of the circuit is

$$Z = R + j(\omega L - 1/\omega C)$$ [6]

(c) Show that the current in the circuit can be expressed as

$$i = i_0 e^{j(\omega t - \phi)}$$

where $i_0 = V_0/|Z|$ and $\phi = tan^{-1}\left(\frac{\omega L - 1/\omega C}{R}\right)$ is the phase angle [8]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

PHYSICS DEPARTMENT

UNIVERSITY EXAMINATIONS
JANUARY, 2001

P341, INTRODUCTORY ELECTRONICS AND ELECTRICAL MEASUREMENTS.

INSTRUCTIONS: ANSWER ANY FOUR (4) QUESTIONS ONLY. ALL QUESTIONS ARE OF EQUAL MARKS.

TIME ALLOWED: THREE (3) HOURS.

Q1 (a) A sinusoidal signal has a value of -5 A at time $t = 0$ and reaches its first maximum (negative) of -10 A at $t = 2$ ms. Write the equation for $i(t)$ **and** predict the value of the current, i, at $t = 5$ms. [6]

(b) (i) Using j notation, calculate the equivalent impedance of the circuit shown in figure 1 at a frequency of 100Hz. [5]

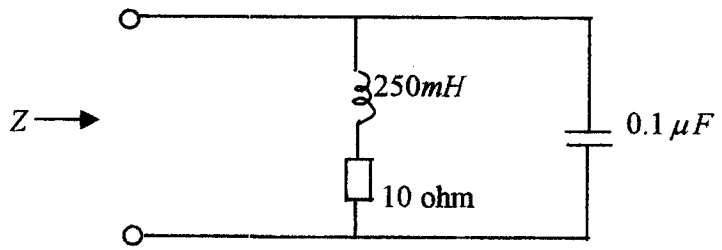


Figure 1

(ii) Given that $I_a = -4$A, $I_c = 1$ A, and $v = 18$ volts, determine i_1, i_2, and I_b, figure 2. [7]

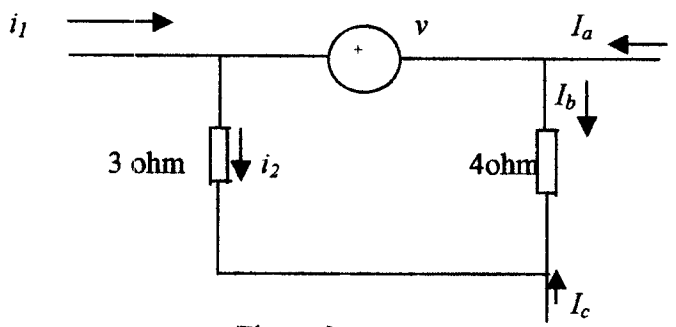


Figure 2

(c) In figure 3, $i_1 = 10e^{-2t}$ A, $i_2 = 4$ A, and $v_c = 3e^{-2t}$ volts. Determine i_L and v_L. [7]

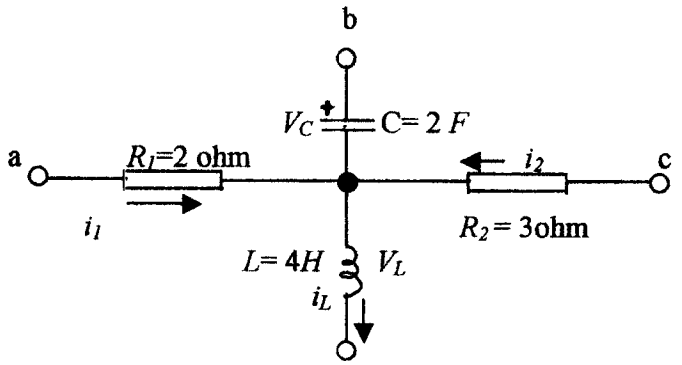


Figure 3

Take $R_1 = 82\,K\Omega$
$R_2 = 15\,K\Omega$
$R_3 = 3.3K\Omega$
$R_4 = 1\,K\Omega$

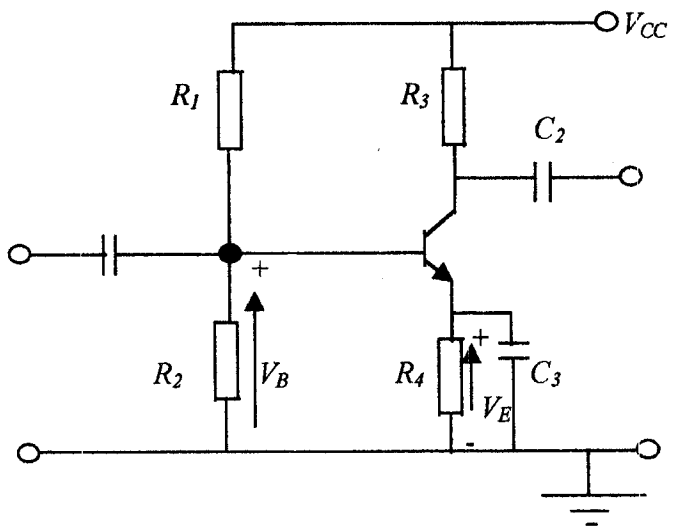


Figure 5

Q5 (a) (i) Distinguish between the following:
- "Negative" and "Positive " feedback
- "Open" and "Closed" loop gains as applied to operational amplifiers [5]

(iii) The self-biasing circuit for decreasing the effect of β or temperature on the operating point of a transistor is essentially a feedback device. Using a well labelled diagram, explain how this works [5]

(b) (i) State four(4) desirable effects of applying negative feedback in op amps [4]

(ii) An amplifier with an initial gain (i.e.open loop gain) A_{OL}= 1000 undergoes a 10% reduction in the gain when a faulty transistor is replaced. Predict the stabilising effect of a feedback loop where β= -0.009 [4]

(c) (i) State five characteristics of an ideal operational amplifier (op amp) [5]

(ii) What is the distinction between the "non-inverting" and "inverting" inputs to an op amp? [2]

Q6 (a) (i) Explain the reason why the JFET is referred to as a "*unipolar*" transistor while its counter-part the BJT is referred to as a "*bipolar*" junction transistor [2]

(ii) A junction FET has the data given in the table below:

Drain Current (*mA*)				
Drain-Source voltage	Gate-Source Voltage			
V_{DS} (*V*)	V_{GS}=0 *V*	=-1 *V*	= -2*V*	= - 3*V*
0	0	0	0	0
4	7	5.0	2.4	0.3
8	10.1	5.9	2.7	0.35
12	10.2	6.2	2.9	0.4
16	10.25	6.3	3.0	0.45
20	10.3	6.35	3.05	0.50
24	10.35	6.4	3.1	0.55

- using the graph paper provided, plot the drain characteristics and hence determine mutual conductance, g_m of the device at V_{DS} = 12 volts [7]
- calculate the drain - source resistance r_d for V_{GS} = -2 *V* [3]
- is the FET *n* or *p* channel? [1]

(b) (i) Explain why thermal run-away is not a problem with a FET. [2]

(ii) The maximum gate current $I_{G(MAX)}$ for a particular type of JFET is 200*nA*, (or 2 x 10^{-9} *A*). Calculate its input resistance when V_{GS} = 2 volts [3]

(c) (i) The MOSFET in figure 6 is to be used as an elementary amplifier, draw an appropriate circuit showing bias voltages V_{GG}, V_{DD} and the load resistor R_L. [3]

(ii) For V_{DD} = 12 *V*, V_{GG} = 8*V*, and R_L = 2*K*Ω, determine the quiscent drain current. [4]

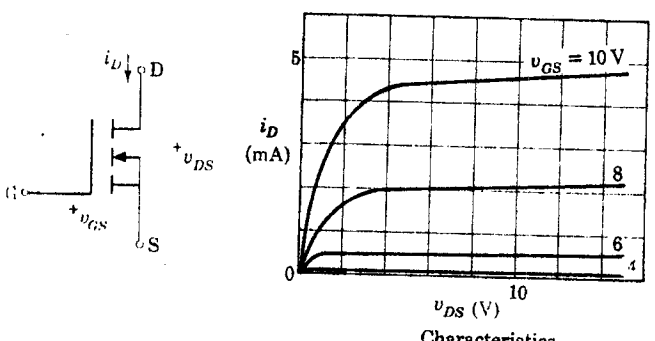


Figure 6 Characteristics

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

Physics Department

UNIVERSITY EXAMINATIONS –2000/2001

P261

Electricity and Magnetism

TIME: THREE (3) HOURS

ATTEMPT ANY FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

MARKS ARE INDICATED AGAINST EACH QUESTION.

Data

Speed of light in vacuum: $c = 3\times10^{8}\text{ms}^{-1}$ Electron rest mass, $m_0 = 9.11\times10^{-31}\text{kg}$

Positron rest mass: $m_0 = 9.11\times10^{-31}\text{kg}$ Electron charge, $-e = 1.602\text{x}10^{-19}\text{C}$

Avogadro's number: $N_A = 6.023\times10^{26}\text{kmole}^{-1}$

Permittivity of free space, $\varepsilon_0 = 8.854\times10^{-12}\text{C}^2\text{N}^{-1}\text{m}^{-2}$

Permeability of free space, $\mu_0 = 4\delta\times10^{-7}\text{NA}^{-2}$

Formulas

$$\vec{E} = \frac{Q}{4\pi\varepsilon_0 r^2}\hat{r} \qquad \vec{F} = q\vec{E} \qquad \vec{D} = \varepsilon_0\vec{E} \qquad \int_S \vec{D}\cdot d\vec{S} = Q$$

$$\vec{H} = \vec{u}\times\vec{D} \qquad \vec{B} = \frac{\vec{u}\times\vec{E}}{c^2} \qquad d\vec{H} = \frac{I}{4\pi r^2}ds\times\hat{r} \qquad \oint\vec{H}\cdot d\vec{l} = I$$

$$\vec{F} = q\vec{v}\times\vec{B} \qquad \vec{F} = \frac{\mu_0 I_1 I_2}{4\pi r^2}d\vec{l}_1\times d\vec{l}_2\times\hat{r}$$

$$\varphi = BA \qquad L = \frac{N\varphi}{i} \qquad v = -\frac{d\varphi}{dt} \qquad v = -L\frac{di}{dt}$$

$$L = L_1 + L_2 \pm 2M \qquad U = \tfrac{1}{2}L_1 i_1^2 + \tfrac{1}{2}L_2 i_2^2 + M_1 M_2 i_1 i_2$$

$$R = \rho\frac{l}{A}$$

$$R_A = \frac{R_3 R_1}{R_1 + R_2 + R_3} \qquad R_B = \frac{R_1 R_2}{R_1 + R_2 + R_3} \qquad R_C = \frac{R_2 R_3}{R_1 + R_2 + R_3}$$

$$Z = R + j(\omega L - \frac{1}{\omega C})$$

Q.1 (a) Can electric lines of force ever intersect? Explain your answer with the aid of a suitable diagram. [3]

(b) Is it possible for an electrostatic potential at a point to be zero, while there is a finite electric field at that point? Explain. [3]

(c) Write down the vector relationship between the electrostatic potential and the electric field. [2]

(d) A spherical shell of radius a has a charge Q_0 uniformly distributed over its surface.

(i) Use Gauss' flux theorem to find the electric field T point outside the shell at a distance r from the centrel. [5]

(ii) Starting with the relationship stated in part (c) find the potential at a distance r from the centre of the shell nd at the surface of the shell. [5+2]

Q.2 (a) Define a conservative field. Use words not equations. [3]

(b) Show that the electric field of an isolated point charge is conservative, and hencededuce that the electric field of a distribution of point charges is also conservative. [4+2]

(c) Determine whether $\vec{E} = x\hat{k}$ is a conservative field. [5]

(d) For the electric potential $V = Br^2$, where B is a constant and r is the magnitude of the position vector, find the magnitude and direction of the electric field. [3+3]

Q.3 (a) What is capacitance? [3]

(b) State one application of capacitors in electronic circuits. [2]

(c) A parallel plate capacitor has the space between the plates filled with a medium whose dielectric constant increases linearly with distance. The distance between the plates Is L and K_1 and K_2 ($K_2 > K_1$) are the values of the dielectric constant at the plates. A charge Q is placed on the plates. Determine

(i) an expression for the dielectric constant K as a function of position x in the dielectric. [4]

(ii) the electric field between the plates. [5]

(iii) the capacitor voltage. [4]

(iv) the capacitance of this parallel plate capacitor. [2]

Q2 (a) (i) What is the distinction between *minority* and *majority* carriers in a semi-conductor ? [2]

(ii) Explain the reason why the concentration of positive and negative charge carriers are not balanced in extrinsic semi-conductors while the balance is complete in intrinsic semi-conductors. [5]

(iii) Prove that the concentration, n, of free electrons per cubic meter of a metal is given by

$$n = \rho \upsilon / AM = N_o \rho \upsilon \text{x } 10^{-3}/A \qquad [5]$$

where ρ = density in kg/m^3
υ = valence, free electrons per atom
A = atomic weight
M = weight of atom of unit atomic weight, kg
N_o = Avogadro's number, molecules/mole

(b) (i) A fundamental difference between a metal and a semi-conductor is that the former is *unipolar* whereas the latter is *bipolar*. Explain in simple terms what this means. [3]

(ii) Given the following data, find the resistivity of intrinsic silicon at 300K. [5]

(intrinsic concentration, 300 K = 1.5 X 10^{10})
μ_n, $cm^2/V\text{-}s$, 300K = 1,300
μ_p, $cm^2/V\text{-}s$, 300K = 500
electronic charge e = 1.6 X$10^{-19}C$

(iii) If a *donor- type* impurity is added to the extent of 1 atom per 10^8 silicon atoms, find the new resistivity. [5]

(Atoms/cm^3 for silicon = 5X10^{22})

Q3 (a) (i) If *donor* impurities are introduced into one side and acceptors into the other side of a single semi-conductor crystal, a *p-n* junction is formed. Describe the processes that lead to the formation of this junction [5]

(ii) The junction cited above possesses the properties of a rectifier. Explain what this means and how it arises. [5]

(b) (i) State what is meant by the following terms as understood in electronics:
- reverse bias; [2]
- forward bias [2]

(ii) Draw a well labelled sketch for the volt-ampere characteristic of an avalanche, or Zener, diode. [3]

(c) The avalanche diode rated at 10 V regulates over a range of diode currents from 5mA to 40 mA. The supply voltage $V = 200$ volts. Calculate the series resistance R_s to allow voltage regulation from a load current $I_L = 0$ up to I_{max}, the maximum possible value of I_L. What is $I_{max.}$? [8]

Q4 (a) A transistor exhibits a change of 0.995 mA in its collector current for a change of 1 mA in its emitter current. Calculate

(i) its common - base short circuit current gain [2]
(ii) its common - emitter-short-circuit current gain [2]

(b) (i) With the aid of well labelled diagrams, differentiate between *transfer characteristic* and *output- characteristic* for an *n-p-n bipolar* transistor. [5]

(ii) A silicon *p-n-p* transistor is used in the circuit shown (figure 4)

- complete the drawing by putting the arrowhead on the emitter symbol and indicating the proper battery polarities for a forward biased emitter-base junction and a reverse biased collector base junction. [3]

- Assuming $V_{BE} = 0.7$ volts, calculate I_B for $V_{BB} = 4$volts and $R_B = 33k\Omega$. [2]

- If $V_{CC} = 15$ volts, $R_L = 1.5\ k\Omega$, and $\beta = 60$, calculate I_C, I_E and V_{CE}. [4]

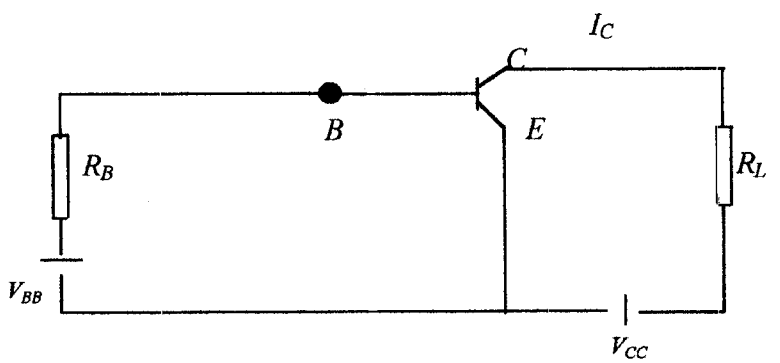


Figure 4

(c) In figure 5, the collector supply voltage V_{CC} is 12 volts and the collector current, I_C is 1.24 mA. Calculate

(i) V_{CE} and
(ii) V_{BE} } [5]

UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS
FIRST SEMESTER 2000/2001
P351
INTRODUCTION TO QUANTUM MECHANICS

Time: Three hours
Answer any four questions
All questions carry equal marks
Total marks: 100

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1. (a) (i) Why is the wave nature of matter not evident for bodies of everyday size moving with everyday speeds? [2]

(ii) Explain the physical interpretation of the wave function and hence why the wave function needs to be normalised. [2]

(iii) Explain why acceptable wave functions and their derivatives have to be continuous throughout all space. [2]

(iv) Explain why expectation values are important in quantum mechanics. [2]

(v) Explain the physical meaning of the eigenvalues of an operator. [2]

(vi) Explain the circumstances in which energy quantisation occurs. [2]

(b)The time-dependent Schrödinger equation for a particle of mass m moving in three dimensions is

$$-\frac{\hbar^2}{2m}\nabla^2\,\Psi(\mathbf{r},t)+V(\mathbf{r},t)\Psi(\mathbf{r},t)=i\hbar\frac{\partial}{\partial t}\Psi(\mathbf{r},t)$$

(i) Show that under certain circumstances this equation leads to the time-independent Schrödinger equation

$$-\frac{\hbar^2}{2m}\nabla^2\,\psi(\mathbf{r})+V(\mathbf{r})\psi(\mathbf{r})=E\psi(\mathbf{r}) \qquad [7]$$

(c) The wave function of a certain particle is

$$\psi(x,t)=\left[Ae^{ipx/\hbar}+Be^{-ipx/\hbar}\right]e^{-ip^2t/2m/\hbar}$$

where A and B are constants.

(i) Obtain the probability density for this wave function. [3]

(ii) Obtain the probability current for the wave function. [3]

2. (a) A particle of mass m is confined within a rectangular box with impenetrable walls of lengths $L_x = L_y = L$ and $L_z = L/2$.

(i) Solve the Schrödinger equation for the particle and obtain the allowed energies and the normalised eigenfunctions. [20]

(ii) Deduce the degeneracies of the two lowest energy levels and list all the eigenfunctions corresponding to these energies. [5]

3. (a) A particle of mass m is incident on a potential of the form $V(x) = 0$ for $x < 0$ and $V(x) = V_0$ for $x > 0$. If $0 < E < V_0$,

(i) solve the Schrödinger equation for the potential, [5]

(ii) show that there is no transmission of particles, [3]

(iii) show that there is a non-zero probability that the particle will penetrate the barrier to a depth x [3]

(b)(i) Define a Hermitian operator and explain the importance of such operators in quantum mechanics [2]

(ii) Prove that the eigenfunctions corresponding to two different eigenvalues of a Hermitian operator ar orthogonal. [5]

(iii) Prove that if two operators commute, they have simultaneous eigenfunctions. Explain the conse quences of this result for the measurements of the two dynamical variables represented by these operators [5]

4. (a) (i) Using the classical expression $\mathbf{L} = \mathbf{r} \times \mathbf{p}$, obtain the quantum mechanical operators for th three Cartesian components of orbital angular momentum. [3]

(ii) Using the basic commutation relations $[x, p_x] = [y, p_y] = [z, p_z] = i\hbar$ for the position and momentun operators, pick a pair of components of $\mathbf{L}$ and compute their commutator. [5]

(iii) By picking one component to illustrate the result, show that $\mathbf{L}^2$ commutes with any one of th components of $\mathbf{L}$. What is the importance of this result? [4]

(iv) Prove that the eigenvalues of $L_z = -i\hbar\partial/\partial\phi$ are $m\hbar$ ($m = 0, \pm1, \pm2, ..$), while the normalise eigenfunctions are $\Phi_m(\phi) = e^{im\phi}/\sqrt{2\pi}$. [5]

(b) A particle of mass m is constrained to move on a ring of radius a.

(i) Show that the Hamiltonian of this particle is $H = L_z^2/2I$, where the z axis passes through the centr O of the ring and is perpendicular to the plane of the ring, and I is the moment of inertia of the particl with respect to the z axis. [4]

(ii) Taking the eigenvalues of L_z to be $m\hbar$, where $m = 0, \pm1, \pm2, ...$, find the energy eigenvalues an eigenfunctions of the system. [4]

5. (a) The potential for the one-dimensional simple harmonic oscillator is $V(x) = \frac{1}{2}kx^2$. Show that th eigenfunctions of this oscillator must be of definite parity. [7]

(b) The time-independent Schrödinger equation for the one-dimensional harmonic oscillator

$$-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}\psi(x) + \frac{1}{2}kx^2\psi(x) = E\psi(x)$$

can be cast in the form

$$\frac{d^2}{dx^2}\psi(\zeta) + (\varepsilon - \zeta^2)\psi(\zeta) = 0$$

with the aid of the substitutions $\zeta = \sqrt{m\omega/\hbar}x$ and $\varepsilon = 2E/\hbar\omega$. This equation has the solution $\psi(\zeta) = e^{-\zeta^2/2}H(\zeta)$, with $H(\zeta) = \sum_{n=0}^{\infty} a_n\zeta^n$. The coefficients of the powers of ζ satisfy the recursion relation

$$a_{n+2} = \frac{2n + 1 - \varepsilon}{(n+2)(n+1)}a_n$$

(i) Show how energy quantisation of the harmonic oscillator arises from this information and thus deduc that the allowed energy values are given by

$$E_n = (n + \frac{1}{2})\hbar\omega, \quad n = 0, 1, 2, ... \quad [7]$$

(ii) Give a reason why the minimum energy is not zero. [2]

(c) The wave function of a certain harmonic oscillator at time $t = 0$ is

$$\psi(x, t = 0) = A[\sqrt{2}\phi_1 + \frac{1}{\sqrt{2}}\phi_2 + \phi_3]$$

where ϕ_n is the orthonormal stationary-state eigenfunction of the oscillator for the nth state and A is a normalisation constant.

(i) Compute A. [3]

(ii) Give the wave function $\psi(x, t)$ for all values of t. [3]

(iii) Calculate the expectation value $\langle E \rangle$ at time t. [3]

6. A certain hydrogen atom has the wave function

$$\psi = Bre^{-r/2a_0}\cos\theta$$

where

$$a_0 = \frac{4\pi\varepsilon_0\hbar^2}{\mu e^2}$$

is the Bohr radius.

(i) Calculate the normalisation constant B. [7]

(ii) Obtain values of the energy, the angular momentum, and the z component of the angular momentum for the system. [10]

(iii) Hence specify the quantum numbers of this state. [3]

(iv) Obtain the most probable value of r for this state. [4]

Note the following:

The Hamiltonian of the hydrogen atom is

$$H = -\frac{\hbar^2}{2\mu}\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial}{\partial r}\right) + \frac{\mathbf{L}^2}{2\mu r^2} - \frac{e^2}{4\pi\varepsilon_0 r}$$

where

$$\mathbf{L}^2 = -\hbar^2\left[\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\frac{\partial}{\partial\theta}) + \frac{1}{\sin^2\theta}\frac{\partial^2}{\partial^2\phi}\right]$$

and

$$L_z = -i\hbar\frac{\partial}{\partial\phi}$$

The energies of the hydrogen atom are

$$E_n = -\frac{\mu}{2\hbar^2}\left(\frac{e^2}{4\pi\varepsilon_0}\right)^2\frac{1}{n^2}$$

The volume element in spherical polar coordinates is $dV = r^2\sin\theta dr d\theta d\phi$.

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

UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT

UNIVERSITY EXAMINATIONS 2000/2001

P421
SOLID STATE PHYSICS I

INSTRUCTION: Answer only four (4) questions in total. All questions carry equal marks, with the marks for each part of the question given indicated by the numbers in parentheses

DURATION: Three (3) Hours

MAXIMUM MARKS: 100%

Use, where necessary:

Electron rest mass $m = 9.1 \times 10^{-31}$ kg
Planck's constant $h = 2\pi\hbar = 6.63 \times 10^{-34}$ Js
Boltzmann's constant $k_B = 1.38 \times 10^{-23}$ JK^{-1}

Direct to reciprocal lattice vectors:

$$\mathbf{A} = 2\pi\frac{\mathbf{b}\times\mathbf{c}}{\mathbf{a}\bullet\mathbf{b}\times\mathbf{c}} \qquad \mathbf{B} = 2\pi\frac{\mathbf{c}\times\mathbf{a}}{\mathbf{a}\bullet\mathbf{b}\times\mathbf{c}} \qquad \mathbf{C} = 2\pi\frac{\mathbf{a}\times\mathbf{b}}{\mathbf{a}\bullet\mathbf{b}\times\mathbf{c}}$$

Fermi function: $F(E) = \dfrac{1}{e^{(E-E_F)/k_BT}+1}$,

where $E_F = \dfrac{\hbar^2}{2m}\left(\dfrac{3\pi^2 N}{V}\right)^{2/3}$ is the Fermi energy

Phonon occupancy: $\langle n(\omega)\rangle = \dfrac{1}{e^{\hbar\omega/k_BT}-1}$

Note: **All figures referred to in the question paper are given on the last page.**

Q1. (a). Explain why in the fourteen Bravais lattices depicted in Figure 1, the following structures are not included:

(i) the base-centred tetragonal, (4)

(ii) the face-centred tetragonal, and (4)

(iii) the face-centred rhombohedral. (4)

(b). For the packing of spheres of radius R in a simple cubic, a body-centred cubic and a face-centred cubic lattice, show that the cube edge and the fraction of the volume occupied by the spheres are given by

simple cubic: $a = 2R$; $f = \frac{\pi}{6}$ (3)

b.c.c. : $a = \frac{4R}{\sqrt{3}}$; $f = \frac{\pi\sqrt{3}}{8}$ (5)

f.c.c. : $a = \frac{4R}{\sqrt{2}}$; $f = \frac{\pi\sqrt{2}}{6}$ (5)

Q2. (a). Explain qualitatively, and if possible quantitatively, why the X-ray diffraction lines observed from small crystallite become broadened. Base the discussion on a one-dimensional finite array of atoms. (5)

(b). (i) Set up the primitive translational **a**, **b**, and **c** for a f.c.c. lattice in a convenient form and get the fundamental vectors **A**, **B**, and **C** of the reciprocal lattice. (5)

(ii) Show that formation of the planes bisecting the fourteen shortest reciprocal lattice vectors yields a Brillouin zone which is a truncated octahedron. (8)

(iii) What is the symmetry of the reciprocal lattice so produced? (4)

(iv) Without making any further analysis, can you make a rapid deduction as to the Brillouin zone for a b.c.c. lattice? (3)

Q3. (a). (i) How would you explain the existence of bound states of XeF_4, in view of the absence of valence electrons in a Xe atom. [Xe: $5s^2 5p^6$, F: $2s^2 2p^5$] (4)

(ii) Why does metallic binding usually occur with atoms having a small number of valence electrons? (4)

(b). The potential energy U of NaCl can be described empirically by

$$U = -\frac{e^2}{4\pi\varepsilon_o R} + Ae^{-R/\rho}$$

where R is the internuclear separation. The equilibrium separation of the nuclei R_o is 2.5 A and the dissociation energy is 3.6 eV.

(i) Calculate A and ρ/R_o, neglecting zero-point vibrations. (7)

(ii) Sketch U and each of the terms in U on one graph. (6)

(iii) Give the physical significance of A and ρ. (4)

Q4. We consider transverse vibrations of a planar square lattice of rows and columns of identical atoms, and let $u_{l,m}$ denote the displacement normal to the plane of the lattice of the atom in the l^{th} column and m^{th} row (see Figure 2). The mass of each atom is M and C is the force constant for the nearest neighbour atoms.

(a). Show that the equation of motion is

$$M\frac{d^2u_{l,m}}{dt^2} = C\left[(u_{l+1,m} + u_{l-1,m} - 2u_{l,m}) + (u_{l,m+1} + u_{l,m-1} - 2u_{l,m})\right] \qquad (8)$$

(b). Assume solutions of the form

$$u_{l,m} = u(0)\exp\left[i\left(lK_x a + mK_y a - \omega t\right)\right]$$

where a is the spacing between nearest neighbour atoms. Show that the equation of motion is satisfied if

$$\omega^2 M = 2C\left(2 - \cos K_x a - \cos K_y a\right) \qquad (6)$$

(c). Show that the region of $\mathbb{K}$ space for which independent solutions exist may be taken as a square of side $2\pi/a$ and sketch ω versus K for $K = K_x$ with $K_y = 0$, and for $K_x = K_y$. (7)

(d). For $Ka \ll 1$, show that

$$\omega = \left(\frac{Ca^2}{M}\right)^{1/2}\left(K_x^2 + K_y^2\right)^{1/2} = \left(\frac{Ca^2}{M}\right)^{1/2} K$$

so that in this limit the velocity is constant. (4)

Q5. (a). (i) Thermal expansion is related to the anharmonic nature of the vibrations of atoms in a solid. Would the Debye model be appropriate for studying thermal expansion of solids? (5)

(ii) Interpret the Debye charateristic temperature θ_D physically. (5)

(b). From the account of energy quantization of a simple harmonic oscillator given by Planck,

(i) show that the Eistein model of a mole of a solid gives the heat capacity as

$$C_v = 3R\left[\frac{e^{\hbar\omega/k_BT}}{\left(e^{\hbar\omega/k_BT} - 1\right)^2}\left(\frac{\hbar\omega}{k_BT}\right)^2\right] \qquad (9)$$

where $R = k_B N_A$ and N_A is the Avogadro's number.

(ii) Show that $C_v \to 0$ as $T \to 0$ but that at low T, C_v increases as $e^{-\hbar\omega/k_BT}$ rather than T^3 as required. (6)

Q6. (a). Interpret physically the Fermi energy E_F. (6)

(b). Show that the derivative of the Fermi function is symmetrical about E_F and that

$$\int_{-\infty}^{\infty} \frac{\partial F_E}{\partial E} dE = -1 \qquad (12)$$

(c). Using 23 as the atomic weight and 9.7×10^2 kg/m^3 as the density of metallic sodium, compute the Fermi energy on the assumption that each sodium atom gives one electron to the conduction band. (7)

********** THE END OF EXAM **********

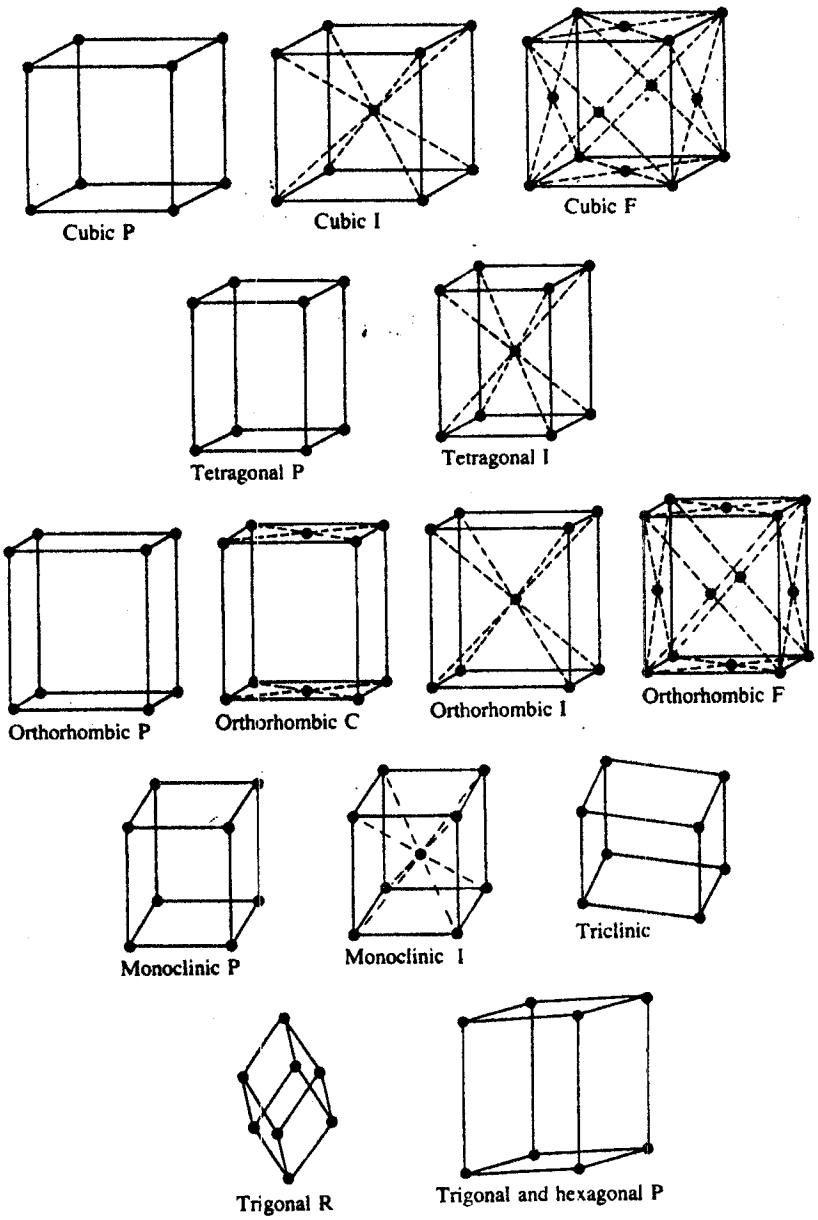

Cubic P
Cubic I
Cubic F
Tetragonal P
Tetragonal I
Orthorhombic P
Orthorhombic C
Orthorhombic I
Orthorhombic F
Monoclinic P
Monoclinic I
Triclinic
Trigonal R
Trigonal and hexagonal P

Fig. 1

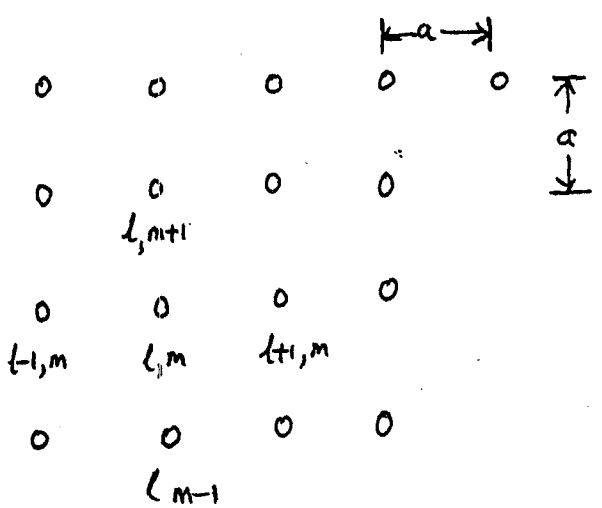

a
a
l, m+1
l-1, m
l, m
l+1, m
l, m-1

Fig. 2

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATION
JANUARY 2001
P441
ELECTRONICS 2

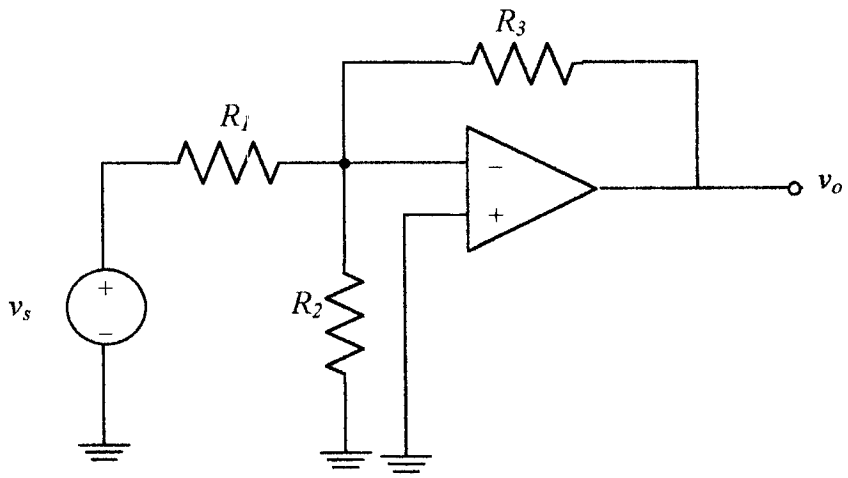
TIME: 3 HOURS MAXIMUM MARKS 100

ANSWER 4 QUESTIONS
ALL QUESTIONS CARRY EQUAL MARKS

Formulas attached at back of paper

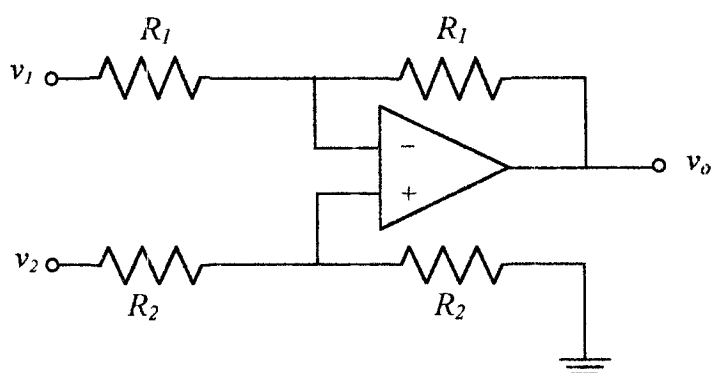
Q.1. a) Use the ideal Op-Amp model to show that the circuit in the figure below has the following gain,

$$\frac{v_o}{v_s} = \frac{-R_3}{R_1 + \frac{1}{A}\left(R_1 + \frac{R_3}{R_2}(R_1 + R_2)\right)}$$ where A is the Op-Amp gain. [15]



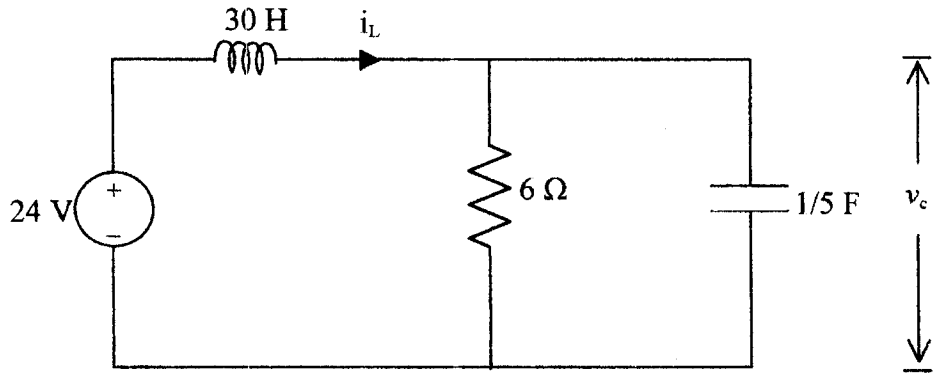
b) For an ideal Op-Amp with feedback, the inverting input and noninverting input have approximately the same voltage and the current going into or out of the inputs is approximately zero. Use this to show that the circuit below gives an output given by, [10]

$$v_o = v_2 - v_1.$$



Q.2. a) For the circuit below find the voltage across the capacitor $v_c(t)$. You are given that

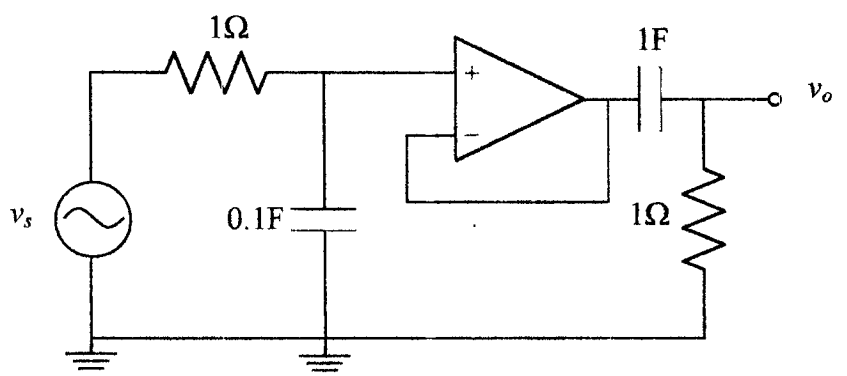
$i_L(0) = 2A$, $v_c = 12V$. [10]



b) A capacitor in an arbitrary circuit has a voltage in the s-domain given by the equation below. If the capacitor has a capacitance of 1F, find the current in the capacitor as a function of time $i(t)$. [15]

$$V_c(s) = \frac{s^3 + 6s^2 + 13s + 12}{(s+1)^2(s^2 + 2s + 5)}$$

Q.3. a) Find the transfer function $H(s) = v_o/v_s$ for the voltage follower circuit below. Use the transfer function to plot the uncorrected and corrected Bode plot of the gain (logw vs dB). Give the values of slopes, breakpoints and peaks. [10]

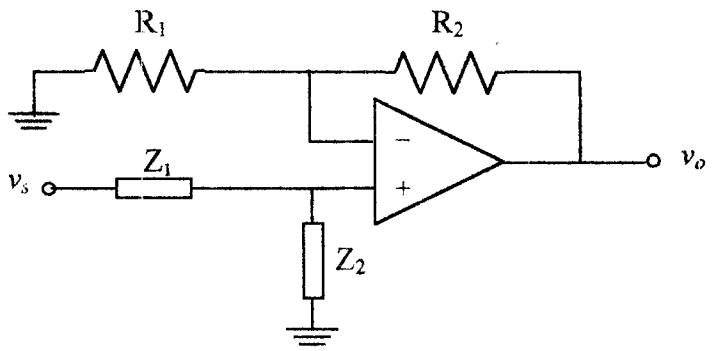


b) Plot the phase response $\phi(w)$ for the same circuit. [5]

c) Plot the Bode gain plot, corrected and uncorrected for the following transfer function.

$$H(s) = \frac{s^2 + s + 10^4}{s^2 + 200s + 10^4}$$

Q.4. a) Find the transfer function v_o/v_s of the circuit below. Hence show how the circuit can be used as a 1st order Butterworth highpass filter. [12]



b) Calculate values of components needed for a pass band gain of 2 and cut-off frequency of 1 kHz. [5]

c) Design a 3rd order Butterworth low pass filter with cutoff frequency at 159 Hz. [8]

Q5. a) Design an Operational Amplifier circuit to solve the following differential equation. Assume that an x(t) generator is available. [13]

$$2\frac{d^2y}{dt^2} - 4\frac{dy}{dt} + 2y = x(t)$$

b) Draw the circuit diagram for the Wien-Bridge Oscillator. Determine the condition for oscillation and the frequency of oscillation. [12]

Q.6. a) Draw a two input NAND gate using MOSFET transistors and explain how it functions using truth tables which indicate the state of each FET transistor. [10]

b) Describe the manufacturing processes and techniques needed to produce a bipolar transistor in an integrated circuit in order. [10]

c) Draw a sample and hold circuit using an Op-Amp and explain how it functions. What is the advantage of using an Op-Amp in the circuit? [5]

END OF EXAMINATION