

45. Rural Geography	-	G	961
46. Remote Sensing mid year	-	G	991
46. Remote Sensing Deferred	-	G	991
48. Urban Geography	-	G	965
49. The geography of Natural Resources	-	G	972
50. Deferred	-	G	972
51. Mathematics	-	M	110
52. Mathematics	-	M	110
53. Mathematics Deferred	-	M	160
54. Mathematical methods II	-	M	160
55. Linear algebra	-	M	210
56. Computer Science I	-	M	220
57. Mathematics	-	M	240
58. Mathematics	-	M	260
59. Real Analysis I	-	M	310
60. Mathematics	-	M	330
61. Theory of Function of a Complex Variable	-	M	360
62. Mathematics	-	M	410
63. Real Analysis II	-	M	420
64. Computer Science II	-	M	430
65. Mathematics	-	M	440
66. Numerical Analysis	-	M	460
67. Applied Ecology	-	M	910
68. Natural Resources Economics	-	NR	430
69. Introductory physics	-	NR	435
70. Classical Mechanics	-	F	110
71. Electricity and Magnetism/Atomic	-	F	250
72. Computational physics I	-	P	260
73. Statistical physics and Thermodynamics	-	P	302
74. Electronics I	-	P	332
75. Solid state physics I	-	P	340
76. Physics of Renewable Energy Resources	-	P	421
and Environment	-	P	485

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

BS 112

THEORY PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS:

1. Answer all the questions in any order, using the answer sheet provided.
2. All questions carry equal marks.
A correct answer carries +4 mark.
A wrong answer carries -1 mark.
"I don't know" carries 0 mark.
Therefore do not guess.

Note: This question paper together with your answer sheet, should be left at the desk where you sat, for the examination.

PLANT BIOLOGY COMPONENT

1. A floral diagram is defined as
 1. an expression of the ground plan of the flower *
 2. an expression of the longitudinal sector of the flower
 3. an expression of the vertical plan of the flower
 - ✓ 4. an expression summarising the number and position of the floral parts
 5. an expression summarising the number of ovules in the ovary *
 6. I do not know
2. A fungus known as Penicillium notatum is considered an important organism because it is used in the preparation of
 1. chlorophylls
 2. starches
 - ✓ 3. antibiotics ✓
 4. aspirins
 5. celluloses
 6. I do not know

3. The Imbibition of water by the seed brings about the synthesis of mRNA which is vital in the production of
1. alkaloids
 2. polypeptides
 3. lipids
 4. sugars
 5. carbohydrates
 6. I do not know
4. Typha is an aquatic plant which develops an underground perennating organ from which aerial shoots and roots arise. This organ is referred to as
1. a rhizoid
 2. a rhizome
 3. a rhizine
 4. a rhizomorph
 5. a stolon
 6. I do not know
5. In the classification process applicable to both extinct and living organisms the next higher taxonomic unit embracing all the related genera is termed
1. the kingdom
 2. the family
 3. the genus
 4. the species
 5. the class
 6. I do not know
6. The quiescent centre is defined as
1. a spherical tissue found at the apex of the leaf where cells exhibit very high mitotic activity
 2. a hemispherical tissue found at the apex of the stem where cells exhibit a very high rate of mitotic activity
 3. a hemispherical tissue found at the apex of the stem where cells exhibit very low meiotic activity
 4. a hemispherical tissue found at the root apex where cells exhibit very high meiotic activity
 5. a hemispherical tissue found at the root tip where cells exhibit very low mitotic activity or none
 6. I do not know

59 FOC 2X

A compound known to effect and maintain dormancy in angiosperm seeds is called

1. Indole acetic acid ✓
2. Indole butyric acid
3. abscisic acid ✓
4. cytokinins
5. gibberellic acid
6. I do not know

In the light reaction of a photosynthetic process occurring within an intact plant, "electron hole" which is created by the loss of a pair of electrons in the chlorophyll molecule is filled-up by another pair of electrons provided by

1. the photolysis of the water molecule
2. the photolysis of the ATP molecule
3. the photolysis of the chlorophyll molecule
4. the synthesis of the water molecule
5. the synthesis of the ATP molecule
6. I do not know

11A
GA

The first chemically detectable compound resulting from the assimilation of carbon dioxide by the C₃ plants in the dark reaction of a photosynthetic process is called

1. aspartic acid
2. malic acid
3. phosphoenol pyruvate ✓
4. 3-phosphoglyceric acid ✓
5. oxaloacetic acid
6. I do not know

3 P 10

Roots of most vascular plants are characterised with the anatomical presence of the endodermis, which is a

1. uniseriate cylinder of cells strapped with a lignosuberin band called the Casparian Strip ✓
2. multiseriate cylinder of cells strapped with a lignosuberin band called the Casparian Strip ✓
3. uniseriate cylinder of cells strapped with a cellulose band called the Casparian Strip ✗
4. multiseriate cylinder of meristematic tissue from which flowers originate ✗
5. multiseriate cylinder of meristematic tissue from which leaves originate ✗
6. I do not know ✗

Renal Pervis
794 800

15. The mushroom belongs to an organismic group whose body structure is made up of units called the
1. flagella
 2. filaments
 3. heterocysts
 4. heterothallic fragments
 5. hyphae
 6. I do not know
16. Spores that develop within the sporangium of the fungus called Saprolegnia, in the class Oomycetes, are referred to as
1. ascospores
 2. basidiospores
 3. conidia
 4. zygosporos
 5. zoospores
 6. I do not know
17. The mode of nutrition displayed by the fungus known as Rhizopus is considered to be
1. autotrophic
 2. holozoic
 3. heterotrophic
 4. parasitic
 5. saprophytic
 6. I do not know
18. The characteristic features of a hornwort called Anthoceros is depicted by the occurrence of a hornlike structure found on the dorsal surface of the thallus, which is referred to as
1. the sporophyte
 2. the gametophyte
 3. the antheridiophore ✓
 4. the archegoniophore ✓
 5. the seta
 6. I do not know
19. The sporophyte of a moss plant is
1. nutritionally dependent on the seta
 2. nutritionally independent of the unfertilised archegonium
 3. nutritionally dependent on the antheridium
 4. nutritionally dependent of the gametophyte ✓
 5. nutritionally independent of the gametophyte
 6. I do not know

*20. According to Theophrastos' system of classification, a shrub is described as

1. a herbaceous plant with several stems arising from the soil surface
2. a herbaceous plant with a single stem arising from the soil surface
3. a herbaceous perennial plant with rhizomatous (underground) stems
- 4. a woody plant with a single stem trunk arising from the soil surface *tree*
5. a woody plant with several stem trunks arising from the soil surface
6. I do not know

21. The stock which connects the ovule to the placenta of the ovary is technically known as the

1. nucellus
- 2. funiculus
3. pedicel
4. rachiole
5. style
6. I do not know

22. A component of the masuku seed known as the testa is mostly comprised of a hardened protective tissue referred to as the

1. epidermis
2. hypodermis
3. endodermis
4. sclerenchyma
- 5. parenchyma
6. I do not know

23. A weather condition in which the relative humidity is very high tends to bring about

1. an increase in the rate of transpiration *very hot*
- 2. a reduction in the rate of transpiration *✓*
3. an increase in the active transport of mineral ions
4. a reduction in the active transport of mineral ions
5. an increase in both the passive and active transport of mineral ions across the endodermis
6. I do not know

*you are right
the change is
very hot
you are
why didn't
make sure
and see*

24. In leaves of a C4 plant, such as maize, it has been established that ribulose biphosphate is a carbon dioxide acceptor known to be localised in the

1. subsidiary cells of the stomata
2. guard cells of the stomata ✓
3. mesophyll cells only ✓ *Enzymes*
4. bundle sheath cells only ✓ *Root*
5. xylem cells of the vascular bundles
6. I do not know

25. The term symplast is applied to a component of the

1. root or stem embracing plasmodesmata, intercellular spaces and cytoplasm *Apoplast*
2. root or stem comprised of the cell wall and intercellular spaces
3. stem or root comprised of the cell wall, cytoplasm and cell membrane *Apoplast*
4. stem or root comprised of the cytoplasm, cell membrane and plasmodesmata ✓ *Symplast*
5. stem or root comprised of the cell wall, cell membrane and intercellular spaces
6. I do not know *47 69*

26. The phenomenon of root pressure, which is illustrated by the exudation of water at the cut end of the stem, is a function of

1. active absorption of solutes followed by the osmotic inflow of water molecules into the root
2. a passive absorption of water and solutes through the apoplast of the root cortex
3. a passive absorption of water and solutes through the symplast of the epidermis and cortex of the root
4. a transpiration process occurring during the day light
5. a passive absorption of water and solutes facilitated by oxygen supply
6. I do not know

27. A laboratory apparatus used to measure root pressure is called

1. potometer *transpiration*
2. porometer
3. hygrometer
4. manometer ✓ *pressure*
5. barometer *pressure*
6. I do not know

10 10 10 10 10
6748 56 10 10

28. A well developed angiosperm ovule that is considered to be ready for fertilization should have

1. initially undergone the process of gametogenesis in which the meiotic division of the ~~pollen mother cell~~ gives rise to four functional sperm cells

2. initially undergone the process of gametogenesis in which the ~~mitotic division~~ of the pollen mother cell gives rise to four functional sperm cells

3. initially undergone the process of gametogenesis in which the meiotic division of the spore mother cell is a single functional cell which ultimately develops into eight nuclei

4. initially undergone the process of gametogenesis in which the meiotic division of the spore mother cell gives rise to four functional cells each of which develops into eight nuclei

5. initially undergone the process of gametogenesis in which the mitotic division of the spore mother cell gives rise to a single functional cell which ultimately develops into a set of three nuclei

6. I do not know

29. The term pollination strictly refers to

1. the fusion of the sperm cell with the egg within the ovule of the angiosperm plant

2. the transfer of all the three sperm cells from a germinating pollen tube to the ovule of the gymnosperm plant

3. the transfer of pollen grains from the anther to the stigma of the angiosperm plant

4. the transfer of sperm cells from the antheridium to the archegonium of the moss plant

5. the transfer of the sperm cells from the antheridium to the archegonium of the fern plant

6. I do not know

30. The TUNICA-CORPUS theory simply relates to a development process in which

1. the corpus is known as a meristem that leads to the production of a plate of tissue strictly arising from the anticlinal division of cells

2. the corpus is known as a meristem that leads to the production of a volume of tissue arising from both the periclinal and anticlinal division of cells

3. the tunica is known as meristem that produces a volume of tissue, and ultimately the epidermis, arising from both anticlinal and periclinal division of cells

4. the tunica is known as a meristem which produces a plate of tissue, and ultimately the epidermis, strictly arising from the periclinal division of cells

5. the tunica is known as a meristem that leads to the production of a plate of tissue, and ultimately the multiseriate cortex, arising from the anticlinal division of cells

6. I do not know

31. The medullary rays noted in stems of the herbaceous plants is a product resulting from the differentiation of

1. parenchyma cells of the medulla in the pith region

2. phloem cells in the vascular bundles

3. the phellogen

4. the interfascicular cambium

5. the fascicular cambium

6. I do not know

32. A mature fruit whose pericarp is comprised of a dry tissue and splits along more than two sutures to reveal three or more locules is known as the

1. achene

2. legume

3. capsule

4. follicle

5. samara

6. I do not know

3. A group of cells characterised by having thin cell walls and isodiametric in their overall shape constitute a tissue type referred to as the

1. xylem
2. sclereids
3. sclerenchyma
4. parenchyma
5. fibres
6. I do not know

4. In most dicot plants branch roots arise from a meristematic tissue known as the

1. cortex
2. endodermis
3. epidermis
4. exodermis
5. pericycle ✓
6. I do not know

5. The unusual phenomenon noted in flowering plants is one in which fertilisation leads to the development of the endosperm tissue whose cells are cytologically found to be

1. haploid
2. monoploid
3. diploid
4. triploid ✓
5. tetraploid
6. I do not know

6. The process termed as photophosphorylation involves the reaction of ADP and an inorganic phosphate ion to form ATP in what is considered to be

1. light independent process
2. light independent carboxylation of process
3. light independent phosphorylation process ✓
4. dark dependent photosynthetic process
5. light dependent phosphorylation process ✓
6. I do not know

7. A transverse section of a relatively young dicot root reveals that a tissue which separates the vascular system from the cortex is called the

1. pericycle
2. fascicular cambium
3. interfascicular cambium
4. endodermis ✓
5. exodermis
6. I do not know

38. The term "velamen" is applied to
1. a uniseriate epidermis found in leaves of ground orchids
 2. a uniseriate epidermis found in stems of ground orchids
 3. a multiseriate epidermis found in roots of epiphytic orchids
 4. ✓ a multiseriate epidermis found in roots of ground orchids
 5. a multiseriate hypodermis found in roots of aquatic plants
 6. I do not know
39. The movement of carbon dioxide from the surrounding environment into a leaf via a stomatal pore can be described as
1. a normal respiratory process
 2. a normal diffusion process
 3. an osmotic event
 4. a transpiration process
 5. an aspect of cytoplasmic streaming
 6. I do not know
40. A condition in which a living eukaryotic cell undergoes complete plasmolysis after being suspended in a physiological solution suggests that
1. the physiological solution is hypotonic with reference to the cell sap
 2. the cell's sap is hypertonic with reference to the surrounding physiological solution
 3. the osmotic pressure of the physiological solution is lower than that of the cell's sap
 4. the osmotic pressure of the cell's sap is lower than that of the physiological solution ✓
 5. the cell's components are not membrane and, therefore, allow the free diffusion of molecules into the cell
 6. I do not know
41. A compound leaf of a dicot plant is characterised by
1. a blade which is not lobed
 2. a blade exhibiting a toothed margin
 3. a feature where several leaves are attached around the nodes
 4. a feature where a pair of petiolate leaves are arranged in opposite locations at a single node
 5. a feature where two or more leaflets are attached on a single rachis of a petiolate leaf
 6. I do not know

2. A chloroplast is a plastid best described as

1. a prokaryotic organelle enveloped by a single membrane and containing chlorophylls.
- 2. a prokaryotic organelle enveloped by a set of two membranes and containing chlorophylls
3. a eukaryotic organelle enveloped by a single membrane and containing chlorophylls
- +4. a eukaryotic organelle enveloped by two membranes but lacking chlorophylls
- 5. a eukaryotic organelle enveloped by two membranes and containing chlorophylls ✓
6. I do not know

3. The vascular bundles of a herbaceous monocot stem, as illustrated by the grass Hyparrhenia, are considered to be "closed" because

1. they possess procambium
2. they possess true cambium
3. they possess secondary cambium termed phellogen
4. they lack phellogen
- 5. they lack cambium ✓
6. I do not know

4. The central core of a well developed tree called "Mubanga" throughout Zambia, which is comprised of xylem tissue that has lost the capacity to conduct water and mineral solutes, is botanically termed as

1. Pericopsis angolensis
2. sapwood
3. heartwood ✓
4. protoxylem
5. metaxylem
6. I do not know

5. A feature of the dicot plant where a sharp spine bears pinnately compound leaves reflects an organ structure which is said to be

1. a modified leaf.
2. a modified pro-root
- ✓3. a modified stem ✓
4. a modified petiole ✓
5. a cladole
6. I do not know

46. A transverse section of the leaf of a tropical grass exhibiting the "Kranz anatomy" is characterised by the presence of
1. the mesophyll tissue which is clearly differentiated into non-chlorophyllous palisade and spongy cells
 2. the hypodermis containing chloroplasts
 3. the sclerenchyma containing chloroplasts
 - ~~4.~~ the vascular bundles surrounded by parenchyma sheath cells devoid of chloroplasts
 5. the vascular bundles surrounded by a derivative of mestome sheath cells containing chloroplasts
 6. I do not know
47. The event of fertilization in angiosperm plants triggers the transformation of the ovule into a seed, and this entails
1. ✓ the mobilization of food reserves, such as starch, proteins and lipids, which are converted into simple sugars, amino acids and fatty acids
 2. the mobilization of simple sugars, amino acids and fatty acids, which are converted into starch, proteins and lipids
 3. the breakdown of proteins into polypeptides
 4. the breakdown of hydrolytic enzymes in the aleurone layer
 5. the hydrolytic breakdown of the ovule's intergument
 6. I do not know
48. With regards to events that lead to the germination of the seed, it has been established that gibberellic acid plays an antagonistic role against
1. messenger RNA synthesis
 2. protein synthesis
 3. the process leading to endosperm formation
 4. indole-3-acetic acid
 - ~~5.~~ abscisic acid
 6. I do not know
49. A female plant of Marchantia undergoing sexual reproduction is typified by presence of
1. the archegoniophore on the dorsal surface of thallus
 2. the archegonia on the ventral surface of the thallus
 3. the antheridia at the apex of the thallus
 - ~~4.~~ the antheridiophore at the apex of the thallus
 5. the gemma cups on the dorsal surface of the thallus
 6. I do not know

0. The structure of a pineapple fruit reveals the external morphology which suggests that it is

1. a single-seeded fruit derived from a single ovary
2. a several-seeded fruit derived from a single ovary
3. a several-seeded fruit derived from a single flower
- 4. a fleshy fruit derived from the fusion of several ovaries ✓
5. a fleshy fruit derived from a single flower containing many seeds
6. I do not know

ANIMAL BIOLOGY COMPONENT

1. Which of the following statements about lipids is NOT true

1. lipids are relatively insoluble in water ✓
2. like carbohydrates, lipids are composed of carbon, hydrogen and oxygen atoms ✓
3. lipids are important biological fuels ✓
4. they serve as structural components of cell membranes ✓
- 5. they are not regarded as essential ✗
6. I do not know

1. The term "TISSUE" can be applied to

1. any structure in a living organism
- 2. similar cells grouped into a structural and functional unit ✓
3. a copulatory structure
4. any organ in the body
5. 4 and 2 are correct
6. I do not know

1. Epithelium consist of:

1. ~~tiny~~ ^{thin} like material making up the main part of the cell
- 2. cells lining a cavity within the body ✓
3. a preparation made from a liquid like blood
4. tiny parts inside the animal cell
5. both 4 and 2 are correct
6. I do not know

1. Which of the following bones is found in the mammalian leg?

1. humerus ✓
2. ulna
3. scapula
- 4. fibula ✓
5. radius
6. I do not know

5. Which of the following is NOT a tissue?

1. nerve
2. bone
3. cartilage
4. stomach
5. muscle
6. I do not know

6. The number of cervical vertebrae in mammals is

1. seven
2. five
3. four
4. twelve
5. ten
6. I do not know

7. Striated muscles are sometimes referred

1. voluntary
2. involuntary
3. fast acting
4. found in vertebrates only
5. antagonistic
6. I do not know

8. Choose the correct order

1. cell, tissue, organ, organism
2. tissue, cell, organism, organ
3. organism, tissue, cell, organ
4. cell, organism, organ, tissue
5. organism, macromolecule, cell, organ
6. I do not know

9. ATP is required in muscle for:

1. relaxation only
2. contraction only
3. relaxation and contraction
4. flexion only
5. adduction only
6. I do not know

10. The tendency of an organism to maintain constancy of the internal environment is known as:

1. adaptation
2. thermal constancy
3. homeostasis
4. secretion
5. ecolysis
6. I do not know

61. Which of the following is NOT a function of the liver?
1. bone marrow formation
 2. bile secretion
 3. homeostasis maintenance
 4. converts excess glucose to glycogen
 5. converts excess amino acids to fatty acids and urea
 6. I do not know
62. In which region does carbohydrate digestion begin?
1. duodenum
 2. stomach
 3. liver
 4. large intestine
 5. none of the above
 6. I do not know
63. In which region does protein digestion begin?
1. duodenum
 2. stomach
 3. liver
 4. large intestine
 5. mouth
 6. I do not know
64. Which mineral is needed for haemoglobin production?
1. iodine
 2. iron
 3. calcium
 4. potassium
 5. both 3 and 4
 6. I do not know
65. The hardest substance outside the mammalian tooth is made of *(You obviously failed multiple choice)*
1. ivory
 2. cement
 3. enamel
 4. pulp
 5. dentin
 6. I do not know
66. The outer portion of the human kidney is
1. cortex
 2. medulla
 3. ureter
 4. renal pelvis
 5. epithelial
 6. I do not know

7. The main region in the alimentary canal of a vertebrate animal where absorption occurs is matumbo gangono.

1. large intestine
2. stomach
- 3. small intestine
4. kidney
5. fibrin
6. I do not know

8. Which of the following is an organ?

1. bone
2. cartilage
3. ligaments
4. blood
- 5. brain ✓
6. I do not know

9. Which of the following organs is the MOST important

food intake

1. spleen
2. heart
3. lungs
4. kidneys
- 5. brain ✓ ←
6. I do not know

10. The products of protein digestion are

1. fatty acids
2. simple sugars
- 3. amino acids ✓
4. polypeptides
5. 3 and 4
6. I do not know

11. Cardiac muscles are

- 1. involuntary
2. voluntary
3. fast acting
4. found in vertebrates only
5. not very important
6. I do not know

12. The capacity of an organism to detect stimuli is termed

1. metabolism
- 2. responsiveness
3. feed back
4. co-ordination
5. transmission
6. I do not know

73. The weight of the human liver is about
1. 2.3 kg
 - 2. 1.4 kg
 3. 3.0 kg
 4. 0.8 kg
 5. 1.2 kg
 6. I do not know
74. The structure through which gaseous exchange actually takes place is:
1. sinuses
 2. larynx
 - 3. alveoli
 4. epiglottis
 5. pleural cavity
 6. I do not know
75. Which of the following is NOT a connective tissue?
1. bone
 2. cartilage
 3. tendons
 4. ligaments
 - 5. none of these
 6. I do not know
76. In the mammal, the epidermis is present in the
1. stomach
 2. duodenum
 3. mouth
 4. lungs
 - 5. skin ✓
 6. I do not know
77. Which gland is the source of the enzyme trypsin
1. salivary glands
 - 2. pancreas ✓
 3. small intestine
 4. large intestine
 5. none of the above
 6. I do not know
78. The sutures found between the human skull are
1. flexible
 2. inflexible
 3. movable
 - 4. immovable ✓
 5. none of the above
 6. I do not know

79. The enzyme pepsin works best at a pH of about

1. 4.0
2. 7.5
3. 8.0
4. 13.8
- 5✓ none of the above
6. I do not know

80. Peristalsis

1. stops food from getting into the wind pipe
2. hydrolyses starch
3. destroys bacteria that reach the stomach
- 4. is the movement that pushes food material down the alimentary canal ✓
5. none of the above
6. I do not know

81. The energy expenditure at rest is known as

- 1. basal metabolism ✓
2. respiration
3. carbon dioxide produced
4. water produced
5. all the above
6. I do not know

82. In insects the process of gaseous exchange is carried out through the:

- 1. malpighian tubules ✓
2. small intestine
3. gill like structures
4. tracheae ✓
5. none of the above
6. I do not know

83. The products of protein digestion are:

1. fatty acids
2. simple sugars
- 3. polypeptides ✓
4. nucleic acids
5. vitamins
6. I do not know

84. The approximate length of the alimentary tract in the rat Rattus norvegicus is:

1. 1.35 m
- 2. 1.20 m
3. 1.00 m
4. 1.05 m
5. 1.00 m
6. I do not know

85. Which of the following blood cells is nucleated and lack haemoglobin

1. leucocyte
2. erythrocyte
3. platelets
4. plasma
5. fibrinogen
6. I do not know

86. The locality in which digestion begins in man is:

1. duodenum
2. stomach
3. small intestine
4. large intestine
- 5. none of the above
6. I do not know

87. Which of the following organs appear to play a very important role in the digestion process

1. liver
2. stomach
3. small intestine
4. large intestine
5. colon
6. I do not know

88. The zygote of a mammal develops inside a specialized structure called the:

1. placenta
- 2. uterus ✓
3. fallopian tube
4. vagina
5. ovary
6. I do not know

9. The enzyme present in saliva that initiates the hydrolysis of starch is called

1. lactase
- ☒ 2. amylase
3. lipase
4. pepsin
5. trypsin
6. I do not know

10. The surface area of the lungs of mammals is increased greatly by means of:

1. villi
2. coelom
- ☒ 3. alveoli
4. bronchi
5. microvilli
6. I do not know

11. Which of the following is NOT an endocrine organ of the mammal:

1. pituitary body
2. thyroid gland
3. parathyroid glands
4. adrenal glands
5. none of the above
6. I do not know

12. Which of the following is the correct definition of respiration.

1. breathing
- ☒ 2. intracellular oxidation of organic molecules to release energy
3. gradient created due to differential partial pressures
4. both 1 and 2 are correct
5. movement of molecules
6. I do not know

13. Most of the carbon dioxide is carried in the blood as:

- ☒ 1. bicarbonate ion
2. bicarbonate salt
3. as carbonic acid
4. as water
5. as carbohydrates
6. I do not know

Which blood cells transport oxygen

1. platelets
2. monocytes
3. red blood cells
4. neutrophils
5. eosinophils
6. I do not know

All respiratory systems must have:

1. lungs
2. gills
3. trachea
4. thin moistened membranes
5. all of the above
6. I do not know

Which organ delivers urine to the outside of the body?

1. urethra
2. renal tubules
3. renal pelvis
4. Bowman's capsule
5. ureter
6. I do not know

The ultimate source of energy for almost all living organisms is:

1. protein molecules
2. sunlight
3. carbohydrate molecules
4. lipid molecules
5. soil organic matter
6. I do not know

Which of the following glands was once considered the master gland?

1. pituitary gland
2. thyroid gland
3. adrenal glands
4. pineal body
5. thymus
6. I do not know

99. The clear fluid, which makes up the watery part of the blood is called:

1. lymph
2. serum
- ☒ 3. plasma
4. blood exudate
5. all of the above
6. I do not know

100. Which of the following organs is the least important:

- ☒ 1. spleen
2. heart
3. lungs
4. brain
5. kidneys
6. I do not know

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

BS 212

PLANT AND ANIMAL PHYSIOLOGY

THEORY PAPER

THREE HOURS

ER: FIVE QUESTIONS, TWO FROM EACH SECTION AND THE LAST QUESTION FROM EITHER SECTION.

USE SEPARATE ANSWER BOOKS FOR EACH SECTION.

SECTION A

PLANT PHYSIOLOGY

- (a) Explain the following terms: water potential, solute potential, pressure potential.
- (b) In an experiment to study the solute potential of a cell during absorption of water the results plotted in Fig. 1 were obtained.
- (i) What was the volume of the cell in arbitrary units when it had reached full turgor?
- (ii) What was the pressure potential when the cell volume was 102 arbitrary units?

Discuss the conditions other than plant factors, which affect water loss from leaves.

EITHER write on chromophores of photosynthetic pigments in higher plants and algae.

OR write on how light energy is captured by photosynthetic pigments and utilized in the light reactions of photosynthesis.

Discuss the roles of auxins and gibberellins in internode growth of stems.

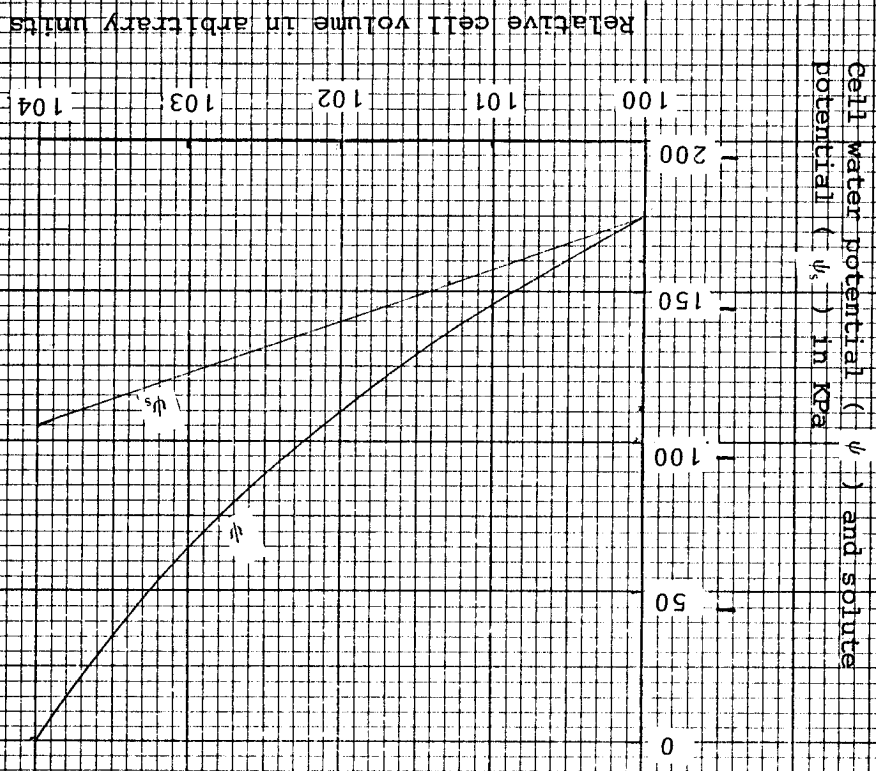


Fig. 1

SECTION B

ANIMAL PHYSIOLOGY

What is gastrulation? Describe the main morphological and biochemical changes which occur during gastrulation.

Discuss the evidence drawn from different species showing that egg cytoplasm is highly organised. What is the significance of this organisation?

Explain how gases are transported by the blood in a mammal.

Discuss the roles of hormones in osmoregulation in mammals and compare this with osmoregulation in aquatic animals.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SUPPLEMENTARY/DEFERRED EXAMINATIONS - JANUARY 1996

BS 212

PLANT AND ANIMAL PHYSIOLOGY

PRACTICAL PAPER

TIME: ONE HOUR THIRTY MINUTES

ANSWER: ALL QUESTIONS

USE SEPARATE ANSWER BOOK FOR EACH SECTION

SECTION A

PLANT PHYSIOLOGY

Variations in the rate of water vapour loss from leaves of different species can be linked to differences in epidermal structure.

An experiment was carried out to compare the water vapour loss from daffodil leaves and from maize leaves. Pieces of blue (dry) cobalt chloride paper 1 cm^2 , were attached to the upper and lower surfaces of the leaves by means of clear adhesive tape. Colour changes were observed at 15 minutes intervals over a period of 90 minutes. As the cobalt chloride paper became moist, it changed from blue to pink.

The colour changes during each 15 minute period were matched against a standard range of colours from blue (0) to pink (5). The colour changes were plotted against time and are shown in the graph (Figure 3).

- (a) Compare the differences in the rate of water vapour loss from leaves of the two plants.
- (b) The number of stomata on each surface of a daffodil leaf and of a maize leaf were estimated by counting the stomata in several 4 mm^2 areas of epidermis. From these, the mean number of stomata per cm^2 was then calculated. The mean numbers are given in the table below.

Species	Mean number of stomata per cm ²	
	Upper epidermis	Lower epidermis
Daffodil	3550	1850
Maize	5100	6300

Explain the relationship between rate of water vapour loss and number of stomata.

- (c) State two other structural features of a leaf which might influence the rate of water vapour loss. In each case give reasons for your answer.

SECTION B

ANIMAL PHYSIOLOGY

2. You have been given two specimens of urine A and B.
- Carry out tests to determine if there is Glucose and Albumin in each of the Specimens.
 - Write down the experimental procedure you have used.
 - Name the hormones and their origin that regulate glucose level in the blood.
 - How does the ingestion of food affect the pH of urine?
 - How does high glucose level in the blood affect the oxygen carrying capacity of red blood cells?
 - Explain the following physiological conditions: Give well reasoned physiological explanations for each of the following:
 - People produce large volumes of dilute urine on a cool day than on a hot day.
 - If blood pressure drops as a result of blood loss due to serious injury urine production stops.

- (iii) Protein may be detected in the urine of a person suffering from kidney failure.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

BS 222

THEORY PAPER

TIME: THREE HOURS

NUMBER: FIVE QUESTIONS INCLUDING TWO (2) FROM EACH SECTION AND ONE FROM ANY SECTION. ALL QUESTIONS CARRY EQUAL MARKS.

SECTION A

- (a) What is the principal difference between Pirid's Hour Glass theory and the Dumbell model on the origin of life?
- (b) Discuss the theories of the origin of the metazoa.
- (a) Define respiration.
- (b) Discuss the various principal respiratory adaptations in aquatic and terrestrial arthropods.

Discuss the Public Health and economic importance of the Nemathelminthes.

Define the following:

- (i) Monoecious
- (ii) Dioecious
- (iii) Homeostasis
- (iv) Osmoregulation
- (v) Cephalization
- (vi) Aberrant stock
- (vii) Polyphyletic origin
- (viii) Nematocyst
- (ix) Holozoic
- (x) Acoeloid

SECTION B

Define and give examples of any five(5) of the following terms as used in this course.

- (i) Paedogenesis
- (ii) Chiroptera
- (iii) Oviparous
- (iv) Biochrome
- (v) Vestigial organs
- (vi) Homocercal fin
- (vii) Duplex uterus

With the aid of diagram, compare the reproductive cycle of the African Mottled Eel (Anquilla bengalensis labiata) with that of a frog (Xenopus laevis).

Describe the main respiratory features of a fish, and compare its respiratory mechanism with that of birds.

Compare and discuss characteristics which distinguish two groups of vertebrates; reptiles and mammals. Describe the main feature which places the reptile as the borderline between poikilotherms and homeotherms. How do reptiles regulate their body temperatures?

END OF EXAMINATION

Real clear

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SUPPLEMENTARY/DEFERRED EXAMINATIONS - JANUARY 1996

BS 331 -

THEORY PAPER

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS

1. Outline the evidence which established that higher plant photosynthesis consists of two light reactions cooperating in series.
 2. Discuss the mechanism of water-splitting in photosynthesis in the leaves of higher plants.
 3. Why does oxygen reduce the efficiency of photosynthesis rather than enhance it?
 4. What is the origin of hydrogen ions in illuminated chloroplasts of higher plants, how are the hydrogen ions distributed in the thylakoid system and what is the significance of such distribution in heterotrophic mode of nutrition.
 5. How is gaseous nitrogen converted into organic nitrogen in the root nodules of leguminous plants?
 6. Compare and contrast the effects of Auxins and of Gibberellins in the growth of stems.
 7. Discuss in detail how light, relative humidity and temperature influence water uptake by roots and water loss through leaves.
 8. Discuss the role of internal growth substances in
 - (a) phototropic response of stems
 - (b) Root gravitropism
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

BS 332 .

ANIMAL PHYSIOLOGY

THEORY PAPER

E: THREE HOURS

WER: ANY FIVE QUESTIONS

Give several examples of symbiotic micro-organisms in alimentary canals and explain how they benefit the host?

Explain how the blood flow in the capillaries is regulated?

Explain briefly how the major nitrogenous waste products are produced in animals and discuss how the excretion of these waste products are associated with their habitat.

Explain the respiratory changes that take place in a human during diving and exercise.

Explain the role of hormones in osmotic and ionic regulations of vertebrates?

What are pheromones?

Compare and contrast the action of pheromones with that of hormones.

Describe the structural and functional differences between gills and lungs.

Write short notes on any four of the following:-

- (a) Bohr effect
 - (b) Catecholamines
 - (c) Pyrogens
 - (d) Acclimatization
 - (e) Hibernation
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY MID-YEAR EXAMINATIONS - JUNE 1995

BS 341

MICROBIOLOGY

THEORY PAPER

TIME: THREE HOURS

ANSWER:

FIVE QUESTIONS, TAKING NOT MORE THAN THREE FROM EITHER SECTION A OR B. ANSWERS MAY BE ENHANCED BY INCLUDING DIAGRAMS, RELEVANT TABLES AND GRAPHS. ALL QUESTIONS CARRY EQUAL MARKS.

SECTION A: BACTERIOLOGY.

1. With the help of a labelled diagram of a typical bacterial cell; state the functions of the cell components and cell surface structures.
2. Discuss briefly on the following:
 - (a) Factors you would consider in the formulation of a medium for growth of microorganisms.
 - (b) Pure culture and methods for maintaining pure cultures.
3. Select any three (3) types of microbial fermentations and give for each:
 - (a) the chemical reactions by which it proceeds.
 - (b) at least two (2) microbial species involved in the process
 - (c) possible industrial application(s).
4. Rickettsiae, Chlamydiae and Mycoplasmata are all referred to as members of the Order Rickettsiales:
 - (a) What makes them close to each other?
 - (b) By which features are they different from ordinary bacteria?
 - (c) Give, at least one pathogenic species of each group and disease caused?

SECTION B: VIROLOGY.

1. (a) Define the term host as it relates to viruses.
(b) Define virus. what are the minimal features needed to fit your definition? Viruses can be defined in either biological or chemical terms. Give both definitions.
2. Chemotherapeutic agents are lacking for most virus diseases. From what you know about the stages of virus multiplication, write (in general terms) how you might try to assay (detect) a chemotherapeutic agent which acts at each of these stages?
3. Draw the graph which illustrates a "one-step" growth curve. Several stages are known to occur, name them. Now answer the following questions in reference to the stages indicated in your graph (provide all the details on the graph to gain full marks):
 - (a) In which stage does attachment of the virus particles to cells occur and explain the phenomenon of adsorption?
 - (b) In which stage are "early" enzymes formed and what are the functions of the "early" enzymes?
 - (c) In which stage does virus nucleic acid replication predominantly occur and why?
 - (d) In which stage does cell lysis occur and what is the role of the enzyme(s) needed for cell lysis?
 - (e) If it were to occur, in which stage would virus genetic recombination likely occur?
 - (f) In which stage would the self-assembly process predominantly occur and why?
4. Describe the role which the lambda repressor protein plays in the lambda infection process. How do repressor protein and the cro protein interact? How does the SOS response of bacteria due to DNA damage by such agents as ultraviolet rays, X-rays etc affect the function of cI and cro in relation to lysogenicity?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SUPPLEMENTARY/DEFERRED EXAMINATIONS - JANUARY 1996

BS 341 .

MICROBIOLOGY

THEORY PAPER

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS, TAKING NOT MORE THAN 3 FROM EITHER SECTION A OR B. ANSWERS MAY BE ENHANCED BY INCLUDING DIAGRAMS, RELEVANT TABLES AND GRAPHS. ALL QUESTIONS CARRY EQUAL MARKS.

SECTION A: BACTERIOLOGY

1. What was meant by spontaneous generation of microorganisms? Discuss two experiments by Louis Pasteur which disproved the theory of spontaneous generation of microorganisms.
2. Discuss factors you would consider in formulating a medium for growth of lactic acid bacteria and environmental factors important for growth of microorganisms.
3. What should be the particular use of alcoholic, lactic and acetic fermentation?

Illustrate your answer by giving for each process:

- (a) Biochemical reactions
- (b) Main product obtained
- (c) Examples of involved microorganisms

4. Define:
 - (a) disinfectant
 - (b) detergent
 - (c) antibiotic
 - (d) Narrow and broad spectrum of antibiotic activity

Illustrate your answer by giving some examples.

SECTION B: VIROLOGY

1. Define the terms

- (a) Mean burst time
- (b) Mean burst size
- (c) Eclipse period and
- (d) Latent period

2. Discuss poliovirus as an example of a virus infecting humans under the two major headings

- (a) "Biological" properties and
- (b) Development of immunity and use of named vaccines to protect individuals from poliomyelitis disease.

3. Discuss in general, giving examples, the methods used to detect viruses. What do you understand by the concept of host specificity and its use in propagating viruses in vitro.

4. Two major classes of host mutants resistant to virus infection are known, those not absorbing virus and those to which virus absorbs and injects but the nucleic acid is destroyed inside. Suppose you had a bacterial host mutant resistant to phage T4, how would you determine which class it belongs to?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

BS 342 .

BIOLOGICAL SCIENCES

THEORY PAPER

TIME: THREE HOURS

ANSWER: ANY FIVE QUESTIONS

1. Fungi have recently been given a phylum of their own, distinct from plants and animals. Is this decision justifiable?

Explain your answer and support it with reasons.

2. Compare and contrast the structure of a hyphal apical cell with the oldest one in the same hyphal filament.

3. Discuss the experimental evidence which seems to explain the formation of the hyphal apex in fungi.

4. Discuss as fully as possible, the three theories currently in existence, which attempt to explain the ways in which cytoplasm streams to the hyphal apex in fungi.

5. Discuss the phenomenon of growth in fungi under the following separate headings:

- (a) methods of fungal growth assessment
- (b) the lag phase
- (c) the acceleration phase
- (d) the exponential phase

6. Write short notes on three of the following topics:

- (a) Carbon metabolism in fungi
- (b) Active liberation in three named examples of fungi
- (c) Rhizomorphs
- (d) Sclerotia
- (e) Septal pores and their significance

- . Microbial communities almost always exist as mixed populations leading to various forms of interactions. Discuss the different forms of associations of different organisms in an ecosystem.
 - . (a) Write in some detail on the role of some named bacteria in the nitrification process and the postulated steps.
 - (b) What is the effect of the nitrogen cycle on the environment and agriculture practice?
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

BS 352

PARASITOLOGY

THEORY PAPER

TIME: THREE HOURS

ANSWER FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

1. Environmental sanitation is key to the control of parasitic infections. Discuss.
2. Write notes on TWO of the following:
 - (a) Parasitic larval stages
 - (b) Pernicious malaria
 - (c) Pneumocystis carinii
 - (d) Complicated amoebiasis
 - (e) Differences between African and American trypanosomiasis.
 - (f) Antigenic variation in parasitic infections.
3. Illustrate how the knowledge of the life cycle of Plasmodium falciparum can be used to control it.
4. Discuss a named cestode with respect to life cycle, transmission and laboratory diagnosis.
5. Schistosomiasis is endemic in Zambia. What control measures would you recommend for a rural set up.
6. Describe FOUR of the following:
 - (a) Morphology of Enterobius vermicularis
 - (b) The differences between Entamoeba histolytica and Entamoeba coli
 - (c) Life cycle of Trichuris trichiura or Ascaris lumbricoides
 - (d) Morphological differences between plasmodium falciparum and plasmodium malariae
 - (e) Stage III of African Trypanosomiasis symptoms

- (f) Snail hosts for Schistosoma
- (g) Biological control of vectors
- (h) Pathogenesis of Ascaris lumbricoides

7. Discuss hookworm disease with respect to Geographical distribution, transmission and pathogenesis.
 8. Write an essay on the types of life cycles found in parasitic nematodes.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

BS362

GENETICS

THEORY PAPER

TIME: THREE HOURS

ANSWER: TWO QUESTIONS FROM SECTION A AND ALL THE QUESTIONS FROM SECTION B. THE SECTION A QUESTIONS CARRY 40% OF THE TOTAL MARKS, AND THE SECTION B QUESTIONS CARRY 60% OF THE TOTAL MARKS.

ANSWERS: FOR EACH SECTION MUST BE TIED UP SEPARATELY WITH YOUR COMPUTER NUMBER AND LETTER OF THE SECTION WRITTEN CLEARLY ON EACH COVER SHEET.

SECTION A

1. Geographically isolated communities tend to become inbred to some extent. Explain what effect this may have on the incidence of disease in these communities.
2. What is meant by the term 'continuous variation'? Give an example of a trait showing continuous variation in humans or animals and explain how its hereditary component might be measured.
3. Discuss the problems of meiosis in polyploids and indicate the ways in which plants and animals have been adapted to polyploidy.
4. What types of segregation can be observed in tetrads? Illustrate how the segregation types arise in the case of (a) two unlinked genes; (b) two partially linked genes. How can one measure by tetrad analysis the recombination frequency between two linked loci?

SECTION B

5. After mating between Normal, grey antennae female flies of genotype AaBb and twisted, ebony male flies of genotype aabb, there were 39 Normal grey, 23 Normal ebony, 29 twisted grey and 45 twisted ebony flies.
- (i) Test the data for the goodness of fit with the expected, 1:1:1:1 ratio.
 - (ii) Partition the chi-square into its component degrees of freedom.
 - (iii) Present results in a table showing initial chi-square analysis, partitioned chi-square values, degrees of freedom and corresponding probability range.
 - (iv) State your conclusions
6. In a human population at equilibrium 200 people in a random sample are blood group O, 125 blood group A, 60 are blood group B and 15 are blood group AB. Calculate the number of people heterozygote for blood group A. Show all steps in your calculation.
7. Differentiate F^+ from Hfr cells
8. Differentiate between virulent and temperate phages
9. In mice dark coat colour is dominant over albino, and normal ears are dominant over short ears. If these effects are caused by two independently segregating gene pairs write the possible genotypes for the parents of each of the following crosses. Use the symbols D and d for dark and albino coat-colour alleles, and E and e for the normal and short ears respectively.

PARENTS

PROGENY PHENOTYPES

	Dark normal	Dark short	Albino normal	Albino short
(a) Dark normal x dark normal	89	31	29	11
(b) Dark normal x dark short	18	19	0	0
(c) Dark normal x albino normal	20	0	21	0
(d) Albino normal x albino normal	0	0	28	0
(e) Dark short x dark short	0	32	0	10
(f) Dark normal x dark normal	46	16	0	0
(g) Dark normal x dark short	29	31	9	11

10. Describe briefly the major types of genetic exchange in bacteria.

11. How would you distinguish between male and female *Drosophila*?

12. Briefly explain the meaning of any three of the following:

- (i) Heterosis
- (ii) Balanced polymorphism
- (iii) Coefficient of inbreeding
- (iv) RFLPs
- (v) Sickle cell anemia is a molecular disease

13. When the common bean, Phaseolus vulgaris, true-breeding for white flowers were crossed with P. vulgaris true-breeding for purple flowers, all the F_1 progeny were purple. After selfing the F_1 , the F_2 segregated into the following phenotypes:

Family	Purple flowers	White flowers	Total	Chi-square	DF	P
1	118	82				
2	116	83				
3	118	90				
4	120	80				
5	117	77				

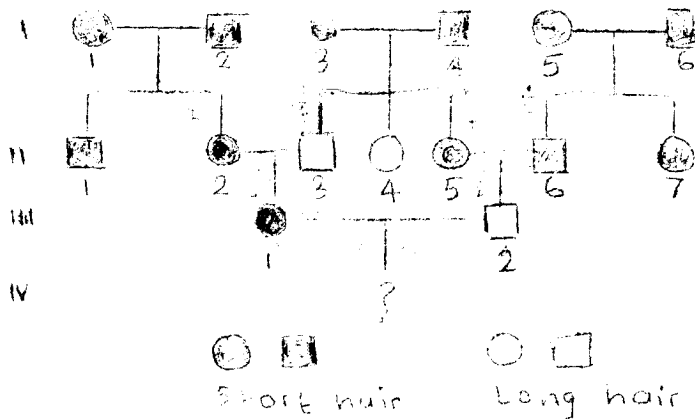
Total:

Pooled:

Heterogeneity:

Fill in the table and state whether or not the results of the families are homogeneous, and whether or not the pooled results have a good fit with an expected 3:1 ratio.

14. In rabbits the autosomal gene S for short hair is dominant to its recessive s for long hair. Assuming that in the pedigree II-2 and II-6 are S/s, what is the probability that any offspring of a mating between III-1 and III-2 will have (i) long hair, (ii) short hair? You may consider all possible alternative genotypes wherever you think this appropriate.



END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY MID-YEAR EXAMINATIONS - JUNE 1995

B.A. 372
INVERTEBRATES
THEORY PAPER

TIME: THREE HOURS

ANSWER:

ANY FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS

1. Compare and contrast the various principal respiratory adaptations in aquatic and terrestrial invertebrates.
 2. (a) Compare the feeding mechanisms of mosquitoes and ticks.

(b) How are they behaviorally and structurally adapted to their feeding habits?
 3. (a) What is movement?

(b) How does it differ from locomotion?

(c) Compare locomotion in the protozoa to that occurring in the arthropods.
 4. (a) Discuss the statement that the "Arthropods are the most successful, and most highly evolved of all animal phyla, living or extinct".

(b) What are the main characteristics of the three principal sub-phyla of the phylum Arthropoda.
 5. Discuss the evolution of cephalization in the invertebrates.
 6. Parasitism is widespread in various groups of the invertebrates. Discuss some of the major adaptations to parasitism among the invertebrates.
 7. (a) Discuss the theories of the origin of the metazoa.

(b) What is the origin and functional significance of the coelom?
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

BS 455

WILDLIFE ECOLOGY

PAPER I

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE
NECESSARY. ALL QUESTIONS CARRY EQUAL MARKS.

1. Describe the main characteristics of a wildlife habitat, and relate these to the concept of carrying capacity.
2. Discuss the main differences between the social groups of Wild Dogs (Lycaon pictus) and Baboons (Papio ursinus).
3. Define a territory and then explain how this concept is applied in Kafue lechwe (Kobus lechwe katusensis).
4. In the given list of wildlife species, select any two (2) and describe:
 - (i) Field impression (external features)
 - (ii) Habitat and distribution in Zambia
 - (iii) Habits (behaviour)
 - (iv) Economic value and conservation status

Animal species

Laughing Hyaena (Crocuta crocuta)

Cane Rat (Thryonomys swinderianus)

Sitatunga (Tragelaphus spekei)

Nile Crocodile (Crocodylus niloticus)

5. Briefly explain how a wildlife species would portion its food energy in digestion and metabolism, and give examples of factors that are involved in energy budgeting.
6. Define thermolysis in the vertebrate species, and describe thermal energy exchange between a browsing animal and its environment in the semi-arid woodland savanna.

7. Describe the significance of chemical communication in wildlife species. Give sources and pathways of pheromones and indicate their mode of transmission.
 8. What are the major limitations of the concept of sustainable yield, and discuss this in relation to wildlife harvesting.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1985

BS 455

WILDLIFE ECOLOGY

PAPER II

ME: THREE HOURS

SWER:

VE QUESTIONS. QUESTION ONE IS COMPULSORY. ANSWER
ESTION ONE AND FOUR (4) OTHERS. ILLUSTRATE YOUR
SWER WHERE NECESSARY. QUESTION ONE CARRIES 30 MARKS, AND ALL
HER QUESTIONS CARRY 20 MARKS EACH.

You are required to use the map provided to answer this question. Read the description of the map carefully. It is assumed that you have just completed an ecological study of the area, and from this study, answer the following questions:

(i) From your results briefly describe habitats A and B. (10 marks)

(ii) According to your results, the following animal species show distinct habitat preferences.

Zebra (Equus burchelli)

Wattled Crane (Grus carunculatus)

Oribi (Ourebia ourebi)

Kafue Lechwe (Kobus leche kafuensis)

Rank habitat selection by listing them according to the order of preference for each species, and give reasons. (20 marks)

Describe the general ovarian cycle in bovids, and discuss the importance of corpora lutea in studying wildlife species.

List and discuss four (4) methods that you would use in determining physical condition of an antelope. Indicate their limitations.

4. Define the following as used in this course.

- (i) Capchur gun
- (ii) Road strip census method
- (iii) Point centered quarter method
- (iv) Ad libitum
- (v) Ethogram

5. Briefly describe one common method used to determine:

- (i) Sex in birds
- (ii) Age in an elephant

6. Give reasons why populations of most wildlife species are declining in Zambia. Complete protection of wildlife has been adopted as the workable solution for conservation of wildlife. Discuss.

7. State the main advantages of using mechanical animal capture, and then compare this with the chemical method. List difficulties associated with translocation and restocking operations in wildlife management.

END OF EXAMINATION

Description of the Area

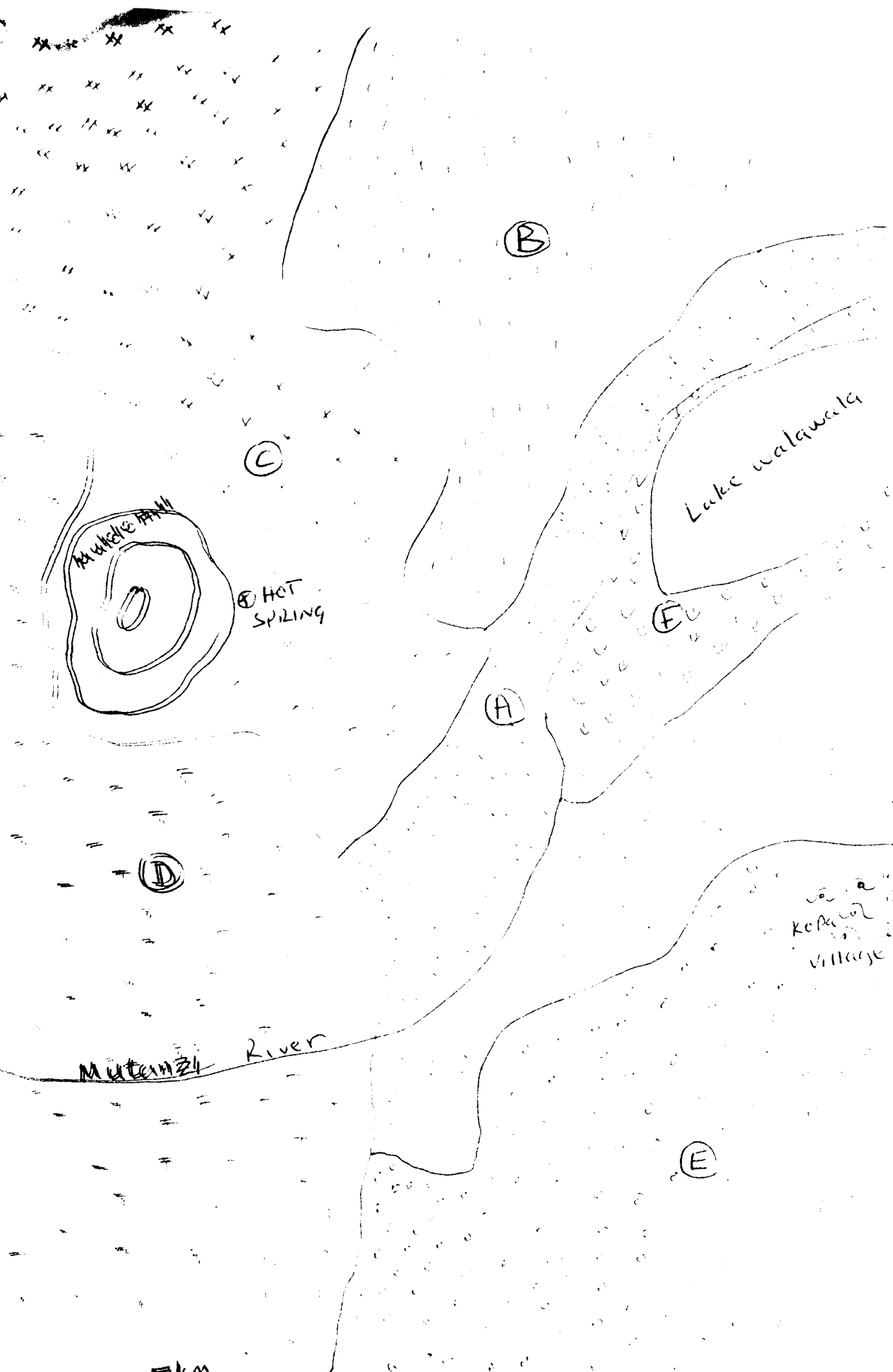
Vegetation types:

- A: Termitaria grassland
- B: Munga woodland
- C: Chipya woodland
- D: Miombo woodland
- E: Hyparrhenia grassland
- F: Swamp

The area is located in the South of Central Province of Zambia. Average annual rainfall is approximately 800 mm. The lake is fresh water, and has fish. The river is perennial with riparian vegetation mainly Diopyros sp and Syzygium sp. The Hot Spring is salty.

There is only one village of about seven households. Its main activity is fishing. Farming is done at a low scale in vegetation type E. Hunting is important.

The area is being considered for protection because of its importance to conservation. You have been asked to carry out an ecological study of the area. And from your study information answer question one.



(B)

(C)



HOT
SPRING

Lake watawata

(F)

(A)

(D)

Mutanzhi River

Kapa
village

(E)

1 km

THE UNIVERSITY OF ZAMBIA

UNIVERSITY MID-YEAR EXAMINATIONS - JUNE 1995

85 225

PLANT PATHOLOGY

PRACTICAL PAPER

TIME ALLOWED: THREE HOURS

ANSWER: ALL QUESTIONS

1. Examine specimens 1.1 - 1.5 and give the following information on them.
 - a. Type of parasitism
 - b. Type of sorus
 - c. Latin names of hosts
 - d. Latin names of pathogens
 2. Compare symptoms of diseases of 2.1 and 2.2 and give the following information in each case.
 - visual symptoms of 2.1 and 2.2
 - common names of the diseases
 - scientific names of causal organisms
 3. Examine 3.1 and 3.2 and describe in each case the:
 - name of the reproductive apparatus
 - shape and branching of the reproductive apparatus
 - position of the pathogen on host
 - common names of the two diseases
 - identification of pathogens
 4. Give a comparative account of symptoms in 4.1 and 4.2 and identify their possible causes.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
DEFERRED UNIVERSITY EXAMINATIONS - FEBRUARY 1995

BZ210

BIOLOGY OF CELLS AND SYSTEMS

THEORY PAPER I

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS, AT LEAST TWO TO BE CHOSEN FROM EACH
SECTION AND THE FIFTH FROM EITHER SECTION

SECTION A

CELL MOLECULAR BIOLOGY

1. Give reasons why all physiological processes take place in water.
2. Proteins are the only macromolecules with enough specificity to carry out key cellular functions. Discuss.
3. At a molecular level, explain the effect of temperature, pH, and reactant concentration on an enzyme catalysed reaction.
4. Write short notes on the following:
 - (a) the "anatomy" of an enzyme
 - (b) phospholipids
 - (c) the electron transport chain
 - (d) the fluid mosaic model of the cell membrane.

SECTION B

PLANT PHYSIOLOGY

5. Plant hormones are involved in the physiological regulation of root development. Discuss.
 6. Describe the role of micronutrient elements in plants.
 7. Give an outline of the mechanisms involved in the phenomenon of root pressure in higher plants.
 8. Explain the role played by products of the light reaction in the C₃ photosynthetic pathway.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY DEFERRED EXAMINATIONS - JANUARY 1995

BZ 210

BIOLOGY OF CELLS AND SYSTEMS

THEORY PAPER II

TIME: THREE HOURS

ANSWER:

FIVE QUESTIONS: TWO QUESTIONS FROM EACH SECTION AND THE LAST QUESTION FROM EITHER SECTION. ALL QUESTIONS CARRY EQUAL MARKS. USE SEPARATE ANSWER BOOKS FOR EACH QUESTION.

SECTION A

GENETICS

1. Explain mechanisms that generate genetic variability in sexually reproducing organisms during meiosis.
2. Write short notes on four of the following:
 - a. Pre-determination of offspring phenotypes.
 - b. Organelle DNA.
 - c. Operon system.
 - d. Hardy-Weinberg law.
 - e. Directional selection.
3. Distinguish between the following:
 - a. Inversion and reciprocal translocation chromosomal aberrations.
 - b. Transcription and translation.
4. A survey was conducted in the Kalingalinga area of Lusaka to determine the prevalence of the sickle cell disease. One out of five hundred children were found to be born with the sickle cell disease in the population. Calculate,
 - a. the frequency of the sickle cell gene in the Kalingalinga population.
 - b. the frequency of the heterozygotes for the gene and,
 - c. the probability of a Kalingalinga couple bearing a child with the sickle cell disease.

SECTION B

ANIMAL PHYSIOLOGY

5. What problems do freshwater fishes, marine fishes and terrestrial vertebrates face in maintaining proper osmotic concentrations of their extracellular fluids? How are these overcome?
6. Explain why respiration, temperature regulation and water balance in terrestrial animals are closely interrelated. Give examples.
7. The dissociation curve of haemoglobin is S-shaped or sigmoid. Explain the significance of this shape of the curve in relation to the activities of the molecules in the body.
8. What are extra-embryonic membranes, what are their functions and when do they develop in an organism.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

DEFERRED UNIVERSITY EXAMINATIONS - FEBRUARY 1995

BZ230

PLANT AND ANIMAL BIOLOGY

THEORY PAPER

TIME: THREE HOURS

ANSWER: FIVE questions, at least ONE from each section.
Illustrations may enhance your answer. All questions carry equal marks.

SECTION A
HIGHER PLANTS

1. Describe the reproductive processes displayed by a named heterosporous fern normally found along the riverine vegetation types of Zambia.
2. Give an account of the vegetative and reproductive structures of a forested angiospermous moss.
3. Explain the extent to which gibberellin influences the breeding systems of some ferns.

SECTION B
LOWER PLANTS

1. Compare and contrast the structural features of the desmids and diatoms.
2. What structural and reproductive features characterize such prokaryotic organisms known as the bacteria?
3. Give an illustrated account of the structure of a named brown alga.

SECTION C
INVERTEBRATES

1. What evolutionary advantages do you think have been suggested for and how are molluscs related to the bryozoans?
2. Give a detailed account of the life cycle of a named insect.
"The life cycle of a named insect, showing the stages of development from egg to adult, and the role of the adult in the life cycle of the insect."
3. Give a detailed account of the life cycle of a named arthropod, showing the stages of development from egg to adult, and the role of the adult in the life cycle of the arthropod.

9. A typical land snail and an octopus are placed in the same phylum Mollusca, although the two organisms look very different from each other. Compare and contrast structures of these two organisms and show the basis for placing them in the same taxonomic unit.

SECTION D
VERTEBRATES

10. Why are reptiles better adapted to terrestrial life than amphibians?
11. Give the structural and functional characteristics which the birds share with:
- (i) reptiles
 - (ii) mammals
12. Define and give examples on any four of the following:
- (a) Neoteny
 - (b) Paedogenesis
 - (c) Heterodont
 - (d) Metamorphosis
 - (e) Parthenogenesis
 - (f) Mesoderm

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - OCT/NOV 1995

CH10
INTRODUCTORY CHEMISTRY

COMPUTER NUMBER: _____ TUTORIAL GROUP: _____

TIME ALLOWED: THREE HOURS

INSTRUCTIONS: The examination has two (2) sections: A and B.

SECTION A: You are required to:

- (i) Answer all fifteen (15) questions.
- (ii) Answer the questions in the space provided after each question.
- (iii) Each question carries four (4) marks.

SECTION B: You are required to :

- (i) USE ANSWER BOOKLETS provided.
 - (ii) Indicate your COMPUTER NUMBER AND TUTORIAL GROUP NUMBER on your answer booklet.
 - (iii) Answer any FOUR(4) of the FIVE(5) questions given.
 - (iv) Make sure your work is NEATLY presented.
 - (v) Each question carries fifteen(15) marks.
-

PHYSICAL CONSTANTS ARE GIVEN ON PAGE 2

TOTAL MARK
FOR
SECTION A

--

C110

USEFUL INFORMATION

Avogadro's Number (L, N_A)	=	6.02×10^{23} per mole
Speed of light in vacuum (c)	=	3.0×10^8 m.sec ⁻¹
Universal gas constant (R)	=	8.314 J.K ⁻¹ .mol ⁻¹
	=	0.082 dm ³ .atm.K ⁻¹ .mol ⁻¹
Planck's constant (h)	=	6.63×10^{-34} J.sec
Faraday's constant (F)	=	$96\,500$ C.mol ⁻¹
Rydberg constant (R)	=	$109\,678$ cm ⁻¹
Molar volume gas at stp	=	22.414 dm ³ . mol ⁻¹
1 atm = 101 325 Pa = 101 325 N.m ⁻² = 760 mmHg = 760 torr		

ATOMIC NUMBERS AND RELATIVE ATOMIC MASSES

${}_1\text{H} = 1.01$	${}_6\text{C} = 12.01$	${}_7\text{N} = 14.01$	${}_8\text{O} = 16.00$
${}_9\text{F} = 19.00$	${}_{10}\text{Ne} = 20.18$	${}_{11}\text{Na} = 23.01$	${}_{12}\text{Mg} = 24.31$
${}_{13}\text{Al} = 27.00$	${}_{15}\text{P} = 31.00$	${}_{16}\text{S} = 32.06$	${}_{17}\text{Cl} = 35.45$
${}_{19}\text{K} = 39.10$	${}_{20}\text{Ca} = 40.08$	${}_{22}\text{Ti} = 48.00$	${}_{24}\text{Cr} = 52.00$
${}_{25}\text{Mn} = 55.00$	${}_{26}\text{Fe} = 55.85$	${}_{38}\text{Sr} = 87.60$	${}_{53}\text{I} = 127.00$
${}_{55}\text{Cs} = 133.00$			

STANDARD REDUCTION POTENTIALS (E^0) AT 25°C

$2\text{H}^+(\text{aq}) + 2\text{e} \rightarrow \text{H}_2(\text{g})$	(SHE)	$E^0 = 0.000\text{v}$
$\text{Cu}^{2+}(\text{aq}) + 2\text{e} \rightarrow \text{Cu}(\text{s})$		$E^0 = + 0.34\text{v}$
$\text{Al}^{3+}(\text{aq}) + 3\text{e} \rightarrow \text{Al}(\text{s})$		$E^0 = - 1.66\text{v}$
$\text{Zn}^{2+}(\text{aq}) + 2\text{e} \rightarrow \text{Zn}(\text{s})$		$E^0 = - 0.76\text{v}$
$\text{Hg}_2^{2+}(\text{aq}) + 2\text{e} \rightarrow \text{Hg}(\text{l})$		$E^0 = + 0.85\text{v}$
$\text{Zn}^{2+}(\text{OH})_2 + 2\text{e} \rightarrow \text{Zn} + 2\text{OH}^-$		$E^0 = - 1.25\text{v}$
$\text{H}_2\text{O} + \text{HgO} + 2\text{e} \rightarrow \text{Hg} + 2\text{OH}^-$		$E^0 = + 0.10\text{v}$

C110

SECTION A

- i. Two students determined the density of the metal titanium. Their results were as follows:

Student A:

4.49 g/cm³, 4.50 g/cm³, 4.52 g/cm³, 4.50 g/cm³.

Student B:

4.48 g/cm³, 4.47 g/cm³, 4.44 g/cm³, 4.53 g/cm³.

Which student had the more accurate results, and which student the more precise results given that the accepted value for the density of titanium is 4.51 g/cm³. Explain your answer.

- 2/ Between copper (Cu) and aluminium (Al) which metal will corrode in moist air at pH 7.0? Take as a criterion of corrosion a metal ion concentration of at least 10⁻⁶M.

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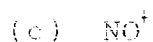
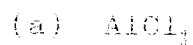
C110

3. 100cm^3 of oxygen effuses through a pin-hole orifice in 40 sec. Under the same conditions of temperature and pressure the same volume of a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2) effuses in 45.4 sec. Calculate the percent composition of the mixture.
4. A calorimeter is to be calibrated. A current of 6.00A at 12.00v is passed for 30 sec through a resistance heater in the calorimeter. The temperature increase recorded is 0.876°C . Calculate the calibration factor of the calorimeter in $\text{J}/^\circ\text{C}$.

--

CHC

Indicate whether the following would be expected to serve as a Lewis acid or Lewis base



A student prepared a 0.010M NH_3 solution and by a freezing point-lowering experiment, determined that the NH_3 had undergone a 4.2% ionization. Calculate the K_b for NH_3 .

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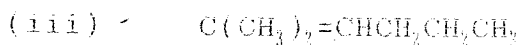
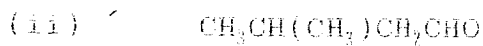
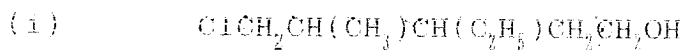
C110

7. 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?

8. Give the IUPAC name for the following compounds:



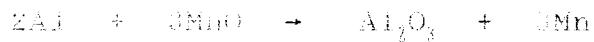
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CL10

9. Isopropyl alcohol has a vapour pressure of 91 mmHg at 40°C. Calculate its vapour pressure at 25°C, taking the molar heat of vaporisation to be 43.1 kJ/mol.

10. Coal from Maamba Collieries is said to contain 3.2% water. After drying the "moisture free" residue contains 72.5% carbon. Calculate the percentage of carbon in the coal on the "wet basis".

11. Aluminium and manganese oxide react according to the equation



A mixture containing 100g Al and 200g MnO was heated to initiate the reaction. Which reagent is in excess, and by how much?

TOTAL MARK ON PAGE:

C110

At a certain temperature and a total pressure of 1.0 atm, the vapour contains 40% by volume of I atoms.



(a) Calculate K_p for the equilibrium.

(b) At what total pressure (without temperature change) would the percentage of I atoms be reduced to 20%?

The mass percentage of HCl in concentrated hydrochloric acid is 36.0%. Calculate for this solution:

(i) the mole fraction of HCl.

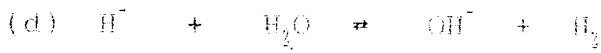
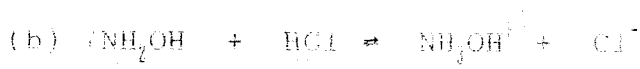
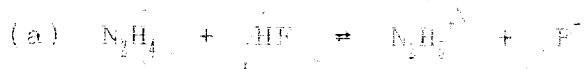
(ii) the molality of HCl.

Calculate the total number of orbitals associated with the quantum number, $n = 3$. Also name the kind of orbitals in question.

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C110

5. Identify the two acid-base conjugate pairs in each of the following reactions:



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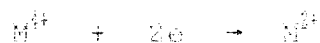
C110

SECTION B

ATTEMPT ANY FOUR(4) QUESTIONS

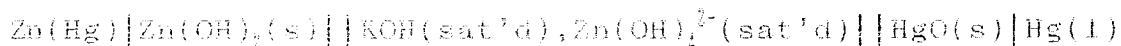
INSTRUCTION: Indicate the questions you have answered on the front page of your answer booklet(s).

1. (a) The standard potential for the half reaction

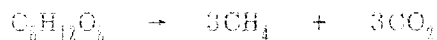


is +0.98v. Is M^{2+} a good or poor reducing agent? Explain.

- (b) The mercury cell is an alkaline zinc/mercury cell that is very widely used to power transistor radios, watches, hearing aids, etc. It can be represented as



- (i) What is the overall reaction equation for the cell?
- (ii) Find the potential of the cell.
- (c) Calculate the volume of methane, CH_4 , measured at 300K and 800torr, that can be produced by the bacterial breakdown of 500g of a simple sugar according to the equation.



2. (a) The first ionization energy of cesium (Cs) atom is recorded as 375.8 kJ/mol. What is the wavelength in nanometres (nm) of the radiation that is sufficient to ionize a single cesium atom?
- (b) The following reaction is used to prepare phosphine gas, PH_3 .



Given the following standard enthalpies of formation:

Q110

Substance	ΔH_f° (kJ/mol)
$\text{Ca}_3\text{P}_2(\text{s})$	-604
$\text{Ca}(\text{OH})_2(\text{s})$	-986
$\text{H}_2\text{O}(\text{l})$	-286

Calculate the standard enthalpy of formation of $\text{PH}_3(\text{g})$ if ΔH for the reaction is -568 kJ.

- (c) Which of the following electron configurations would correspond to the ground state and which is an excited state? Give your reasons.

(i) $1s^2 2s^2 2p^1$ (ii) $1s^2 2p^1$
 (iii) $1s^2 2s^2 2p^1 3s^1$

3. (a) How many moles of HCl must be added to 1.0 dm³ of a mixture containing 0.010M CH_3COOH and 0.010M NaOCCCH_3 in order to give a solution whose pH = 3.0?

- (b) Calculate the pH in the titration of 25.0 ml of 0.160M acetic acid by NaOH after the addition to the acid a solution of

(i) 10.0ml of 0.160M NaOH.
 (ii) 25.0ml of 0.160M NaOH.
 (iii) 30.0ml of 0.160M NaOH

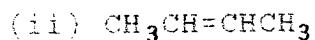
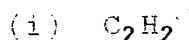
- (c) In carbon chemistry, what is meant by the term catenation?

4. (a) Exactly 3.847g of an acid HA of an unknown molecular mass was diluted with water to 250 ml in a volumetric flask. 25 ml of this solution required exactly 10.0 ml of 0.25M NaOH solution for complete neutralisation. Find the molecular mass of the acid.

- (b) A solution is saturated with respect to strontium carbonate, SrCO_3 , $K_{sp} = 7.9 \times 10^{-10}$ and strontium fluoride, SrF_2 , $K_{sp} = 7.9 \times 10^{-10}$. The $[\text{CO}_3^{2-}]$ is found to be $1.2 \times 10^{-3}\text{M}$. Calculate $[\text{F}^-]$.

- (c) 1.50g of an unknown compound was dissolved in 15.0g cyclohexane, C_6H_{12} . The freezing point of the solution was 2.70°C . Calculate the molar mass of this compound. Freezing point of pure cyclohexane is 6.50°C ; $K_f(\text{cyclohexane}) = 20.2^\circ\text{C.kg/mol}$.

5. (a) Write the reaction equation for
- (i) the complete combustion of ethanol
 - (ii) 1-butene with concentrated aqueous hydrogen bromide (show structural formula for the organic reactants and products).
 - (iii) ethene with dilute sulfuric acid (show structural formula for the organic reactants and products).
- (b) Ethanoic acid and octanoic acid are organic acids.
- (i) Which of them would you expect to show the highest solubility in water. Explain your answer.
 - (ii) Ethanoic acid shows dimerisation when it dissolves in a non-polar solvent like benzene. Explain this.
- (c) Give the hybridisation on each carbon atom, and the bond angles around each carbon atom in the following molecules:



END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

C220

ANALYTICAL/INORGANIC/PHYSICAL CHEMISTRY

TIME: THREE HOURS

SECTION A: ANALYTICAL CHEMISTRY

ANSWER: ANY TWO QUESTIONS FROM THIS SECTION

-
1. (a) Distinguish between the following forms of the student t-test
- (i) t test when an accepted value is known
 - (ii) Paired t test
 - (iii) t test with multiple samples
- (b) What is a Q test and what is it used for?
- (c) What is an F test and what is it used for?
- (d) You are developing a new colorimetric method for determining the glucose content of a blood sample. You have chosen the standard Folin-Wu method with which to compare your results. From the following two sets of replicate analyses on the same sample, determine whether the variance of your method differs significantly from that of the standard method.

Your Method, mg/L

Folin-Wu Method, mg/L

127

130

125

128

123

131

130

129

131

127

126

125

129

Mean (\bar{x}_1) = 127

Mean (\bar{x}_2) = 128

The tabulated F value for $v_1 = 6$ and $v_2 = 5$ is 4.95

The tabulated F value for $v_1 = 7$ and $v_2 = 6$ is 4.21

2. (a) Explain or define the following:

- (i) Gravimetric factor.
- (ii) Precipitation from homogeneous solution (PFHS).
- (iii) Common Ion and Diverse Ion effects.
- (iv) Solubility product (K_{sp}).
- (v) Occlusion, surface adsorption and post precipitation.
- (vi) Coprecipitation in the broad and restricted senses.

(b) Ten milliliters of 0.20 M AgNO_3 is added to 10 mL of 0.10 M NaCl . Calculate the concentration of Cl^- remaining in solution at equilibrium and the solubility of the AgCl .

$$K_{sp} \text{ for } \text{AgCl} = 1.0 \times 10^{-10}$$

(c) What is the solubility of PbSO_4 , in g/L, if the solubility product is 1.6×10^{-8} .

$$\text{Molecular Mass of } \text{PbSO}_4 = 303.26$$

3. (a) Explain the following terms

- (i) Strong electrolyte and a weak electrolyte
- (ii) Brønsted acid - base theory
- (iii) Conjugate acid and conjugate base
- (iv) Lewis acid-base theory
- (v) pH of a solution as defined by Sørensen.
- (vi) Buffer solution

(b) Calculate the pH of a buffer solution prepared by adding 10 mL of 0.10 M acetic acid to 20 mL of 0.10 M sodium acetate.

$$K_a \text{ for acetic acid} = 1.75 \times 10^{-5}$$

(c) A buffer solution is 0.20 M in acetic acid and sodium acetate. Calculate the change in pH upon adding 1.0 mL of 0.10 M hydrochloric acid to 10 mL of this buffer solution.

$$K_a \text{ for acetic acid} = 1.75 \times 10^{-5}$$

SECTION B: INORGANIC CHEMISTRY

INSTRUCTIONS: ANSWER ANY TWO QUESTIONS

1. (a) Sodium thiosulfate is widely used in laboratory and in industry. Give one example of its application and state the reactions involved for each sector. How is sodium thiosulfate prepared in laboratory?
- (b) The visible colour of complexes is mainly due to the d-d transition. Explain, why copper (I) complexes are colourless, but copper (II) complexes are coloured?
2. (a) Name the following complexes.
 - (i) $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2][\text{Cr}(\text{CN})_4\text{SO}_4]$
 - (ii) $\text{K}[(\text{CO})_5\text{Fe}-\text{OH}-\text{Fe}(\text{CO})_5]$
- (b) Calculate zero point energy of an electron trapped in a box of length, 2 nanometer (nm).
3. (a) Determine the hybridisation state of the central atom, (phosphorous) in PCl_5 molecule. Mention the angles involved.
- (b) The work function of potassium is 3.68×10^{-19} J. If just one photon of ultraviolet light of frequency 10^{15} Hz strikes the surface of sodium, what would be the maximum energy of an ejected electron? Also calculate the speed of the ejected electron.

USEFUL INFORMATIONS AND PHYSICAL CONSTANTS

Atomic numbers

P = 15; Cl = 17; Cu = 29

Mass of electron = 9.11×10^{-31} Kg

Planck's constant = 6.63×10^{-34} J.Sec.

SECTION C: PHYSICAL CHEMISTRY

ANSWER ANY TWO QUESTIONS

USEFUL INFORMATION:

$$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1} \text{ OR } 0.082 \text{ l atm dm}^3 \text{ mol}^{-1} \text{ K}^{-1}.$$

1. (a) Derive equations for entropy change for
 - (i) Isothermal expansion of an ideal gas from volume, V_1 to V_2 .
 - (ii) Isochoric temperature change of a gas from T_1 to T_2 .
- (b) Calculate the entropy change when a mono atomic gas at 25°C and 1 atm pressure in a container of volume 500cm^3 is allowed to expand to twice its initial volume and simultaneously heated to 100°C (for mono atomic gas $C_v = \frac{3}{2} R$).
2. (a) Define the rate determining step of a reaction mechanism
- (b) Derive the rate of formation (Rate law) of CH_4 from the mechanism below.

$$\text{CH}_3\text{CHO} \xrightarrow{k_1} \text{CH}_3 + \text{CHO}$$

$$\text{CH}_3 + \text{CH}_3\text{CHO} \xrightarrow{k_2} \text{CH}_4 + \text{CH}_3\text{CO}$$

$$\text{CH}_3\text{CO} \xrightarrow{k_3} \text{CH}_3 + \text{CO}$$

$$2\text{CH}_3 \xrightarrow{k_4} \text{C}_2\text{H}_6$$
- (c) Given that experimentally the rate law for the formation of CH_4 has been determined as

$$\text{Rate} = \frac{d[\text{CH}_4]}{dt} = k [\text{CH}_3\text{CHO}]^{\frac{3}{2}}$$

for the mechanism in (b)

State what could be the supporting evidence to the validity of the mechanism above.

- (d) Define two complex reactions you know and show the ample treatment of their kinetics.
3. (a) Show graphically how the molar conductivity depends on concentration for a weak and strong electrolyte and explain the differences observed between the two.
- (b) The resistance of a 0.01 mol dm^{-3} aqueous solution of acetic acid was measured in a conductivity cell whose cell constant is 0.367 cm^{-1} and found to be 2220 Ohm .
- (i) Find the value of molar conductivity of the solution.
- (ii) Given that at infinite dilution the molar ionic conductivities of H^+ and CH_3COO^- are 349.6 and $40.9 \text{ } \Omega^{-1} \text{ cm}^2 \text{ mol}^{-1}$ respectively calculate the degree of dissociation, α , equilibrium constant, K_a , and $\text{p}K_a$ for the acid.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
DEFERRED UNIVERSITY EXAMINATIONS - JANUARY - 1995

C 240

TIME: THREE (3) HOURS

INSTRUCTIONS:

This examination has three Sections. These are Section A: Organic Chemistry, Section B: Organic Chemistry and Section C: Biochemistry. Attempt to spend one hour answering questions from each Section.

- 2 -

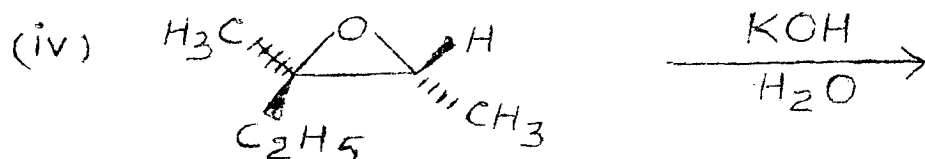
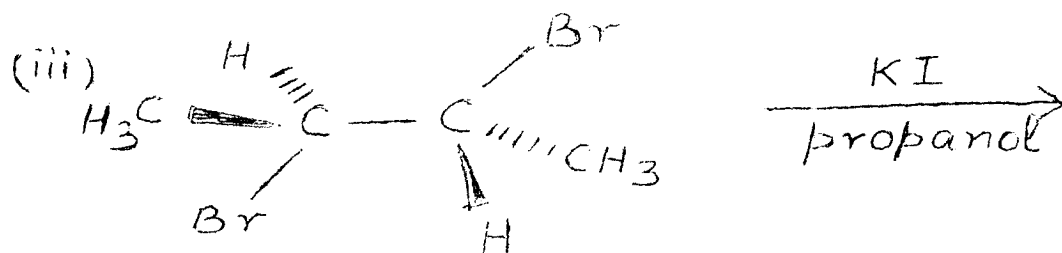
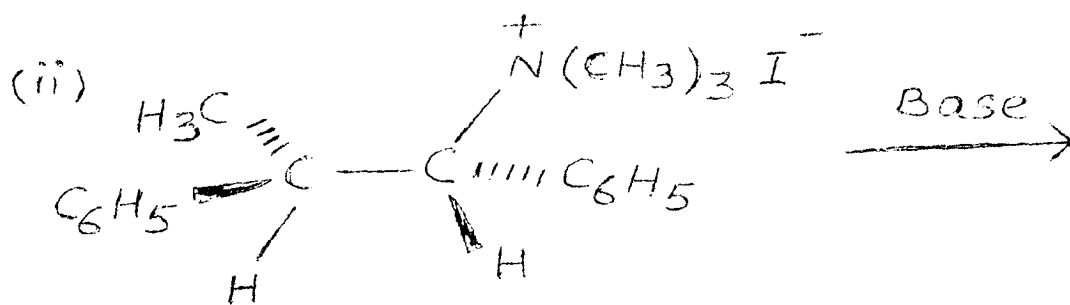
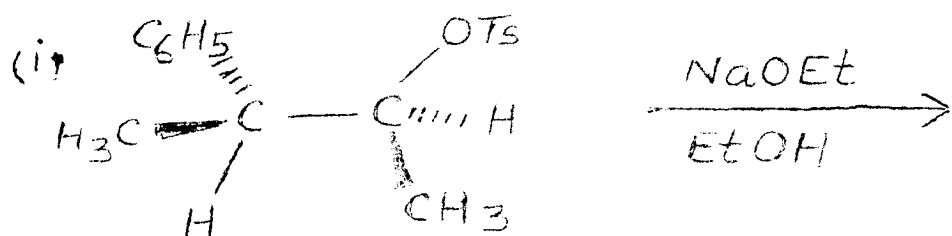
SECTION A

TIME: 1 HOUR

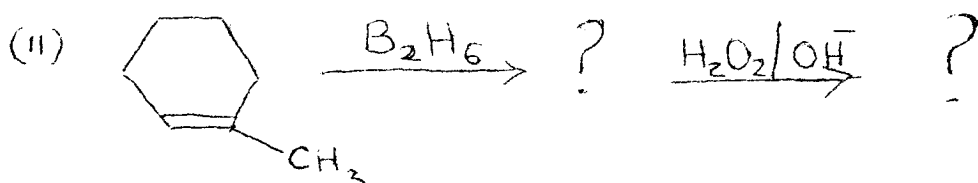
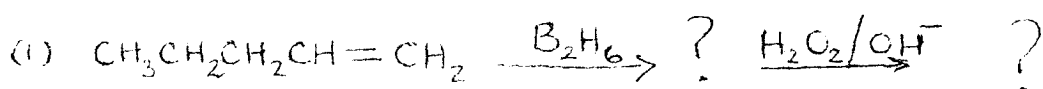
ANSWER ANY 2 OUT OF 3 QUESTIONS

SECTION A

1. Give the names and structures of the stereoproducts of the following reactions:



- 2(a) Give the products and general mechanism of the following reactions

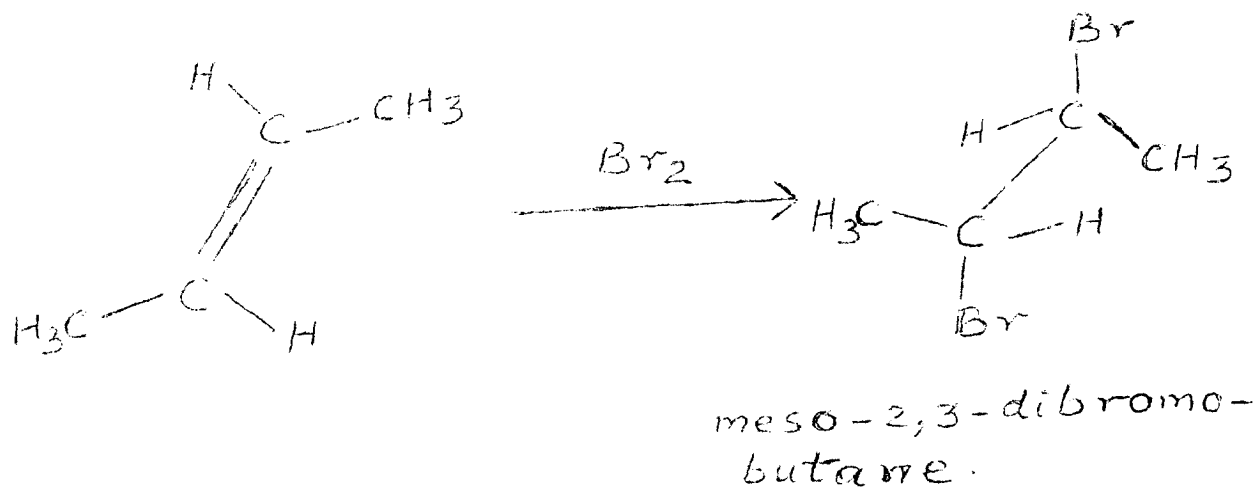


Q2 (Contd')

b) Indicate whether each of the following statements refers to S_N2, S_N1, both reaction mechanisms or none of them.

- (i) reaction is Unimolecular and typically is first order.
- (ii) the reaction is quite sensitive to steric hindrance.
- (iii) the reaction is greatly accelerated by polar solvents.
- (iv) rearrangements are frequent.
- (v) the reaction is bimolecular and typically shows second-order kinetics.
- (vi) Inversion of configuration occurs at the carbon substituted.
- (vii) racemization is typical, but other stereochemical phenomena are sometimes observed (e.g. partial inversion of configuration as well as possibility of retention of configuration.)
- (viii) the reaction is insensitive to steric hindrance, except in very special cases.
- (ix) the reaction is rather insensitive to the polarity of the solvent (unless charges are formed or destroyed in approaching the transition state).

3. Provide a comprehensive explanation as to why trans-2-butene gives only meso-2,3-Dibromobutane upon reactions with Br_2 ?

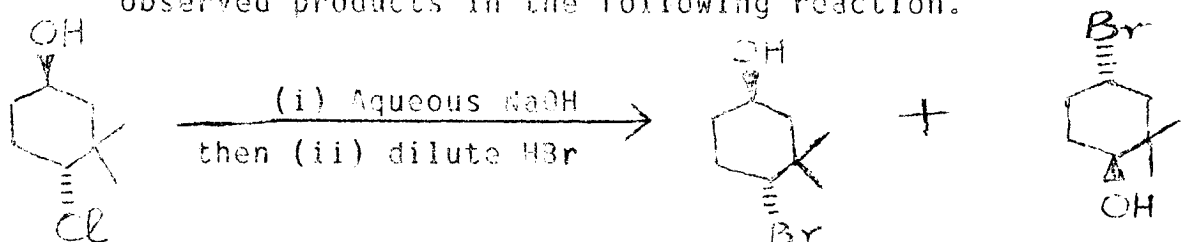


SECTION B

INSTRUCTIONS

1. ANSWER ANY TWO QUESTIONS
 2. TIME ALLOWED FOR THIS SECTION IS ONE (01) HOUR
-

- 1(a) Provide a mechanistic explanation for formation of the observed products in the following reaction.



- (b) One (1) mole of a compound A reacted with three (3) moles of periodic acid, HIO_4 , to give two (2) moles of methanoic acid and two (2) moles of formaldehyde. On this basis suggest the most likely structure for A.
- (c) Attempted preparation of C from B using Williamson ether synthesis unexpectedly gave a compound D, $\text{C}_5\text{H}_{10}\text{O}$, in good yield. What is D?

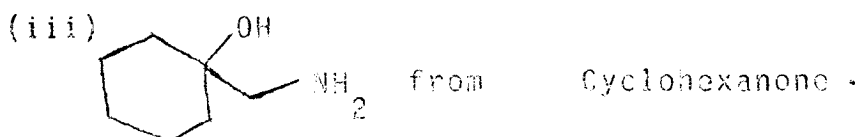
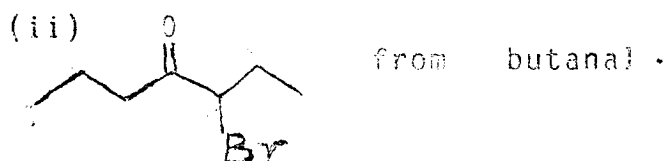
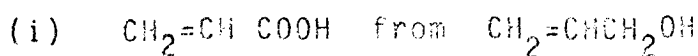
BC

Propose a reaction mechanism to explain the formation of the unanticipated product D from B.

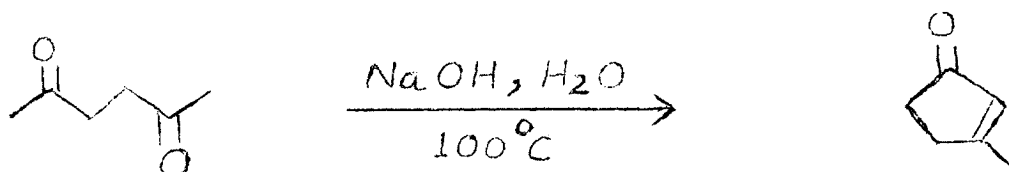
- 2(a) Esters can be condensed with aromatic aldehydes in presence of alkoxides. For example, benzaldehyde, $\text{C}_6\text{H}_5\text{CHO}$, reacts with ethyl acetate in presence of sodium ethoxide to give ethyl cinnamate, $\text{C}_6\text{H}_5\text{CH}=\text{CHCOO}-\text{C}_2\text{H}_5$. Show all steps in the most likely mechanism of this reaction.

SECTION B

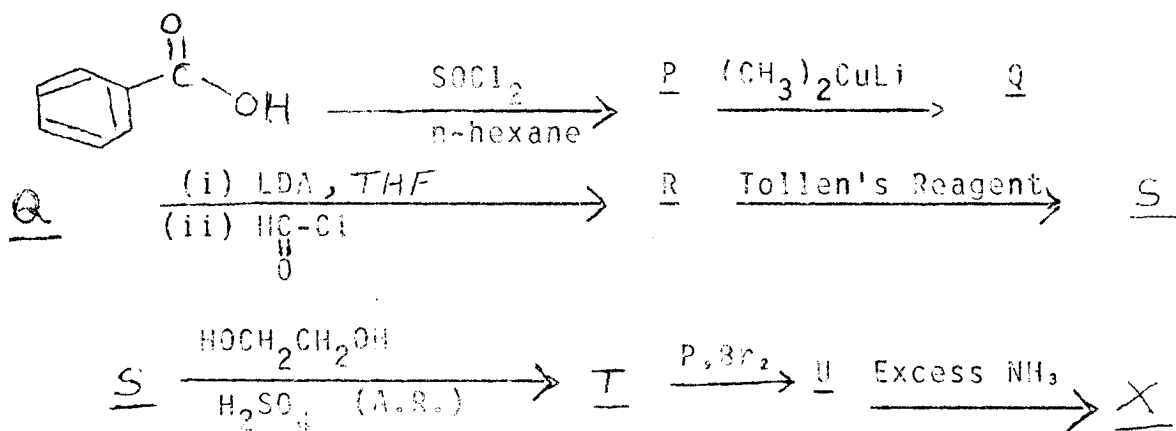
- 2(b) Propose a stepwise synthesis for two of the following compounds from indicated starting materials and any other reagents. Reaction mechanisms are not required.




- 3(a) Suggest a reaction mechanism to explain the following reaction.



- 3(b) (i) Deduce the structure of a biologically active compound X from the following synthesis. Give the structures of intermediates P to U.



[NOTE THAT THF = 

- (ii) Write a mechanism of the reaction involved in the formation of T from S.

SECTION C

Answer any FOUR questions

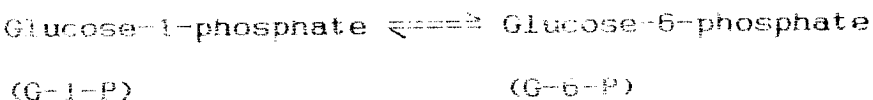
Q1. (a) The ΔG° of hydrolysis of acetylphosphate to acetate and phosphoric acid is -10kcal/mol (pH 7.0) and that of ATP to ADP and P_i is -7.3kcal/mol (pH 7.0).

What is the ΔG° and K_{eq} of the following reaction at pH 7.0 (temp. 25°C)?



($R = 1.987\text{cal/mol/}^\circ\text{K}$)

(b) Consider the following reaction;



catalysed by the enzyme phosphoglucomutase.

Given that $\Delta G^\circ = -1800\text{cal/mol}$ and $R = 1.9878\text{cal/mol/}^\circ\text{K}$,

(i) Does the reaction proceed as written, if so, what are the final concentrations of G-1-P and G-6-P assuming you started with 0.1M G-6-P?

(ii) What cellular conditions would allow continuous production of G-1-P?

Q2. (a) Distinguish between the terms nucleoside and nucleotide.

(b) If an *E. Coli* cell is a flat ended cylinder of diameter 1.00 μ m and length 2.00 μ m;

(i) What is the volume of the cell in cm^3 ? If this cell contains one chromosome of molecular weight 2.50×10^9 ,

(ii) What is the intracellular molarity in moles per litre of DNA and,

(iii) its concentration in micrograms/ cm^3 ?

(iv) Calculate the approximate length of bacterial chromosome in mm.

NOTE:

1Kb = 1000base pairs

Avogadro's number = 6.022×10^{23} particles/mole, the average molecular weight of a nucleotide residue in DNA is 310, the diameter of DNA is 2.00nm and each nucleotide pair occupies 0.34nm along the DNA molecule. $1\mu\text{m} = 10^{-6}\text{m}$, $1\text{nm} = 10^{-9}\text{m}$.

Q3. (i) Calculate the % of V_{max} observed at substrate concentration

(a) K_m

(b) $0.01K_m$

for a Michaelis -Menten type of Enzyme.

(ii) Explain how enzymes speedup biochemical reactions.

(iii) What determines the specificity of an enzyme?

Q4. (i) Define pI

(ii) Ala has the following pK' 's values , 2.35 and 9.69.

What is its pI value?

(iii) If formic acid and its salt are used to make a 0.5M buffer $pH = 2.0$, what would be the molar concentration of the acid and its salt in the buffer?

(pK' value of formic acid is 3.75)

Q5. Collagen is a protein found in the bone, skin, and cartilage. It exists as a triple helical structure. Distinguish between collagen helix and α -helix.

GOOD LUCK.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

C 240

ORGANIC CHEMISTRY

E: 3 HOURS

INSTRUCTIONS:

THIS EXAMINATION HAS TWO SECTIONS. THESE ARE SECTION A:
ORGANIC CHEMISTRY, AND SECTION B BIOCHEMISTRY.
YOU MUST SPEND TWO HOURS ANSWERING QUESTIONS FROM
SECTION A AND ONE HOUR ANSWERING QUESTIONS FROM SECTION B.

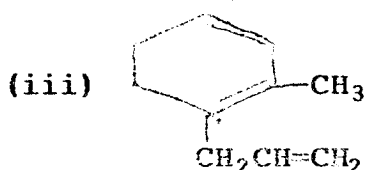
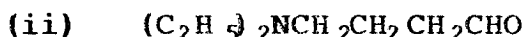
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SECTION A: ORGANIC CHEMISTRY

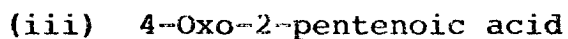
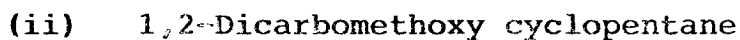
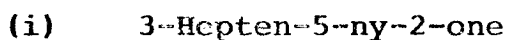
TIME: 2 HOURS

ANSWER ANY 4 OUT OF 6 QUESTIONS

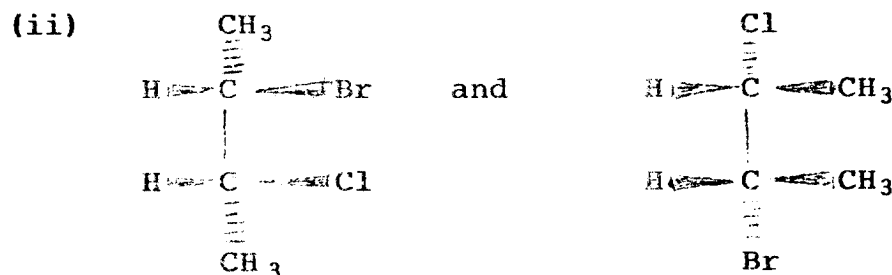
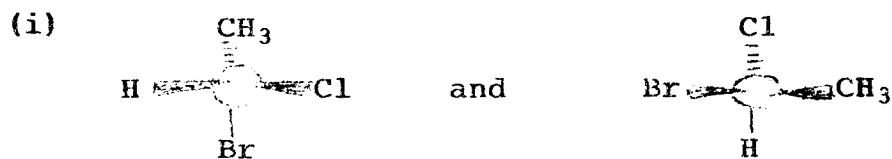
1. (a) Give the systematic I.U.P.A.C names for each of the following compounds



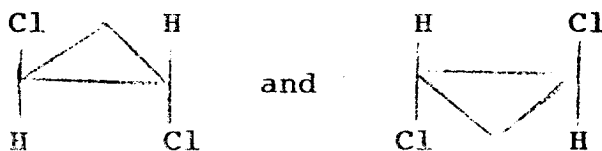
(b) Draw the structural formulae for each of the following compounds



(c) What is the relationship between the following pairs of compounds



(iii)



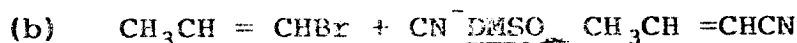
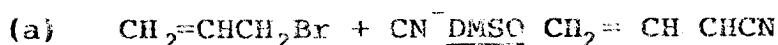
(iv)

Using the R,S-nomenclature, give the full I.U.P.A.C name for the compounds in (ii) above.

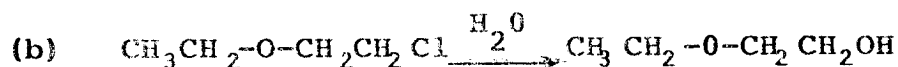
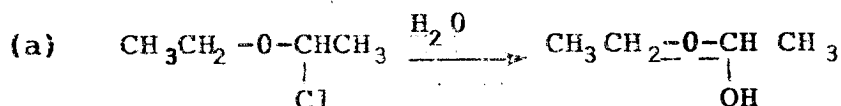
(d) Write structural formulae for all stereoisomers of 1,3-dichloro-2,4-dimethyl cyclobutane and indicate which ones are optically inactive.

(a) For each of the following pairs of reactions, predict which one is faster and give your reasons.

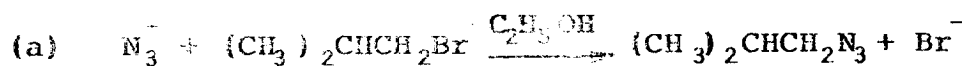
(i)



(ii)

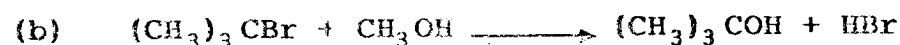
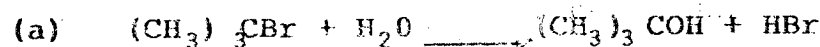


(iii)*

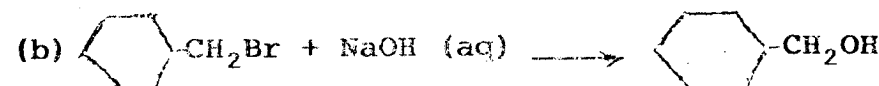
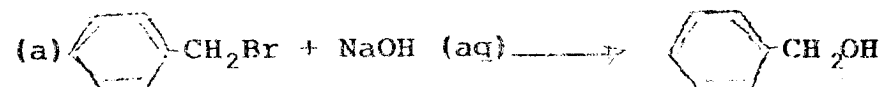


Note: $\text{p}K_a(\text{HN}_3) \approx \text{p}K_a(\text{C}_6\text{H}_5\text{SH})$

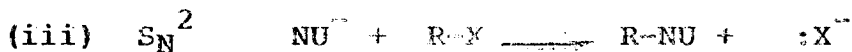
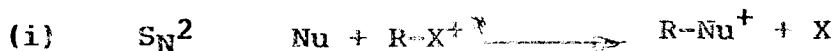
(iv)



(v)




(b) The following Nucleophilic substitution reactions were carried out in polar aprotic solvent. Draw the transition state for each reaction and state the effect of the solvent on the rates of the reaction.



(c) Provide a brief explanation as to why

(i) $CH_3CH=CHCH_2Cl$ yields the same product as $CH_3CH(Cl)CH=CH_2$ with aqueous NaOH in S_N1 reaction mechanism.

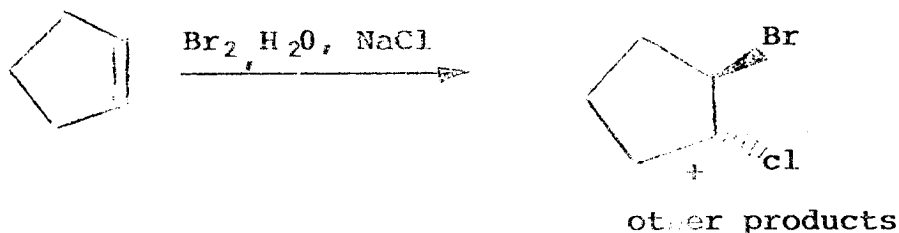
(ii) -Cl is very unreactive towards nucleophiles in S_N2 reaction mechanism.

(a) The dehalogenation of meso-2,3-dibromobutane with potassium iodide in ethanol yields only trans-2-butene. The reaction follows the following kinetic expression:

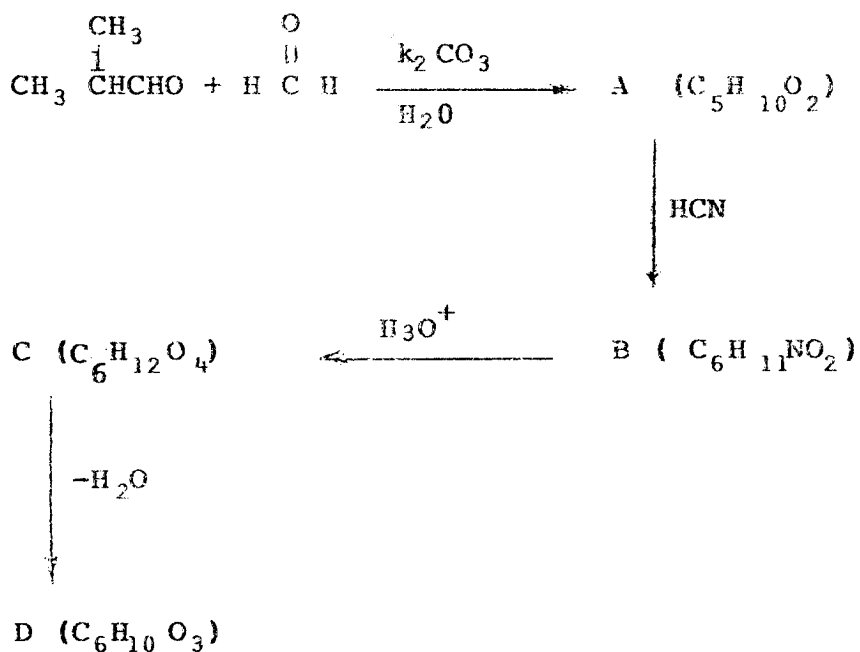
$$\text{Rate} = k [I^-] [\text{dihalide}]$$

- (i) is this a trans or anti elimination?
- (ii) on what do you base your answer?
- (iii) provide a mechanism for the reaction and give the structure for the transition state.

(b) Provide a reasonable mechanism for the reaction given below and give other products that you would expect from this reaction.



- (a) (i) Identify structures for compounds A to D



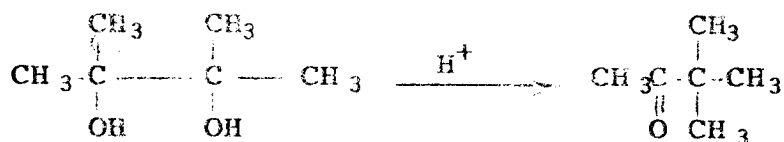
- (ii) Give the mechanism for the formation of compound A.

- (b) Triphenylphosphine can be used to convert epoxides to alkenes as show below.

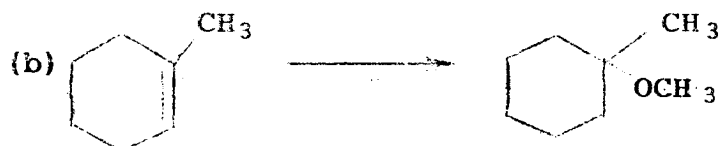


Propose a likely mechanism for this reaction.

- (c) Provide a mechanism for the reaction shown below.

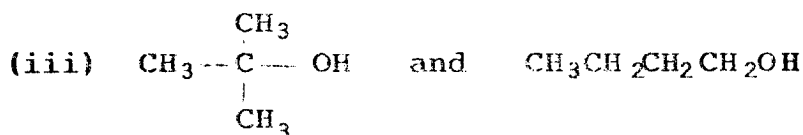
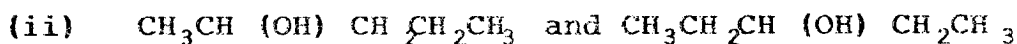
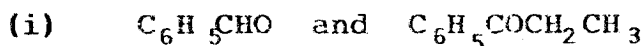


5. (a) (i) Starting with ethanol as the only available organic compound, show how you would make
- Formaldehyde (Methanal)
 - 2 - Butenal
- (ii) Show how you would make the following conversions using the compounds indicated and any necessary inorganic reagents.



- (b) Give products and their I.U.P.A.C names resulting from the reaction of 1-methylcyclohexene with.
- mercuric acetate and then basic sodium borohydride
 - Diborane and then basic hydrogen peroxide
 - Ozone followed by acidic hydrogen peroxide
 - Osmium tetroxide and then acidic work-up
 - m -chloroperbenzoic acid.

6. (a) By means of simple chemical tests, explain how you would distinguish between the following pairs of compounds.



(b) A C240 student was given an unknown compound E, C_6H_{10} , on which he carried out the following reactions. He confirmed that compound E decolourised both bromine and potassium permanganate solutions. On reaction of E with sulphuric acid followed by hot water he obtained only one compound F, $C_6H_{12}O$, which readily reacted with hydrochloric acid to give G, $C_6H_{11}Cl$. Compound G, on reaction with magnesium turnings in dry ether, followed by addition of ethanal (acetaldehyde) and then water gave him an alcohol H, $C_8H_{16}O$. On dehydration of H with concentrated sulphuric acid, he obtained the saytzeff product, I, which on ozonolysis followed by oxidative work-up gave him cyclohexanone and ethanoic acid (acetic acid).

- (i) Summarise the above reaction sequences in a diagramatic form
- (ii) What are the structures of compounds E to I?

C240 Biochemistry

SECTION B

Time: 1 hour

Answer any FIVE Questions

Q1. (a) Calculate the $[H^+]$ of

(i) blood plasma, pH 7.4

(ii) Cola, pH 3.4

(b) (i) Calculate the pH of an aqueous solution prepared by combining 50ml of 0.1M NaOH and 200ml of 0.1M acetic acid ($pK_a = 4.75$)

(ii) Calculate the pH if a additional 25ml of 0.2M NaOH are added to the solution.

(c) if a weak acid X ($pK_a = 3.55$) and its salt are used to make a 0.5M buffer, pH = 4.0, what are the molar concentrations of the acid and its anion in the buffer?

Q2. (i) A protein has 0.29% trp by weight, what is the minimum MW of the protein? (H = 1.00, O = 16.00, N = 14.00, C = 12.00)

(ii) What would be the predominant species of the following amino acids at pH 4? pH 9.5?

(a) glu

(b) met

	<u>pKa1</u>	<u>pKa2</u>	<u>pKa3</u>
glu	2.19	9.67	4.25
met	2.28	9.21	

Q7. (a) How does the rate of a reaction by an enzyme vary with

- (i) temperature
- (ii) pH
- (iii) substrate concentration, and
- (iv) enzyme concentration.

(b) What are

- (i) coenzymes
- (ii) apoenzymes
- (iii) holoenzymes
- (iv) prosthetic factors?

(c) Why are enzymes said to have the properties of a catalyst?

(d) Explain the meaning of the following terms when used to describe an enzyme catalysed reaction:

- (i) denaturation
- (ii) deactivation
- (iii) turnover number
- (iv) ES.

END OF EXAM.....

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS

OCTOBER 1995

C-310 Biochemistry Paper I

Time: THREE hours

SECTION A:

Answer ALL Questions in this section

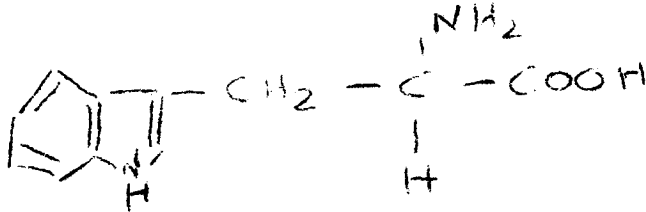
Q1. What is the effect of each of the following treatments on the oxygen affinity of HbA in vitro?

- a) increase in pH from 7.2 to 7.4
- b) increase in $p\text{CO}_2$ from 10 to 40 torr.
- c) increase in [BPG] from 2×10^{-4} to $8 \times 10^{-4}\text{M}$
- d) Dissociation of $\alpha_2\beta_2$ into subunits.

Q2. After a preincubation with *p*-chloromercuribenzoate, the binding of an enzyme with substrate was no different from that of untreated enzyme, but the catalytic activity of the treated enzyme was found to be 40% less. What conclusion can be drawn from this type of observation?

Q3. A polypeptide that binds strongly to a column packed with a strong cation-exchange resin at pH 3.5 can be washed off the column by passing a buffer of pH 8 through the column. Explain why.

Q4. Consider the following structure and note which of the following statements are true and which are false.



- a) It is an aromatic amino acid.
- b) It is a phenol
- c) It contains 2 asymmetric C atoms.
- d) It is a derivative of phe.
- e) The structure represents the compound trptophan.

Q5. Which of the following characteristic are associated with myoglobin(M), haemoglobin(H), both of them(B) or neither of them(N)?

- a) majority of structure in α -helical conformation.
- b) oxygen carrier.
- c) carbon dioxide carrier.
- d) not an allosteric protein.
- e) heme group(s) in polar crevice.
- f) protoporphrin IX.
- g) sigmoidal oxygen dissociation curve.
- h) tertiary structure.
- i) quarternary structure.
- j) blocked N-terminal residue.

Q6. (i) What does the pentose phosphate pathway produce in the cell?

(ii) Explain how this pathway controlled?

.....

SECTION B:

Answer any THREE Questions in this section

(All questions in this section carry equal marks)

Q7. (i) Given the following polypeptide;

H_2N^+ -gly-phe-asg-lys-trp-pro-met-ala-ser-val-thr-arg-gly-ala-lys-ile-his-met-leu-arg-COO $^-$

Which amino acid(s) can be identified by treating the polypeptide with each of the following;

- a) 2,4-dinitrofluorobenzene
- b) carboxypeptidase A
- c) dansylchloride

(ii) What is the probable sequence of the peptide given the following information about it;

amino acid composition;

(ala, leu, arg, met, phe, thr, 2val)

treatment of the peptide with

. Sanger's reagent yields DNP-ala

. trypsin; two fragments (ala, arg, thr) and (leu, met, phe, 2val)

which when treated with Sanger's reagent yields DNP-ala and -val, respectively.

. CNBr ; two fragments (ala, arg, homoserine lactone, thr, 2val) and (leu, phe) which when treated with Sanger's reagent yields DNP-ala and -leu, respectively.

Show your reasoning very clearly.

(11) A polypeptide obtained from the treatment of a protein with trypsin was shown to contain leu, asp, lys, ser, and tyr. For the determination of the amino acid sequence, the peptide was cycled through the Edman degradation procedure three times. The composition of the peptide after each cycle was as follows;

after cycle 1; lys, asp, ser, leu.

after cycle 2; lys, ser, asp.

after cycle 3; lys, ser.

Showing your reasoning clearly, determine the sequence of the pentapeptide.

Q8. a) What do you understand by the term Bohr effect?

b) (i) Explain in molecular terms the allosteric behaviour of Hb.

(ii) Why is Mb not capable of exhibiting allosterism?

c) Give TWO reasons why the protein is necessary in the binding of the oxygen to the heme group in myoglobin. Provide experimental evidence to support your answer.

Q4. The equilibrium constant K for the binding of oxygen to myoglobin is 10^6 M^{-1} , where K is defined as

$$K = [\text{MbO}_2] / [\text{Mb}][\text{O}_2]$$

The rate constant for the combination of oxygen with myoglobin is $2 \times 10^7 \text{ M}^{-1} \text{ S}^{-1}$.

a) What is the rate constant for the dissociation of oxygen from oxymyoglobin?

b) What is the mean duration of the oxymyoglobin complex?

Q9. (a) The active site takes up a relatively small part of the total volume of an enzyme. Why is it necessary for the enzyme to have many amino acid residues that do not take part directly in catalysis?

(b) The hydrolysis of pyrophosphate to yield orthophosphate is important in driving forward biosynthetic reactions such as the synthesis of DNA. This hydrolytic reaction is catalysed in *E. coli* by a pyrophosphatase that has a mass of 120kd and consists of six identical subunits. For this enzyme, a unit of activity is defined as the amount of enzyme that hydrolyses 10 μ moles of pyrophosphate in 15 minutes at 37°C under standard assay conditions. The purified enzyme has a V_{max} of 2800units per milligram of enzyme.

(a) How many moles of substrate are hydrolysed per second per milligram of enzyme when the substrate concn is much greater than K_m ?

(b) How many moles of active site are there in 1 mg of enzyme? Assume that each subunit has one active site.

(c) What is the turnover number of this enzyme?

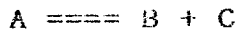
Q10. (i) Outline the reactions of the TCA cycle giving the structures of the compounds used and the products made as well as the enzymes and the cofactors involved.

(ii) What are the main control points in the TCA cycle and how are they controlled?

(iii) Why are there so many control points in TCA cycle?

(iv) Explain the apparent absence of oxygen in the TCA cycle even though the process is said to be aerobic.

Q11. (i) Consider the hypothetical reaction (pH 7, 25°C, 1 atm)



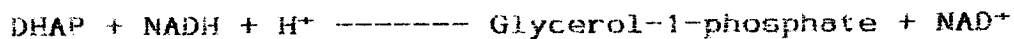
The initial concn of A is 0.2M; at equilibrium only 1% of A remains.

calculate

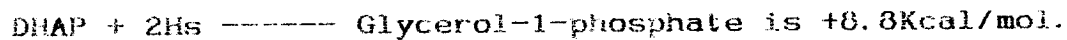
- a) the K_{eq} and
- b) the change in free energy for the synthesis of A from B and C.
- c) what is the change in free energy for the synthesis of A from B and C?

(ii) $\Delta G'_{\circ}$ for the hydrolysis of ATP is -7.3 kcal/mole and that of phosphocreatine is -10.3kcal/mole, what is the $\Delta G'_{\circ}$ for phosphocreatine production from ATP and Creatine?

(iii) In the cell the enzyme (a dehydrogenase) that catalyses the reduction of DHAP to glycerol-1-phosphate utilizes NADH as the source of reducing power. The NADH is in turn oxidized to NAD^{+} . The complete reaction is



Given that the $\Delta G'_{\circ}$ for the oxidation of NADH to NAD^{+} is -14.8kcal/mol and that for the reaction



Calculate the $\Delta G'_{\circ}$ for the formation of glycerol phosphate from DHAP using NADH as a reducing power.

END OF EXAM....

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SUPPLEMENTARY/DEFERRED EXAMINATIONS - JANUARY 1995
C 320

TIME: THREE HOURS

ANSWER: ANY FOUR QUESTIONS

Q1. (a) Convert the following frequencies to wavelengths in nanometers. Indicate the spectral region within which the wavelength falls.

(i) $4.283 \times 10^{14} \text{ s}^{-1}$ (ii) $1.333 \times 10^{15} \text{ s}^{-1}$

(b) Convert the following wavelengths to frequencies in hertz (waves/s)

(i) 536 nm (ii) 14.3 μm

(c) A 25.00 ppm KMnO_4 solution had an absorbance of 0.674 at 515 nm in a 5.00 cm cell.

Calculate the molar absorptivity of KMnO_4 at this wavelength. What would be the molar absorptivity in a 1.00 cm cell? [$\text{KMnO}_4 = 158.03$]

(d) A 25.0 ml aliquot of Kafue River water was treated with a mild reducing agent and then excess 2,9-dimethyl-1,10-phenanthroline. This reagent reacts with copper but not iron (II). After diluting to 50.0 ml, the solution had an absorbance of 0.388 at 455 nm. From the calibration curve, this absorbance corresponded to a concentration of 3.1 ppm Cu.

Calculate the copper concentration, in parts per million in the original sample. If the density of the water sample is 1.00 g/ml, calculate the percent Copper in the water. [$\text{Cu} = 63.546$]

- (e) ✓ The ultraviolet spectra of o- and p-cresol overlap extensively. A 5.0 ml sample containing the two compounds was dissolved and diluted to 50.0 ml with isooctane. This solution had absorbances of 0.716 at 264 nm and 0.318 at 272 nm. A solution of 4.63×10^{-4} M o-cresol had absorbances of 0.730 at 264 nm and 0.178 at 272 nm. A solution of the para isomer of the same concentration had absorbances of 0.548 at 264 nm and 0.433 at 272 nm. If all measurements were made in 1-cm cells, calculate the molar concentration of each isomer in the sample.

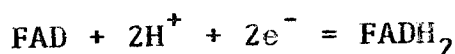
- Q2. (a) Explain principle of atomic absorption spectroscopy.
- (b) What are the differences between flame emission spectroscopy and AAS.
- (c) The iron content of a municipal water supply was determined by an atomic absorption procedure. The absorbance of the water, after a five-fold dilution, was 0.646 at 248.3 nm. A standard solution, prepared by dissolving 0.1483 g of pure iron wire in acid, diluting to 250 ml, and then making a 100-fold dilution, had an absorbance of 0.813. Calculate the ppm Fe in the water sample.
- (d) A dietary supplement capsule weighing 4.84 g was ground into a fine powder. Two portions of the solid, both weighing 0.137 g, were dissolved in dilute acid and transferred to 50 ml volumetric flasks. To one of these, 5.00 ml of 40.0 ppm Mn^{2+} was added, then both flasks were diluted to the mark with distilled water. When aspirated into the flame of an atomic absorption spectrometer set at a manganese absorption wavelength, the absorbances of the unknown and unknown plus standard were 0.374 and 0.641 respectively. Calculate the percentage of Mn in the capsule.
- [Mn = 54.938]

- Q3. (a) i. Explain principle of DC polarography
 ii. How can you remove oxygen from polarographic cell and why?
 iii. How can you suppress the maxima in polarography
- (b) A 541.7 mg sample of silver was dissolved in acid, diluted with water, and transferred to an electrolysis cell equipped with an electronic coulometer. The solution was electrolysed at -0.3 V versus SCE to reduce Cu^{2+} to Cu^0 , which required 98.66 C of electricity. The potential of the working electrode was adjusted to -0.85 V versus SCE, where 24.07 C was required to reduce Ni^{2+} to Ni^0 . Finally 41.13 C was required to reduce Zn^{2+} to Zn^0 at -1.40 V versus SCE.

Calculate the % Cu, % Ni and % Zn in the sample.

$$[\text{Cu} = 63.54, \text{Ni} = 58.71, \text{Zn} = 65.37]$$

- (c) A 10.0 ml aqueous solution of the biochemical compound flavin adenine dinucleotide (FAD) was assayed by controlled-potential coulometry at -0.8 V versus SCE.



The area under the current-time curve was 33.7 mA.min. Determine the concentration of FAD in the sample.

- (d) Calculate diffusion coefficient of Pb^{2+} if the concentration of lead in polarographic cell was $5.0 \times 10^{-4} \text{ mol l}^{-1}$ and diffusion current was 4.5 μA . From the capillary fallen down 90 drops after 3 min, which weight 0.360 g of Mg.

- Q4. (a) Name the three principal evaluation methods used in chromatography. Explain how each of these three methods is used.

- (b) Assume that 100 mg of internal standard is added to 1.00 g of sample mixture. Measurement of the resultant chromatogram shows four components (including the internal standard) with the following peak areas in arbitrary units.

$$A_1 = 27 ; A_{\text{std}} = 80$$

$$A_2 = 20 ; A_3 = 70$$

$$\text{Area sum} = 197$$

Calculate the amounts of components A_1 , A_2 and A_3 , in milligrams, in the sample mixture.

- Q5. (a) Name three types of open tubular capillary columns mainly used in gas chromatography.
- (b) On a 100 cm capillary column of 0.25 cm bore, the helium carrier gas velocity is 37 cm/sec.
The retention time (t_R) for decane is 1.27 min and the peak width at half height is 0.88 sec.
Calculate t_m , k' , N_{eff} and H .
- (c) On a 122 cm long column operated at 160 °C the following retention times for octane and heptane were obtained.
For Heptane: $t_R = 1.22$ min; $W_b = 0.14$ min.
For Octane: $t_R = 1.43$ min; $W_b = 0.20$ min.
The air peak (t_m) appeared at 0.90 min.
Calculate the relative retention (or selectivity) and the resolution (R_s) for heptane and octane.

END OF EXAMINATION

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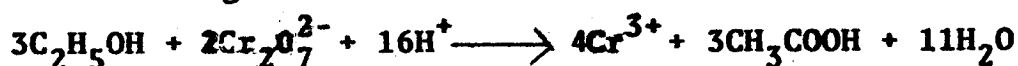
C320
ANALYTICAL CHEMISTRY

PAPER II

TIME: THREE HOURS

ANSWER ANY FOUR QUESTIONS

1. (a) Explain back-emf, overpotential, overvoltage, concentration polarization and IR drop.
- (b) (i) Explain glass electrode and calomel electrode respectively.
- (ii) Asymmetry potential in glass electrode.
- (iii) Alkaline and Acid error in glass electrodes.
- (c) Explain briefly potentiometric titration and amperometric titrations respectively.
- (d) A 50.0ml aliquot of liquid from a sewage holding tank was brought to pH 13 with sodium hydroxide and diluted to 100 ml. The voltage across a sulfide ion and calomel electrode immersed in the solution was 0.337V. After addition of 10.0ml of 2.5×10^{-3} M Na_2S the voltage across the electrode was 0.324V. Calculate the concentration of sulfide in the water as ppm S^{2-} [A.M.S. = 32.066]
- (e) A 5.00ml sample of brandy was diluted to 1.000liter in a volumetric flask. The ethanol in a 25.0ml aliquot of the diluted solution was distilled into 50.0ml 0.020M $\text{K}_2\text{Cr}_2\text{O}_7$ and oxidized to acetic acid with heating. Reaction:



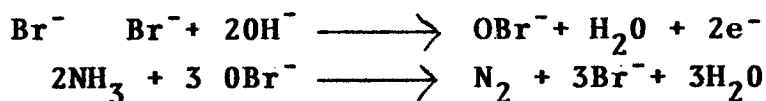
After cooling 20.0ml of 0.1253 MFe²⁺ were pipetted into the flask. The excess Fe²⁺ was then titrated with 7.46ml of the standard K₂Cr₂O₇ to a diphenylamine sulfonic acid end point. Calculate the percent (w/v) C₂H₅OH (46.07g/mol) in the brandy.

2. (a) Explain principle of coulometric titration.
- (b) A 2.5g sample of iodized salt is dissolved in water and electrolyzed at + 0.72 V vs. SCE to oxidized I⁻ to I₂. A charge of 270mC passes before the current reaches its residual current values 19μA. Electrolysis time was 65min.

You as a head of laboratory ask to do this analysis more efficient. You decided that analysis cannot take longer time than 10 min.

What will be current use for this condition. There is another possibility to reduce time of analysis? [M.M. KI = 166.01].

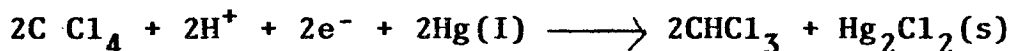
- (c) A protein sample is analyzed by a Kjeldahl procedure by digesting with sulphuric acid to convert protein nitrogen to ammonium sulphate. The ammonia produced in determined by adjusting the pH to 8.6 and titrating coulometrically with electrogenerated hypobromite.



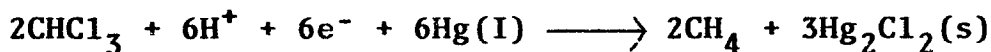
If the titration is performed using 20.5 mA current and the end joint occurs at 150 sec. How many milligrams of protein were present in the sample? In protein is 16% of nitrogen.

- (d) For the determination in previous problem, you are asked to design a constant current source that will read out directly in micrograms of protein titrated. What current must it supply in order that seconds of titration will be equal to two micrograms of protein?

- (e) At a potential of -1.0V(vs. SCE), carbon tetrachloride in methanol is reduced to chloroform at a Hg electrode.



At -1.80V, the chloroform further reacts to give methane:



A 0.801g sample containing CCl_4 , CHCl_3 and inert organic species was dissolved in methanol and electrolyzed at -1.0V until the current approached zero. A coulometer indicated that 9.17C had been used. The reduction was then continued at -1.80V; an additional 59.65C were required to complete the reaction.

Calculate the percent CCl_4 and CHCl_3 in the mixture.

$$[\text{M.M.}\text{CCl}_4 = 153.823 \text{ and M.M.}\text{CHCl}_3 = 119.31]$$

3. (a) Explain principle of pulse and difference pulse polarography.
- (b) What are differences between diffusion current, kinetic current and adsorption current respectively.
- (c) Calculate the amount of cadmium in the sample. Weight of sample 3.789g was dissolved and prepared stock solution of 250.0 ml. To the polarographic cell is added 20.0ml of unknown + supporting electrolyte; register $h_1 = 38.0\text{mm}$. After than add 2.0 ml of

standard of cadmium which has a concentration 40mg Cd/100ml and register the second polarographic curve; $h_2 = 5.7\text{cm}$.

What is the concentration of cadmium in the sample. [Cd = 112.40].

- (d) An organic substance is reduced polarographically. At a concentration of $4.0 \times 10^{-4} \text{ mol. l}^{-1}$ it gives a wave with a diffusion current of 3.7 micro amper. The diffusion coefficient of the compound in the supporting electrolyte has been determined by other means to be $9.0 \times 10^{-6} \text{ cm}^2/\text{s}$.

(From the capillary fallen down 67 drops after 3.0min, weight 0.612g). What is the Z value for the polarographic reduction of the organic compound².

- (e) What is the relative decrease of concentration of Zn^{2+} ion in percentage after electrolysis on the mercury drop electrode which last 3 minutes. Electrolysis is provided on the potential of the limit diffusion current. Suggest the current of which the electrolysis is constant.

(Condition: 100 drops of mercury fallen down after 5min and weight 0.600g. $D = 9.0 \times 10^{-6} \text{ cm}^2/\text{s}$; $c = 0.5\text{mM}$ and $V = 0.020 \text{ liter}$). (A.M. Zn = 65.37).

4. Define the following chromatographic terms

- (i) Retention volume (V_R)
- (ii) Retardation factor (R_f)
- (iii) Adjusted retention volume (V_R^1)
- (iv) Specific retention volume (V_g°)
- (v) Net retention volume (V_N)
- (vi) Selectivity factor (α)

- (vii) Partition coefficient (K)
- (viii) Partition ratio or capacity factor (k')
- (ix) Plate height (H)
- (x) Plate Number (N)
- (xi) Column resolution
- (xii) Isocratic elution in liquid chromatography
- (xiii) Gradient elution in liquid chromatography.

5. (a) Outline the following causes of peak broadening

- (i) Eddy diffusion
- (ii) Longitudinal diffusion
- (iii) Mass transfer

(b) What are the basic components of a gas chromatograph? Sketch them.

(c) What are the basic components of an HPLC? Sketch them.

(d) The following results were obtained from a gas chromatographic column:

$\bar{U}(\text{cm/s})$	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	10.0
$H(\text{cm})$	0.63	0.44	0.42	0.44	0.47	0.47	0.51	0.61	0.72

Construct a plot of H vs \bar{U} and from this determine the best carrier gas linear velocity \bar{U}_{opt} and the corresponding minimum H value, H_{min} .

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

C340

INORGANIC CHEMISTRY

PAPER I

TIME: THREE HOURS

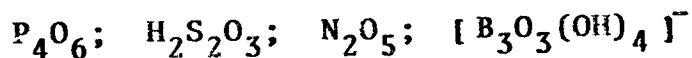
INSTRUCTIONS:

- (i) This examination has six (6) questions.
 - (ii) Answer ANY FOUR (4) questions.
 - (iii) Each question carries Twenty-five marks.
 - (iv) A Tidy and Orderly presentation is a must.
 - (v) Show all steps involved in calculations.
-

1. (a) Write balanced equations for the chemical reactions when,

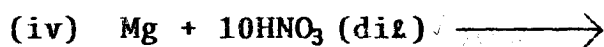
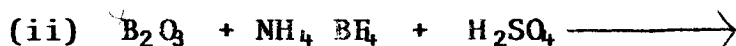
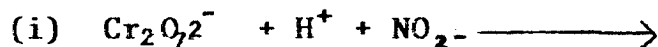
- (i) Ammonium carbonate solution is added to lithium sulfate solution.
- (ii) Potassium permanganate reacts with ferrous sulfate in presence of sulfuric acid.
- (iii) Sodium hydroxide reacts with aluminium sulfate
- (iv) A current of dry chlorine is passed over a strongly heated mixture of boron trioxide and powdered charcoal.
- (v) Steam is passed over heated aluminium carbide.

(b) Draw the structures of the following species.



- (b) Describe the laboratory method for the preparation of phosphine gas. How does it react with
(i) Chlorine (ii) Copper (I) chloride (iii) oxygen.

2. (a) Complete and balance the following reactions.

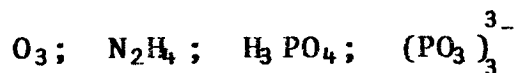


- (b) Give a generalised comparison of alkali metals with those of alkaline earth metals.
(c) Give three commercial uses of each of the following
(i) Sulfuric acid (ii) Phosphates
(d) What are silanes? Write balanced chemical reactions between silicomethane and
(i) silver nitrate (ii) copper sulfate
(iii) Aqueous sodium hydroxide.

3. (a) Give three methods for preparation of sodium thiosulfate. Write balanced reactions when it reacts with
(i) water (ii) cupric chloride
(iii) Barium chloride (iv) dilute sulfuric acid.

- (b) Explain, how would you prepare the following?
(i) Plaster of paris from gypsum.
(ii) Borazole from diborane
(iii) Antimony pentasulfide from antimony pentachloride.
(iv) Boron trioxide from borax.

- (c) Draw the structures of the following molecules and ions.



- (d) What happens when,

- (i) Sulfur dioxide reacts with phosphorous pentachloride.
- (ii) Sodium nitrite is heated with sodium iodide in presence of dilute sulfuric acid.
- (iii) Lithium aluminium hydride reacts with stibine.
- (iv) A mixture of boron oxide, calcium fluoride and dilute sulfuric acid is heated.
- (v) Antimony tetraoxide is heated.

4. (a) Describe the manufacture of hydrogen peroxide from ethyl derivative of anthraquinone. Write the balanced reactions when hydrogen peroxide reacts with

- (i) Potassium iodide in presence of hydrogen iodide.
- (ii) Chromic hydroxide suspended in caustic soda.
- (iii) Sodium hypochlorite.
- (iv) Ozone.

- (b) Complete and balance the following reactions.

- (i) $K_2SiF_6 + 4K \longrightarrow$
- (ii) $CuSO_4 + NH_4OH \longrightarrow$
- (iii) $MnO_4^- + H^+ + NO_2^- \longrightarrow$
- (iv) $Ca(OH)_2 + 3CS_2 \longrightarrow$
- (v) $PCl_5 + SO_2 \longrightarrow$

- (c) Write the balanced chemical reactions between dilute nitric acid and
- (i) H_2S (ii) HI (iii) Zinc
5. (a) How is ammonia manufactured on a large scale by Haber's process?
- (b) Describe in detail the extraction of beryllium metal from its ore beryl.
- (c) Give three commercial uses of each of the following
- (i) Sodium hydroxide (ii) Hypo
- (d) How would you prepare the following compounds.
- (i) Arsenic pentoxide from arsenic trioxide
- (ii) α - sulfur from β - sulfur
- (iii) Hydrazoic acid from sodium azide.
6. (a) Convert one atomic mass unit (1 amu) into million electron volt (Mev).
- (b) Compare the properties of alpha, beta and gamma rays in respect of their origin, ionising power, penetrating power and velocity.
- (c) Write a short account on (i) nuclear exchange forces and (ii) n/p ratio in relation with nucleus stability.
- (d) Calculate (i) the total binding energy (ii) the binding energy per nucleon in million electron volt for the $^{206}_{82}\text{Pb}$ nuclide.

USEFUL INFORMATIONS AND PHYSICAL CONSTANTS

Mass of proton = 1.007838 amu

Mass of neutron = 1.008665 amu

Speed of light = $3.00 \times 10^8 \text{ m.sec}^{-1}$

1 electron volt = $1.60 \times 10^{-19} \text{ J}$

Atomic mass of $^{206}_{82}\text{Pb}$ = 205.97447 amu

1J = $6.25 \times 10^{12} \text{ mev}$

1 amu = $1.66 \times 10^{-27} \text{ kg.}$

END OF EXAMINATION

C340

INORGANIC CHEMISTRY

PAPER II

TIME: **THREE HOURS**

INSTRUCTIONS:

1. THIS EXAMINATION HAS SIX(6) QUESTIONS.
 2. ANSWER ANY FOUR (4) QUESTIONS.
 3. EACH QUESTION CARRIES TWENTY FIVE MARKS.
 4. A TIDY AND ORDERLY PRESENTATION IS A MUST.
-

1. (a) Using a flowsheet diagram, describe the extraction of thorium from thorite, a mineral of thorium metal.
(b) Draw the structures of the following molecules and ions.
 XeF_6 ; I_2O_7 ; XeO_4 ; $[\text{ClO}_2\text{F}_4]^-$
(c) Cerium, Ce ; europium, Eu and ytterbium, Yb show unusual oxidation states. Why is this so?
2. (a) Explain, what is meant by the term ' Total Lanthanide contraction?'
(b) Determine the ground state spectroscopic terms and their corresponding magnetic moment (μ_J) for the following lanthanide ions.

(i)	Gd^{3+}	(ii)	Er^{3+}
	64		68

(c) What happens when,
(i) Barium chlorite is treated with dilute sulfuric acid.
(ii) A mixture of silver fluoride and iodine is heated.
(iii) Bromine dioxide reacts with sodium hydroxide.
(iv) Perchloric acid is dehydrated by phosphorus pentoxide.
(v) Xenon tetrafluoride reacts with boron trichloride.
(vi) Xenon hexafluoride reacts with water.

3. (a) The **stepwise** stability constant (k_n) for the addition of ammonia (NH_3) ethylenediamine ($\text{H}_2\text{N CH}_2\text{CH}_2\text{NH}_2$ abbr.en) to Ni^{2+} ion in solution are given below.

Ammonia

n	1	2	3	4	5	6
$\log k_n$	2.70	2.11	1.60	1.08	0.60	-0.10

Ethylenediamine

n	1	2	3
$\log k_n$	7.51	6.3	4.3

- (i) Explain why $\log k_6$ is small, and what implications this suggests.
 - (ii) Considering the occupation of four positions about the central metal atom show that chelation results in the overall stabilization of the metal complex.
- (b) Molecular orbital theory discusses the bonding between metal centre and the ligand in terms of σ - and π -bonding. With particular reference to PF_3 , PH_3 and PEt_3 (where $\text{Et} = -\text{CH}_2\text{CH}_3$) ligands discuss the factors that contribute to the stabilization of a metal - ligand bond.
4. (a) Account for the variation of ionic radii of divalent first row transition metal ion in a weak tetrahedral ligand field.
- (b) Using a weak octahedral ligand environment show for a d^5 configuration that crystal field splitting of d orbitals results in a crystal field energy gap of $10 Dq$.
- (c) List the major differences between the Valence Band Theory (VBT) and the Molecular Orbital Theory (MOT)

5. (a) The ground state octahedral weak ligand field term for a complex in E_g .
- (i) How many d electrons are present?
[clearly show how you arrive at your answer]
- (ii) Calculate μ_{eff} for the complex, given that $Dq = 1,400 \text{ cm}^{-1}$ and ζ (Zeta-value for metal ion) is 540 cm^{-1} .
- (b) What is Racah Parameter?
What role does it play in complexation?
6. (a) Write briefly on each of the following:-
- (i) Factors that affect the magnitude of Δ_o .
- (ii) Stability of complexes vs Pearson's acids and bases.
- (iii) Chelation and entropy of reaction (Give a specific example).
- (b) Name the following compounds.
- (i) $\text{Fe}(\text{CO})_3$ (ii) $\text{VO}(\text{acac})_2 \text{py}$
- Where $\text{acac} = \text{CH}_3 \text{COCH}(\text{CO}) \text{CH}_3$
- py = pyridine

END OF EXAMINATION

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C350

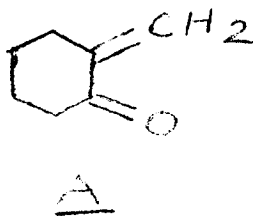
ORGANIC CHEMISTRY

PAPER I

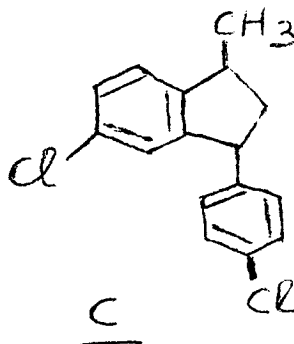
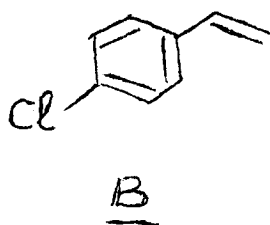
TIME: THREE HOURS

ANSWER ANY FOUR QUESTIONS

-
1. (a) Attempted bromination of 2-methyl-2-phenyl propane using liquid bromine and aluminium (III) bromide unexpectedly gave bromobenzene and 2-methyl-propene. Suggest a likely mechanism for this transformation.
- (b) (i) Suggest a sequence of reactions involving Hofmann elimination and Mannich reaction that can be used to synthesize compound A.



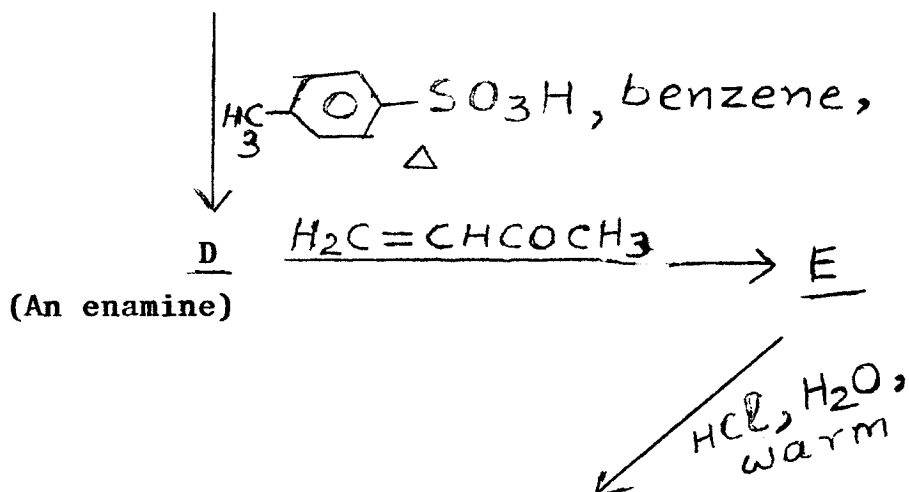
- (ii) Give mechanisms of the reactions involved.
- (c) On heating with aqueous sulphuric acid, compound B reacts to form a dimer C in good yield.



Provide a mechanistic explanation for this reaction.

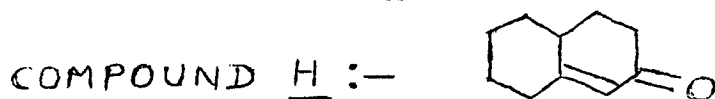
2. (a) (i) Identify compounds D to G and give mechanisms of the following reactions.

Cyclohexanone + Piperidine



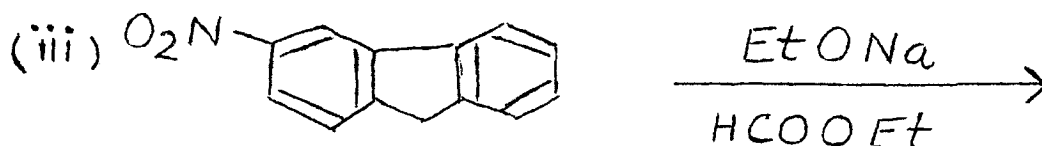
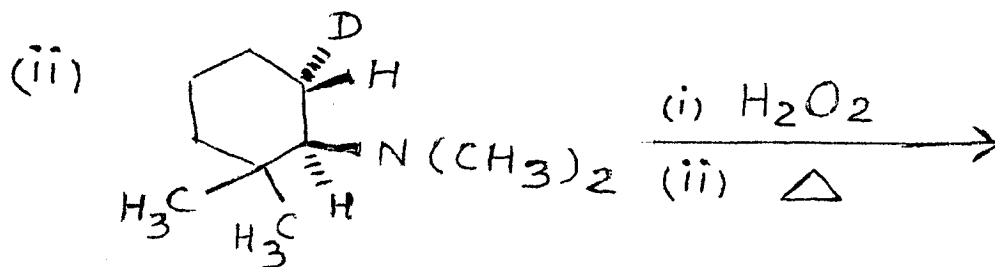
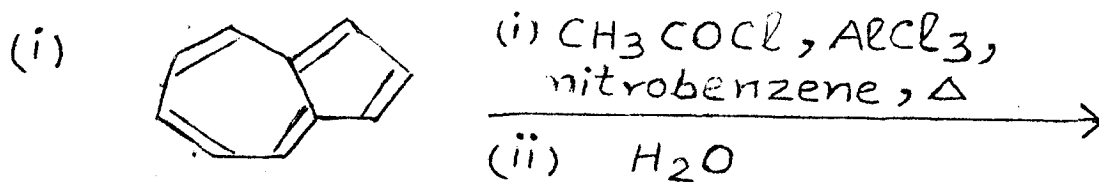
G ($\text{C}_5\text{H}_{11}\text{N}$) + F ($\text{C}_{10}\text{H}_{16}\text{O}_2$)

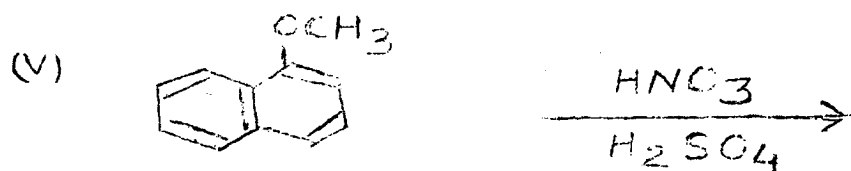
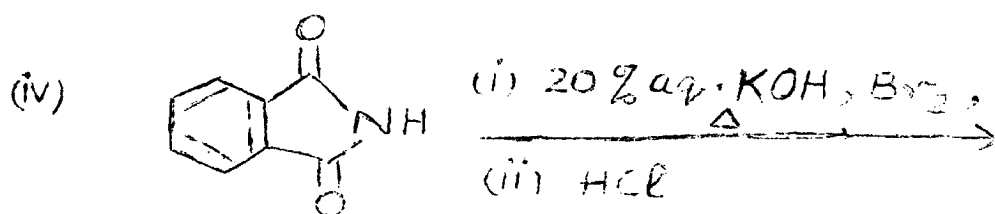
- (ii) The expected product F in the above reaction actually cyclized under the reaction conditions to give a compound H.



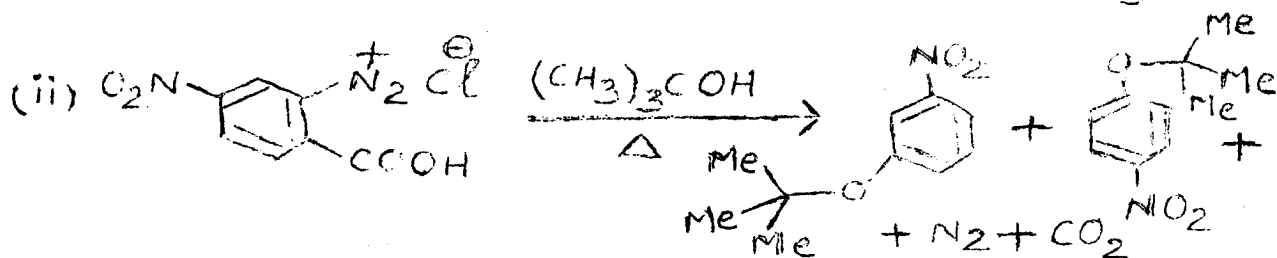
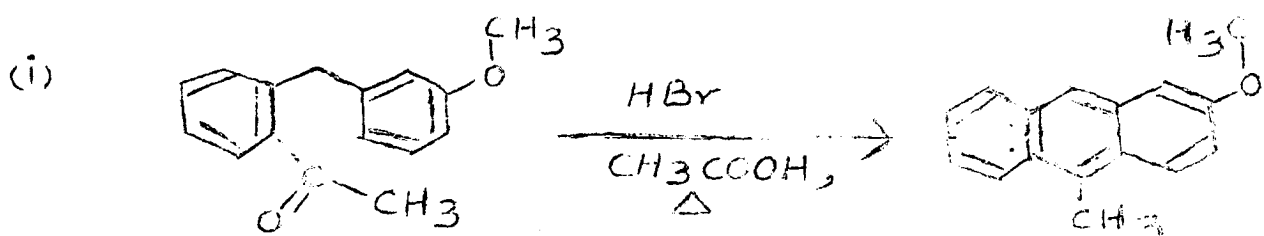
Show all steps involved in the formation of H from F.

- (b) Give structures of the major organic products expected to be formed in reactions (i) to (v).

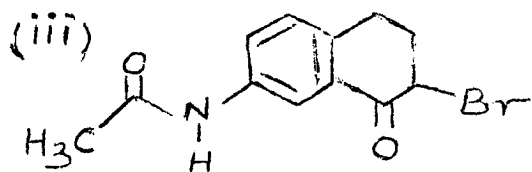
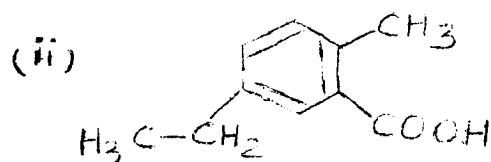
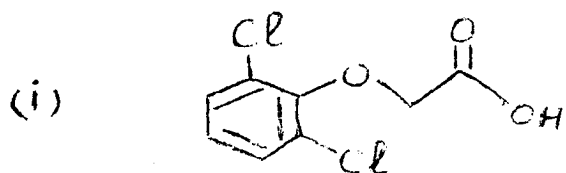




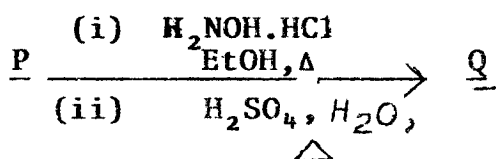
3. (a) Suggest mechanisms for each of the following reactions.



(b) Propose synthetic routes for TWO of the following compounds starting from benzene, or a monofunctionalised benzene.



4. (a) (i) Identify compounds P and Q from the following data. Show your reasoning.



COMPOUND P , $\text{C}_6\text{H}_{10}\text{O}$

IR (Neat); $\bar{\nu}$ (cm^{-1}); Selected bands : 2950, 1705

^1H NMR (CCl_4) ; δ (ppm) : 2.25(m, 4H);
1.8 (m, 6H)

^{13}C NMR (Neat) ; δ (ppm) : 210 (s), 42 (t);
28(t); 26(t)

COMPOUND Q , $\text{C}_6\text{H}_{11}\text{NO}$

IR (CHCl_3) ; $\bar{\nu}$ (cm^{-1}) ; Selected bands :
3300 (broad, strong); 2900,
1650

^1H NMR (CDCl_3) ; δ (ppm): *7.1 (s, 1H, broad);
3.2 (m, 2H); 2.5 (m, 2H);
1.7 (m, 6H)

^{13}C NMR (d_6 -acetone); δ (ppm) : 180 (s) ; 43 (t);
38(t) ; 31 (t) ; 30(t) ;
24(t).

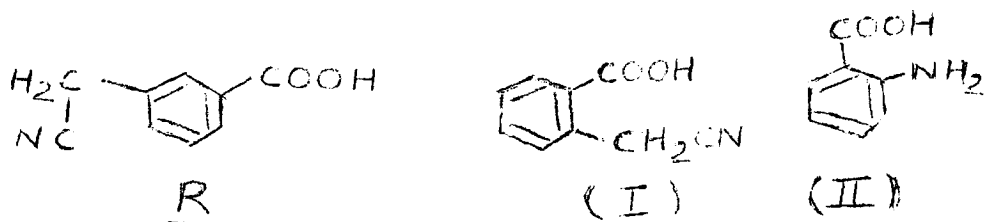
NOTE: 1. * = the NMR signal disappears on shaking
the compound with D_2O .

2. s = singlet; d = doublet; t = triplet;
q = quartet; m = multiplet.

3. d_6 -acetone = $\text{D}_3\text{C}-\text{C}(\text{O})-\text{CD}_3$

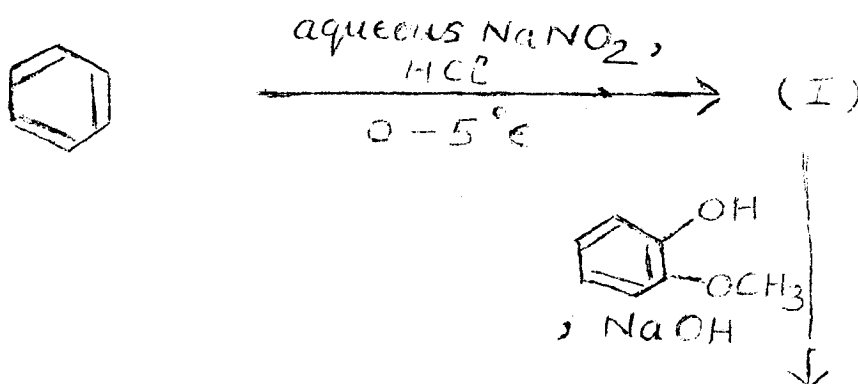
(ii) Give mechanism of the above reaction.

5. (a) (i) Reaction of 2-chlorobenzoic acid with sodium amide, NaNH_2 , and liquid ammonia in presence of acetonitrile, CH_3CN , gave a compound R and 3-aminobenzoic acid.

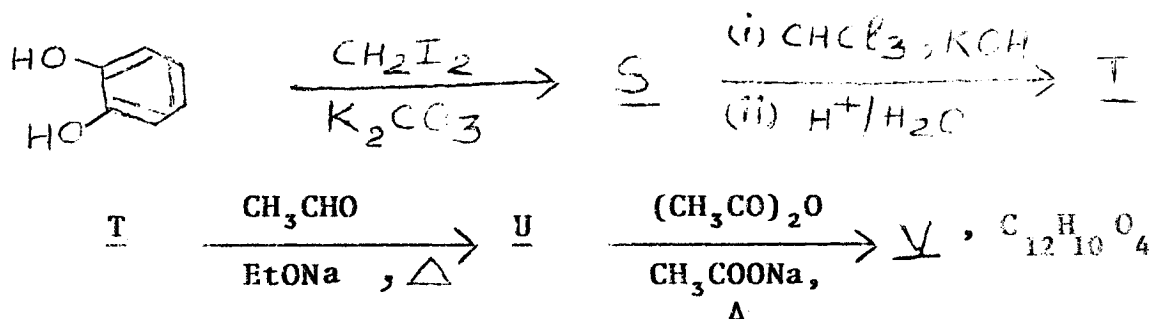


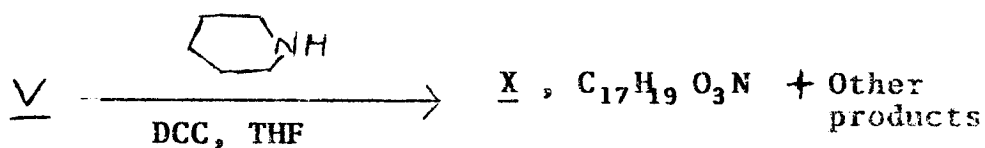
Suggest a mechanism for this reaction and explain why compounds (I) and (II) were not formed.

- (ii) Predict the products and give mechanisms of the following reactions.



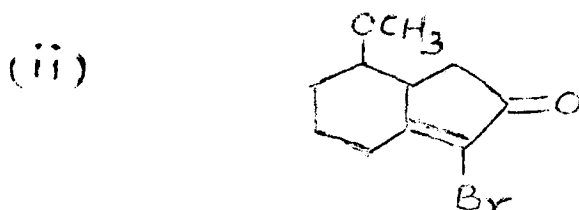
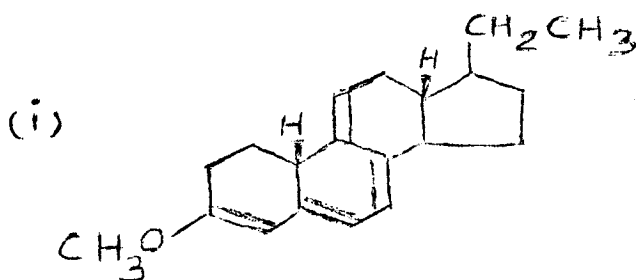
- (b) (i) Identify compounds S to X in the following synthesis of X.





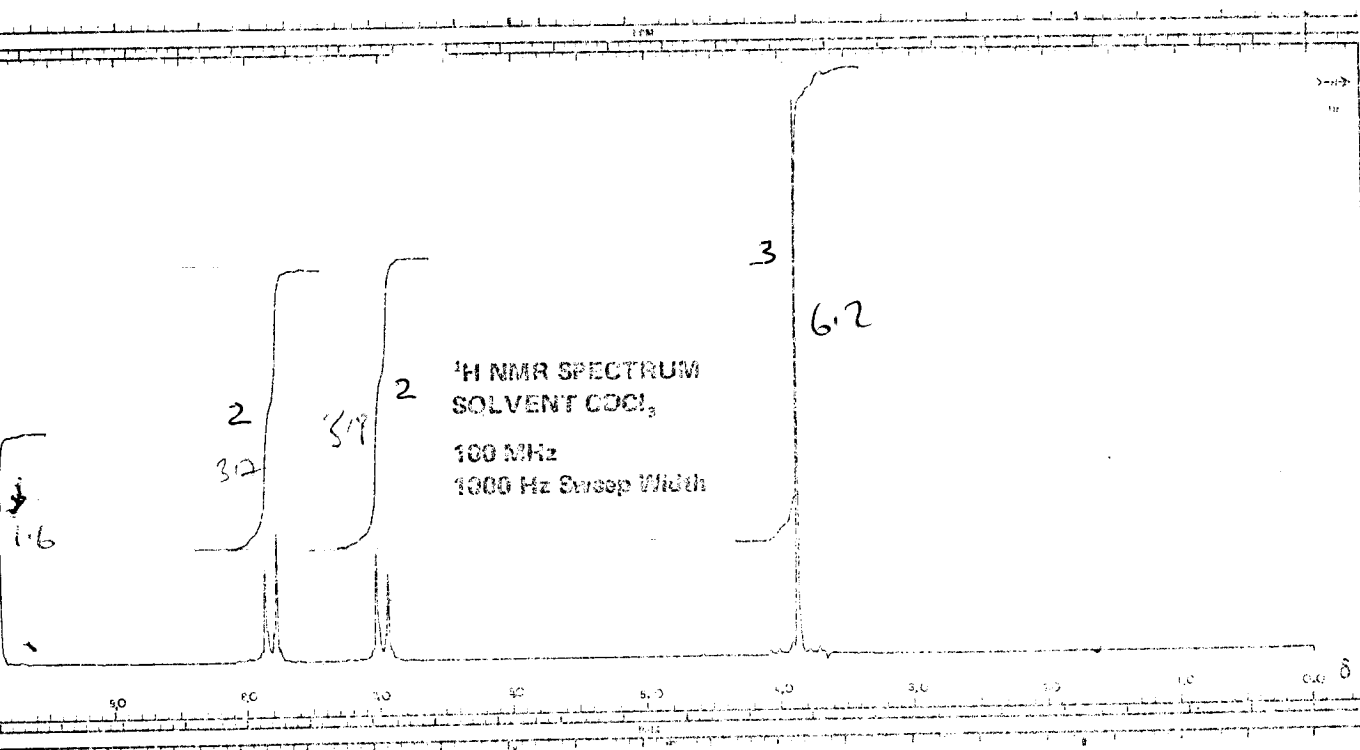
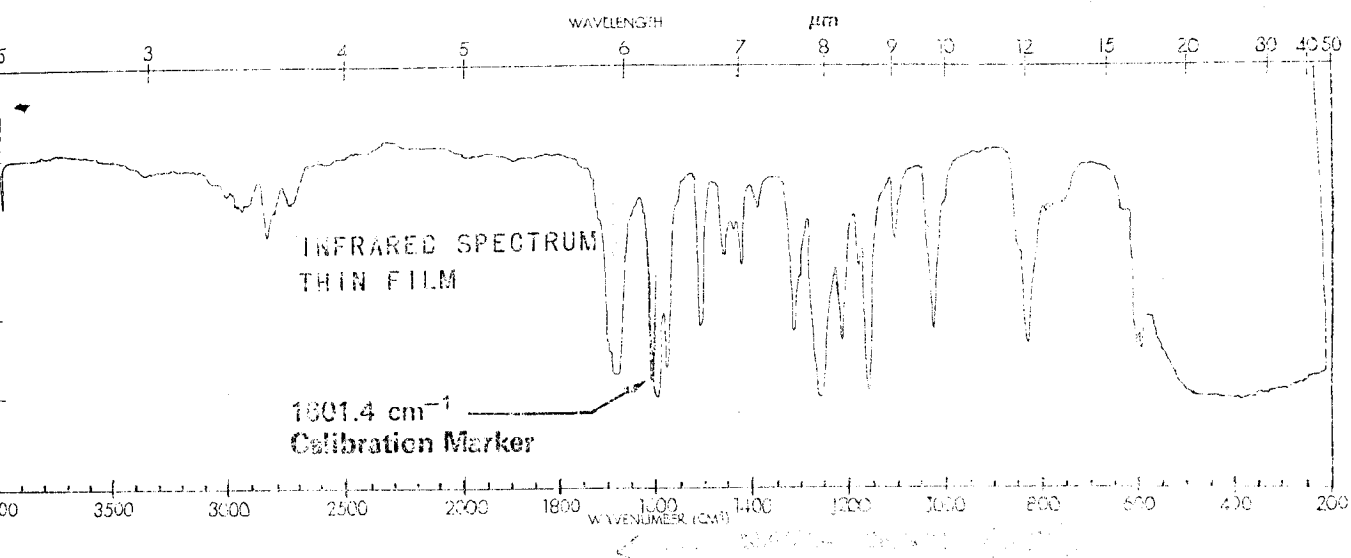
NOTE: DCC = Dicyclohexylcarbodiimide; THF = Tetrahydrofuran.

- (ii) Show all steps in the formation of X from V.
6. (a) Deduce structure of the compound Z, $\text{C}_8\text{H}_8\text{O}$, from the attached IR and ^1H NMR spectra. State your reasoning.
- (b) Calculate the expected positions of the principal uv absorption bands, $\lambda_{\text{max}}^{\text{EtOH}}$, of each of the following compounds. Show your working clearly.



END OF EXAMINATION

COMPOUND Z, QUESTION 6(a)



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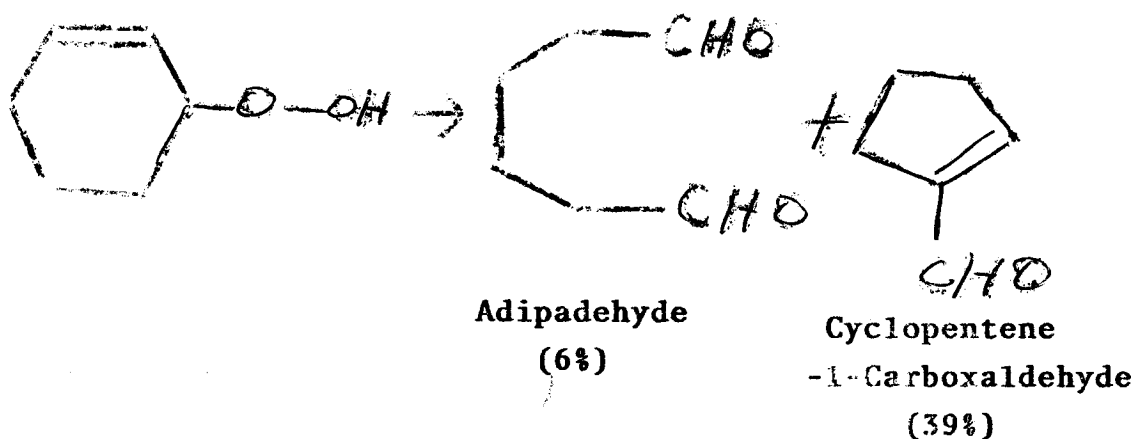
C350
ORGANIC CHEMISTRY

PAPER II

TIME: THREE HOURS

ANSWER ANY FOUR (4) QUESTIONS

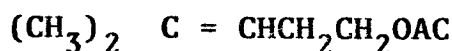
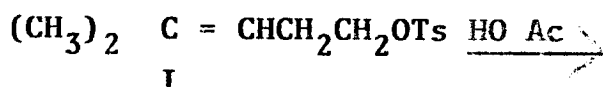
1. Show how D Cram's mechanism accounts for
 - (a) the conversion of optically active threo-3-phenyl-2-butyl tosylate into racemic acetate and
 - (b) the conversion of optically active erythro-3-phenyl-2-butyl tosylate into optically active erythro acetate.
2. (a) Treatment of 1-methyl-1-cyclohexyl hydroperoxide with acid gives a product of formula $C_7H_{14}O_2$, which gives positive tests with CrO_3/H_2SO_4 , 2,4-dinitro phenyl hydrazine and NaOI. What is the likely structure for this compound and how is it formed?
 - (b) (i) Show all steps in the mechanism probably involved in the following transformation.



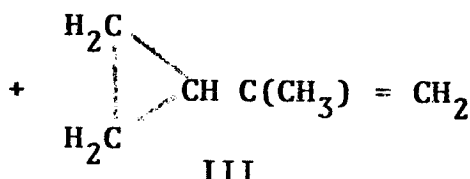
- (ii) An important difference in migratory aptitude is illustrated here. What is it?

3. Account in detail for each of the following sets of observations.

- (a) Compound I reacts with acetic acid 1200 times as fast as does ethyl tosylate and yields not only II but also III.

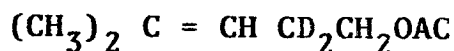
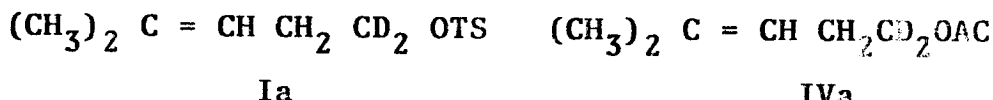


II



III

- (b) When labelled compound Ia is used, product IV consists of equal amounts of IVa and IVb.



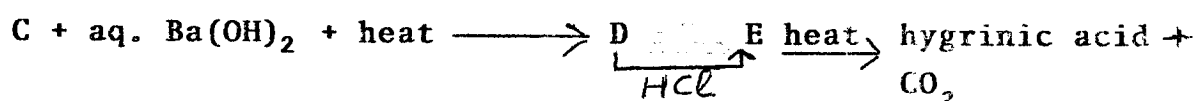
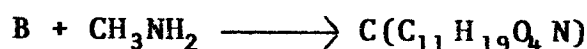
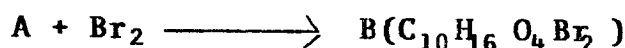
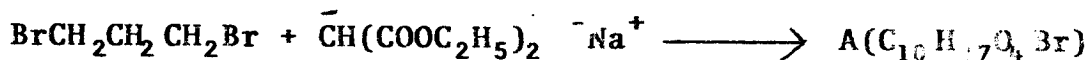
IVb

4. (a) The alkaloid hygrine is found in the coca plant. Suggest a structure for it on the basis of the following evidence.

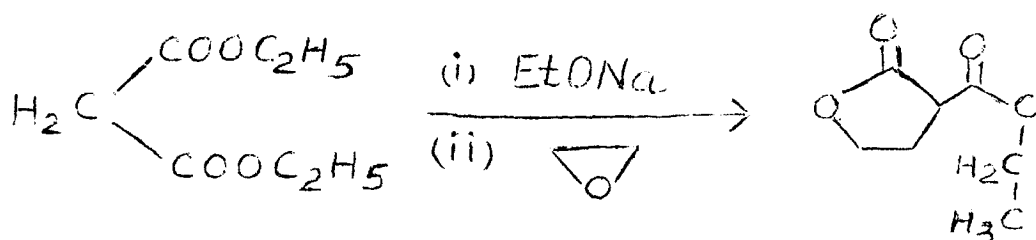
Hygrine ($\text{C}_8\text{H}_{15}\text{ON}$) is insoluble in aqueous NaOH but soluble in aqueous HCl. It does not react with benzene sulphonyl chloride. It reacts with phenyl hydrazine to yield a phenyl hydrazone. It reacts with NAOI to yield a yellow precipitate and a carboxylic acid ($\text{C}_7\text{H}_{13}\text{O}_2\text{N}$). Vigorous oxidation by CrO_3 converts hygrine into hygrinic acid ($\text{C}_6\text{H}_{11}\text{O}_2\text{N}$).

Question 4(a)(continued)

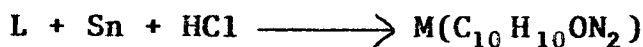
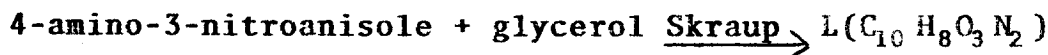
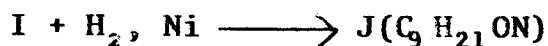
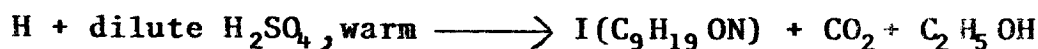
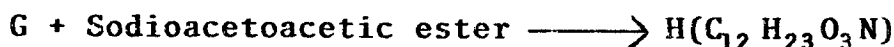
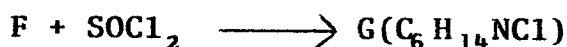
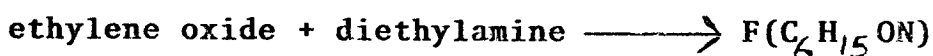
Hygrinic acid can be synthesized as follows:



(b) Suggest a mechanism for the following reaction.

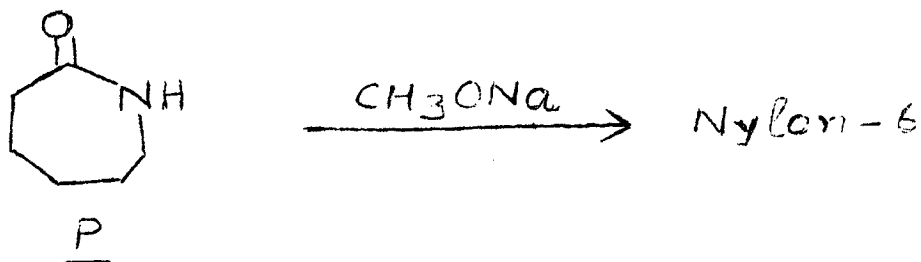


5. (a) Plasmochin (also called Pamaquine), a drug effective against malaria, has been synthesized as follows:

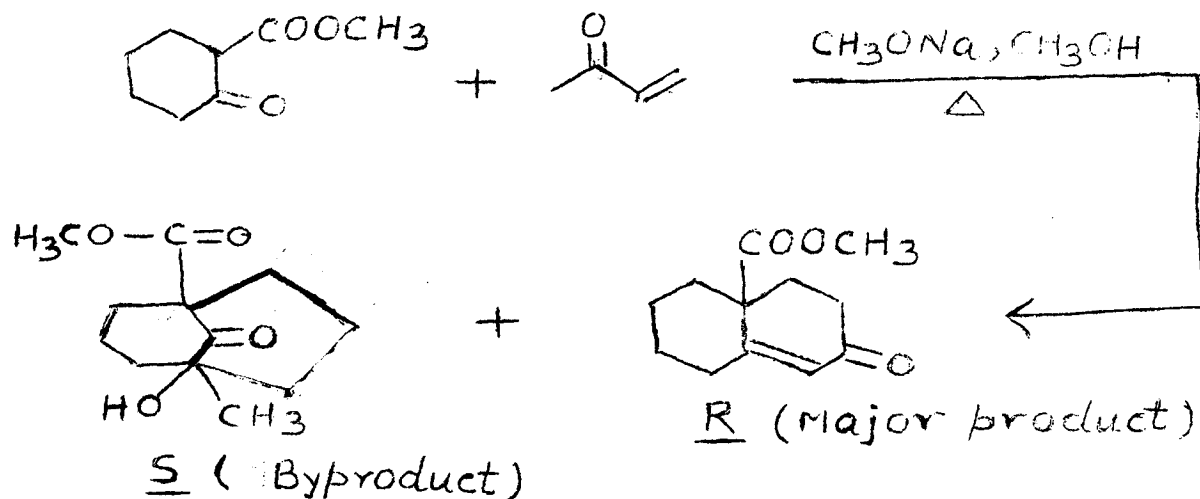


What is the most likely structure of plasmochin?

5. (b) Nylon-6, used in textile industries, is made by alkaline polymerization of P.



- (i) Give the structure of Nylon-6.
- (ii) Suggest a mechanism for the polymerization process.
6. (a) In addition to the expected product R, a byproduct S was also isolated from the reaction shown below.

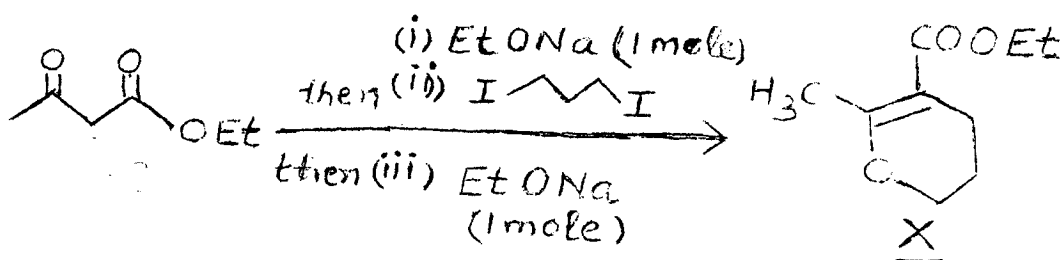


The reaction was found to proceed via a key intermediate Q, structure shown below.



- (i) Show clearly how Q is formed in the above reaction.
- (ii) Propose plausible mechanisms to explain the formation of both the compounds R and S from the intermediate Q.

6. (b) (i) Suggest a stepwise synthesis of 2-amino-3-methylpentanoic acid from malonic ester, $\text{EtOOC-CH}_2\text{-COOEt}$, and any other needed reagents.
- (ii) Propose a reasonable mechanism to account for the formation of compound X in the following reaction.



END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS-OCTOBER/NOVEMBER 1995

C 360

(PHYSICAL CHEMISTRY)

PAPER II

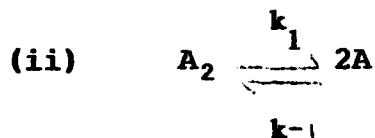
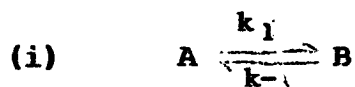
TIME: 3 HOURS

ANSWER ANY 4 QUESTIONS

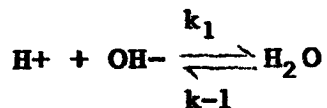
$$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$$

$$F = 96500 \text{ C mol}^{-1}$$

1. (a) Derive the expression for relaxation time for the two reactions below:



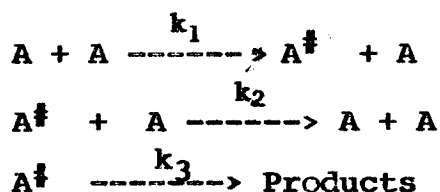
- (b) When a sample of pure water is heated suddenly in a small conductivity cell with a pulse of microwave radiation equilibrium is disturbed to be re-established when additional dissociation of water occurs after a relaxation time of 36 μs at 25°C. Calculate k_1 and k_{-1} given that for the equilibrium



$$\tau = \frac{1}{k_{-1} + k_1 ([\text{H}^+]_e + [\text{OH}^-]_e)}$$

2. (a) Describe the moving boundary method for determining the transport number.
- (b) Explain the following observations:
- (i) for H_3O^+ , $t_+^0 = 0.821$ while $t_-^0 = 0.337$ for Li^+
 - (ii) for aqueous CdCl_2 as the concentration is raised from 0.0050m to 0.50 m t_+ falls from 0.445 to zero and then becomes negative.
- (c) In a moving boundary method to determine the transference number of chloride ion in 0.010mol dm^{-3} sodium chloride solution, the chloride ion moved a distance of 3.0cm in 976 S. The cross section of the tube was 0.427cm^2 and current $2.08 \times 10^{-3}\text{A}$. Calculate t_- .

3. In the decomposition reaction of a molecule whose reaction mechanism has been proposed by Lindemann where molecules may be activated or deactivated as follows:



Use the steady state approximation to show and explain under what conditions the kinetics are first and second order.

4. (a) What are the possible effects of the absorption of light radiations by substances.
- (b) Light of definite wave length was passed through a cell of 5.00cm thickness containing a 0.01 molar solution of a given substance. The intensity of the transmitted light was 0.245 of the incident light, calculate the molar absorptivity of the dissolved substance.
- (c) State the law of photo chemical equivalence.
What do you understand by Quantum yield?
Quantum yield in the reaction between Hydrogen and chlorine is the order of 10^5 whereas in the reaction between Hydrogen and Bromine is 0.01. How will you account for this deviation.

5. (a) Discuss the kinetics of the photochemical reaction between Hydrogen and Bromine. Deduce the rate equation

$$\frac{dC_{\text{HBr}}}{dt} = \frac{k C_{\text{H}_2} I^{\frac{1}{2}}_{\text{abs}}}{1 + k' (C_{\text{HBr}}/C_{\text{Br}_2})}$$

- (b) What is Chemiluminescence? Give suitable examples.
- (c) How many types of adsorption of gases on solids are known to you? Outline the differences between them.
6. (a) Derive Langmuir adsorption isotherm. How is the extent of adsorption affected by pressure? How can the isotherm be verified?
- (b) How many types of adsorption isotherms for physical adsorption have been obtained. Explain these.
- (c) State B.E.T equation. How does it help in determining the surface of the adsorbent?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

C410

BIOCHEMISTRY

PAPER I

TIME: THREE HOURS

ANSWER: FOUR QUESTIONS. ALL QUESTIONS HAVE EQUAL MARKS

1. Describe in detail how the activity of glutamine synthetase in bacteria is regulated.
2. Discuss the principles behind gel exclusion chromatography and SDS-PAGE. In your discussion mention the type(s) of information that can be obtained about a protein when analyzed by either method.
3. Some steroid and peptide hormone receptors mediate the formation of a second messenger. Name one such second messenger and show how the binding of a hormone to its receptor can cause a cellular response (through the action of the chosen second messenger).
4. (a) Briefly describe the major steps leading to the contraction of a striated muscle.

(b)

 In resting frog sartorius muscle, the concentration of K^+ inside the cell is 3.0 mM and that outside is 150mM. Calculate the membrane potential that would exist in the resting muscle if the membrane were permeable only to K^+ . What will be the new potential if the membrane was also permeable to Na^+ , the inside and outside concentrations of Na^+ are 180 and 7mM respectively. Assume that the permeability of K^+ is ten times that of Na^+ at 25°C. $R=8.3 \text{ J.K}^{-1}\text{mol}^{-1}$ and $F=96500 \text{ J.V}^{-1}\text{mol}^{-1}$.

5. (a) Briefly discuss the passive transport of compounds across the plasma membranes (give one specific example).
- (b) Bacteria of the genus *Bacillus* do not make unsaturated fatty acids. Rather, they produce a mixture of straight chain and branched chain fatty acids. What will happen to the ratio of branched chains to straight chains when growth temperature is lowered from 37°C to 20°C. Explain your reasoning.
-

END OF EXAMINATION

HAVE A MERRY CHRISTMAS AND A PROSPEROUS NEW YEAR

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

C 410

BIOCHEMISTRY

PAPER II

TIME: THREE HOURS

ANSWER: FOUR QUESTIONS

1. Justify the assertion that chemical biotransformation in living organisms is biphasic.
2. The human environment is chemically suffused. Critically discuss the human survival mechanism in such an environment and name the extrinsic and intrinsic variable factors in his survival.
3. Write an essay on the role of proteins in redox reactions of xenobiotic biotransformations.
4. (a) How is DNA packed within the nucleus?
(b) What evidence is there that unfolding of the condensed chromosomal DNA is an essential preliminary step in gene expression?
5. Briefly describe the functions of the following proteins in DNA replication:
 - (a) DNA polymerase
 - (b) DNA ligase
 - (c) Single-stranded DNA bonding proteins
 - (d) Topoisomerases
6. (a) Give three ways by which protons affect enzyme catalysed reactions
(b) What role do cofactors play in enzyme catalysed reactions
(c) Starting with the following expression explain in detail how enzymes reduce free energy of activation:

$$\Delta G^* = \Delta H^* - T\Delta S^*$$

7. (a) (i) What are antibodies?
(ii) Describe some of the practical uses of antibodies.
- (b) (i) Discuss ways by which antibody diversity is attained.
(ii) How does the generation of antibody diversity differ from T-cell receptor diversity (generation)?

8. Discuss the following statement:-

"Enzymes are not different from antibodies."

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS -OCTOBER/NOVEMBER 1995

C 420

ANALYTICAL CHEMISTRY

PAPER 1

TIME: THREE HOURS

ANSWER FOUR QUESTIONS OUT OF SIX QUESTIONS IN THIS PAPER

- Q1. (a) Name 2 preservatives you expect to find in fruit drinks. How would you determine them in these drinks?
- (b) *What is this? English?* ^{legal} ~~Kachasu~~ is not a legal drink in Zambia; what makes the drink unfit for human consumption and what tests would you carry out to test for quality of this drink?
- (c) Describe 2 methods used in the determination of proteins in food samples. *put a more in for protein and weight*
- (d) 18mg sample of a nitrogen containing organic compound was subjected to a traditional analysis. Before ammonia was steam-distilled, 20 ml of 0.2N HCl was placed in the receiver. After distillation, 10 ml of 0.2N NaOH was required to back-titrate the excess acid. Calculate % nitrogen in the sample? (use a conversion factor = 6.38).
- (e) How would you determine 2 fat-soluble vitamins in foods?
- Q2. (a) Describe 3 main methods other than tlc used in the determination of drugs of abuse. *1. Be Gravit. 2. Be Grav. 3. Be Grav.*
- (b) Describe how you can use thin layer chromatography (tlc) in the determination of drugs of abuse (give examples to illustrate this)? *Use visible light to see spots. - thin layer chromatography is a technique.*
- (c) Use the following information to calculate what % of stated weight of $C_{21}H_{28}O_2$ is present in a 5mg tablet of ethisterone. Weight of 20 tablets, stated each to contain 5 mg of
- $C_{21}H_{28}O_2 = 4.8896g$
- Weight of powder used in USP assay process = 2.4250g
- Weight of residue obtained from chloroform = 0.05136g
- extract

- (d) Explain why phenol can be titrated successfully in ethylenediamine and pyridine can be titrated better in dioxane than in water.
- (e) Describe briefly how you would carry out non-aqueous titrations highlighting differences in dealing with basic and acidic compounds and why it is necessary to carry out titrations in this environment.

- Q3.
- (a) What are pesticides and name 3 of such compounds and their mode of action?
 - (b) Certain pesticides are a problem in dairy products, name one of them and explain how you would determine it in such products using gas chromatography (gc)?
 - (c) Some pesticides cannot be easily be determined by GC, but can be done by HPLC, why is this so? Give one example to illustrate this fact.
 - (d) What are the main differences between flame ionization detector (FID) and flame photometric (FPD). Which of these detectors would be useful in detecting organophosphates and why?
 - (e) Outline the stages followed in the analysis of pesticide residues.

- Q4
- (a) Outline how a laundry soap is made and mention what parameters are used to assess the quality of the product
 - (b) How would you identify a non-soap detergent and outline how you estimate the % active ingredient of such a product.
 - (c) How would you differentiate a soap from a non-soap detergent and how can you test for the detergency of these products?
 - (d) Describe how determination of total fatty matter in soaps and that of phosphates in detergents are done.
 - (e) Two methods can be used in determining moisture in soaps, describe them and a method used to determine matter-insoluble-in-alcohol in detergents.

5. (a) An enzymatic method for the determination of alcohol is evaluated by comparison with a gc method. The same sample was analysed several times by both methods giving the following results (% ethanol)

Enzymatic method	gc method
13.1	13.5
12.7	13.3
12.6	13.0
13.3	12.9
13.3	

Does the enzymatic method give the same results as the gc method at 95% confidence level? (For 4 degrees of freedom at 95% confidence level is 2.276 and 3 degrees of freedom is 3.182).

- (b) Discuss 4 methods of collecting atmospheric gases for analysis.
- (c) For the determination of proteins in serum, a 2.00 ml sample is treated according to Winkler modified Kjeldahl method, ammonia being distilled into excess boric acid and 21.18 ml of 0.0996 M HCl solution are consumed to titrate ammonium borate ($\text{BO}_2^- + \text{H}^+ \rightarrow \text{HBO}_2$). Calculate the % (w/v) of protein in serum. (conversion factor = 6.25)
- (d) Describe 3 detectors used in HPLC and their principles of operation.
- (e) In clinical chemistry, several components of blood are determined,, name 3 and describe how they are determined.

- Q6. (a) WHO has set up the following MAC (Maximum Acceptable Concentration) in drinking water for Arsenic (As). The practical working range for Flame Atomic Absorption Spect (FAAS) is also given

WHO MAC/ppm	FAAS working range ppm
0.05	2-200

with the aid of sketches describe a method that is an alternative to the burner - nebulizer system and aimed at improving the sensistivity, hence the detection limit for the determination of AS by AAS. (Hint, this method is based on hydride generation).

- (b) Routine analysis of water for domestic use is important. Why? Define the following and the significance of each in water analysis
- (i) Biochemical Oxygen Demand (BOD)
 - (ii) Chemical Oxygen Demand (COD)
 - (iii) water hardness

- (c) In your lab, you are presented with a water sample known to have been contaminated with two metals, copper and potassium, what would you need to determine the levels of these two metals in this water?
 - (d) A 0.2g sample containing Cu is dissolved and diethyl dithiocarbamate colored complex is formed in the presence of EDTA. The solution is then diluted to 50ml and absorbance measured as 0.0260. A 0.5g sample containing 0.24% Cu is treated similarly and the resulting solution has an absorbency of 0.600. Calculate the % of Cu in the sample.
 - (e) Describe two methods of determining Chloride ion in a water sample.
-

END OF EXAMINATION

UNIVERSITY EXAMINATIONS OCTOBER/NOVEMBER 1995

C 420

ANALYTICAL CHEMISTRY

PAPER 2

TIME: 3 HOURS

ANSWER: ANY 4 OUT OF THE QUESTIONS IN THIS PAPER

- Q1. (a) A 2.00g sample of toothpaste was suspended in 50ml of fluoride iron-fluoride ion-strength buffering medium (TISAB) and boiled to extract the fluoride. The mixture was cooled, transferred to 100ml flask and diluted to volume with water. 25ml aliquot was transferred to a beaker, a fluoride ISE and a reference electrode inserted and potential of -155.3 mv was obtained. A 0.1ml spike of 0.5mg/ml fluoride stock solution was added, after which potential was -176.2 mv. Calculate the % fluoride by weight in the original toothpaste sample. (Assume $E = K - 59.2 \log (F^-)$)
- (b) How would you identify nitrogen, sulfur and halogens in organic compounds?
- (c) How would you differentiate nitrosamines from C-nitroso compounds?
- (d) How are amines and thiols detected in organic compounds?
- (e) The following calibration data were obtained for the determination of Ni by FAAS:

standard (ppm) Ni	2	4	6	8	10
%T	62.4	39.8	26.0	17.6	12.3

Calculate Ni concentration for a reading of 20.4% T.

- Q2. (a) In the analysis of pyrite ore ((impure FeS_2)) the sulfur is converted to sulfate, followed by precipitation of barium sulfate. What mass of ore would a laboratory technician take so that the mass of barium sulfate precipitated is equal to 0.2g?
- (b) Discuss 2 schemes you would follow to determine silica in rocks.
- (c) The determination of gold and silver in rocks/ores is (rather) unique, how would you determine the metals in petzite and sylvanite (these rocks contain both Au and Ag)?

- (d) The adjusted retention times (t'_R) for a series of compounds were determined on a non-polar column: n-pentane, 2.8; n-hexane, 5.3; n-heptane, 13.7; n-octane, 29.3; toluene, 16.5 and cyclohexane, 12.4. Calculate Kovats indices for toluene and cyclohexane.
- (e) 3 extraction approaches are well-known in the analysis of rocks/ores, discuss them, highlighting the one(s) that can be used generally.

Q3. (a) ✓ Phosphorus content of soils was determined by the gravimetric quinolinium phosphomolybdate method. If 3.114g of quinolinium phosphomolybdate, $(C_9H_7N)_3PMo_{12}O_{40}$ were obtained from 1.00g sample, find the % P_2O_5 in the sample. Use P=31, O=16, N=14 and Mo=96.

- (b) Discuss the differences between Hutchison/MacLennan and Tinley et al methods in the determination of carbonates in soils.
- (c) Discuss one method you would use to determine:
- (i) organic C and
 - (ii) N in the soil
- (d) Outline the determination of Total Exchangeable Bases (TEB) and Cation Exchange Capacity (CEC) in soils.
- (e) What is "Exchangeable Acidity" and how do you determine it in soils?

Handwritten notes:
 1. H_2O
 2. H_2CO_3
 3. H_2SO_4

- Q4. (a) A sample containing traces of Zn is analysed using ICP. A calibration sample containing 1.4ppm of Zn gives a signal of 124.5 units. If background signal is 8.2 units and concentration equivalent of the background is 0.02 ppm. Calculate the concentration of Zn in a sample that gives a signal response of 94.5 units.
- (b) Briefly describe how to determine "available p" in fertilizers.
- (c) Describe the determination of ammoniacal N and nitrates in fertilizers devoid of organic N.
- (d) Describe 2 methods used to determine K in fertilizers in the presence of sulfates.
- (e) A ^{5.0}~~0.500~~g portion soil sample was weighed in a conical flask. All the basic components were neutralised with 25.00ml of 0.423N HCl solution which was in excess. The CO_2 evolved was then boiled off. If 13.88ml of 0.114N NaOH solution was required to neutralise the excess HCl, calculate the neutralising power of the liming material as % $CaCO_3$.

- Q5. (a) An organic C in a soil sample was determined by the chromic acid oxidation method. A 0.5g of soil was mixed with 0.6g of potassium dichromate and the mixture heated with conc. sulfuric acid. The excess dichromate was titrated against a solution of iron (II) sulfate, requiring 12.5ml. The iron (II) sulfate solution was standardised against 0.32g of potassium dichromate, requiring 20.1ml. Calculate:
- (i) Molarity of the iron (II) sulfate solution and
 - (ii) %C in the sample.
- Use C=12, Fe=56, Cr=52, K=39 and O=16)
- (b) Discuss 2 ways of determining Cu in steel.
- (c) What are the main components of Brass (alloy) and describe how to determine 1 of the components of your choice.
- (d) Bronze is an alloy of Cu and Sn mainly, describe the determination of the 2 elements in the alloy.
- (e) What is "German silver" and describe how to estimate the main elements in this substance.
- Q6. (a) Relative retentions of codeine, heroin, methadone, morphine and propoxyphene are: 1.0, 1.89, 0.55, 1.16 and 5.9 respectively and t_r is 6.00 min. for codeine on a 30% SE-30 column at 215°C. Calculate retention times for the other compounds.
- (b) Van Slyke method used to be a popular method in clinical chemistry. Describe this technique and contrast it with the alternative method used currently.
- (c) Define or explain the following terms:-
- (i) detergency,
 - (ii) surfactant and
 - (iii) emulsifier
- (d) Levels of tin(ppb) recovered from foodstuffs boiled for different times in an open vessel as follows:-
- | | | | | | | | |
|------------------|-----|-----|-----|-----|-----|-----|-------|
| 30 mins. boiling | 57, | 57, | 55, | 56, | 55, | 56, | 55 |
| 75 mins. boiling | 51, | 60, | 48, | 32, | 46 | 58 | 56 51 |
- Test whether the boiling time affects the variability of the results and the mean recovery of tin.
(For 7 degrees of freedom at 95% confidence level F is 3.79)

- (e) An ore sample of mass 4.714g assayed 32.84% Fe_2O_3 as received and 34.09% Fe_2O_3 after drying to constant weight.
Calculate the % water content of the sample as received.
Use $\text{Fe}=56$, $\text{O}=16$.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

C440

INORGANIC CHEMISTRY

PAPER I

TIME: THREE HOURS

ANSWER ANY FOUR QUESTIONS.

1. Draw the 'ideal' shapes of the following chemical species:

- | | | |
|----------------------|---------------------|--------------------------|
| (a) i. BF_3 | ii. PF_3 | iii. SF_3^+ |
| iv. SF_3^- | v. BrF_3 | |
| (b) i. CF_4 | ii. NF_4^+ | iii. IF_4^+ |
| iv. IF_4^- | v. SF_4 | |
| (c) i. CO_2 | ii. NO_2^- | iii. HPO_3^{2-} |
| iv. SO_3 | v. O_3 | |

2. (a) Clearly distinguish between the terms "Symmetry Element" and "Symmetry Operation".

(b) Write short notes on the following

- (i) Order of a point group
- (ii) Irreducible and Reducible representations and
- (iii) A character Table

(c) Determine the point groups of:

- | | | |
|--------------------------------------|----------------------------|-----------------------------|
| i. C_2H_6 (Eclipsed) | ii. B_2H_6 | iii. C_6H_6 |
| iv. C_2H_4 | v. PF_6^- | |

3. The complex ion $[\text{MnCl}_5]^{3-}$ has two possible, 'ideal' geometries. Using group theory concepts deduce the type of atomic orbitals on the central atom and hence the type of hybridization scheme for each of the ideal geometries.
4. Construct a qualitative molecular orbital energy level diagram for each of the following molecules
- i. NH_3 ii. H_2S iii. SiH_4
5. The complex ion $[\text{Re}_2\text{Cl}_8]^{2-}$ has a Re - Re bond with two eclipsed ReCl_4 units. Deduce
- (a) how many IR peaks are expected to be observed?
- (b) How many of these will be due to Re-cl stretching vibrations.
6. Raman spectroscopy is one of the tools that could be used to distinguish isomers. Discuss this concept using $[\text{M X}_2 (\text{CO})_4]$ and $[\text{M X}_3 (\text{CO})_3]$ type of molecules for illustration.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

INORGANIC CHEMISTRY

C440

INORGANIC CHEMISTRY

PAPER II

1. (a) Derive the Partial Terms of the configurations
(i) d^2 (ii) f^2
(b) Using the Partial Terms method derive the Spectroscopic terms of
(i) d^4 (ii) f^2
2. Consider an octahedral symmetry
(a) Deduce the Partial Ligand Field Terms associated with the electron configurations
(i) e_g^1 (ii) e_g^2 (iii) t_{2g}^1
(iv) t_{2g}^2 (v) t_{2g}^3
(b) With the help of the Partial Terms obtained from 2(a), determine a complete set of Ligand field Terms for
(i) t_{2g}^3 (ii) $t_{2g}^2 e_g^1$ (iii) $t_{2g}^1 e_g^2$
(iv) e_g^3
3. (a) Explain the following observations
The electronic spectrum of an aqueous solution of nickel(II) ion exhibits three peaks whereas that of Cu(II) ion exhibits one peak with a shoulder.

- (b) The electronic spectrum of the purple aqueous solution of cobalt (II) ion has the following peaks:

8000 cm^{-1}

19,600 cm^{-1}

21,600 cm^{-1}

Assign transitions to these peaks.

4. (a) Of what use is mass spectroscopy to an inorganic chemist? (Use examples where necessary).
- (b) Account for the presence of a peak at $m/e \approx 361$ in the mass spectrum of GaL_3 ($L \approx \text{PhCOCHCOCF}_3$). Show a mechanism for this.
- (c) Show how NO catalyst assists in the depletion of ozone in the stratosphere.
5. (a) Sketch the energy band structure of germanium with a band gap of 0.7 eV. What elements would you add to make it a p-type semi-conductor? Sketch the resulting energy level structure for acceptor levels that are located 0.01 eV above the top of the valence band.
- (b) Pure WO_3 is an electrical insulator whereas tungsten bronze such as $\text{Na}_{0.5}\text{WO}_3$ is metallic. Sketch the probable band structure of these and indicate which of the d orbitals on W are responsible for the electrical properties.
- (c) Explain why polyacetylene is an electrical conductor whereas polyethene is not. Suggest what kind of materials may be added to polyacetylene to make it
- (i) n-type, (ii) p-type
6. (a) Discuss the structure of corrin and the role of cobalt in the vitamin B_{12} coenzyme.

- (b) Contrast the importance of Mg^{2+} ion to plants and animals.
- (c) Chelatetherapy has been employed in the reduction of metal pollution in the body. Discuss its importance in the treatment of
 - (i) Mercury poisoning
 - (ii) Iron overload.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

C450

ORGANIC CHEMISTRY

PAPER I

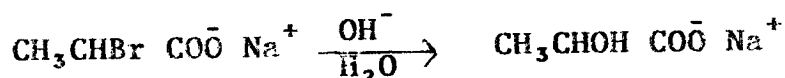
TIME: THREE HOURS

ANSWER ANY 4 QUESTIONS

1. Consider the catalytic hydrogenation of propene by the Wilkinson's catalyst ($\text{RhCl}(\text{PPh}_3)_3$).
 - (a) Give an elaboration of the 4 steps involved in the proposed mechanism for this reaction.
 - (b) Why is this reaction regarded as a typical example of a reaction showing SYMPHORIA in a chemical reaction process? Explain.
 - (c) Indicate the changes taking place in the:
 - (i) Valence electrons
 - (ii) Coordination state
 - (iii) Oxidation state of the metal from the beginning through upto the end of this reaction.
2. Give the name and structure(s) of compounds with the following spectra.
 - (i)
 - (ii)
3. Give the name and structure(s) of compounds with the following spectra
 - (i)
 - (ii)

4. (a) By drawing structures, show the stereochemical course of reaction of optically active erythro-3-bromo-2-butanol with hydrogen bromide

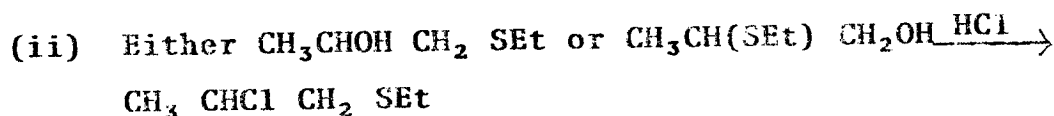
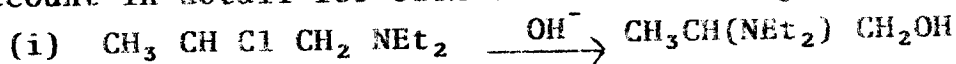
(b) Sodium α -bromopropionate undergoes hydrolysis with retention of configuration



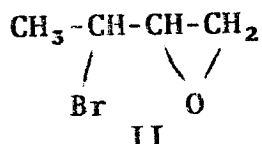
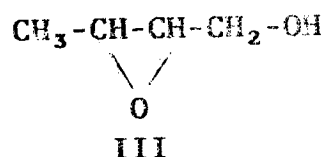
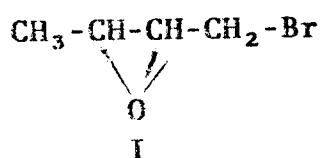
Sodium α -bromopropionate Sodium lactate

Give the most plausible interpretation of this experimental result.

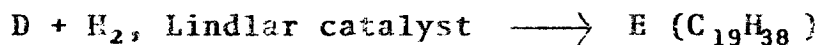
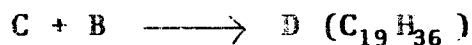
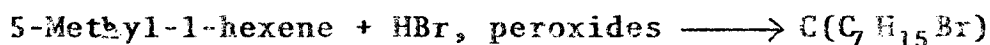
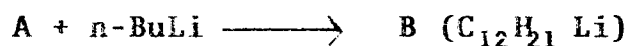
(c) Account in detail for each of the following observations



(iii) Treat of either epoxide I or epoxide II with aqueous OH^- gives the same product III



5. (a) Disparlure, the sex pheromone for the gypsy moth has been synthesized in the following way



Optically inactive

What is the structure of disparlure?

- (b) Unlike the product obtained above, the natural pheromone is optically active. By looking at the structure of the molecule, deduce what the optical activity is due to.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
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C450

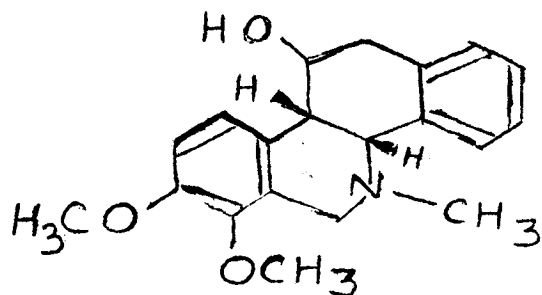
ORGANIC CHEMISTRY

PAPER II

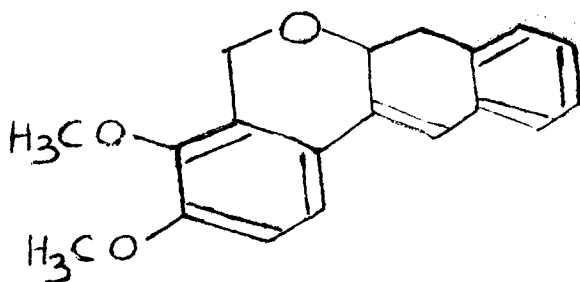
TIME: **THREE HOURS**

ANSWER: **ANY FOUR QUESTIONS**

1. (a) Treatment of the alkaloid A with excess dimethyl sulphate and aqueous sodium hydroxide unexpectedly gave a compound B in good yield. Suggest a reasonable mechanism to explain the formation of the unanticipated product B.

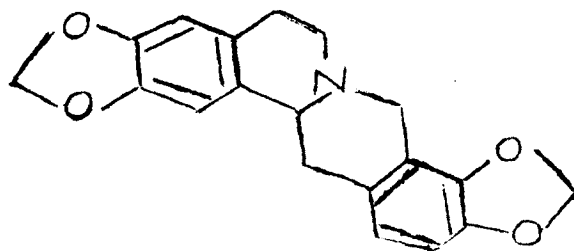


A



B

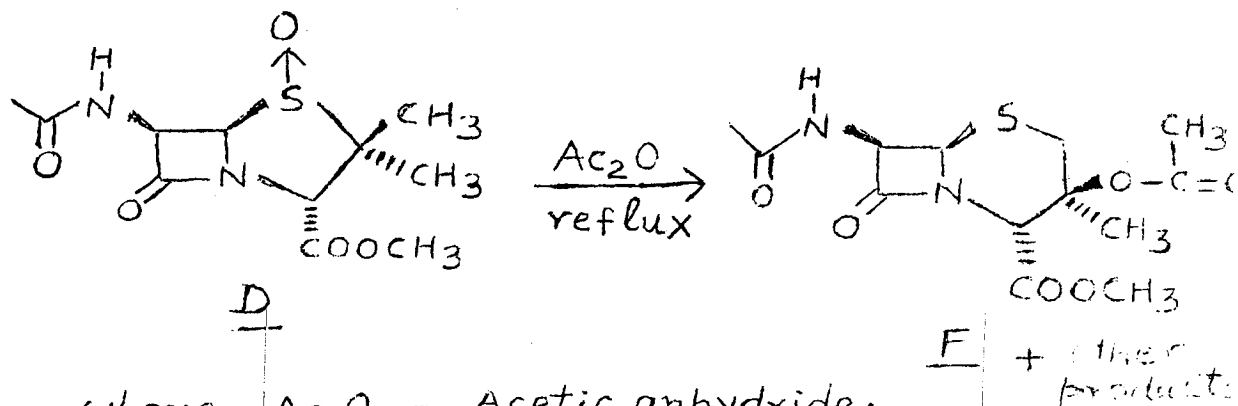
- (b) Using the disconnection approach, devise a synthesis of the alkaloid C from readily available non-heterocyclic starting materials. Show your analysis.



C

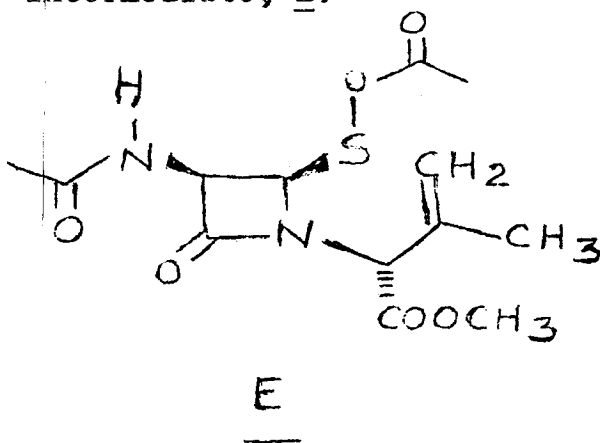
2. (a) (i) Briefly explain how penicillins are inactivated by Gram-positive cocci.

(ii) Penicillin sulphoxide, D, can be transformed into a more potent anti-biotic cephalosporin, F, as shown below.



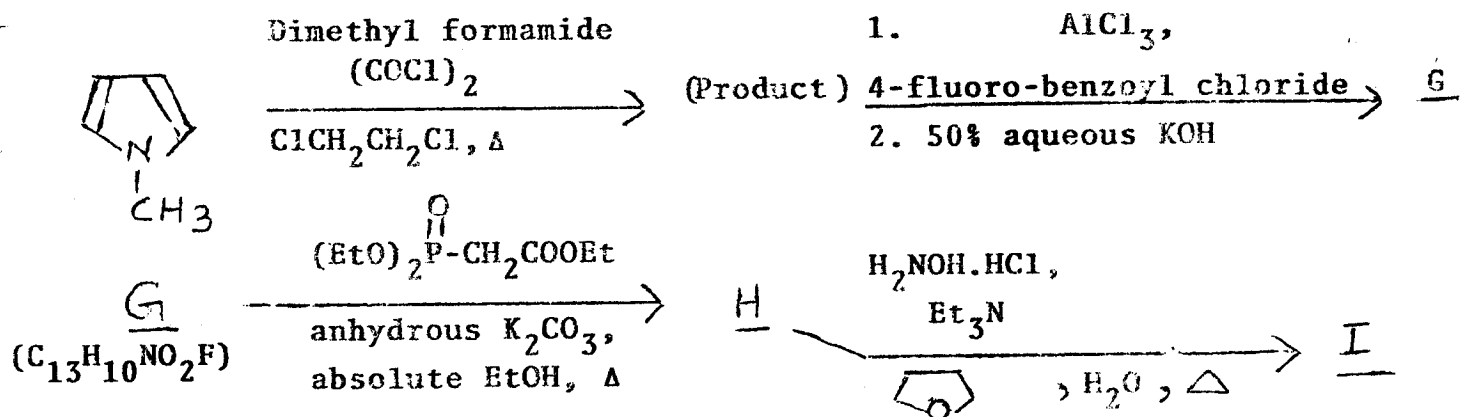
where Ac_2O = Acetic anhydride.

This reaction is thought to proceed via a sulfenic anhydride intermediate, E.



On this basis suggest a plausible mechanism for the above reaction.

2. (b) (i) Deduce the structure of a potent anti-bacterial agent I. Show the structures of all the intermediates involved.



- (ii) Give the mechanism of the reaction involved in the formation of H from G.

3. (a) Deduce the structure of a disaccharide X, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$, from the following data. Show your reasoning.

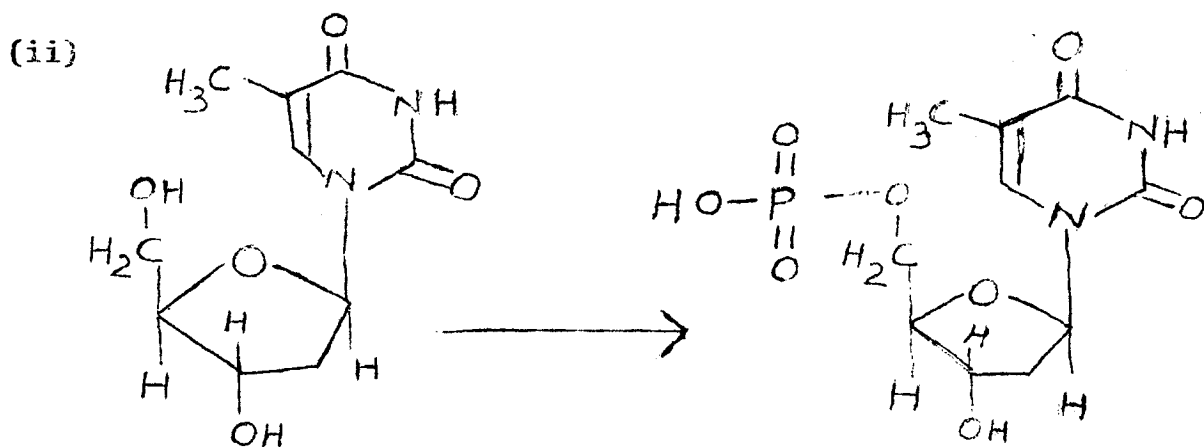
Acid hydrolysis of X gave D-glucose and a D-aldohexose J. Exhaustive methylation of X followed by mild acid hydrolysis produced 2,3,4-tri-O-methyl-D-glucose and 2,3,4,6-tetra-O-methyl derivative of J in equimolar ratio. Sodium borohydride reduction of J gave an optically inactive compound K, $\text{C}_6\text{H}_{14}\text{O}_6$. Ruff degradation of J produced an aldopentose L, which was oxidized by dilute nitric acid to an optically active dicarboxylic acid, M, $\text{C}_5\text{H}_8\text{O}_7$.

COMPOUND X: $^1\text{H NMR}$ (D_2O , 60 MHz); δ (ppm):

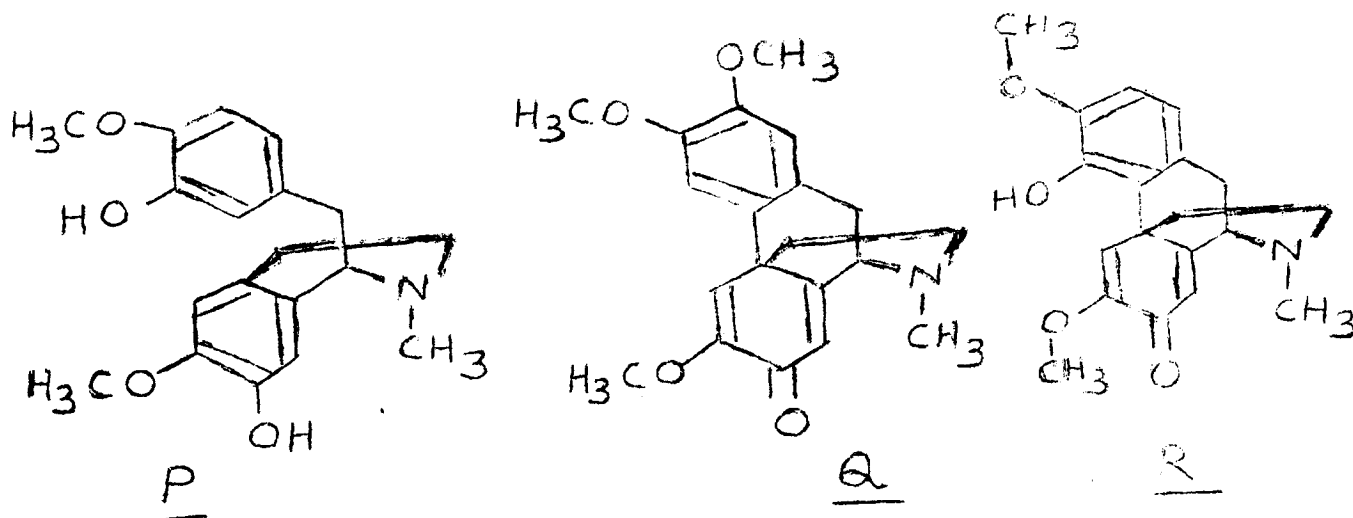
5.6 (d, 1H, $J = 7.8$ Hz); 5.4 (d, 1H, $J = 7.4$ Hz) +
 other signals at $\delta 4.5 - 3$ integrating for the
 remaining protons.

3. (b) Show clearly how the following transformations may be achieved in good yield.

(i) D-glucose $\xrightarrow{\hspace{1cm}}$ 3-amino-3-deoxy-D-glucose

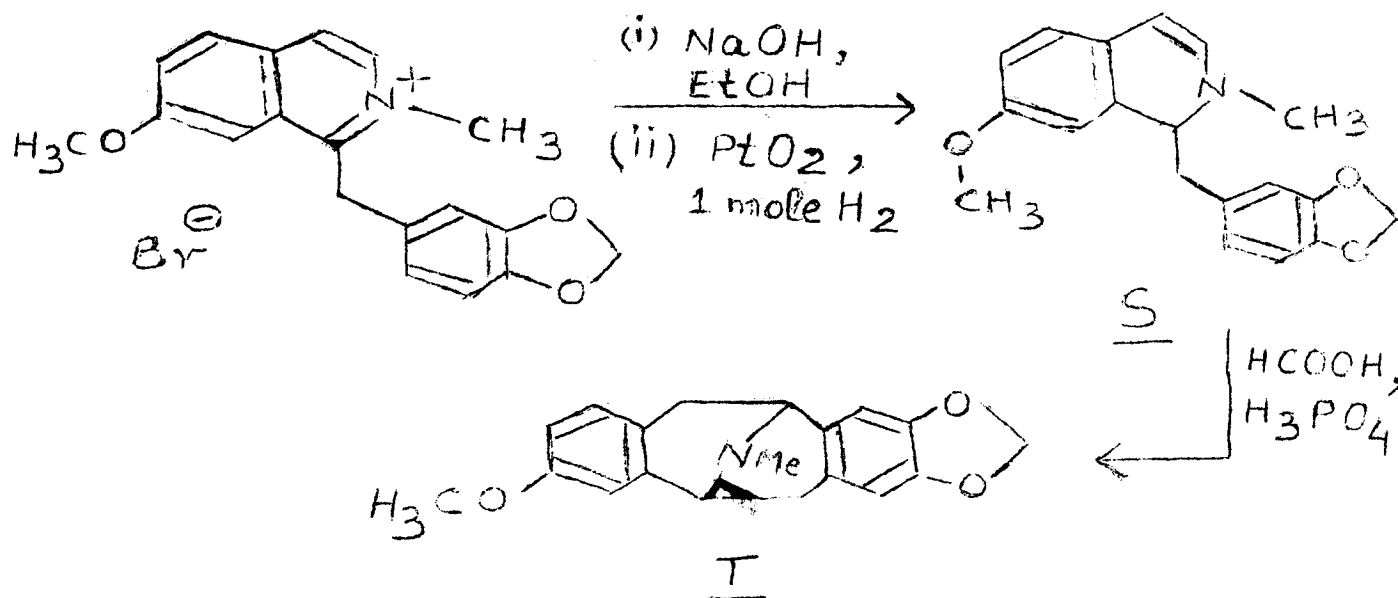


4. (a) Labelling experiments have shown that compound P is the key intermediate in the biosynthesis of alkaloids Q and R in plants.



On this basis propose a plausible biogenetic pathway for compounds Q and R from the key intermediate P. Explain the reactions involved in your proposal.

4. (b) Suggest mechanisms of the following reactions

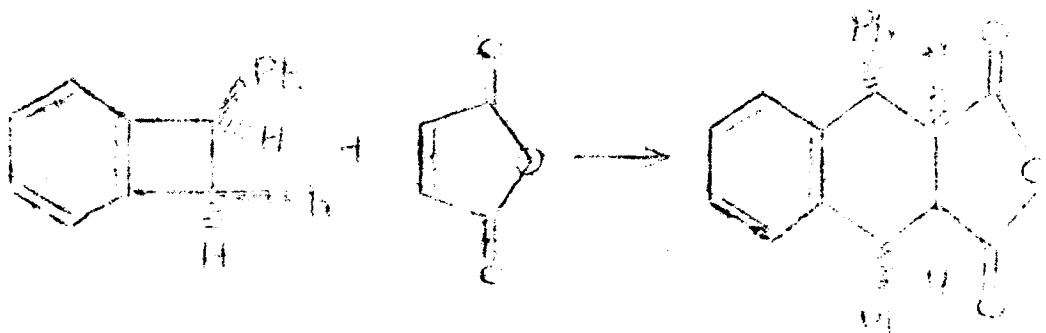


5. (a) Consider the reaction of an allyl anion with an allyl cation from the orbital symmetry point of view.

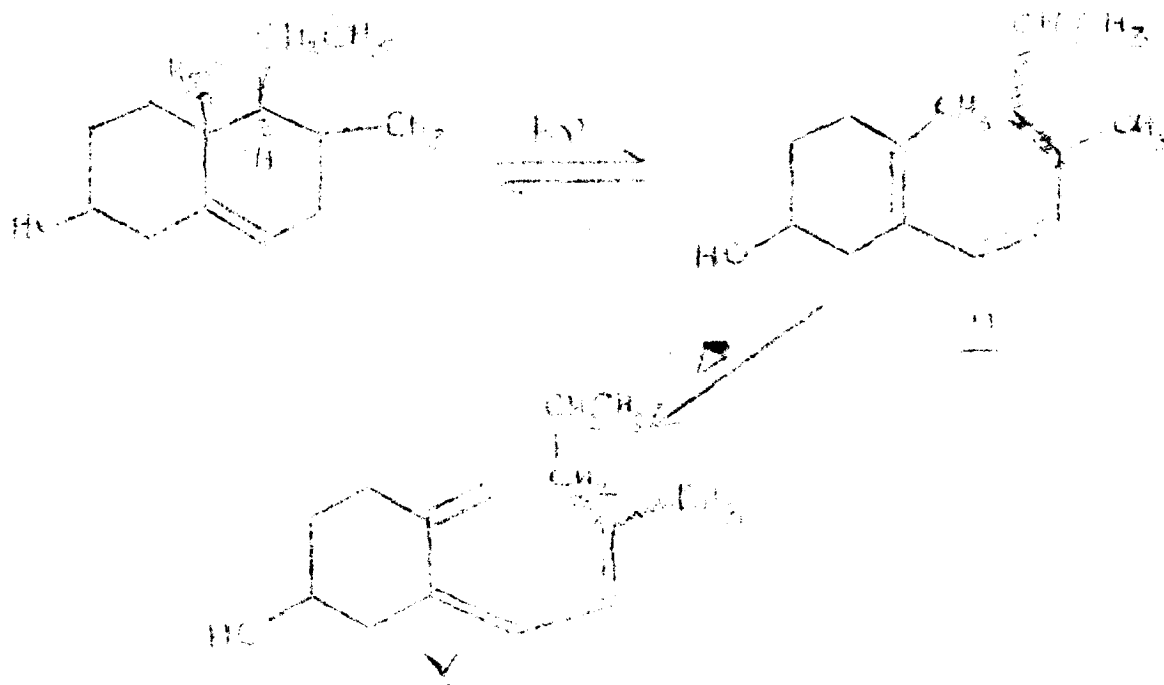
Show which of the following frontier molecular orbital interactions is more important in this reaction.

- $\text{HOMO}_{\text{allyl cation}} / \text{LUMO}_{\text{allyl anion}}$
- $\text{HOMO}_{\text{allyl anion}} / \text{LUMO}_{\text{allyl cation}}$

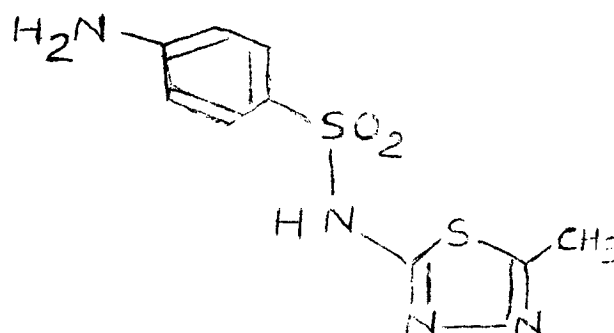
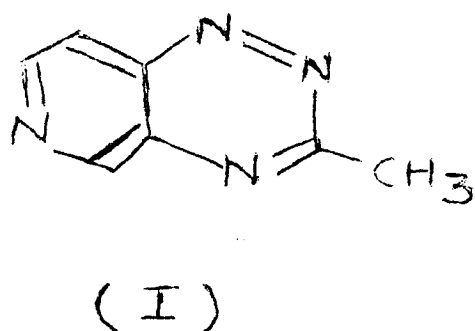
(b) Give the mechanism and stereochemistry of the product for the following reaction.



6. (a) Explain the following reactions in terms of orbital symmetry rules and deduce the stereochemistry of the products U and V.



- (b) Suggest a stepwise synthesis of ONE of the following anti-bacterial agents from readily available starting materials.



- (c) Explain the most likely mode of anti-bacterial action of compound (II) shown in question 6(b) above.

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

C460

PHYSICAL CHEMISTRY

PAPER I

TIME: THREE HOURS

ANSWER ANY FOUR QUESTIONS

USEFUL INFORMATION:

$$c = 2.998 \times 10^8 \text{ ms}^{-1}$$

$$h = 6.626 \times 10^{-34} \text{ Js}$$

$$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$m_e = 9.109 \times 10^{-31} \text{ kg}$$

$$m_p = 1.673 \times 10^{-27} \text{ kg}$$

$$F = 9.6485 \times 10^4 \text{ C mol}^{-1}$$

$$= 23.060 \text{ cal mol}^{-1} \text{ eV}^{-1}$$

$$k = 1.381 \times 10^{-23} \text{ J K}^{-1}$$

$$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$= 1.987 \text{ cal K}^{-1} \text{ mol}^{-1}$$

$$= 0.082 \text{ L atm K}^{-1} \text{ mol}^{-1}$$

- I. (a) Write down a general eigenvalue equation and explain it by giving a suitable example.
- (b) If $\hat{P} = \frac{d}{dx}$ and $\hat{Q} = x$ and $f(x) = x^2 + 2x + 1$
Are the operators commutative? What is the value of the commutator?
- (c) What do you understand by ∇ and ∇^2 . What are the values of ∇^2 in cartesian and polar coordinates?
- (d) Show that if the eigenfunctions of two operators \hat{A} and \hat{B} are the same functions \hat{A} and \hat{B} commute with each other.
- (e) Define a conservative system. Illustrate by two examples that both the definitions are alike.
- (f) Define Hamiltonian function and show that for a conservative system it is equivalent to the total energy of the system.
- (g) Write down the equations of motion in Lagrangian form and Hamiltonian form.
- II. (a) Describe the evidence for the failure of classical mechanics.
- (b) Give the physical interpretation of the Ψ function.
- (c) What are acceptable wave functions?
- (d) Normalise the wave function

$$\Psi = (\text{constant}) \sin\left(\frac{n\pi x}{a}\right)$$
- III. (a) What is a Hermitian operator? Prove that the eigenvalues of a Hermitian operator are real.
- (b) How are the operators for different observables set? Construct the quantum mechanical operator for the kinetic energy.

- (c) On the basis of postulates of Quantum mechanics derive the Schrodinger Wave equation.
 - (d) State and explain Postulates IV and V of Quantum mechanics.
- IV. (a) Calculate the allowed wave functions and energies for a particle constrained to move in a One dimensional box.
- (b) Show that a particle in a One dimensional box cannot have a definitely known momentum and that the average value of the momentum is Zero.
- (c) Find the wavelength of the light emitted when a 1×10^{-27} g: particle in a "3-A" One dimensional box goes from the $n=2$ to $n=1$ level.
- V. (a) What are the methods used for obtaining solutions to the wave equation in a system having more than one electron? Explain one of these.
- (b) Obtain an expression for the energy of an electron in a hydrogen atom or hydrogen like ion.
- (c) Give the physical significance of Hydrogen like orbitals. What do you understand by Radial distribution function?
- (d) In Hydrogen atom write the expression for the Radial function $R(r)$ when normalised.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1991

C460

PHYSICAL CHEMISTRY

PAPER II

TIME: . THREE HOURS

ANSWER ANY FOUR QUESTIONS

USEFUL INFORMATION:

$$c = 2.998 \times 10^8 \text{ ms}^{-1}$$

$$h = 6.626 \times 10^{-34} \text{ Js}$$

$$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

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$$F = 9.6485 \times 10^4 \text{ C mol}^{-1}$$
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$$= 1.987 \text{ cal K}^{-1} \text{ mol}^{-1}$$
$$= 0.082 \text{ L atm K}^{-1} \text{ mol}^{-1}$$

- I. (a) Show that $[\hat{L}_x, \hat{L}_y] = i\hbar\hat{L}_z$
where \hat{L}_i are operators for components of angular momentum. What can you conclude about the possibility of simultaneously measuring two different components of the angular momentum of a particle?
- (b) What are Ladder operators? How can the computation of \hat{L}^2 be simplified by its use?
- (c) What are the postulates of Spin Angular Momentum?
- (d) What are atomic units of mass, charge, length, Angular momentum and Energy? Express Hamiltonian in atomic units.
- II. (a) Express the rotational part of the energy in terms of frequency and wave numbers.
- (b) The first line in the rotation spectrum of CO has been measured as 3.84235 cm^{-1} . Calculate the moment of inertia and hence the bond length.
- (c) Calculate the force constant for H^{35}Cl from the fact that the fundamental vibration frequency is $8.667 \times 10^{13} \text{ s}^{-1}$.
- (d) Compare the oscillation frequency of a harmonic oscillator and an anharmonic oscillator. Give the selection rule in both the cases.
- III. (a) Discuss the Vibration-rotation spectra of a diatomic molecule.
- (b) Describe the different contributions to the Polarization.
- (c) Calculate the value of the nuclear magneton. How is it related to Bohr magneton?

- (d) Calculate the magnetic field strength required to give a precessional frequency of 9500 MHz for a free electron.

$$(g_e = 2.0023; \mu_B = 9.2741 \times 10^{-28} \text{ JG}^{-1})$$

- IV. (a) Derive Maxwells Distribution Law for the distribution function for the x component of velocity in a gas.
- (b) Obtain expressions for most probable speed v_p and Mean speed $\langle v \rangle$.
- (c) Calculate the rms speed of Nitrogen molecules at 25°C. For nitrogen molecules M has the value 28.02g.
- (d) For oxygen at 25°C the collision diameter is 0.361nm. What is the mean free path at 1 atm pressure?
- V. (a) State and explain the concept of an Ensemble of a system. What are (i) Canonical (ii) Microcanonical and (iii) Grand canonical ensembles?
- (b) How can the following thermodynamic quantities be expressed in terms of the Partition function Q? Give the derivations.
- (i) Internal Energy
 - (ii) Entropy
 - (iii) Helmholtz energy and
 - (iv) Enthalpy
- (c) Give the expressions for
- (i) Translational Partition function for a perfect gas.
 - (ii) Rotational Partition function for a diatomic molecule.
 - (iii) Electronic Partition functions of atoms and

- (iv) Vibrational Partition function for a diatomic molecule.
- (d) Calculate the characteristic vibrational temperature Θ_v and the vibrational partition function q_v for Hydrogen gas at 3000 K. The fundamental vibration frequency is 4405.3 cm^{-1} .

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

CA210

ANALYTICAL CHEMISTRY

TIME: ONE (1) HOURS

ANSWER ANY TWO QUESTIONS

1. (a) Distinguish between the following forms of the student t test

- (i) t-test when an accepted value is known
- (ii) Paired t test
- (iii) t test with multiple samples

(b) What is a Q test and what is it used for?

(c) What is an F test and what is it used for?

(d) You are developing a new colorimetric method for determining the glucose content of a blood sample. You have chosen the standard Folin-Wu method with which to compare your results. From the following two sets of replicate analyses on the same sample determine whether the variance of your method differs significantly from that of the standard method.

<u>Your Method, mg/L</u>	<u>Folin-Wu Method mg/L</u>
127	130
125	128
123	131
130	129
131	127
126	125
129	

Mean (\bar{x}_1) = 127

Mean (\bar{x}_2) = 128

The tabulated F value for $v_1 = 6$ and $v_2 = 5$ is 4.95

The tabulated F value for $v_1 = 7$ and $v_2 = 6$ is 4.21

2. (a) Explain or define the following:

- (i) Gravimetric factor
- (ii) Precipitation from homogeneous solution (PFHS)
- (iii) Common Ion and Diverse Ion effects
- (iv) Solubility product (K_{sp})
- (v) Occlusion, surface adsorption and post precipitation
- (vi) Coprecipitation in the broad and restricted senses.

(b) Ten milliliters of 0.20 M AgNO_3 is added to 10 mL of 0.10 M NaCl. Calculate the concentration of Cl^- remaining in solution at equilibrium and the solubility of the AgCl.

$$K_{sp} \text{ for AgCl} = 1.0 \times 10^{-10}$$

(c) What is the solubility of PbSO_4 , in g/L, if the solubility product is 1.6×10^{-8} .

$$\text{Molecular Mass of PbSO}_4 = 303.26$$

3. (a) Explain the following terms

- (i) Strong electrolyte and a weak electrolyte
- (ii) Brønsted acid-base theory
- (iii) Conjugate acid and conjugate base
- (iv) Lewis acid-base theory
- (v) pH of a solution as defined by Sørensen.
- (vi) Buffer solution

(b) Calculate the pH of a buffer solution prepared by adding 10mL of 0.10 M acetic acid to 20 mL of 0.10 M sodium acetate.

$$K_a \text{ for acetic acid} = 1.75 \times 10^{-5}$$

(c) A buffer solution is 0.20 M in acetic acid and sodium acetate. Calculate the change in pH upon adding 1.0 mL of 0.10 M hydrochloric acid to 10 mL of this buffer solution.

$$K_a \text{ for acetic acid} = 1.75 \times 10^{-5}$$

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

G140

INTRODUCTION TO HUMAN GEOGRAPHY

PAPER I

TIME: THREE HOURS

ANSWER: FOUR QUESTIONS - TWO FROM EACH SECTION

NOTE: ILLUSTRATE YOUR ANSWERS WHEREVER POSSIBLE. USE
OF AN APPROVED ATLAS IS ALLOWED.

SECTION A

- Q1. With the use of examples, state the importance of modifying the Hagerstrand model before its application to Developing countries.
- Q2. With the aid of diagrams, explain how labour costs and economies of agglomeration affect the location of an industry according to Alfred Weber.
- Q3. Describe the contrasts in the derivation of the K - value between the traffic principle and the marketing principle. Use diagrams to illustrate your answers.
- Q4. Describe the Zonal theory of Urban Morphology.

SECTION B

- Q5. Evaluate the view that culture is the Key to socio-economic development.
- Q6. Give differences between women in development and Gender and development?
- Q7. Assess the view that Industrialization has not adequately diffused to Africa and suggest what needs to be done to achieve such development.
- Q8. 'Rapid population growth is the root cause of poverty in some developing countries today,' Discuss.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

G140

INTRODUCTION TO HUMAN GEOGRAPHY

PAPER II PRACTICAL

TIME: THREE HOURS COMPUTER NO: _____

ANSWER: ALL QUESTIONS IN SECTIONS A AND B AND TWO IN SECTION
 C. THE USE OF ELECTRONIC CALCULATORS AND AN APPROVED
 ATLAS IS ALLOWED.

SECTION A

MAP READING

- Q1. (a) Why should every good map have a legend?
- (b) What is the basic difference between a four figure and six figure grid references?
- (c) What is an auxillary contour and how does it differ from ordinary contours on a topographical map?
- (d) What is the basic difference between a spot height and a precise bench-mark?

(e) What do you understand by the term map projection?

Q2. (a) What is the difference between oblique and vertical air photographs?

(b) Calculate the scale of an air photograph if the camera used has a focal length of 20cm and the aircraft is flying at an average height of 1000 metres.

(c) Air photographs are taken in such a way that exposures are timed to allow a 60% forward overlap between successive photographs in the same strip and also a 25% lateral overlap between adjacent strips. What term do geographers use to describe pairs of photographs that overlap in this way?

(d) What is the name of the device that allows one to view two overlapping air-photos taken from slightly different points of view at the same time?

- (e) Briefly explain how maps and air photos complement each other?

Q3. (a) Calculate the vertical exaggeration for a profile drawn with a vertical scale of 1:100000 and a horizontal scale of 1:300000 (show all work)

(b) Draw a linear scale in the space below in metric units for a map drawn at the scale of 1:100000 given that the maximum space available is 17 centimetres (show all work).

(c) Express 1:100000 as a scale in words (show all work)

(d) Express 5 centimetres to one kilometre as a representative fraction (show all work)

- (e) A senior geography student wanted to draw a map on a scale of 1:50000 on A4 paper. On realizing that the map would not fit in the space available, he decided to reduce the map five times. What is the scale of the reduced map?

Q4. Use topographic map sheet 1332 D1 to answer this question.

- (a) Identify the features found at the following grid references:

(i) 675926 _____

(ii) 695991 _____

- (b) Using the square method calculate the approximate area covered by Chipata municipal or township area?

- (c) What is the average gradient along the municipal boundary from grid reference 611891 near the foot of Kanjala hill to grid reference 595818 near the summit in degrees?

- (d) Calculate the approximate distance in Kilometres of the D123 road from the road junction in grid square 5693 to the edge of the map in grid square 4592.

- (e) Calculate the grid bearing of the trigonometrical station in grid square 5099 from the road junction in grid square 5993.

Q5. Using the sheet of A4 metric graph paper provided, draw a straight-line profile along easting 49 from grid reference 490840 to grid reference 490952. Use a vertical scale of 1 centimetre to 100 metres. On your profile show the positions of the following:

- (i) Lutembwe and Msekera streams
- (ii) the roads to Katete and Msoro
- (iii) the power line

SECTION B:

MAP INTERPRETATION

Use map extract 1332 D1 in answering questions in this section. In the answer booklet provided:

- Q6. (a) Name the drainage pattern that describes the Lutembwe ~~stream~~ and its tributaries and briefly explain how relief has influenced this drainage pattern
- (b) How does the drainage pattern you have identified in
- (a) differ from a radial pattern?
- Q7. (a) Draw a map at a scale of 1:200000 showing major physiographic regions of the area covered by the map sheet.
- (b) Name and describe each region you have identified.

- Q8. (a) Explain the meaning of a "settlement pattern".
- (b) Why is the site two kilometres north of St. Anne's Mission (grid reference square 6293) not ideal for settlement?
- (c) What major factors do you think were taken into consideration when choosing the settlement of Chipata town (use map evidence only).

SECTION C

- Q9. By the use of an appropriate index, determine the centrality of localities whose service types are contained in Table 1 and comment on your results.

Table 1: Service types by locality in Country X

Service Type	L O C A L I T Y				Total in town X
	A	B	C	D	
1. Banking	0	1	12	2	18
2. Hotel	0	2	4	0	8
3. G/shops	3	5	26	10	68
4. Health	0	1	3	1	5
5. G/markets	1	0	3	1	7

- Q10. Show the cartographic technique you can use in analysing the population composition of country Y given in Table 2 and briefly describe the emerging population structure.

Table 2: Population Distribution by Age/Sex Country Y,
1980

<u>Age Group</u>	<u>Male</u>	<u>Female</u>
0-4	410,880	480,110
5-9	310,001	350,778
10-14	190,170	201,710
15-19	150,117	178,701
20-24	131,781	132,802
25-29	120,817	124,789
30-34	98,171	108,890
35-39	70,501	70,200
50-44	38,890	55,701
45-49	36,170	43,901
50-54	24,812	39,907
55-59	20,907	37,101
60-64	18,170	30,709
65-69	15,901	20,701
70+	10,101	18,178

Q11. Using data given in Table 3, estimate the lifetime inter-district migration in Central Province and give factors influencing the pattern obtained.

Table 3: Life-time inter-district migration central
province

Place of birth	P l a c e o f E n u m e r a t i o n				
	1	2	3	4	5
1. Kabwe R.	133,165	3244	1987	2733	620
2. Kabwe U.	8125	77891	4088	1789	1991
3. Mumbwa	3742	1203	80183	904	187
4. Mkushi	2974	3034	265	70726	1171
5. Serenje	1524	2987	4330	478	82543

Source, CSO (1995), 1990 Censuses of Population and Housing
Final Report.

Q12. Given the poverty line of K8,500, assess the spatial poverty situation in country X by the use of data in Table 4 and interpret your findings. All the calculation must be shown.

Table 4: House hold income by Regions Country X, 1993

REGION	HH-1	HH-2	HH-3	HH-4	Pop(N)	Sample(n)
A	K5,200	3,670	2,009	4,110	15	4
B	K7,400	6,450	6,000	7,430	10	3
C	K4,150	2,560	1,500	3,166	8	3
D	K6,100	4,330	5,790	6,017	10	5

Q13. Table 5 presents an incomplete Life Table for males of country X and Y:-

- (a) Calculate the missing deaths (dx) (-)
- (b) Estimate the Life expectancies at each age (?)
- (c) Comment on your results.

Table 5: Life Table for Males, country X and Y

Country X

n	lx	dx	qx	Tx	Eo
0	100,000	-	0.135	7521428	-
15	98,364	-	0.002	5945562	-
45	96,829	-	0.144	3024224	-
65	81,040	-	0.125	1208647	-
95	12,507	-	0.930	4293	-
100	167	-	1.000	263	-

Country Y

Lx	dx	qx	Tx	Eo
100,000	-	0.127	7499887	-
99,188	-	0.003	6007435	-
95,901	-	0.153	2997989	-
80,177	-	0.110	1074889	-
13,008	-	0.911	3997	-
96	-	0.988	245	-

END OF EXAMINATION

Intermediate Physical GeographyTime Three hoursAnswer Question one and three others.Note Question one carries 40% of the total marks for the paper. Candidates are advised to use their time accordingly. Illustrations and examples should be used wherever appropriate. Use of a calculator is allowed.

1. The International Development Bank (IDB) is thinking of setting up a small scale project on fish farming near Chililambombwe, Copperbelt.

The idea is to use a small lake (85 Km square) within the Munyonsi river catchment area for this project.

At a hydrological station along the river, the wet cross section measures 75 cm deep and 145 cm wide.

The catchment area upstream the hydrological station measures 412 Km square.

Using the climatological data from the nearest meteorological station, determine whether there is enough water to make this project a success and calculate the average waterspeed in the river at the hydrological station.

Month	P (mm)	Ea (mm)	Month	P (mm)	Ea (mm)
Jan.	28	31	July	78	21
Feb.	36	35	Aug.	98	48
March	40	28	Sept.	115	53
April	10	15	Oct.	85	41
May	5	21	Nov.	73	36
June	0	27	Dec.	48	39

2. a) Describe and explain the daily cycle of local winds in Lake Kariba area.

b) Calculate the figure for evaporation from the lake by using the data from Lusitu boma:

Precipitation 430 mm/year

Temperature 25.2 degr. C.

Lake Kariba measures on the 1:1500000 map roughly 1.5 by 17 cm.

3. With the aid of a diagram, explain and name the earth surface wind systems and how the change in the position of the earth in relation to the sun during the year, affects the earth surface wind systems.

Explain this in relation to the climate of Zambia.

4. With the aid of a diagram, describe the structure and the operation of the following instruments:

a sun shine recorder,
an altimeter,
a self recording hygrometer and
a minimax thermometer.

5. Explain the use of a lysimeter and, in relation with this, discuss the results of the research, done by Professor Penmann at "Rothamsted Experimental Station, Harpendon, England" in the beginning of this century.

6. Explain the processes associated with all of the following:
rainfall at a warm front,
thunderstorm with hail,
mid summer night sun within 66.5 degr. S. and
the dry and wet adiabatic rate.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY DEFERRED EXAMINATIONS - JANUARY/FEBRUARY 1995

G220 II

GEOMORPHOLOGY

TIME: THREE HOURS

ANSWER: QUESTION ONE AND THREE OTHERS

NOTE: QUESTION ONE CARRIES 40% OF THE TOTAL MARKS FOR THE PAPER. CANDIDATES ARE ADVISED TO USE THEIR TIME ACCORDINGLY. ILLUSTRATIONS AND EXAMPLES SHOULD BE USED WHEREVER APPROPRIATE.

USE OF A CALCULATOR IS ALLOWED.

1. Write explanatory notes on all of the following:

- (a) Geographical cycle
- (b) Igneous rock
- (c) Principle of uniformitarianism
- (d) Pools and riffles
- (e) Stalactites
- (f) Turbulent and laminar flow
- (g) Solifluction
- (h) Bifurcation ratio
- (i) Fluvial terraces
- (j) Seif dune

2. Climate affects geomorphic processes both directly and indirectly. Discuss

3. Define the term metamorphism, and show how the process is related to the theory of plate tectonics.

4. How has volcanism contributed to the origin and growth of continental and oceanic crust?
5. Discuss the factors that create differential weathering and erosion.
6. One could imagine a bornhardt dome appearing as a consequence of any of the three different processes. Explain.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY DEFERRED EXAMINATIONS - FEBRUARY, 1995

G 220

INTRODUCTION TO PHYSICAL GEOGRAPHY

PAPER III

BIOGEOGRAPHY AND SOILS

TIME: THREE HOURS

ANSWER: FOUR QUESTIONS, TWO FROM SECTION A AND TWO OTHERS FROM SECTION B. ALL QUESTIONS CARRY EQUAL MARKS

THE USE OF AN APPROVED ATLAS IS ALLOWED.
YOU ARE ENCOURAGED TO USE MAPS AND DIAGRAMS WHEREVER POSSIBLE TO ILLUSTRATE YOUR ANSWER.

SECTION A: BIOGEOGRAPHY

1. Write short explanatory notes on all of the following
 - (a) Eutrophication
 - (b) Characteristics of population growth
 - (c) Detritus food web
 - (d) Biogeochemical cycles
 - (e) Ecological efficiency
2. Discuss the underlying trends in the process of succession.
3. Describe the characteristics of a species and its habitat that would produce large population fluctuations and contrast those that would promote small population fluctuations.
4. Functional and Binomial classifications of organisms are commonly used in biogeography. Describe with examples how these two classifications are used and indicate one advantage and disadvantage of each.

SECTION B: SOILS

5. Describe the processes of soil formation and illustrate your answer with an example of a soil type.
6. (a) Explain how soils naturally become acidic in the humid tropics.
(b) What are the problems of acidic soils and how do you ameliorate them?
7. In what ways may climate influence soil type in the following environments if the parent material was basalt
(a) in a semi-arid area
(b) in a humid area.
8. Write a brief account of each of the following
(a) cmol/kg as unit of measure of cation exchange capacity
(b) Isomorphous substitution
(c) Soil salinity
(d) USDA soil classification
(e) Alfisols

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

G220

INTRODUCTION TO PHYSICAL GEOGRAPHY

PAPER III

BIOGEOGRAPHY AND SOILS

TIME: THREE HOURS

ANSWER: FOUR QUESTIONS, TWO FROM SECTION A AND TWO OTHERS FROM SECTION B. ALL QUESTIONS CARRY EQUAL MARKS.

THE USE OF AN APPROVED ATLAS IS ALLOWED. YOU ARE ENCOURAGED TO USE MAPS AND DIAGRAMS WHEREVER POSSIBLE TO ILLUSTRATE YOUR ANSWER.

SECTION A: BIOGEOGRAPHY

1. Discuss how topography and abiotic influences limit the distribution of plants and animals.
2. How do Tropical forests and the Boreal forests or Taiga respond to climatic conditions?
3. (a) Discuss with examples two types of competition and how they affect population distribution of an organism.
(b) How do organisms prevent competition among themselves?
4. Write short explanatory notes on all of the following:
 - (a) Binomial nomenclature
 - (b) Logistic and Malthusian population growth patterns
 - (c) Nitrification in the Nitrogen cycle
 - (d) Standing Biomass
 - (e) Net and Gross Primary Productivity

SECTION B: SOILS

5. The soils in the high rainfall area of Zambia are said to be acidic and have low fertility. Explain the causes for the acidity and low fertility with respect to at least four of the main soil forming processes.
6. (a) What is Cation Exchange Capacity (CEC) and how does it develop in soils?
(b) Explain the possibility of a soil with high CEC having low soil fertility status.
7. How does time affect soil formation and how can you tell the age of a soil? Illustrate with examples the age of soils with respect to Alfisols, Ultisols, Inceptisols and Oxisols.
8. Distinguish between the following
 - (a) humus and mottles
 - (b) Soil reaction and Base saturation
 - (c) leaching and erosion
 - (d) texture and structure
 - (e) parent material and concretions

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY DEFERRED EXAMINATIONS - JANUARY/FEBRUARY 1995

G230

CARTOGRAPHIC AND QUANTITATIVE TECHNIQUES IN GEOGRAPHY

PAPER II: DATA PROCESSING AND PRESENTATION

TIME: THREE HOURS

ANSWER: THREE QUESTIONS, TWO FROM SECTION A AND ONE FROM SECTION B

SECTION A: STATISTICAL GRAPHS AND DIAGRAMS

- Q1/ Examine the data given in the table below extracted from records of the sales achieved by staff of Chonzi and Company Limited in 1994.

Sales (K'000)	Frequency
Under 3	2
3 and under 6	10
6 and under 9	12
9 and under 12	15
12 and under 18	10
18 and under 21	9
21 and over	5

- (a) Using the data given in the table above, construct a histogram.
- (b) Briefly explain the basic difference between a histogram and a simple bar chart.

- Q2. ✓ Geo-information systems Limited has produced an annual report which includes the following information relating to the company's cash flow with comparative data from the previous year:

Year	1994	1993
Salaries	60 ①	50 ①
Taxation	20 ②	16 ②
Interest on Loans	10 ③	10 ③
Renewal of Equipment	18 ④	16 ④
Investment Costs	24 ⑤	20 ⑤
Repairs	8 ⑥	8 ⑥
Totals	140	120

- (a) Using the data given in the table above show, the change in circumstances from 1993 to 1994 in relative terms using the most appropriate statistical technique.
- (b) Briefly discuss the merits and limitations of the method you have selected.
- Q3. ✓ (a) Use the most appropriate technique to show the data provided in the table below on a single diagram.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp °C	21	21	20	17	15	13	13	13	14	16	18	20
Ppt (mm)	18	15	23	48	97	111	94	86	58	41	28	20

Station: Capetown, Location: 38°S, 8°E

- (b) Briefly comment on the relationship between rainfall and temperature and their distribution from January to December.

- Q4. You have been appointed personal assistant to the production manager of the University Press. It is planned to present information to the students in an attempt to encourage greater interest in the business operations of the University Press. You have been requested to contribute to this by providing suitable data presentations. The relevant data is as follows:

Year	1994	1993	1992	1991
Sales	60	58	45	40
Wages	25	22	19	13
Production Costs	8	6	5	4
Material Costs	18	16	13	10
Taxation	0	3	1	2
Other Costs	8	7	5	5
Profit	1	4	2	6

- (a) Prepare a visual display to show sales.
- (b) Briefly comment on the advantages and disadvantages of the method you have used.

SECTION B: STATISTICAL MAPPING

- Q5. (a) Using the outline map of an imaginary City of Chonzi provided and the information in the table below, construct a population density map of the city.

Ward	Area (Sq. Km)	Population (1990)
Iyo	10,726	935,448
Tisa	9,364	260,495
Yeni	7,712	466,038
Adesi	9,224	375,445
Mayo	5,385	275,028

- (b) Briefly explain what other information you would require if you were asked to construct a distribution of population map.

- Q6. (a) On the outline map of Zambia Provided with provincial boundaries marked, represent the data in the table below using the most appropriate statistical technique

Province	Male ('000)	Female ('000)	Total ('000)
Copperbelt	800	750	1,580
Lusaka	610	600	1,210
Eastern	470	500	970
Luapula	260	270	530
Southern	470	480	950
Central	420	450	870
North Western	180	200	380
Western	280	330	610
Zambia	3,850	3,980	7,830

- (b) Briefly comment on the merits and limitations of the method you have used.

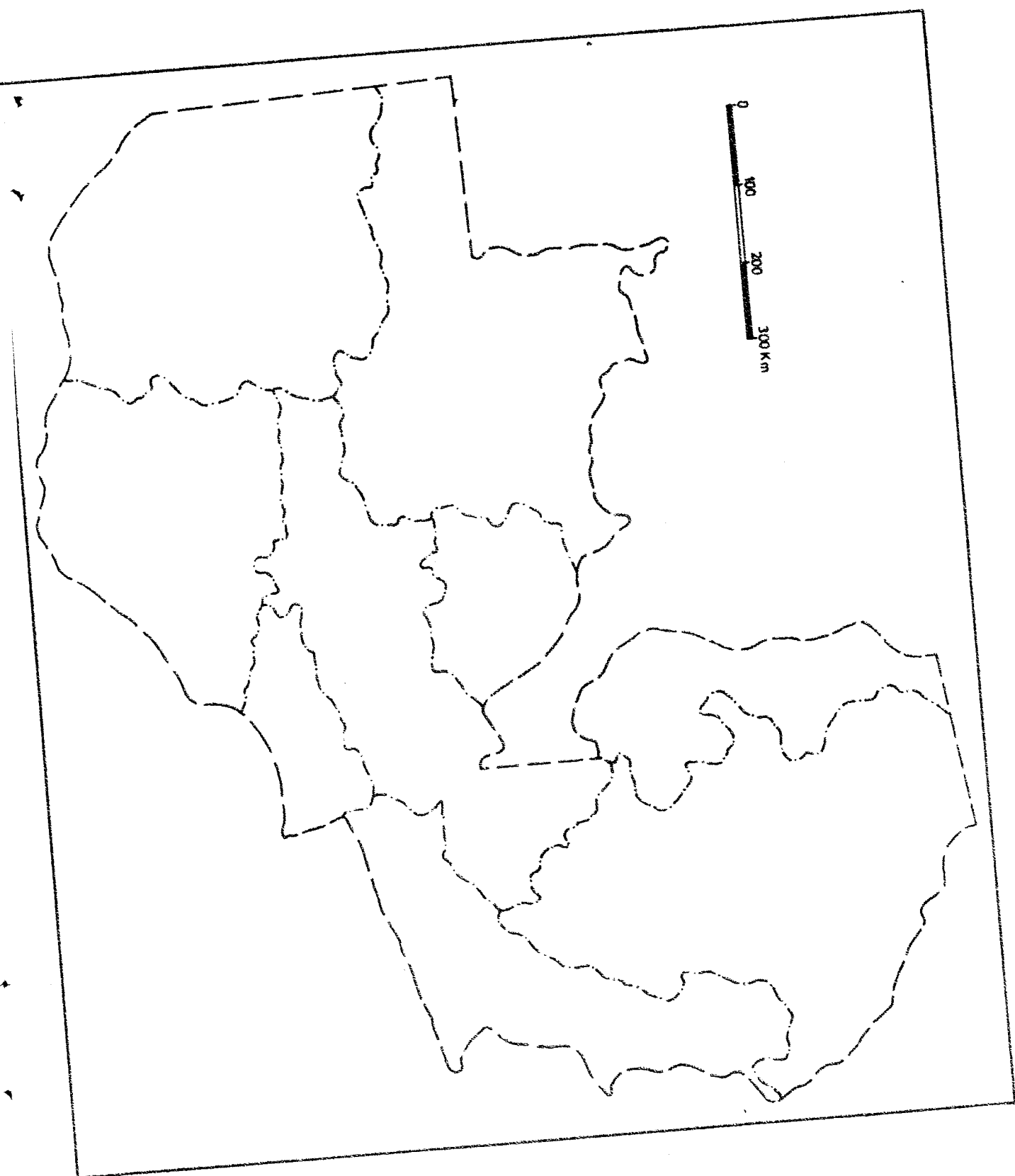
- Q7. (a) On the outline map of Brazil with selected towns and cities marked, show the relative populations of the towns using a method of your own choice.

Town	Population (1970)
Sao Paulo	5,901,533
Rio de Janeiro	4,296,782
Belo Horizonte	1,232,708
Recife	1,078,819
Salvador	1,000,647
Porto Alegre	885,567
Fortaleza	842,231
Belem	642,514
Curitiba	603,227
Brasilia	544,862

- (b) What other method can you use to show the data given in the table above and what are the advantages of the method you have used over the one you have mentioned.

END OF EXAMINATION

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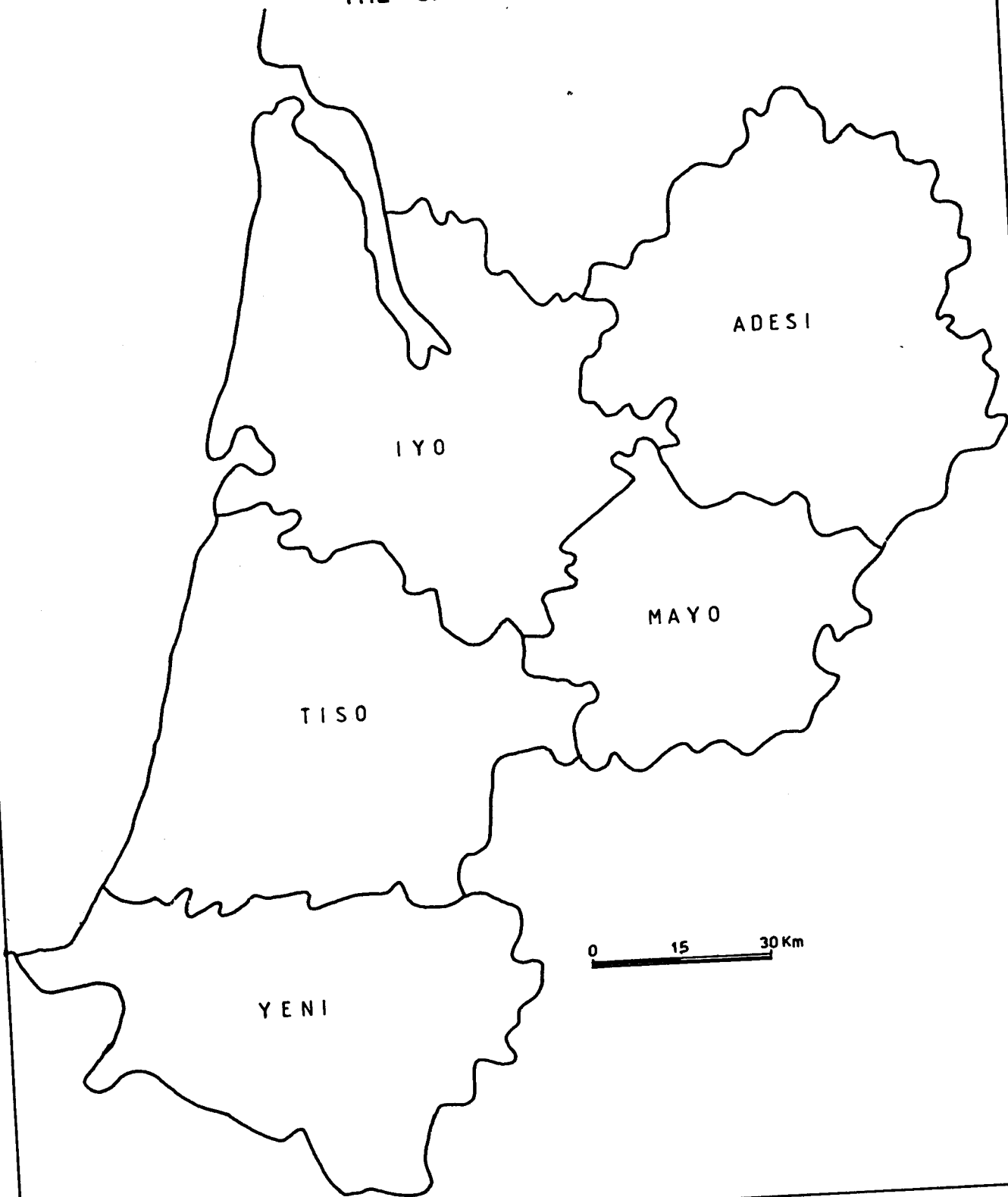


BRAZIL



0 1000 Km

THE CITY OF CHONZI



THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

G230 CORRESPONDENCE

CARTOGRAPHIC AND QUANTITATIVE TECHNIQUES IN GEOGRAPHY

CARTOGRAPHIC TECHNIQUES

PAPER II

TIME: THREE HOURS

ANSWER: THREE QUESTIONS - TWO FROM SECTION A AND ONE FROM SECTION B.

THE USE OF AN APPROVED ATLAS AND ELECTRONIC CALCULATORS IS ALLOWED.

SECTION A

STATISTICAL DIAGRAMS

Q1. The data given in table 1 below represent the masses of sixty male rats. The sample was obtained from a population of male rats, using a table of random numbers to guarantee that the sample was random. The weights are arranged in order of magnitude in ascending order.

Table 1: Masses of Male Rats in grams

18.2	21.8	23.4	24.5	26.3	28.1
18.8	21.9	23.4	24.7	26.3	28.1
19.4	22.2	23.7	24.8	26.3	28.3
19.7	22.3	23.9	24.8	26.6	29.1
20.2	22.5	23.9	24.9	26.8	29.9
20.5	22.7	24.1	25.2	27.0	30.1
20.6	23.2	24.2	25.3	27.1	30.2
20.8	23.2	24.3	25.3	27.5	31.8
21.6	23.2	24.4	25.5	27.7	32.1
21.7	23.3	24.5	25.9	27.8	32.8

(a) Construct a frequency distribution of male rat weights beginning with a weight of 18.2 grams.

- (b) (i) How many rats had a weight of less than 25.6 grams.
- (ii) How many rats had a weight of 20 grams and more.
- (c) Sketch a histogram for the masses of male rats.

Q2. A class of Geography students at the University of Zambia conducted a land use study of Chipata and its hinterland in 1995 during a field course survey. Table 2 below shows the result:

Table 2: Land use in Chipata and its Hinterland

Land Use Category	%
Grassland	46
Arable Land	26
Woodland	13
Built-up area	10
Derelict Land	5

You have been requested by the field course co-ordinator to present the above data in a form suitable for display on the Geography Department notice board. He wants the data not only to be attractive but also easy to understand. In order to provide the maximum flexibility for display on the notice board, he wants two versions. Draw the two versions highlighting the contribution of derelict land to the overall land use of Chipata and its hinterland.

Q3. Use the most appropriate cartographic technique to show the data given in table 3 below on a single diagram and briefly comment on the relationship between temperature and precipitation as shown on your diagram.

Table 3: Temperature and Precipitation Figures for Harare
Position: 17°45'S, 31°E. Attitude 1352m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp. Oc	21	21	20	19	16	14	13	16	19	22	22	21
Ppt.(mm)	191	188	114	25	13	0	0	3	8	28	94	147

SECTION B

STATISTICAL MAPPING

- Q4. On the outline map of south-west France provided (Fig.1) with district boundaries marked, construct a map using the most appropriate statistical mapping technique employing data given in table 4 below and then comment on the merits and limitations of the method you have used.

Table 4: District Population of S.W. France

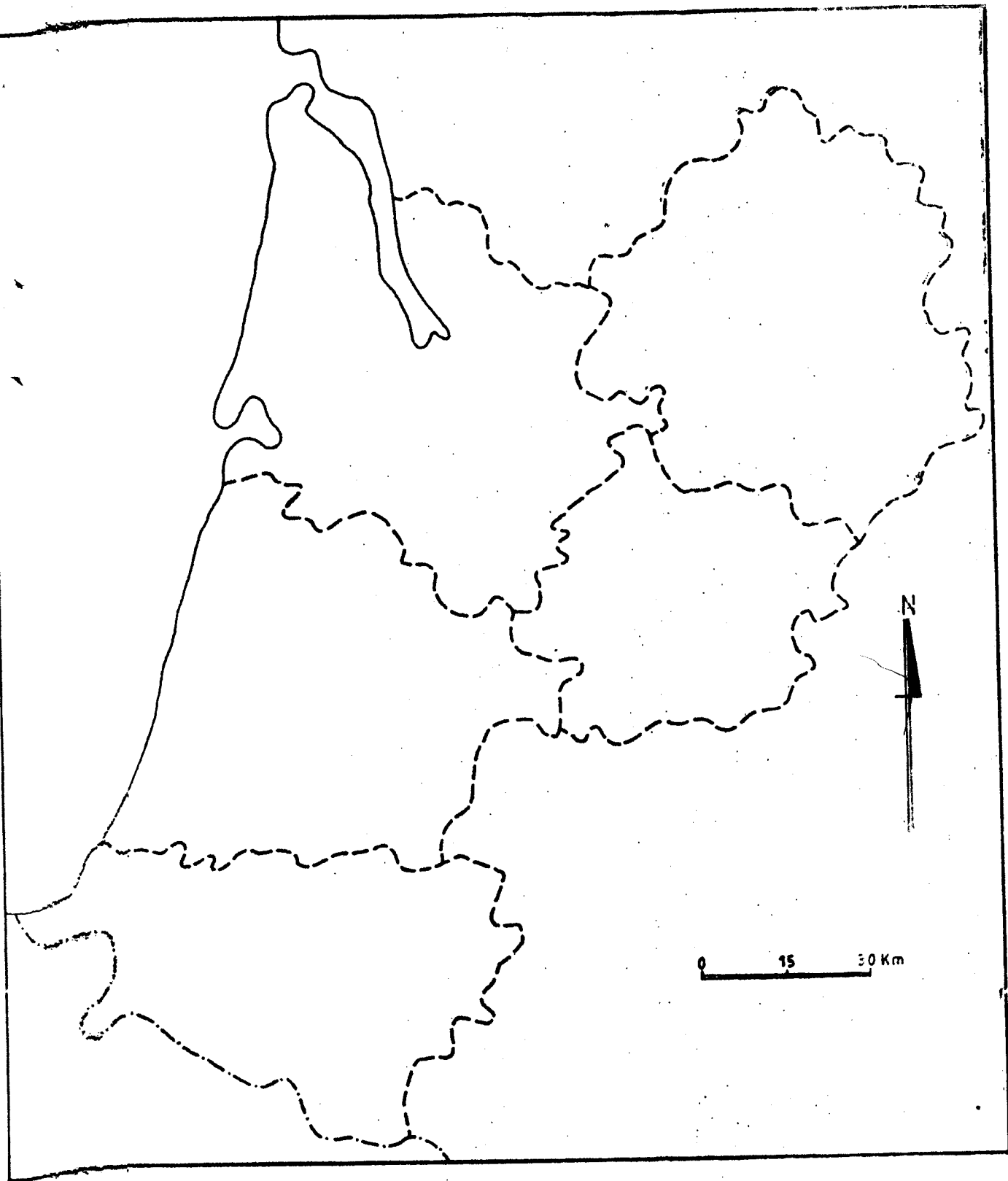
District	Area (km2)	Population
Gironde	10,726	935,448
Landes	9,364	260,395
Pyrennees		
Atlantiques	7,712	466,038
Lot et Garonne	5,385	275,028
Dordogne	9,224	375,455

- Q5. On the outline map of Zambia Fig.2 provided, construct a map to show the number of airline passengers flying between Lusaka International Airport and the provincial towns listed in table 5 below and briefly comment on the merits and limitations of the method you have used.

Table 5: Passenger Traffic from Lusaka International
Airport

Destination	Number
Ndola	2697
Mansa	974
Kasama	2277
Chipata	2561
Livingstone	2996
Mongu	1436
Solwezi	1170
Kabwe	1775

END OF EXAMINATION



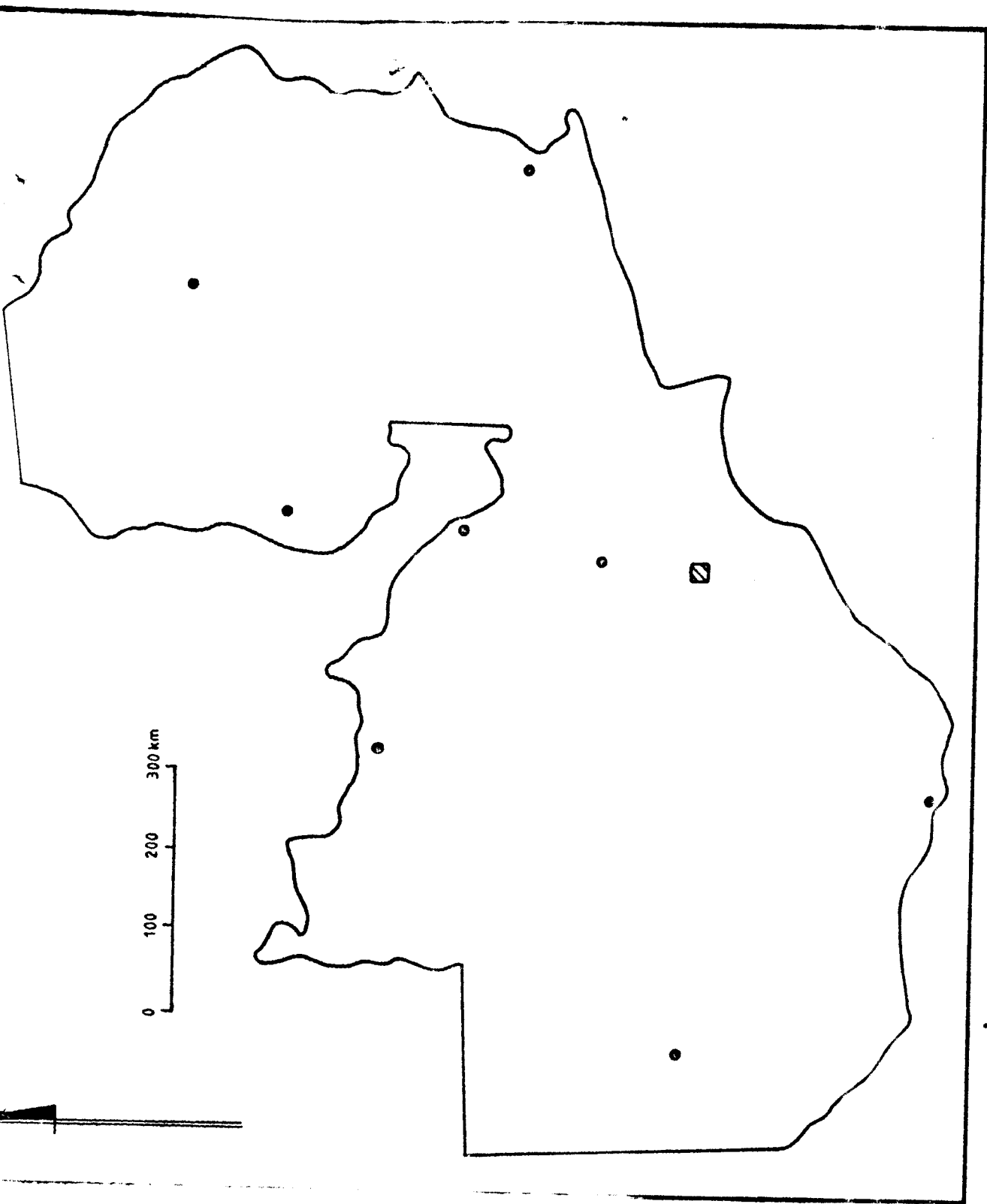


Figure 2

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

G 340

GEOGRAPHY OF AFRICA WITH SPECIAL REFERENCE TO ZAMBIA

TIME: THREE HOURS

ANSWER: FOUR QUESTIONS, ONE FROM SECTION A, ONE FROM SECTION B
AND TWO FROM SECTION C.

NOTE: CANDIDATES ARE ADVISED TO MAKE USE OF ILLUSTRATIONS
AND EXAMPLES WHEREVER APPROPRIATE. USE OF AN
APPROVED ATLAS IS ALLOWED.

SECTION A

Q1. Write brief explanatory notes on all of the following:

- (a) Problems associated with water transport in East Africa.
- (b) The detrimental effects of the break-up of the East African Common Market on the economies of the affected states of Uganda, Tanzania and Kenya.
- (c) Problems induced by rapid urban growth in East Africa.
- (d) The negative effects of large scale tourism in East Africa.
- (e) The vicious cycle of poverty as it affects Tanzania in her efforts to industrialize.

Q2. It has generally been observed that Kenya's trade gap widened even further from the time of political independence in 1963 to the early 1980s as illustrated in the table below:

YEAR	EXPORT VALUE (US\$ MILLION)	IMPORT VALUE (US\$ MILLION)	TRADE BALANCE (US\$ MILLION)
1959	76	148	- 72
1964	128	183	- 55
1970	177	326	- 149
1974	390	812	- 422
1980	620	1400	- 780

Briefly explain the reasons for this unfortunate state of affairs.

- Q3. Outline the causes of the environmental crisis in the Sahel, and suggest solutions to deal with it.

SECTION B

- Q4. Outline the main features of African traditional religions in the context of world religions; and to what extent can Africans be considered 'notoriously religious'?
- Q5. Evaluate the view that the strategy of Socio-economic development followed by the Ivory Coast since Independence is a great success in comparison to other African countries in the region.

- Q6. EITHER

- (a) Review South Africa's natural resource potential and discuss the extent to which the country's superiority over other countries in the Sub-region is largely a function of the said potential.

OR

- (b) Botswana's mining, agricultural and manufacturing industries are a testimony to show that South Africa is the major economic blood stream of the arid country's economy. Discuss.

SECTION C

- Q7. Suggest ways in which Zambian farmers can cope with the persistence of drought in the region.
- Q8. To what extent do pre-colonial Tribal Migrations in Zambia suggest unity in diversity in the emergent nation?
- Q9. Write an essay on the advantages and disadvantages of liberalized marketing in Zambia and evaluate the potential of the strategy in boosting small-holder agriculture.
- Q10. Assess Zambia's tourism potential and suggest ways in which it can be improved with the aim of attracting more local and foreign tourists and raising more revenue for the country.

Q11. 'Unless Zambia's economy is diversified, the government will not quickly transform the country's economy through the Structural Adjustment Programme'. Discuss.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY MID-YEAR EXAMINATIONS - JUNE 1995

G 961

RURAL GEOGRAPHY

TIME: THREE HOURS

ANSWER: ANY FOUR QUESTIONS, ALL QUESTIONS CARRY EQUAL MARKS

NOTE:

CANDIDATES ARE ADVISED TO MAKE USE OF ILLUSTRATIONS AND EXAMPLES WHEREVER APPROPRIATE. USE OF AN APPROVED ATLAS IS ALLOWED.

1. Define Rural Geography and show its relationship to Agricultural Geography.
 2. Explain the steps to be undertaken in conducting a Participatory Rural Appraisal (PRA) and evaluate its usefulness.
 3. Show how water and land rights in rural Botswana are being contested by different users, and what lessons can be learned by other African countries.
 4. What factors account for the evolution of permanent house types and settlements in rural Zambia?
 5. What is the theoretical basis of the integrated approach to rural development and to what extent has this been utilized in the promotion of rural development in Zambia?
 6. With the use of examples evaluate the view that the cash cropping peasantry in Africa is a colonial creation.
 7. Discuss the effects of the Structural Adjustment Programme on Rural Industrialisation in Zambia.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

G 965

URBAN GEOGRAPHY

TIME: THREE (3) HOURS

ANSWER: FOUR QUESTIONS - QUESTION ONE (1) AND ^{2 and} ANY OTHER ^{Two} ~~THREE~~ (2)

USE OF A CALCULATOR IS ALLOWED

MATERIALS: ONE (1) GRAPH PAPER

- Q1. By the use of the "Rank-size Rule" and "Primacy" concepts, describe and analyse the distribution of the urban population of large urban areas of Zambia over time from the census data given in the table 1:

All calculations must be shown:-

Table 1: Population distribution of large urban areas of Zambia, 1980 and 1990.

Urban Area	Urban Population	
	1980	1990
Chingola	130,872	142,383
Chililabombwe	56,582	48,055
Kabwe	136,006	154,318
Kalulushi	53,383	31,474
Kitwe	283,962	288,602
Livingstone	61,296	76,875
Luanshya	113,420	118,143
Lusaka	538,830	769,353
Mufulira	138,824	123,936
Ndola	250,502	329,228

Source: CSO. 1980 and 1990 Census final Reports.

Q2. Write brief notes on all of the following:-

- (i) Johnston's approaches in the study of contemporary Urban Geography.
- (ii) Nodality and Hierarchy of urban centres.
- (iii) Theories of urban and regional growth.
- (iv) Sector and Multiple nuclei models.
- (v) Elements and aspects of the RUF.

Q3. Discuss the major determinants of rapid urbanisation in Zambia since 1969.

Q4. State and explain major problems hindering town planning efforts by local governments in Zambia today and suggest possible solutions.

Q5. Give possible reasons for fertility and mortality differentials by locality type in African countries.

Q6. Evaluate previous government's efforts aimed at providing cheap and affordable accommodation to the majority of urban population and show how these differ from the current proposed Housing strategy policy of the Ministry of Local Government and Housing?

Q7. "More and more urban folks are being marginalised by this animal called SAP...." How realistic is this statement with respect to the status of the urban poor and the urban environment?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

G 972

THE GEOGRAPHY OF NATURAL RESOURCES

TIME: THREE HOURS

ANSWER: ANY FOUR QUESTIONS

- Q1. 'The population problem is not a problem of the absolute number of people using the environmental resources of a given occupied space, but that of the level of technological advancement.' Evaluate this view with respect to population control as an ecological imperative for sustainable use of the African environment.
- Q2. It has generally been suggested that natural processes can be assisted in order to avoid waste accumulation in the environment. Briefly explain how this can be accomplished.
- Q3. To what extent does the 'sharing ethic of the spaceship earth' give credence to global environmental conventions?
- Q4. Compare and contrast the Malthusian and the neo-Malthusian views concerning population and resource relationships.
- Q5. Assuming drought is endemic on the African continent, show why today traditional societies bear the most social impact of drought.
- Q6. Kenneth Boulding (1968) described the current economic systems as 'cowboy' and 'spaceman.' With the help of examples, explain the major-differences between these two economic systems.
- Q7. Either
- (a) With reference to either forest or wildlife resources, assess the success of the control based approach to environmental management in Zambia.
- Or
- (a) Outline the circumstances under which environmental management merely becomes a theoretical conceptual strategy.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

G 981

CARTOGRAPHY

TIME: THREE (3) HOURS

ANSWER: FOUR QUESTIONS

NOTE:

CANDIDATES SHOULD USE DIAGRAMS AND EXAMPLES WHEREVER RELEVANT.
USE OF AN APPROVED ATLAS IS ALLOWED.

1. Write brief explanatory notes on five of the following:
 - (a) Dasymetric mapping
 - (b) Portolan Charts
 - (c) Hill shading
 - (d) 'T in O' maps
 - (e) The work of Gerardus Mercator
 - (f) Conformal projections
 2. Explain the ways in which geographic data may be illustrated on a monochrome map.
 3. Discuss the factors you would consider in designing and producing a tourist map, to be printed in multi-colour.
 4. Explain why cartographic generalization is so vital in mapping.
 5. It has been suggested that the content and nature of maps is influenced both by available technology and perceived map needs. Discuss this in relation to the Cartographic history of Zambia.
 6. 'Cartographers still have the belief that the only use of computer-assisted cartography is as an aid to the "pen-pushing" copying of maps' (Boyle, 1981). Discuss this statement with respect to the multiple applications of computer-assisted cartography.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY MID-YEAR EXAMINATIONS - JUNE 1995

G 991

REMOTE SENSING

TIME: THREE HOURS

INSTRUCTIONS:

ANSWER ALL QUESTIONS IN SECTION A AND ANY TWO
IN SECTION B. USE OF A CALCULATOR IS ALLOWED.

SECTION A (60 MARKS)

1. Write brief notes on any five of the following:
 - a) Electromagnetic energy and atmospheric attenuation
 - b) Spectral reflectance and spectral characteristics of vegetated and non-vegetated surfaces.
 - c) Film types used in Aerial photography
 - d) Photogrammetry and Photo interpretation
 - e) Ground control and ground control methods
 - f) Orthogonal and central projection
2.
 - a) A photo survey is carried out at a height of 4560m above the mean altitude of the area. The camera used has a focal length of 152.00mm.
 - i) What is the mean scale of the photo?
 - ii) What is the scale at a hilltop situated 380 metres above the mean attitude of the terrain?
 - iii) What is the scale at a valley floor 228 metres below the mean attitude of the terrain?

- b) Assume we are going to measure the size of two forest plots on a valley slope. One is rectangular, while the other is triangular in shape and the width decreases upslope. The two areas are situated on the same level in the terrain. The height difference between the foot and the top of the areas is 300m. The flight height above the foot of the areas is 3040m. The focal length of the camera used is 152mm. A dot grid with 1 dot representing 25mm² is used for the area measurement.

Compute the following:

- i) Approximate size of the rectangular plot if it occupies 30 dots in the photo?
- ii) The size of the triangular plot if 30 dots fall within its boundary, and if the mean level is used when calculating the correction factor.
- iii) The area in (ii), when a 30 percent correction factor is used.

3. (a) A project area is 16km long in the east-west direction and 10.4km in the north-south direction. The air base is 1.21km, the side lap is 25 percent, the focal length is 152.4mm, negative format is 230mm and elevation is 500m above sea level.

Compute the following:

- (i) The scale of the photographs covering the area
- (ii) The ground dimensions of an individual photograph
- (iii) The area of the neat model
- (iv) The number of photographs required to cover the area.

(b) A stereo pair of aerial photos were taken from a flying height of 4000 metres above sea level with a wide angle camera. The air base was 1500 metres. With the photos properly oriented, parallax bar readings of 12.57mm and 13.04mm were obtained with the floating mark set on principal points P1 and P2, respectively. On the left photo, b was measured as 93.73mm and on the right photo b" was 93.30mm. Parallax bar readings of 10.96mm and 15.27mm were taken on points A and B. Also the X and Y photo coordinates of points A and B measured relative to the flight axis on the left photo were $X_a = 53.41\text{mm}$, $Y_a = 50.84\text{mm}$, $X_b = 88.92\text{mm}$, and $Y_b = -46.69\text{mm}$. Calculate:

- (i) The elevations of points A and B
- (ii) The horizontal length of line AB.

SECTION B (40 MARKS)

4. Given an area comprising the following land cover classes:

- (i) Cropped land - dominant crop groundnuts
- (ii) Grazing land
- (iii) Mixed dense forest; and
- (iv) Small urban centre,

Use your knowledge of spectral reflectance characteristics of different surfaces to define the rules delimiting the classes based on image interpretation keys and provide an interpretation key for the land cover classes.

- 5. Evaluate the view that Remote Sensing technology is an appropriate technology only to nations/countries whose economies can sustain the technology.
- 6. Provide a methodological procedure for a multi-stage and multi-temporal study of urban area change detection.

7. (a) Explain the nature of the reflectance in the near infrared range, between two deep lakes, one with clean and clear water, and the other with turbid water.
- (b) List and explain the factors which would contribute to dark tone on an aerial photograph taken with panchromatic film.
- (c) Explain the relationship between film speed and emulsion grain size.
-

END OF EXAMINATION

UNIVERSITY SUPPLEMENTARY/DEFERRED EXAMINATIONS - JANUARY 1996

REMOTE SENSING

INSTRUCTIONS: ANSWER ALL QUESTIONS IN SECTION A AND TWO
 IN SECTION B.

- 1

- (ii) 0.5 microns (1 micron = 0.0001 cm) as the average spectral region in which the photograph was sensed.

Advise the Council on the least size of an object that can be resolved and state if it is adequate for the purposes the photo-interpretation is intended.

4. An area with rugged terrain is photographed using a camera with a focal length of 150 mm. The terrain has two different positions. A is 3500 m above sea level and B is 3200 m above sea level, and the flying height is 2800 m above the mean altitude of position B.
- (a) What is the flying height above sea level?
 - (b) What is the flying height above sea level A?
 - (c) What is the scale of the photo at level A and B?
 - (d) If we measure the length in the photo of two fields situated on levels A and B respectively, and we find them all to be 5 mm, what is the true length of the fields?

SECTION B (40 Marks)

5. Using a sketch of the electromagnetic spectrum, show the reflectance characteristics of water, bare soil, and vegetation, and outline the factors affecting their reflectance characteristics.
6. "Derivation of useful and meaningful information from Remotely sensed data is, in the main, based on the process of interpretation". Discuss.
7. To what extent does the premise that Remote Sensing should ultimately remove the need for information gathered at ground level, justify the expenditure on the technology.
8. Explain the following theories and give reasons why each one is important in remote sensing:
- (a) Wave theory
 - (b) Corpuscular theory

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF MATHEMATICS

M110 DEFERRED EXAMINATION 1995

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS
 NO CALCULATORS ALLOWED
TIME ALLOWED: THREE (3) HOURS

- 1 a. Find the value of m for which the equation $x^2 + (m + 3)x + 4m = 0$ has equal roots. For what value of m is the sum of roots zero. Suppose α, β are the roots of the given equation when $m = 1$, find the quadratic equation whose roots are $\frac{1}{\alpha}$ and $\frac{1}{\beta}$.
- b. Use mathematical induction to prove that for all integers $n \geq 1$
- $$1^3 + 2^3 + \dots + n^3 = \frac{n^2(n+1)^2}{4}$$
- c. For what value of A does $x^3 - 4x^2 + Ax + 3$ yield the same remainder when divided by $x - 1$ or $x + 1$.
- 2 a) Show that if λ is positive but not greater than 3, the roots of the equation $(\lambda - 2)x^2 - (8 - 2\lambda)x + (8 - 3\lambda) = 0$ are real. Find the range of λ for which one root is real and positive and the other root is real and negative.
- b) Find the first three terms and general term in the expansion in ascending powers of x of
- $$\frac{(x + 5)}{(1 + 3x)(2 - x)}$$
3. a) Find the limits of the following
- i) $\lim_{t \rightarrow \infty} \frac{6t + 5}{3t - 8}$ ii) $\lim_{x \rightarrow \pi/2} \frac{1 - \sin x}{1 + \cos 2x}$
- b) Find the derivative of $y = x^{1/4}$ from the first principles. Hence find the equation of the tangent to $y = x^{1/4}$ at $(0,0)$.
- c) Find the derivative of $y = x \tan^{-1} x = \frac{1}{2} \ln(1 + x^2)$ with respect to x . Hence write down $\int \tan^{-1} x dx$.
4. a) Show that the function $y = \tan x - 8 \sin x$ has two stationary values between $x = 0$ and $x = 2\pi$. Draw a rough graph of the function between these values of x .

- b) By substituting $t = \tan x$, show that

$$\int_0^{\pi/4} \frac{dx}{1 + \sin 2x} = \frac{1}{2}$$

5. a) Sketch the graph of the function $f(x) = x(x-3)^2$ showing its turning points and points of inflexion if it has.

- b) Find the fourth roots of $z = 1 - \sqrt{3}i$

- c) Find the length of the tangent from the point $(5, -1)$ to the circle $(x - 1/2)^2 + y^2 = \frac{25}{4}$

6. a) Given the sets A, B, prove that $(A - B) \cup (B - A) = (A \cup B) - (A \cap B)$

- b) Prove that $3x - 2$ is a factor of $3x^3 - 2x^2 + 3x - 2$. Hence find the solution set of the equation $3x^3 - 2x^2 + 3x - 2 = 0$ when x belongs to the set of

- i) Integers \mathbb{Z}
- ii) rational numbers \mathbb{Q}
- iii) real numbers \mathbb{R}
- iv) complex number \mathbb{C}

- c) Find the domain and range of the function $\frac{x+1}{2x-1}$. Determine if this function is one to one or many to one. Also determine if it is invertible. If yes find the domain and range of the inverse function.

7. a) Prove that $\frac{\sin 3\theta}{1 + 2\cos 2\theta} = \sin \theta$ and

hence show that $\sin \pi/12 = (\sqrt{3} - 1)/(2\sqrt{2})$

- b) If $Z = \cos \theta + i \sin \theta$ Show that $z + \frac{1}{z} = 2\cos \theta$ and $z - \frac{1}{z} = 2i \sin \theta$.

Prove that

$$\sin^7 \theta = \frac{1}{64}(35\sin \theta - 21\sin 3\theta + 7\sin 5\theta - \sin 7\theta). \text{ Hence find}$$

$$\int (35\sin \theta - 64\sin^7 \theta) d\theta$$

- c) Find the equation of the lines with equation $2x^2 + 5xy - 12y^2 = 0$. Also find the angle between the line.

8. Find the inverse of the matrix

$$A = \begin{pmatrix} 1 & 1 & 1 \\ 1 & -1 & 2 \\ 2 & 1 & -1 \end{pmatrix} \quad \text{and hence solve the system of equations}$$

$$\begin{aligned}x + y + z &= 7 \\X - y + 2z &= 9 \\2x + y - z &= 1\end{aligned}$$

b) Prove that

$$\begin{vmatrix} 2\cos\theta & 1 & 0 \\ 1 & 2\cos\theta & 1 \\ 0 & 1 & 2\cos\theta \end{vmatrix} = \frac{\sin 4\theta}{\sin\theta}$$

c) If $a = 2i - 4j + 2k$ and $b = 3i + 4j - 5k$ are any two vectors, find a unit vector in the direction of vector $\frac{1}{2}a - b$

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATIONS - OCT/NOV 1994/95
MATHEMATICS M110

TIME ALLOWED: THREE(3) HOURS

INSTRUCTIONS: Answer any FIVE(5) questions.
Calculators, tables are not permitted.

1. a) Let $E = \mathbb{R}$, the set of real numbers such that

$$A = \{x \mid x^2 \geq 1\},$$

$$B = \{x \mid |x| \leq 2\} \text{ and}$$

$$C = \{-3, -2, -1, 0, 1, 2, 3\}.$$

Find: (i) $A \cap B$ (ii) $A \cap C$ (iii) $B \cap C$.

- b) (i) If $f(x)$ is a polynomial in x , show that when $f(x)$ is divided by $x - a$, the remainder is $f(a)$.

(ii) The polynomial $f(x) = x^3 + px + q$ is exactly divisible by $(x + 2)$ and $(x - 3)$, find the values of p and q . With these values of p and q , find the roots of $f(x) = 0$.

2. a) The coefficient of x^3 in the expansion of $(1 + x)^n$ is four times the coefficient of x^2 . Find the value of n . With this value of n , find the seventh term, leaving your answer in factorial form.

- b) (i) Explain what is meant by the statement:

α) f is a function from set X to set Y .

β) f is an even function.

(ii) Let the function $f(x) = \frac{ax + b}{x + c}$

where a, b, c are real and $x \neq -c$. Show that if $f(x)$ is an even function then $ac = b$. Deduce that if $f(x)$ is an even function then $f(x)$ must reduce to the form $f(x) = k$, where k is a constant.

3. a) (i) For the quadratic function $f(x) = ax^2 + bx + c$, where a, b, c are real and $a \neq 0$, complete the square and sketch the graph of $f(x)$ when $a < 0$ and $b^2 - 4ac < 0$.

(ii) If α and β are roots of the equation $x^2 + 2x - 5 = 0$, find the value of $\alpha - \beta$.

- b) Express the complex number

$$z_1 = \frac{11 + 2i}{3 - 4i} \text{ in the form } x + iy, \text{ where } x \text{ and } y \text{ are real.}$$

Given that $z_2 = 2 - 5i$, determine the real numbers p, q such that $p z_1 + q z_2 = -4 + i$.

4.

- a) Prove that

$$\frac{\sin 3A}{\sin A} + \frac{\cos 3A}{\cos A} = 4 \cos 2A.$$

- b) (i) Let m be a positive integer. State De Moivre's theorem for $(\cos \theta + i \sin \theta)^n$ when

$$\alpha) \quad n = m \qquad \beta) \quad n = \frac{1}{m}.$$

(ii) If $z = 1 + i\sqrt{3}$, express z in the form $r[\cos \theta + i \sin \theta]$. Hence, find $|z|$ and $|z^5|$.

Give also the values of $\arg z$ and $\arg(z^5)$ lying between $-\pi$ and π . Show that $\operatorname{Re}(z^5) = 16$ and find the value of $\operatorname{Im}(z^5)$.

- c) The coordinates of the points P, Q and R are $(4, -3)$, $(-1, -2)$ and $(2, t)$ respectively. Calculate the value of t given that P, Q and R are collinear.
-

5. a) The circle S has the equation

$$x^2 + y^2 - 6x - 8y = 0.$$

- (i) Find the coordinates of the centre and radius of the circle.
- (ii) Show that the point A with coordinates (7,2), lies inside the circle.
- (iii) Show that the chord of S which is bisected at A has equation $y = 2x - 12$.
- b) If the coordinates of three points A, B and C are (1,2), (0,4), (1,-5) respectively, find the equation of the straight line on which a fourth point P(x,y) lies such that
- $$AP^2 + BP^2 = 2CP^2 - 19.$$
-

6. a) A is the matrix such that

$$A = \begin{pmatrix} 1 & p & q \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

where p, q are real numbers. Calculate A^2 and A^3 . Suggest a formula for A^n . Prove by mathematical induction that your formula is correct.

- b) Find a unit vector which is in the opposite direction to the sum of the vectors $(3i + 2j + k)$ and $(-5i - 3j + 6k)$. Prove that this unit vector is perpendicular to the vector $(9i - 4j + 2k)$.
-

7. (a) Express $y = \frac{2x^2 + 3x + 5}{(x+1)(x^2+3)}$

in partial fractions. Hence show that $\frac{dy}{dx} = -\frac{2}{3}$ when $x = 0$

- (b) For the curve $y = x^3 - 6x^2 + 9x$

- (i) Solve the equation $y = 0$.
- (ii) Find the coordinates of the turning points
- (iii) Determine the nature of the turning points.
- (iv) Sketch the graph.
-

8. (a) z is a complex number such that $z = \cos x + i \sin x$ where $-\pi < x < \pi$.

Show that

$$z - \frac{1}{z} = 2i \sin x$$

$$z^n - \frac{1}{z^n} = 2i \sin nx.$$

Prove that

$$\sin^4 x = \frac{1}{8}(\cos 4x - 4\cos 2x + 3)$$

Hence evaluate $\int_0^{\pi/4} \sin^4 x \, dx$.

- (b) Sketch the graph of the quadratic function $y = x(x - 1)$.
Hence find the total area bounded by the curve $y = x(x-1)$, the x -axis and the line $x = 2$.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATIONS OCT/NOV 1994/95
MATHEMATICS M160

TIME ALLOWED: THREE(3) HOURS

INSTRUCTIONS: i) Attempt any five(5) questions including atleast one (1) from section B.

ii) Use of tables and calculators is allowed.

iii) Write down on the answer booklet the numbers of questions you have answered.

SECTION A

- Q1. i) Give the definition of a one to one function. Hence if $f(x) = \frac{x-2}{x+1}$ and $g(x) = \frac{1}{x}$ find $g \circ f$ and show whether or not it is one to one.
- ii) Find the domain and range of $g \circ f$.
- iii) Give the definition of an odd and an even function. Determine whether $g \circ f$ is even or odd.
- b) Find the area bounded by the curve $y = x^2 - 4$ and the ordinates $x = 0$ and $x = 3$.
-

- Q2. a) Prove the identity $\frac{1 - \tan^2 x}{1 + \tan^2 x} = 2\cos^2 x - 1$.
- b) Find the solution of the equation $\sin 2\theta - \sin \theta = 0$ for $0 \leq \theta \leq 2\pi$
- c) Solve the inequality $x^2 - x - 6 \leq 0$
-

- Q3. a) i) Solve the equation $3^{x+2} = 5^{x-1}$.
 ii) If $\log_7 2 = 0.356$ and $\log_7 3 = 0.566$

Find the value of

$$\log_7 \left(\frac{7}{15} \right)^2 + \log_7 \left(\frac{25}{12} \right) - \log_7 \left(\frac{7}{3} \right)^2$$

- b) i) If $z = 1 + i$, write z in the form
 $z = r(\cos\theta + i\sin\theta)$.

- ii) If $z = \cos\theta + i\sin\theta$,

$$\text{Find } z + \frac{1}{z}, \quad z - \frac{1}{z}, \quad z^n + \frac{1}{z^n}, \quad z^n - \frac{1}{z^n}.$$

$$\text{Hence show that } \cos^3\theta = \frac{1}{4}\cos 3\theta + \frac{3}{4}\cos\theta.$$

- Q4. a) Differentiate $y = x^{1/4}$ from first principles. Hence find the equation of line perpendicular to the curve at (1,1).
 b) Find the constants p and q such that $x - 2$ is a common factor of

$$x^3 - x^2 - 2px + 3q \quad \text{and} \quad qx^3 - px^2 + x + 2$$

- c) Evaluate the integrals

$$\text{i) } \int \frac{x + \sqrt{x}}{\sqrt{x}} dx \quad \text{ii) } \int_0^\pi x \cos x dx$$

Q5. a) Evaluate the following limits

$$\text{i) } \lim_{x \rightarrow -1} \frac{x+1}{x^2-1} \quad \text{ii) } \lim_{x \rightarrow \infty} \frac{x^2+1}{x}$$

b) Define continuity of a function f at $x = c$.

$$\text{If } f(x) = \begin{cases} \frac{(x-1)(x+1)}{x-1}, & x \neq 1 \\ 5, & x = 1 \end{cases}$$

Sketch the graph of $f(x)$. Use the definition of continuity to determine whether or not $f(x)$ is continuous at $x = 1$.

c) i) Complete the square for $g(x) = x^2 + 2x - 3$ and find the maximum or minimum turning point.

ii) If α and β are roots of $g(x) = 0$, write down the quadratic equation whose roots are $\frac{1}{\alpha}$ and $\frac{1}{\beta}$.

Q6. a) Find the conjugate of $\frac{1}{2-i}$ in the form $a + bi$.

b) Find the stationary points of the curve

$y = \frac{1}{3}x^3 - \frac{1}{2}x^2$. Determine their nature and sketch the curve.

c) Evaluate any three of the following:

$$\text{i) } \int \frac{x}{x^2+x-2} dx \quad \text{ii) } \int x \ln x dx \quad \text{iii) } \int \cos 2x \sin 3x dx$$

$$\text{iv) } \int x \sqrt{1-x^2} dx$$

SECTION B

- Q7. a) A bag contains 5 red and 4 blue balls. 3 balls are picked out one at a time and are not replaced. Find the probability that atleast 1 of the 3 balls is blue
- b) In an experiment of tossing a die twice write down the sample space of the totals. Find the probability of getting total less than 7 if
- no other information is given.
 - the total is odd
- c) A and B play 12 games of chess of which 6 are won by A, 4 are won by B, and 2 end in a draw. They are to play a tournament consisting of 3 games. Find the probability that
- A wins all three games
 - A and B win alternatively
 - B wins atleast one game.
-

- Q8. a) Independent random variables X and Y have probability distributions as shown in the tables

x	0	1	2	3
$P(X=x)$	0.3	0.2	0.4	0.1

y	0	1	2
$P(Y=y)$	0.4	0.2	0.4

- Find $E(X)$, $E(Y)$, $\text{Var}(X)$, $\text{Var}(Y)$
 - Construct the probability distribution for the random variable $X + Y$.
 - Verify that $E(X + Y) = E(X) + E(Y)$ and

$$\text{Var}(X + Y) = \text{Var}(X) + \text{Var}(Y).$$
- b) The continuous random variable X has pdf $f(x)$ where

$$f(x) = k(4-x), \quad 1 \leq x \leq 3.$$

- i) Find the value of the constant k
 - ii) sketch $y = f(x)$
 - iii) Find $P(X \geq 2)$.
-

- Q9. a) The diameter of bolts produced by a particular machine follow a normal distribution with mean 1.34cm and standard deviation 0.04cm. A bolt is rejected if its diameter is less than 1.24cm or more than 1.40cm. Find the percentage of bolts which are accepted.
- b) A machine is producing components whose lengths are normally distributed about a mean of 6.50cm. An upper tolerance limit of 6.54cm has been adopted and, when the machine is correctly set, 1 in 20 components is rejected as exceeding this limit. On a certain day it is found that 1 in 15 components is rejected for exceeding this limit. Assuming that the mean has not changed but that the production has become more variable, estimate the new standard deviation

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATIONS OCTOBER-NOVEMBER 1995

M210 - MATHEMATICAL METHODS II

TIME ALLOWED: Three(3) Hours.

INSTRUCTIONS: Attempt any five(5) questions.

1. a) Find and classify the critical points for the function

$$f(x) = x^4 - 8x^3 - 270x^2, \quad -\infty < x < \infty$$
 Also find the absolute minimum of $f(x)$.

- b) Solve the differential equation

$$x dy - y dx = (x^2 + y^2) dx.$$

2. a) Calculate $\lim_{n \rightarrow \infty} s_n$, where

$$s_n = \frac{1}{n^3} + \frac{2^2}{n^3} + \frac{3^2}{n^3} + \dots + \frac{(n-1)^2}{n^3}.$$

- b) Solve the following differential equations:

i) $x^2 y \frac{dy}{dx} = (1+x) \csc y;$

ii) $\frac{d^2 y}{dx^2} + 2 \frac{dy}{dx} + y = e^x$

(see A + B)

3. a) Determine the pair of straight lines represented by the equation

$$xy - y - x + 1 = 0,$$

by using a rotation of the coordinate axes.

- b) The area of a rectangle is given by $A = xy$, where x is the base and y is the altitude. Let r be the length of a diagonal and θ the angle it makes with the base. Compute A_r and A_θ .

4. a) Find the area of the region enclosed by the x -axis and the curve $y = x \sin x$, $\pi \leq x \leq 2\pi$.

- b) Find the length of the curve $y = \ln(\cos x)$, $0 \leq x \leq \pi/3$.

- c) Prove that $z = x^2 + x f(xy)$ is a solution of $x \frac{\partial z}{\partial x} - y \frac{\partial z}{\partial y} = x^2 + z$.

5. Sketch the curve of

$$y = \frac{4(x^3 - 7x)}{(x-2)^2(x+5)}$$

6. Find the area of the surface generated by revolving the curve
 $y = \sqrt{x^2 + 2}$, $-1 \leq x \leq 1$, about the x-axis.

7. a) Evaluate the following limits:

i) $\lim_{x \rightarrow \pi/2} \frac{\tan x}{\tan 3x}$;

ii) $\lim_{x \rightarrow \pi/2} (\sin x)^{\tan x}$.

- b) Show that

$$\int_0^{\infty} \frac{x}{(1+x)^3} dx = \frac{1}{2} \int_0^{\infty} \frac{dx}{(1+x)^2} = \frac{1}{2}.$$

8. a) At what point on the parabola $y = \frac{1}{4}x^2$ is the radius of curvature a minimum?
- b) Use the Taylor series for $\sin x$ about $a = \frac{\pi}{6}$ to compute $\sin 33^\circ$ to three decimal places.

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATIONS 1995
M220 LINEAR ALGEBRA

TIME ALLOWED: Three(3) hours

INSTRUCTIONS: Attempt any FIVE(5) QUESTIONS

1. Briefly explain the meaning of each of the following:

(i) The reduced row-echelon form of an $m \times n$ matrix A ;

(ii) the augmented matrix of a system of equations.

(a) Reduce the matrix

$$\begin{pmatrix} 2 & -1 & 0 & 1 & -1 \\ -1 & 1 & 2 & 1 & 5 \\ 1 & 0 & 2 & 2 & 4 \end{pmatrix}$$

to its row-echelon form. Hence or otherwise solve the system of equations

$$\begin{aligned} 2x_1 - x_2 + x_4 &= -1 \\ -x_1 + 2x_3 + x_4 &= 5 \\ x_1 + 2x_3 + 2x_4 &= 4 \end{aligned}$$

(b) Find the conditions which λ and μ must satisfy for the system of linear equations

$$\begin{aligned} x + y - 4z &= 0 \\ 2x + 3y + z &= 1 \\ 4x + 7y + \lambda z &= \mu \end{aligned}$$

to have (i) a unique solution
(ii) no solution
(iii) an infinite number of solutions.

2. Give the definition of

(i) a subspace U of a vector space V over a field K ,

(ii) a basis S for a vector space V over a field K .

(a) Prove that a subset W of V is a subspace of V if and only if $0 \in W$ and $u, v \in W \Rightarrow \alpha u + v \in W \quad \forall \alpha \in K$. Hence verify that a subset $W = \{(\alpha_1, \alpha_2, \alpha_3) : \alpha_1 + \alpha_2 + \alpha_3 = 0\}$ is a subspace of $V_3(\mathbb{R})$.

- (b) (i) Determine the dimension of the vector space U spanned by vectors $u_1 = (1, 2, 0, 3)$, $u_2 = (2, -1, 0, 0)$ and $u_3 = (-1, 3, 0, 3)$.

Extend the basis B_1 of U which you obtain to a basis B_2 of $V_4(\mathbb{R})$.

- (ii) Let $V = \{(x_1, x_2, x_3, x_4) : x_2 + x_3 + x_4 = 0\}$ and $W = \{(x_1, x_2, x_3, x_4) : x_1 + x_2 = 0, x_3 = 2x_4\}$. Find a basis of $V \cap W$.
-

3. What is meant by the following terms as applied to linear transformations?

- i) A linear transformation T is a K -isomorphism.
- ii) A normal form of the matrix of linear transformation T .
- a) Let $T: V \rightarrow W$ be a linear transformation and let $\dim V = \dim W = n$. If $\{v_1, v_2, \dots, v_n\}$ is a basis for V such that $\{T(v_1), T(v_2), \dots, T(v_n)\}$ is a basis for W . Prove that T is a K -isomorphism.
- b) If $T: V_4(\mathbb{R}) \rightarrow V_3(\mathbb{R})$ has matrix

$$\begin{pmatrix} 1 & 2 & 3 & 4 \\ 0 & 1 & -1 & 5 \\ 3 & 4 & 11 & 2 \end{pmatrix},$$

find bases B_1 and B_2 of $V_4(\mathbb{R})$ and $V_3(\mathbb{R})$ respectively, with respect to which the matrix of T is in normal form N . Hence write down matrices H and K such that $N = K^{-1}AH$.

4. If $T: V \rightarrow W$ is a transformation from a vector space V into a vector space W over a field K , define what is meant by

- (i) the matrix of T relative to the bases

$B_1 = \{v_1, v_2, \dots, v_n\}$ and $B_2 = \{w_1, w_2, \dots, w_m\}$ for V and W respectively,

- (ii) the image of T and the kernel of T .

- a) Let $T: V_3(\mathbb{R}) \rightarrow V_2(\mathbb{R})$ be the linear transformation defined by

$$T(x, y, z) = (2x + y - z, 3x - 2y + 4z).$$

Find the matrix of T in the following bases of $V_3(\mathbb{R})$ and $V_2(\mathbb{R})$ respectively:

$$B_1 = \{v_1 = (1, 1, 1), v_2 = (1, 1, 0), v_3 = (1, 0, 0)\} \text{ and}$$

$$B_2 = \{w_1 = (1, 3), w_2 = (1, 4)\}.$$

- b) (i) Prove that $\text{Im } T$ is a subspace of W .

(ii) Let T be defined as in (a). Find conditions for $(\alpha, \beta, 0)$ to be in the kernel of T .

5. Let V be a finite dimensional vector space over a field K . Define

(i) an inner product on V .

(ii) the orthogonal complement U^\perp of a subset U of V .

- (a) If $u = (\alpha_1, \alpha_2)$ and $v = (\beta_1, \beta_2)$ are vectors in $V_2(\mathbb{R})$, prove that

$$(u, v) = \alpha_1 \beta_1 - \alpha_1 \beta_2 - \alpha_2 \beta_1 + 3\alpha_2 \beta_2$$

is an inner product.

- (b) Find, relative to the standard inner product on $V_4(\mathbb{R})$, an orthogonal complement for the subspace U of $V_4(\mathbb{R})$ spanned by the vectors

$$u_1 = (1, 2, 2, 0), u_2 = (0, 1, 5, 4), u_3 = (1, 1, 3, 4).$$

If $u, v \neq 0$ are vectors in an inner product space $V_3(\mathbb{R})$, define the projection of u on v as the vector

$$w = \frac{v}{\|v\|^2} (u, v). \text{ Show that } w \text{ and } v - w \text{ are orthogonal.}$$

6. What is meant by each of the following terms:

- (i) An eigenvalue of an $n \times n$ matrix A over a field K ;
- (ii) A diagonalizable matrix $A \in M_n(K)$.

(a) If $A \in M_n(K)$ has n distinct eigenvalues prove that A is diagonalizable.

(b) Given that

$$A = \begin{pmatrix} 1 & 0 & -1 \\ 1 & 2 & 1 \\ 2 & 2 & 3 \end{pmatrix}$$

(i) Determine the eigenvalues and their corresponding eigenvectors.

(ii) Write down the matrix P such that $P^{-1}AP$ is a diagonal matrix.

7. What is meant by each of the following terms as applied to quadratic forms on vector spaces V ?

- (i) The rank of a quadratic form $q(v)$
- (ii) the quadratic form $q(v)$ is positive definite

Let $q(v)$ be the quadratic form on $V_3(\mathbb{R})$ given by

$$q(v) = 2x^2 + 5y^2 + 3z^2 + 4yz + 2zx + 4xy.$$

Determine

- (a) Whether the given form is positive definite
- (b) the rank of $q(v)$
- (c) an orthonormal basis for $V_3(\mathbb{R})$ such that $q(v)$ is a diagonal quadratic form.

END OF EXAM.

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATION 1994/95
M240 COMPUTER SCIENCE I

TIME ALLOWED: Three(3) Hours

INSTRUCTIONS: Answer Any Five(5) Questions

1. a) i) What is an Operating System?
- ii) List down the six main functions of the Operating System.
- iii) Which of the functions listed in (ii) above do you think is the least applicable on Personal Computers? Why?
- b) i) Interactive Mode and Batch Mode are the two basic modes of computer operation nowadays. What is the main difference between the two modes? Give one example of each.
- ii) The following Pascal program computes an employee's gross pay and net pay. The program is written in Batch Mode. Write an Interactive version of the program.

```
PROGRAM PAYROLL(INPUT,OUTPUT,INPUT-FILE,OUTPUT-FILE);
```

```
CONST TAX = 35;
```

```
VAR HOURS,RATE,GROSS,NET : REAL;
```

```
INPUT-FILE,OUTPUT-FILE : TEXT;
```

```
BEGIN
```

```
  READLN(INPUT-FILE,HOURS);
```

```
  READLN(INPUT-FILE,RATE);
```

```
  GROSS := HOURS*RATE;
```

```
  NET := GROSS - TAX;
```

```
  WRITELN(OUTPUT-FILE,'GROSS PAY IS K':1,GROSS);
```

```
  WRITELN(OUTPUT-FILE,'NET PAY IS K':1, NET)
```

```
END.
```

2. a) Give the main difference between

- i) a local and a global variable
- ii) a formal and an actual parameter
- iii) a syntax and a run-time error.

b) Consider the following Pascal program:

```
PROGRAM EXAM(INPUT,OUTPUT);

VAR A,B,C : INTEGER;

    Z      : REAL;

PROCEDURE MDM(X : REAL;VAR M : INTEGER);

VAR Y : REAL;

BEGIN

    READLN(A);

    etc.

END;

BEGIN

    READLN(B,Z);

    READLN(Y);

    C := A + B;

    MDM(Z,B);

    MDM(C,B);

    etc.

END.
```

List down, if any, the

- i) local variables(or subprograms)
- ii) global variables(or subprograms)
- iii) formal parameters
- iv) actual parameters

c) Which statements/s, if any, in the program in part(b) would give

- i) syntax errors?
- ii) run-time errors?

3. ATTEMPT: part(a) and part(b) plus EITHER part(c) OR part(d):-

- a) Give one similarity and one difference between an array and a set.
- b) Consider the following Pascal program:

```
PROGRAM FAIREWELL(INPUT,OUTPUT,INPUT-FILE,OUTPUT-FILE);
TYPE LETTERS      = 'A'..'Z';
VAR SETA,SETB      : SET OF LETTERS;
    CH              : CHAR;
    I               : INTEGER;
    INPUT-FILE,
    OUTPUT-FILE    : TEXT;
BEGIN
    I := 0;
    RESET(INPUT-FILE);
    REWRITE(OUTPUT-FILE);
    SETA := ['A','E','I','O','U'];
    SETB := [ ];
    WHILE NOT EOF(INPUT-FILE) DO
    BEGIN
        WHILE NOT EOLN(INPUT-FILE) DO
        BEGIN
            READ(INPUT-FILE,CH);
            IF CH IN SETA THEN
            BEGIN
                I := I + 1;
                SETB := SETB + [CH]
            END;
            READLN(INPUT-FILE)
        END
    END;
    WRITELN(OUTPUT-FILE,I);
    FOR CH := 'A' TO 'Z' DO
        IF CH IN SETB THEN
            WRITE(OUTPUT-FILE,CH);
    WRITELN(OUTPUT-FILE)
END.
```

- i) What does the program do?
- ii) Suppose that INPUT-FILE contains the message:

DIRAMBA IS PROBABLY THE MOST HATED PERSON IN ZAMBIA ! !

What would be the values of I and SETB after running the program?

c) Given:

```
Program Arrays(Output);  
Var X,Y : array[1..2] of Integer;  
    i,j : integer;
```

```
Begin  
    For i := 1 to 2 do  
        Begin  
            X[i] := i;  
            Y[i] := i  
        End;  
    For i := 1 to 2 do  
        Begin  
            X[i] := 2*X[i];  
            For j := 1 to 2 do  
                Y[j] := Y[j] + X[i]  
            End  
        End  
    End  
End.
```

After running the above program, what would be the values of the following?

i) X[1] ii) X[2] iii) Y[1] iv) Y[2]
v) X[3] vi) j

d) Write a procedure called BINARY that uses the Binary Search method to search an array of 20 integer values(which are in ascending order) for a specific integer value read in. Assume the array to be searched is A.

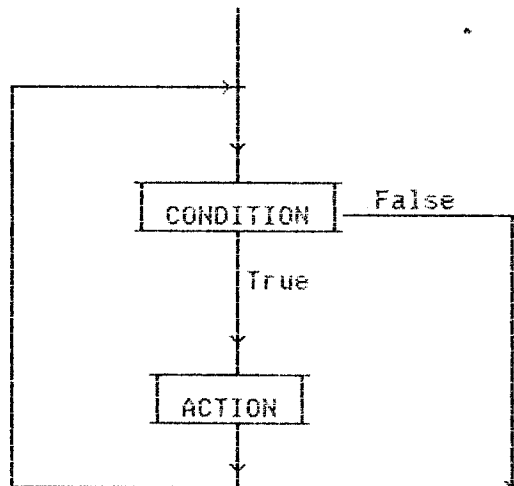
4. a) Distinguish between an iterative and a recursive subprogram.
b) The product of two natural numbers M and N can be defined recursively as:

$$\text{PRODUCT}(M,N) = \begin{cases} M & \text{if } N = 1 \\ M + \text{PRODUCT}(M,N-1) & \text{if } N > 1. \end{cases}$$

Write a Pascal recursive function called PRODUCT that computes the product of two non-negative integers. Hence, show that $6 \times 20 = 120$.

c) Write an iterative version of the function in (b) above.

5. a) The following diagram illustrates the WHILE--DO statement. The arrows show the flow of program execution:



Draw a corresponding diagram for the REPEAT--UNTIL statement.

- b) Suppose that you are to write a program using a repetitive control structure. Which one would you use between a WHILE and a REPEAT statement? Why?
- c) Consider the following Pascal Program:

```

PROGRAM FAIREWELL(INPUT,OUTPUT);
VAR N : INTEGER;
    CH : CHAR;
BEGIN
    N := 0;
    READ(CH);
    WHILE (CH <> '.') DO
    BEGIN
        IF(CH <> ' ') THEN
            N := N + 1;
        READ(CH)
    END;
    WRITELN(N)
END.
  
```

- i) What does the program do?
- ii) Rewrite the program using the REPEAT statement.
- NOTE: Your program should produce the same output as that of the above program, for whatever input values.

6. a) What is a dynamic data structure?
Give one example.
- b) Consider the following Pascal program:

```

Program Farewell(Output);
Type Integer-pointer =  $\uparrow$ Integer;
Var First, Latest, Next : Integer-pointer;
Begin
    New(First);
    First $\uparrow$  := 50;
    New(Latest);
    Latest $\uparrow$  := 60;
    New(Next);
    Next $\uparrow$  := 70;
    First := Latest;
    Latest $\uparrow$  := Next $\uparrow$ 
END.

```

After executing the program, what would be the values of the following?

- i) First \uparrow ii) Latest \uparrow iii) Next \uparrow
- c) Give the values of the following boolean expressions, after executing the program in (b) above:
- i) First \uparrow > Latest \uparrow
- ii) First < Latest
- iii) Latest <> Next
- iv) Latest \uparrow > First \uparrow
- v) First = latest
- d) Assume the following definitions and declarations:

```

Type Name-pointer:  $\uparrow$ Name-record;
    Name-record = Record
        name : string[15];
        Link : name_pointer
    End;

Var Name : String[15];
    First, PTR, Loc : Name-pointer;
    Found : Boolean;
    I : Integer;

```

Write a Pascal program segment to search a simple linked list of names for the occurrence of a particular name read in. If the name is found, save its location as the value of the pointer LOC, otherwise print an error message. Assume that First points to first name in the list.

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATIONS OCT/NOV 1994/95

MATHEMATICS M260

W12 912

TIME: Three(3) hours

- INSTRUCTIONS:
- a) Answer Any Four(4) Questions. All the necessary work and assumptions where necessary must be given.
 - b) Statistical table will be provided while calculators are allowed.

1. a) i) A sociologist is interested in estimating the percentage of UNZA students who have smoked marijuana. One hundred students are randomly selected and the question she wants to ask is "Have you ever smoked marijuana?" but to allay any fears they might have about their confidentiality being breached, she does it indirectly. First, each student is asked to pick a random number between 00 and 99 (without revealing its identity). Any one whose number is between, say 00 and 69 is then asked to answer the marijuana question. The other students are instructed to answer a trivial nonsensitive question, "Does your computer number end with an odd digit?" each student writes the answer on a slip of paper, without ever indicating which question he/she is responding to. Suppose it turns out that 44% of the responses were "Yes" What fraction would we estimate was answering "Yes" to the marijuana question?.
- ii) A toy manufacturer buys ball bearing from three different supplies, 50% from supplier A, 30% from supplier B, and the rest from supplier C. Past experience has shown that quality control standards of the three suppliers are not all the same. Of the ball bearing produced by supplier A, 2% are defective, suppliers B and C produce defective bearing 3% and 4% of the time respectively. If there is a defective ball bearing what is the probability that it was supplied by A.
- b) i) An ecologist has trapped a male rhino, a female rhino, and a cub(young). She intends to fit each of them with a radio-transmitting collar (tag) so that they can be kept under electronic surveillance after they are released. To allow each rhino to be distinguishable from the other two, each collar will transmit on a different frequency. Write out a sample space

describing the ecologist's options in assigning the three collars to the three rhinos.

- ii) Mulenga is not a terribly bright student. His chances of passing C110 are 0.35, his chances of passing M110 are 0.40% and his chances of passing both are 0.12. Are the events "Mulenga passes C110" and "Mulenga passes M110" independent? What are his chances of failing both courses?

c)

Let $f(x) = k(x - 60)^2$, $60 \leq x \leq 80$.

- i) Find the value of k that makes $f(x)$ a probability density function.
- ii) If the above $f(x)$ is the probability function describing the likelihood that a motorist travelling x kilometers per hour will be caught in a police radar trap. What is the probability that a motorist travelling in excess of 75 kmh will not be caught?

2. a) i) It has been reported that a certain bacteria is found in about 60% of the chicken eggs which failed to hatch with a developed embryo. An undergraduate student at the School of Veterinary Medicine is asked to do the study to validate this report. If she wants to estimate the true percentage to within 5% with 98% confidence, how many eggs which failed to hatch with a developed embryo will she require?

- ii) The analysis of the amniotic fluid from a random sample of 16 pregnant women yielded an average protein in the amniotic fluid of 0.86 with a standard deviation of 0.23. Find a 99% confidence interval for the true average protein in amniotic fluid.

- b) To study the effect of cigarette on blood platelet aggregation, blood samples from 11 individuals before and after they smoked a cigarette and measured the extent to which the blood platelets aggregated. The data are given below. Is there any evidence at 0.05 level of significance that smoking increases platelet aggregation?

	1	2	3	4	5	6	7	8	9	10	11
Before	25	25	27	44	30	67	53	53	52	60	20
After	27	29	37	56	46	82	57	80	61	69	43

c) A scientist inoculates several mice, one at a time, with a disease germ until he finds 3 that have contracted the disease. If the probability of contracting the disease is 0.3,

- i) What is the probability that 8 mice are required?
- ii) What is the expected number of mice required?

3. a) For many years Sodium Nitrate has been used as a curing agent for bacon, and until recently it was thought to be harmless. But now it appears that during frying, Sodium Nitrate induces the formation NP_y , a substance suspected of being a carcinogen (cancer causing). In one study focusing on this problem, measurements were made of the amount of NP_y recovered after the frying of five randomly selected slices of each of the four commercial brands of bacon. The researcher wanted to know if these four brands produce the same amount of NP_y on the average.

- i) Write the appropriate model.
- ii) What are the treatments in this model.
- iii) Complete the following ANOVA table for the above experiment.
- iv) Answer the researcher's question at 0.01 level of significance.

Source of variation	Sum of square	df	mean square
Treatment			
Error	53		
Total	129	19	

b) Independent random samples from two strains (breads) of mice used in an experiment yielded the following measurements on plasma glucose levels following a traumatic experience.

strain A	5	9	10	4	7	8	5	6	14	9
strain B	9	9	9	15	8	10	13	8	9	10

i) Do these data provide sufficient evidence at 0.01 level of significance to indicate that the average glucose level is less in the population of strain A mice than in the population of strain B mice following a traumatic experience.

ii) What assumptions have you made to have your analysis valid.

c) A sociologist interviews 100 families where the husband and wife, early in their marriage, decided to keep having children until they had their first girl. (All the 100 couples did eventually have a female child). The data is as follows

Number of children	1	2	3	4	5 or more
Number of families	55	19	12	8	6

Assume that p the probability of having a girl is $1/2$. Can the distribution of number of children be adequately described by a geometric distribution at 0.05 level of significance for the couples who follow the above rule.

4. a) A market research study has investigated the relationship between an adult's self perception and attitude towards small cars. A total of 299 persons living in a large metropolitan area were surveyed. On the basis of their responses to a questionnaire, each was "assigned" to one of the three distinct personality types: (A) cautious - conservative, (B) middle of-the roader (c) confident explorer. At the same time, each was solicited for their overall opinion of small cars. The results are displayed below.

		Self - Perception		
Opinion of small cars		A	B	C
	Favorable	79	58	49
	Neutral	10	8	9
	Unfavourable	10	34	42

Test whether these two straits are independent. Use the 0.025 level of significance.

b) A study was conducted to determine whether the final grade in an introductory Sociology course was related to a student's performance on verbal ability test administered before college entrance. The verbal test scores and final score for a random sample of ten students are shown below.

student	1	2	3	4	5	6	7	8	9	10
verbal ability(x) rest score	39	43	21	64	57	47	28	75	34	52
final score (y) in introductory sociology	65	78	52	82	92	89	73	98	56	75

- i) Find the least squares line relating y to x .
 - ii) Predict a student's final grade in the introductory course when his or her verbal test score is 50.
- c) Acrophobia is a fear of heights. It can be treated mainly in three therapies: contact desensitization,(A) Demonstration participation(B) and live modellings(C). These three techniques were compared in a recent study involving 15 volunteers, all of whom had a history of severe acrophobia. It was realized at the outset, though, that their level of acrophobia was not all the same. The 15 were given a Height advanced test(HAT), on the basis of their score the 75 volunteers were divided into five groups, G_1 being the lowest score and so on. Each of the three therapies was then assigned at random to one of the three subjects in each group when the counselling sessions were over, the subjects retok the HAT. The object of the study was to test the equality of the therapies at $\alpha = 0.01$.
- i) What is the appropriate model.
 - ii) Complete the ANOVA table below for this study.
 - iii) Carry out the appropriate test.
 - iv) Find the 95% confidence interval for the mean difference between A and B if the mean for A and B are 13.6 9.0 respectively for this situation.

ANOVA TABLE

Source of variation	Sun of squares	df	Ms
Treatment	260.9		
Block			
error	68.4		
Total	767.4		

5. a) i) An epidemiologist wished to compare two rabies vaccines to check if she could conclude that they differ in effectiveness. Ten subjects who had previously received a booster dose of type A vaccine had mean 4.5 and standard deviation 2.5 of anti-body responses, while nine of the subjects who had received a booster of type B vaccine the mean and standard deviations were 2.5 and 2.0 respectively. Do the appropriate analysis.
- ii) For a multiple Sclerosis patients we wish to estimate the mean age at which the disease was first diagnosed. We want a 98% confidence interval that is 10 years wide. If the population variance is 90, how large should our sample be?
- b) Weight (kg) and chest size(cm) of infants at birth of a random sample of 9 infants are given below

infant	1	2	3	4	5	6	7	8	9
weight	2.8	2.2	4.4	5.5	3.2	4.3	2.3	4.3	3.7
chest size	30	26	32	37	27	28	28	30	29

- i) Calculate the sample correlation coefficient for weight and chest-size.
- ii) Test at 0.05 level of significance
 $H_0: \rho = 0.3$ versus $H_a: \rho > 0.3$
- iii) Find a 95% confidence interval for the population correlation coefficient ρ for weight and chest-size at birth.

- c) i) For routine equipment, the standard deviation of the length of life is an important factor in determining whether it is cheaper to replace all the pieces at fixed intervals or to replace each piece individually when it breaks down. An industrial statistician has calculated that it is economical to replace a certain gadget at fixed intervals if the standard deviation is less than 8 days. A random sample of 71 pieces gave a standard deviation of 6.2 days. Should the replacement be at fixed intervals or not, test at 0.05 level of significance.
- ii) An investor believes that although the price of stock A usually exceeds that of stock B, stock A is a riskier investment, where the risk of a stock is measured by the variation in daily price changes. Suppose we obtain a random sample of 25 daily price changes for stock A and 20 for stock B. Test the investor's belief that stock A is a riskier investment at 0.5 level of significance if the sample standard deviations for daily price changes for stock A and B are 0.76 and 0.46 respectively.

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATIONS OCT/NOV. 1994/95
MATHEMATICS M310

M911 / M912

TIME ALLOWED: Three(3) hours

INSTRUCTIONS: Attempt any FIVE(5) questions.

Q1. a) If $T = x^3 - xy + y^3$, $x = \rho \cos \phi$, $y = \rho \sin \phi$

find i) $\frac{\partial T}{\partial \rho}$

ii) $\frac{\partial T}{\partial \phi}$

b) A region R in the xy plane is bounded by
 $x^2 + y^2 = a^2$, $x^2 + y^2 = b^2$, $x = 0$, and $y = 0$, where
 $0 < a < b$.

i) Determine the region R' into which R is mapped under
the transformation

$$x = \rho \cos \phi, \quad y = \rho \sin \phi \quad \text{where} \quad \rho > 0, \quad 0 \leq \phi \leq 2\pi.$$

ii) Compute $\frac{\partial(x,y)}{\partial(\rho,\phi)}$ and show that

$$\frac{\partial(\rho,\phi)}{\partial(x,y)} = \frac{1}{\rho}$$

Q2. a) For the space curve $x = 3\cos t$, $y = 3\sin t$, $z = 4t$

find i) the unit tangent T

ii) the principal normal N , curvature k
and radius of curvature ρ .

iii) the binormal B , torsion τ and radius
of torsion σ .

b) If $A = x^2 y i - 2xz j + 2yz k$ find $\text{curl } A$

- Q3. a) Let $f(t)$ be a given function defined $\forall t \geq 0$. Define the Laplace transform $\mathcal{L}(f)$ of $f(t)$. Show that
- $$\mathcal{L}(\cosh at) = \frac{s}{s^2 - a^2}$$
- b) If $\mathcal{L}(f') = s\mathcal{L}(f) - f(0)$ derive the Laplace transform of $f''(t)$. Hence show that if
- $$y = \frac{t \sinh t}{2}, \quad \text{then} \quad \mathcal{L}(y) = \frac{s}{(s^2 - 1)^2}$$
- c) Use the Laplace transform to solve the initial value problem of the differential equation $y'' + 4y' + 3y = 0$,
 $y(0) = 3, y'(0) = 1$
-

- Q4. a) Let $f(t)$ be a periodic function with period T . By letting

$$\cos n\omega_0 t = \frac{1}{2} \left(e^{in\omega_0 t} + e^{-in\omega_0 t} \right)$$

$$\text{and } \sin n\omega_0 t = \frac{1}{2i} \left(e^{in\omega_0 t} - e^{-in\omega_0 t} \right), \quad \omega_0 = \frac{2\pi}{T}$$

in the trigonometric Fourier series,

$$f(t) = \frac{1}{2}a_0 + \sum_{n=1}^{\infty} (a_n \cos n\omega_0 t + b_n \sin n\omega_0 t)$$

derive the complex Fourier series

$$f(t) = \sum_{n=-\infty}^{\infty} c_n e^{in\omega_0 t}. \quad \text{Use the definition of } a_n \text{ and } b_n \text{ to}$$

compute c_n and c_{-n} and show that

$$c_n = \frac{1}{T} \int_{-T/2}^{T/2} f(t) e^{-in\omega_0 t} dt, \quad n = 0, \pm 1, \pm 2, \dots$$

- b) Compute c_n , the complex Fourier series coefficient of the rectified sine wave periodic function
- $$f(t) = A \sin \pi t, \quad 0 < t < 1, \quad f(t+T) = f(t).$$

- Q5. a) Give a definition of a periodic function. Hence determine whether or not $f(t) = \cos 10t + \cos(10 + \pi)t$ is periodic.
- b) If $f(t) = f(t + T)$ verify that $\int_{\alpha}^{\beta} f(t)dt = \int_{\alpha+T}^{\beta+T} f(t)dt$
- c) Sketch the graph of
- $$f(t) = \begin{cases} 0, & -\pi < t < 0 \\ \frac{1}{\pi} t, & 0 < t < \pi \end{cases}$$
- and find the Fourier series for it.
-

- Q6. a) State the divergence theorem of Gauss. Hence evaluate $\iiint_S F \cdot n dA$ where S is a closed surface.
- b) i) If $f(x,y)$ and $g(x,y)$ are two continuous functions of x and y with continuous first partial derivatives, show that $f(x,y)$ and $g(x,y)$ are functionally dependent if their Jacobian vanishes.
- ii) Discuss whether or not the solutions $y_1 = e^{-5x}$ and $y_2 = e^{2x}$ to the differential equation $y'' + 3y' - 10y = 0$ are linearly independent.
-

- Q7. a) State Green's theorem in the plane. Verify the theorem by evaluating $\oint_C (2xy - x^2)dx + (x + y^2)dy$ where C is the closed curve of the region bounded by $y = x^2$ and $y^2 = x$
- b) If $r(u,v) = x(u,v)i + y(u,v)j + z(u,v)k$ $u,v \in \mathbb{R}$ represents a smooth surface S , define the surface integral of a vector function F over S . Evaluate the surface integral when $F = yi + 4xj$, $S: z = -x + 2y$, $1 \leq x \leq 4$, $2 \leq y \leq 3$.

- Q8. a) Use the method of langrange multipliers to find the shortest distance from the origin to the hyperbola $x^2 + 8xy + 7y = 225$, $z = 0$
- b) Solve the differential equation $y'' + y = 0$ if the solution is assumed in the form of power series

$$y = \sum_{m=0}^{\infty} a_m x^m$$

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATIONS OCTOBER (1995)

M330 REAL ANALYSIS I

TIME ALLOWED: 3 HOURS

INSTRUCTIONS: ATTEMPT ANY FIVE(5) QUESTIONS

1. a) Define the following:

- i) An open set G a subset of \mathbb{R} .
- ii) A one-one function $f: A \rightarrow B$ in \mathbb{R} .
- iii) Continuity of a function f at a point $x_0 \in \mathbb{R}$.
- iv) The completeness axiom for real numbers.

b) Prove each of the following:

- i) The set G is open if and only if $G = G^i$ (interior of G).
- ii) If f and g are continuous at a point c and $f(c)$ respectively such that $g \circ f$ is defined then $g \circ f$ is continuous at c .
- iii) If S is a subset of \mathbb{R} that is bounded above and if $T = \{-x: x \in S\}$, then T is bounded below and that $\inf T = -\sup S$.

c) Determine $\sup S$ and $\inf S$ if they exist for

$$S = \left\{ \frac{(-1)^n \cdot n}{5n+1} : n \in \mathbb{N} \right\}.$$

2. a) Define each of the following:

- i) A limit point of a set S , a subset of \mathbb{R} .
- ii) A compact set K , a subset of \mathbb{R} .
- iii) A convergent sequence (x_n) in \mathbb{R} .
- iv) A common refinement.

b) Prove each of the following:

- i) The intersection of an arbitrary collection of closed sets in \mathbb{R} is closed.
- ii) Closed subset of a compact set is compact.

b) iii) A convergent sequence (x_n) is bounded.

c) Analyse the following series

$$i) \sum_{n=0}^{\infty} \frac{(n!)^2 x^n}{(2n)!} \quad ii) \sum_{n=0}^{\infty} \frac{n^3 x^n}{n!}.$$

3. a) Define each of the following:

- i) An open covering of a subset K of \mathbb{R} .
- ii) A uniformly continuous function $f:A \rightarrow \mathbb{R}$ on $A \subseteq \mathbb{R}$.
- iii) Upper and lower Darboux sums.
- iv) divergence of a sequence to $+\infty$.

b) Prove the following:

- i) If K is a compact subset of \mathbb{R} and if $f:K \rightarrow \mathbb{R}$ is continuous on K , then the set $f(K)$ is compact.
- ii) For every $\varepsilon > 0$ \exists a partition $[a,b]$ such that $U(p,f) - L(p,f) < \varepsilon$ if and only if f is Riemann integrable on $[a,b]$.
- iii) $f(x) = x^2$ is uniformly continuous in $(0,1)$.

c) Discuss the convergence or divergence of the sequence

$$\frac{(-1)^n n}{\sqrt{3^n + 1}}.$$

4. a) Define the following:

i) A Cauchy sequence (x_n) .

ii) Conditional convergence of an infinite series.

iii) Derivative of a function at a point.

iv) Greatest member of a set.

b) Prove each of the following:

i) Every convergent sequence of real numbers is a Cauchy sequence.

ii) If f is differentiable at c and g is differentiable at $b = f(c)$ then $g \circ f$ is differentiable at c and $(g \circ f)'(c) = g'(f(c))f'(c)$.

iii) If f is continuous on $[a, b]$ then f is Riemann integrable on $[a, b]$.

c) Discuss the convergence or divergence of the series

$$\sum_{n=1}^{\infty} \frac{2^n}{3^{n+1} + 1}.$$

5. a) Define the following:

- i) A Riemann integral.
- ii) A continuous function $f:A \rightarrow \mathbb{R}$ on $A = [a,b]$,
a subset of \mathbb{R} .
- iii) An inverse image of $T(\subseteq B)$ under a function $f:A \rightarrow B$.
- iv) An interior point of a set $G \subseteq \mathbb{R}$.

b) Prove the following:

- i) A function f defined by $f(x) = x^3$ is Riemann integrable on $[0,1]$.
- ii) If $f:\mathbb{R} \rightarrow \mathbb{R}$ is a continuous function on \mathbb{R} and if F is a closed subset of \mathbb{R} , then $f^{-1}(F)$ is closed in \mathbb{R} .
- iii) If $\lim_{n \rightarrow \infty} x_n = x$ and $\lim_{n \rightarrow \infty} y_n = y$ then

$$\lim_{n \rightarrow \infty} (x_n + y_n) = x + y.$$

c) Let $f:A \rightarrow B$ and $g:B \rightarrow C$ be functions. Prove that if $H \subseteq C$, then $f^{-1}(g^{-1}(H)) = (g \circ f)^{-1}(H)$.

6. a) State the following:

- i) Heine-Borel theorem.
- ii) Cauchy's condensation test for series of real numbers.
- iii) Dedekind's property.
- iv) Rolle's theorem.

b) Prove the following:

- i) If K_1 and K_2 are compact sets in \mathbb{R} , then $K_1 \cup K_2$ is also compact.

- ii) If $\alpha > 1$, then $\sum_{n=1}^{\infty} \frac{1}{n^{\alpha}}$ converges and if

$$\alpha \leq 1, \text{ then } \sum_{n=1}^{\infty} \frac{1}{n^{\alpha}} \text{ diverges.}$$

- iii) The Mean Value theorem.

c) Use the Mean Value theorem to prove that

$$(1 - a/b) < \ln b/a < b/a - 1.$$

if $0 < b$
~~if $x \in [a, b]$ and $f(x) = \ln x$~~

7. a) Define the following:

- i) A uniformly convergent sequence (f_n) of functions on $A \subseteq \mathbb{R}$.
- ii) Separated sets A and B .
- iii) Connected set $E \subset \mathbb{R}$.
- iv) A monotone increasing sequence (x_n) .

b) Prove the following:

- i) If $|f_n(x)| \leq M_n$, $n = 1, 2, \dots$, where M_n are positive constants such that $\sum M_n$ converges, then $\sum f_n(x)$ is uniformly convergent.
- ii) If f is a continuous function of \mathbb{R} into \mathbb{R} , and if E is a connected subset of \mathbb{R} then $f(E)$ is connected.
- iii) If (x_n) is bounded and (x_n) is monotone increasing then (x_n) converges to $\sup\{x_n : n \in \mathbb{N}\}$.

c) Prove that $\sum_{n=1}^{\infty} \frac{\cos nx}{n^2}$ is uniformly convergent for all x .

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATIONS OCT/NOV 1994/95
MATHEMATICS M360

TIME ALLOWED: Three(3) hours

INSTRUCTIONS: Answer any four(4) questions.
Full credit will only be given when essential work is shown. Tables will be provided while calculators are allowed.

1. a) A certain disease is present in about 1 out of 1000 persons in a given population, and a program of testing is to be carried out using a detection device which gives a positive reading with probability 0.99 for a diseased person and with probability 0.05 for healthy person. Find the probability that a person who has a positive reading actually does have the disease.

- b) Consider the joint density function of X and Y

$$f_{X,Y}(x,y) = \begin{cases} 8xy & 0 \leq x \leq y \leq 1, \\ 0 & \text{otherwise.} \end{cases}$$

Find

- i) The marginal densities of X and Y
- ii) The correlation coefficient of X and Y .
- c) i) State the Cauchy-schwartz inequality and use it to show that the absolute value of the correlation coefficient is always less than or equal to unity.
- ii) Derive the moment generating function of the sum $Y = X_1 + X_2 + \dots + X_n$ where X_j 's are independent random variables each with density e^{-x} , for $x > 0$ and use it to find the mean and variance of Y .
-

2. a) Define the following terms

- i) Likelihood function
ii) Maximum likelihood estimator
iii) Consistent estimator
iv) Uniformly minimum variance unbiased estimator.
v) Mean squared error of an estimator.

2. b) i) State the Neyman-Pearson lemma
- ii) Use the Neyman-Pearson lemma to construct the test for $H_0: \theta = 9$ is $H_1: \theta = 25$, given a random sample X_1, X_2, \dots, X_{36} from $N(0, \theta)$ at 0.05 significant level.
- c) Suppose a random sample of size 5 is drawn from a uniform on $(0, \theta)$ and we wish to test $H_0: \theta \leq 2$ is $H_1: \theta > 2$ by rejecting H_0 if $y = \max(X_1, \dots, X_5) \geq k$.
- i) Find the value of k that makes the probability of committing type I error equal to 0.05.
- ii) With the above value of k find the power function.
-
3. a) Define the following terms
- i) Power function
- ii) Size of the test
- iii) Most powerful test
- iv) Monotone likelihood ratio
- v) Generalized likelihood ratio test.
- b) Let y_1, y_2, \dots, y_n be a random sample from
- $$f_X(x, \theta) = \theta^2 x e^{-\theta x}, \quad x > 0, \quad \theta > 0$$
- i) Find an estimator for θ using the method of moments.
- ii) Find the MLE for θ
- iii) Find the Cramer-Rao lower bound for θ
- iv) Find the UMVUE for θ if it exists.
- c) i) Prove that if X_1, X_2, \dots, X_M are normally and independently distributed with means μ_j and variances σ_j^2 respectively then $W = \sum_{j=1}^M \frac{(X_j - \mu_j)^2}{\sigma_j^2}$ has a chi-square distribution with M -degrees of freedom.

ii) Applying the results in (i) above show that if $Y_1, Y_2, \dots, Y_n \stackrel{iid}{\sim} N(\mu, \sigma^2)$ then

$$u = \sum_{j=1}^n \frac{(y_j - \mu)^2}{\sigma^2} \text{ has a chi-square}$$

distribution with n degrees of freedom

4. a) i) Let X be uniformly distributed on $(0,1)$. Find the density of $Y = \frac{\log_e(1-X)}{-a}$, for $a > 0$.

ii) Let $Z \sim N(0,1)$ and $X \sim \chi_m^2$, Z and W are independent find the density of $Y = Z/\sqrt{W/m}$.

$$f_X(x) = \frac{x^{m/2-1} e^{-x/2}}{\Gamma(\frac{m}{2}) 2^{m/2}}, \quad x > 0$$

b) i) An estimator w_n for the parameter θ is said to be asymptotically unbiased if $\lim_{n \rightarrow \infty} E(w_n) = \theta$.

Let X_1, X_2, \dots, X_n be a random sample from uniform $(0, \theta)$.

Let $W_n = \max(X_1, X_2, \dots, X_n)$. Is W_n asymptotically unbiased? Justify your answer.

ii) Find the mean square error for W_n .

c) A production supervisor suspects a difference exists between the proportions P_A and P_B of defective items produced by machine A and machine B respectively. Experience has shown that the proportion defective for each of the two machines is in the neighbourhood of 0.03. If the supervisor wants to estimate the difference in the proportions correct to within 0.005 with probability 0.95, how many items must be randomly sampled from the production of each machine. (Assume that we want $n_A = n_B = n$).

5. a) A study was conducted in Lusaka following an increase in prices of washing detergents. The objective was to compare the mean supermarket prices of the four leading brands, Boom (B), magic(M) Dynamo(D), and Strike(S). Ten supermarkets were selected, and the price per gram was recorded for each brand. The means for B,M,D and S were 2.431, 2.495, 2.493 and 2.417 respectively. The treatment sum of squares was 50.00×10^{-3} and mean square for error (MSE) was 1.7963×10^{-4}

i) Write the appropriate model and name the design employed.

ii) Test the hypothesis of interest at 0.01, level of significance.

iii) Find the 95% confidence intervals for B and M.

- b) i) Derive the sum of squares for the unbalanced completely randomized design.

ii) Show the equivalence of a two-sample t-test when the population variances are equal and the F-test for testing

$H_0: \mu_1 = \mu_2$ versus $H_a: \mu_1 \neq \mu_2$, i.e, the number of treatments is two in the unbalanced completely randomized design.

- c) A seed company advertises that each of its seeds has an 80% chance of germinating. A detailed analysis of 50 of the company's seed packets, containing four seeds each, gives the following information.

# of seeds that germinated	0	1	2	3	4
# of packets	6	4	15	20	5

Is the company's claim substantiated at 0.05 level of significance.

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATIONS (OCTOBER 1995)

M410

(THEORY OF FUNCTIONS OF A COMPLEX VARIABLE)

INSTRUCTIONS: There are seven (7) questions in this paper and candidates have to attempt any five(5) questions of their choice. All questions carry equal marks

TIME ALLOWED: Three (3) Hours

1. a) Prove that $U = e^{-x}(x \sin y - y \cos y)$ is harmonic and find $V(x,y)$ such that $f(z) = u(x,y) + i v(x,y)$ is analytic.

b) i) Prove that $\frac{d}{dz} \left\{ \ln z \right\} = \frac{1}{z}$.

ii) Evaluate $\int_C \frac{e^{2z}}{(z+1)^4} dz$ where c is the circle $|z| = 3$.

2. a) Find the Residue of $F(z) = \frac{\cot z \coth z}{z^3}$ at $z = 0$.

b) Evaluate $\frac{1}{2\pi i} \int_C \frac{e^{zt}}{z^2(z^2 + 2z + 2)} dz$ around the circle c with equation $|z| = 3$.

3. a) Find a bilinear transformation which maps points $Z = 0, -i, -1$ into $W = i, 1, 0$ respectively.

b) State and prove Rouché's theorem and use it to show that every polynomial of degree n has exactly n - zeros.

4. a) Find the complex potential for a fluid moving with constant speed V in the direction making an angle δ with the positive X - axis.
- b) Determine the velocity potential and stream function.
- c) Determine the equations for the stream lines and equipotential lines.
5. a) Use the definition of the derivative to find $f'(z)$ at the point z given that $f(z) = (1 - 4z^2)^2$.
- b) Let $U(x,y)$ and $V(x,y)$ denote real valued functions whose first order partial derivatives with respect to x and y exist every where in a neighborhood of a non zero point p in the xy -plane and are continuous at that point.
- i) Use coordinate transformations and chain rule to show that $V_r = V_x \cos \phi + V_y \sin \phi$ and $V_\phi = V_y r \cos \phi - V_x r \sin \phi$. What are the similar expressions for U_r and U_ϕ ?
- ii) Solve the pair of equations obtained in part(i) above for U_x and U_y to show that
- $$U_x = U_r \cos \phi - U_\phi \frac{\sin \phi}{r}.$$
6. a) i) Briefly explain the concept of uniform convergence as applied to a sequence $U_n(z)$ with the sum $U(z)$.
- ii) Show that the sequence $\left\{ \frac{1}{1 + nz} \right\}$ converges to zero uniformly for all z such that $|z| \geq 3$.

b) Expand $f(z) = \frac{1}{(z+1)(z+3)}$ in a Laurent series valid for

i) $1 < |z| < 3$ ii) $0 < |z + 1| < 2$

7. a) Prove that

i) $\sin^{-1} z = -i \operatorname{Log} \left[iz + \left(1 - z^2 \right)^{1/2} \right]$

ii) $\sinh z = \sin \underset{\lambda}{x} \cosh y + i \cosh x \sin y$

b) State and prove Taylor's theorem for an analytic function f . Hence expand $f(z) = \cos z$ in a Taylor series about the point $z_0 = \pi$

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATIONS - OCT/NOV 1995

MATHEMATICS M420

TIME ALLOWED: THREE(3) HOURS

INSTRUCTIONS: ATTEMPT FIVE(5) questions in ALL AND at least
two(2) questions from each Section

SECTION A(STRUCTURE AND REPRESENTATIONS OF GROUPS)

(Attempt at least two(2) questions from this section)

1. Define each of the following terms

- i) An inner automorphism of a group G
- ii) the stabilizer G_α of $\alpha \in \Omega$ as applied to permutation groups on Ω

(a) i) Show that the set of inner automorphisms $\text{Inn}(G)$ in G is a normal subgroup of the group of automorphisms $\text{Aut}(G)$ of (G) , and that $\text{Inn}(G) \cong G/Z(G)$

ii) Show that if G is a permutation group on Ω , then the stabilizer of α, G_α is a subgroup of G for each $\alpha \in \Omega$.

If for $\alpha, \beta \in \Omega$ there exists some $\sigma \in G$ such that $\alpha = \sigma\beta\sigma^{-1}$, then show that $G_\beta = \sigma G_\alpha \sigma^{-1}$. Hence deduce that if G is transitive on Ω then all the stabilizer subgroups G_α are conjugate in G .

b) Let G be a ^{frankish} permutation group on Ω such that $\text{Aut}(G)$ has an element α of order 2 which leaves only the identity element of G fixed. Then use the fact that each $\sigma \in G$ has an expression of the form $\sigma = x^{-1}x^\alpha$, for some $x \in G$, to show that $G_\gamma = G_\delta$ for all $\gamma, \delta \in \Omega$. Hence deduce that G is a regular permutation group.

2. Define each of the following terms

(i) a syLOW p-subgroup of a group G

(ii) the direct product of two groups H and K

a) (i) Given that G is a group of order $p^\alpha k$, where p is a prime and $(p, k) = 1$, then show that G contains a subgroup of order p^α .

(ii) Let N_1, N_2, \dots, N_r be normal subgroups of a group G such that the following conditions hold:

$$G = N_1 N_2 \dots N_r$$

$$\text{and } N_1 N_2 \dots N_{i-1} \cap N_i = \{1\}.$$

Then show that every element g in G has a unique expression of the form $g = n_1 n_2 \dots n_r$, where $n_i \in N_i$.

Deduce that if in addition, for each $i \neq j$, the order of N_i is relatively prime to N_j , then $\langle N_1, N_2, \dots, N_r \rangle \cong N_1 \times N_2 \times \dots \times N_r$.

b) Show that if each syLOW subgroup of a finite group G is normal, then G is a direct product of its syLOW subgroups.

Deduce that a group of order 15 is a direct product of its syLOW subgroups.

3. Define each of the following terms

(i) a solvable group (ii) a nilpotent group

(a) (i) Given that a group G contains a solvable normal subgroup N such that G/N is solvable, show that G is a solvable group.

(ii) Prove that every subgroup of a nilpotent group is nilpotent.

(b) (i) Show that the symmetric group S_5 is not solvable

(ii) Prove that a finite group all of whose syLOW subgroups are normal is nilpotent.

Hence confirm that a group G whose order is pq , where p and q are primes such that $p > q$ and q does not divide $p-1$ is nilpotent.

4. Define each of the following terms

(i) a completely reducible representation T of a group G

(ii) a group Algebra KG .

(a) (i) Prove that over an algebraically closed field K whose characteristic does not divide the order of a group G , all matrix representations of G are completely reducible.

(ii) Show that there is a bijection between the representations of a finite group G and the representations of the group algebra KG .

(b) (i) Let $G = \langle x | x^3 = 1 \rangle$. Then show that the mapping

$T(x) = \begin{pmatrix} 0 & 1 \\ -1 & -1 \end{pmatrix}$ is a completely reducible representation of G over the field of complex numbers \mathbb{C} .

(ii) Determine the character table of the group

$$G = \langle a, b | a^3 = b^2 = 1, ba = a^2b \rangle.$$

SECTION B (MODULE THEORY AND GALOIS THEORY)

(Attempt atleast two(2) questions from this section)

5. Define each of the following terms

(i) a torsion element of an R -module M

(ii) the order ideal $o(m)$ of an element m of an R -module M .

a) (i) Show that an element m of an R -module M is a torsion element of M if and only if it has a non-zero order ideal $o(m)$.

(ii) If R is an integral domain, then show that the set T of torsion elements of an R -module M is an R -submodule of M , and that M/T is a torsion-free R -module.

b) (i) Show that a vector space V over K is a torsion free K -module.

(ii) Let r be a non-zero element of \mathbb{Z}_5 . Then determine its order ideal $o(r)$, hence deduce that \mathbb{Z}_5 is a torsion-free \mathbb{Z} -module.

6. Define each of the following terms .

- (i) a normal extension $E:K$ as applied to field extensions
 - (ii) the Galois group $G(E:K)$ of a field extension $E:K$.
- (a) (i) Show that if $E:K$ is a field extension such that K is a fixed field for some finite group of automorphisms of E , then $E:K$ is a normal and separable extension.
- (ii) Let G be the Galois group of a field extension $E:K$ which contains a subgroup H . Let L be the subfield of E which is left fixed by H . Then prove that if H is a normal subgroup of G , then $L:K$ is a normal extension; and that in this case, the Galois group G^* of $L:K$ is isomorphic to G/H .
- b) Construct the splitting field E for the polynomial $x^4 - 2$ over \mathbb{Q} , and find the Galois group of the field extension $E:\mathbb{Q}$.

Determine all the subfields L of E such that $L:\mathbb{Q}$ is a normal extension.

7. What is the meaning of each of the following terms:

- (i) the Galois group of a polynomial $f(x) \in K[x]$
 - (ii) the polynomial equation $f(x) = 0$ is solvable by radicals.
- (a) (i) Prove that if the polynomial equation $f(x) = 0$ over a field of characteristic zero is solvable by radicals, then its Galois group is solvable.
- (ii) Show that if p is a prime, and $f(x) \in \mathbb{Q}[x]$ is an irreducible polynomial of degree p such that $f(x)$ has precisely two non-real roots in \mathbb{C} , then its Galois group is the symmetric group S_p .
- (b) Show that $x^5 - 8x + 6 \in \mathbb{Q}[x]$ is not solvable by radicals. Hence deduce that a general quintic is not solvable by radicals.
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END OF EXAM

THE UNIVERSITY OF ZAMBIA
 DEFFERED/SUPPLEMENTARY 1995
 M430 REAL ANALYSIS II

TIME ALLOWED: Three(3) Hours

INSTRUCTIONS: Attempt any five(5) Questions

1. a) Define
 - i) a finite set,
 - ii) a countable set.
- b) Let A and B be finite sets.
 Prove that $A \cup B$ is also finite.
- c) Prove that the set $\{x: 0 < x < 1, x \in \mathbb{R}\}$ is uncountable.
2. a) Define
 - i) a partial order relation in a non-empty set,
 - ii) a totally ordered set.
- b) Let \mathcal{Q} be the power set of the set \mathbb{Q} of the natural numbers.
 For $A, B \in \mathcal{Q}$ say that $A < B$ if $B - A$ is finite and $A \subseteq B$. Show
 that $<$ is a partial order on \mathcal{Q} .
- c) State Zorn's Lemma, and hence use it to prove that every
 partially ordered set contains a maximal totally ordered subset.
- a) i) Define a metric d in a non-empty set X .
- ii) Let d be a metric on X . Show that d_1 defined by

$$d_1(x, y) = \frac{d(x, y)}{1 + d(x, y)}$$
 is also a metric on X .
- b) i) Define the space ℓ_p^n , for $1 \leq p < \infty$.
- ii) State Baire's Category Theorem (without proof).
 Hence, assuming that ℓ_p^n is a metric space whose induced
 metric is defined by $d(x, y) = \|x - y\|_p$, prove that the
 space ℓ_p^n is second category.

4. a) State and prove Cantor's intersection theorem for nested sequences of sets in a metric space, clearly listing the condition under which the theorem is valid.

b) Compute $\bigcap_{n=1}^{\infty} A_n$ and $\bigcap_{n=1}^{\infty} B_n$ for the sequences

$A_n = [0, \frac{1}{n}]$ and $B_n = [n, \infty)$ in the usual real line \mathbb{R} .

Reconcile your conclusion with Cantor's Theorem in these two instances.

c) Let A be a subset of a metric space (X, d) .

Prove that $d(X, A) = 0$ ~~if and only if~~ $\Leftrightarrow X = \bar{A}$ (the closure of A).

5. a) Define i) a bounded linear operator $T: X \rightarrow Y$ Where X and Y are normed linear spaces.

ii) $\|T\|$ for such an operator.

b) i) if $A \subset \mathbb{R}$, $B \subset \mathbb{R}$ such that A and B are bounded. Prove that $\sup\{a+b: \forall a \in A, b \in B\} \leq \sup A + \sup B$.

ii) Let $B(X, Y)$ denote the set of all bounded linear operators from $X \rightarrow Y$. Prove that $B(X, Y)$ is a normed linear space.

c) Let $Y \in \ell_q$ where q is such that $\frac{1}{p} + \frac{1}{q} = 1$. Define

$$F_y: \ell_p \rightarrow \mathbb{R}$$

by

$$F_y(x) = \sum_{i=1}^{\infty} x_i y_i$$

Prove that $F_y \in \ell_p^*$ and $\|F_y\| = \|y\|_q$

6. a) Prove that $\forall x, y$ in an inner product space X ,

i) $\|x+y\|^2 + \|x-y\|^2 = 2(\|x\|^2 + \|y\|^2)$.

ii) State the polar identity for inner product norms (without proof).

b) Prove that the normed linear space of complex numbers is an inner product space and show that for each $z \in \mathbb{C}$, $\langle z, z \rangle = |z|^2$

- c) i) Let $\phi_1, \phi_2, \phi_n, \dots$ be orthonormal vectors in an inner product space X and let $x \in X$.

Define the projection of x on $\phi_1, \phi_2, \dots, \phi_n$ by

$$y = \sum_{i=1}^n \langle x, \phi_i \rangle \phi_i.$$

Show that y and $x-y$ are orthogonal.

- ii) Let $\{\phi_1, \phi_2, \dots, \phi_n\}$ be a finite orthonormal set in a Hilbert space H . Prove that if x is any vector in H , then

$$\sum_{i=1}^n |\langle x, \phi_i \rangle|^2 \leq \|x\|^2.$$

- a) i) Define a contraction on a metric space.
 ii) State Banach's Fixed Point Theorem (without proof) for such contraction.
- b) Confirm that with the usual metric on \mathbb{R} the relation
- $$f(x) = \frac{1}{7}(x^3 + x^2 + 1)$$

defines a contraction of $[0,1]$. Use Banach's Fixed Point Theorem to derive an approximate root of the equation

$$x^3 + x^2 - 7x + 1 = 0$$

in $[0,1]$ correct to 3 places of decimals.

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATIONS OCTOBER-NOVEMBER 1995

M430 REAL ANALYSIS II

TIME ALLOWED: Three(3) Hours.

INSTRUCTIONS: Attempt any five (5) questions.

1. a) Prove Bernoulli's inequality which states:
If $a \geq 1$ and $0 < h \leq 1$ then $a^h - 1 \leq 2(a-1)h$.
b) Let (X, d) and (Y, ρ) be metric spaces and $f: X \rightarrow Y$. When is f said to be
i) continuous on X ?
ii) uniformly continuous on X ?
c) The usual metric on \mathbb{R} is $d: \mathbb{R} \times \mathbb{R} \rightarrow \mathbb{R}$ defined by $d(a, b) = |a - b|$.
i) Show that the function $f: [0, \infty) \rightarrow \mathbb{R}$ defined by $f(x) = a^x$, where $a > 1$, is continuous on $[0, \infty)$.
ii) Show that the function $h: [0, 1) \rightarrow \mathbb{R}$ defined by $h(x) = x/(1-x)$ is not uniformly continuous on $[0, 1)$.
2. a) Give the definition of a partially ordered set.
b) Define a well ordered set.
c) Let Φ be the set of ordinal numbers and $\alpha, \beta \in \Phi$. Let $W_\alpha \in \alpha$, $W_\beta \in \beta$ such that $W_\alpha \cap W_\beta = \emptyset$ and let $W = W_\alpha \cup W_\beta$. For any $x, y \in W$ write $x \leq y$ if any of the following hold:
 1. $x, y \in W_\alpha$ and $x \leq y$ in W_α ;
 2. $x, y \in W_\beta$ and $x \leq y$ in W_β ;
 3. $x \in W_\alpha$ and $y \in W_\beta$.i) Prove that W is a partially ordered set with the order relation defined.
ii) Prove that W is well ordered.
3. a) i) Define an inner product space.
ii) Define an orthonormal set in an inner product space.
b) Give an example of an inner product space, showing that it is an inner product space.

- c) Let X be an inner product space. $\forall x \in X$. Let $\|x\| = \sqrt{(x,x)}$. Prove Schwarz's inequality which states that $\forall x, y \in X$, $|(x,y)| \leq \|x\| \|y\|$.
4. a) Let (X,d) be a metric space and $A \subset X$.
 i) When is A said to be compact?
 ii) When is A said to be sequentially compact?
- b) Let (X,d) be a metric space. Prove that if X is sequentially compact then X is compact.
5. a) Define a countable set.
- b) Let A and B be sets. Suppose A is infinite and countable and $f: A \rightarrow B$ is surjective, prove that B is countable.
- c) Prove that the union of two countable sets is countable and deduce that a countable union of countable sets is countable.
6. a) i) Give the definition of a norm in a linear space.
 ii) Define a Banach space.

Let X and Y be normed linear spaces and $\Omega'(X,Y) = \{L: X \rightarrow Y \mid L \text{ is a linear transformation}\}$.

- b) Show that the function $\|L\|: \Omega'(X,Y) \rightarrow \mathbb{R}$ defined by $\|L\| = \sup \left\{ \frac{\|L(x)\|}{\|x\|} : x \in X, x \neq 0 \right\}$ is a norm on $\Omega'(X,Y)$.
- c) Prove that $L \in \Omega'(X,Y)$ is continuous on X if and only if $\|L\| < \infty$.
7. a) Let (X,d) be a metric space. Define the following:
 i) an open ball in X ,
 ii) an open set in X ,
 iii) a closed set in X .
- b) Let (X,d) be a metric space, $x \in X$ and $r > 0$. Show that $\{y \in X: d(x,y) \leq r\}$ is a closed set in X .
- c) In $\mathbb{R}^2 = \{(x,y): x,y \in \mathbb{R}\}$, the following are metrics:
 $d_1((x_1, x_2), (y_1, y_2)) = |x_1 - y_1| + |x_2 - y_2|$;
 $d_2((x_1, x_2), (y_1, y_2)) = \left\{ (x_1 - y_1)^2 + (x_2 - y_2)^2 \right\}^{1/2}$
 $d_3((x_1, x_2), (y_1, y_2)) = \max \{|x_1 - y_1|, |x_2 - y_2|\}$.
 Depict the open ball $S_1((0,0))$ as a set and diagrammatically, in the metric spaces, i) (\mathbb{R}^2, d_1) , ii) (\mathbb{R}^2, d_2) , iii) (\mathbb{R}^2, d_3) .

END - OF - EXAM

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF MATHEMATICS
1995 SESSIONAL EXAMINATIONS
M440 - COMPUTER SCIENCE II

TIME ALLOWED: Three(3) Hours

INSTRUCTIONS: Section A - Compulsory Questions
(Answer Both Questions)

Section B - Attempt Any Three Questions

SECTION A: COMPULSORY

1. a) Define the following terms:

- i) Hamming Code
- ii) Parity Bit
- iii) Peripheral device
- iv) Processor Boundedness

b) Given the following codewords, locate and correct the error using Hamming check digits and even parity.

i) 1011101

ii) How many Hamming check bits would you require for an eight (8) bit data item?

c) The transfer of a data item from a processor to a peripheral device is controlled by three flags, labelled A,B and C. The data item is loaded into a buffer by the processor, and removed from the buffer by the peripheral. Algorithms for the functioning of the processor and peripheral are as follows:

Processor

If flag A = 1, then set it to zero and continue else wait.
If flag B = 1, then set it to zero and continue else wait.
Load data item into the buffer.
Set flag B to 1.
Set flag C to 1.

Peripheral

If flag C = 1, then set it to zero and continue else wait.
If flag B = 1, then set it to zero and continue else wait.
Copy data item from buffer.
Set flag B to 1.
Set flag A to 1.

Initially, flags A and B are set to 1 and flag C is zero.

- i) Write down the steps involved in transferring one character from the processor to the peripheral. State the values of flags at each step.
 - ii) By studying the algorithms, and from your answer to (i), you will realise that the purpose of flag B is to protect the buffer while it is being loaded or unloaded. Briefly state the purposes of flags A and C.
 - iii) If the peripheral works much more slower than the processor, at which point will most of the waiting occur?
 - iv) The Scenario in part(iii) is an example of a boundedness problem associated with computer systems. Name the type of boundedness.
- d) i) Name two major types of secondary storage devices and state the access type of each device.
- ii) Name two major types of semi-conductor storage
- iii) Briefly state why Semi-Conductor Storage is faster than the secondary storage.
- e) i) Define the terms Bit, Byte and Word.
- ii) A computer memory consists of cells each of which can store information, and can be referred to by a number called its address. If a memory has n cells, then it has addresses 0 to $n-1$

If a cell consists of r bits, then it can hold any one of 2^r different bit combinations.

Using the above ideas, give three different organisations of a 96 - bit memory.

2. a) Define the following terms and acronyms.

- i) Communications Network
- ii) CMOS
- iii) Full Duplex
- iv) Modem
- v) Multiplexor
- vi) Session
- vii) Polling
- viii) Monitor Station.

- b) i) Ring, Star and Bus topologies are examples of local Area network topologies. Which of the terms or concepts you have defined in (a) Would NOT be applied in all the three topologies?
- ii) Which of the above concepts are not necessarily associated with the Communications aspects of Computer Systems?

iii) One of the devices defined in (a) is responsible for converting signals from one state to the other. This occurs at both the source and destination. What conversions occur at the Source and destination respectively.?

3. a) What do you understand by the term "Systems Design"?

b) In the design of large computer Systems, the design team needs to analyse the systems' environment for representation at review meetings where the design of the system is discussed.

i) Name five(5) major categories of representatives from the Computer System's environment whose representation on the design team would greatly help the designers. Justify the presence of each category by stating its role at such a review meeting.

ii) Any properly functioning System needs to interact with its environment in as smooth a manner as is practically possible.

Name and describe with the aid of an example, where possible, two (2) types of interactions to which a System may be subjected.

c) i) The design phase of any System is accomplished with the help of several design aids. Three(3) of these design aids being Data Flow Diagrams, Flowcharts and Decision Tables. Briefly define each of these design aids.

ii) The following is the procedure for Invoice Processing in some commercial firm. The procedure is written in Structured english or Pseudocode.

POLICY FOR INVOICE PROCESSING

If the Invoice amount exceeds K500,000.00,

If the account has any invoice more then sixty(60) days overdue

Hold the confirmation pending resolution of the debt.

Else(account is in good standing),

Issue confirmation and Invoice.

Else(Invoice K500,000.00 or less),

If the account has any invoice more than 60 days overdue,

Issue confirmation, Invoice and write message on the credit action report.

Else(account is in good standing)

Issue confirmaiton and Invoice

QUESTION: Represent the above procedure on a Limited Entry decision table stating why the decision table and not the flowchart is the most ideal design aid for the above procedure.

a) Define the following terms

- i) A Relation
- ii) Functional Dependence
- iii) 2NF Relation

Given the relation WAREHOUSE (WHNUMB, CITY, FLOORS, MAYOR) where WHNUMB gives the Warehouse number, CITY gives the city in which the warehouse is situated, FLOORS gives the number of floors the warehouse occupies and MAYOR gives the name of the Mayor of the City where the warehouse is located.

- i) In what normal form is the WAREHOUSE relation?.
 - ii) List all functional dependencies in the relation.
 - iii) Decompose or normalise WAREHOUSE into 3NF Relations.
 - iv) Draw a functional Dependence diagram for WAREHOUSE
- c) What is the difference between a Boyce-Codd Normal form and a 3NF Relation?
- d) In proposing the adoption of a database system the following concepts are normally used.
- i) Redundancy
 - ii) Data Independence
 - iii) Inconsistency
 - iv) Data views

Explain each of the foregoing concepts clearly stating why each would be used in such proposals? Hence or otherwise state the normal form that aims at eliminating Redundant data.

5. a) Define the following terms:

- i) Multiprogramming
- ii) Multiprocessing
- iii) An Operating System
- iv) A Process

b) CPU scheduling deals with the problem of deciding which of the processes in the ready queue is to be allocated CPU time. There are many different CPU Scheduling algorithms. Two of these algorithms are First-come-first-served(FCFS) and Shortest-Job-first(SJF). FCFS executes jobs using the First-In-first-out principle.

Now assume we have a workload shown below. All five jobs arrive at time 0, in the order given.

JOB	BURST TIME
1	10
2	29
3	3
4	7
5	12

- i) Show how each of these jobs would execute on each of the algorithms. Use a gantt chart to show the time relationship.
 - ii) Which algorithm would give the minimum average waiting time?
 - iii) From the results in (i) and (ii), which of the two algorithms would you recommend for use in a real life situation and why?
- c) i) What is the difference between Array Processing and pipelining?
- ii) A certain Computation is highly sequential, that is each step depends on the one preceding it. Explain whether an Array Processor or a Pipeline Processor would be appropriate for this computation.
- d) To compete with the newly invented printing press, a certain medieval monastery decided to mass produce handwritten paper back books by assembling a vast number of scribes in a huge hall. The head monk would then call out the first word of the book to be produced and all the scribes would copy it down. Then the head monk would call out the second word and all the Scribes would copy it down. This process was repeated until the entire book had been read aloud and copied.
- i) Which of the Parallel Processing Systems is best described by the foregoing procedure?
 - ii) Draw a well labelled diagram of the processor System you will have mentioned in (i).
6. a) Define the following terms:
- i) Communicaiton protocols
 - ii) Baud
 - iii) Coaxial Cables
 - iv) Bit serial transmission
 - v) Start and Stop Bits

b) There are two approaches to Local Area Network Architectures: Common Carrier Cables and Ring Architecture.

i) Briefly describe the operations of each of these Local Area Network Architectures.

ii) Briefly contrast the two types of architectures giving one example of an implementation of each architecture and its advantage over the other type.

c) i) What are the four(4) desirable features in any local area network implementation?

ii) In the formulation of a definition for a local Area Network, there are four(4) main points that have to be noted. List the four points.

7. a) Briefly define each of the following terms

i) Addressing

ii) Absolute Addressing mode

iii) An Operation Code (OPCODE)

iv) An Interpreter

v) Compiler

b) A Computer Science Department in a certain University has written to you for advice on the choice of a translating program to be used with a programming language for teaching computer programming to freshers in Computer Science. Their aim is to teach a high level programming language such as Pascal in a microcomputer environment. They expect the students to be taught in an environment that supports interactive program debugging, traceable program execution and ease of control of programs during execution.

i) Name the type of translating program you would recommend giving four(4) reasons in support of the translating program you have chosen.

ii) High level languages are often said to be "people-oriented" where as low level languages are said to be "machine - oriented" What is meant by the foregoing expressions on high and low level languages?

c) What is the use of each of the following 12-bit registers during processor operation?

i) Accumulator(AC)

ii) Program Counter(PC)

iii) Memory Address Register(MAR)

iv) Memory Buffer Register (MBR)

d) Is the subject of addressing a low level or high operation?.

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATION OCT/NOV 1995
MATHEMATICS M460

TIME ALLOWED: Three(3) Hours

INSTRUCTIONS: Answer Any Five Questions.
Statistical tables will be provided.

1. a) Given two random variables X and Y , define the m.g.f. of their joint distribution. Hence define the m.g.f. of a random vector Z of dimension n .
- b) Let the random vector $Z = (z_1, z_2, z_3)'$ be distributed $N(\mu, \Sigma)$

with the m.g.f. given by $M_Z(t) = e^{t'\mu + \frac{1}{2} t'\Sigma t}$

$$= \text{Exp} \left[t_1 - t_2 + 2t_3 + t_1^2 + \frac{1}{2} t_2^2 + 2t_3^2 - \frac{1}{2} t_1 t_2 - t_1 t_3 \right]$$

Find a constant a such that

$$P \left[2z_1 - 3z_2 + z_3 > a \right] = 0.95.$$

- c. Let $X = (X_1, X_2, X_3, X_4)'$ be distributed $N(\mu, \Sigma)$ where

$$\mu = (1, -1, 2, 0)', \Sigma = \begin{pmatrix} 2 & 0 & 1 & 0 \\ 0 & 3 & 0 & 2 \\ 1 & 0 & 5 & 0 \\ 0 & 2 & 0 & 3 \end{pmatrix}$$

- i) Find the distribution of

$$Y_1 = \begin{pmatrix} X_3 \\ X_1 \end{pmatrix}$$

- ii) Find the conditional p.d.f. of

$$\left(X_3, X_1 \mid X_2 = x_2, X_4 = x_4 \right) \text{ and comment on your answer.}$$

2. a) Suppose the linear regression model

$$Y_i = \beta_0 + \beta_1 x_i + \varepsilon_i, \quad i = 1, 2, \dots, n \text{ with errors } \varepsilon_i,$$

independent and $N(0, \sigma^2)$ was fitted to a set of 17 observations. The following statistics was computed:

$$\text{Fitted line } \hat{Y} = 13.301 + 2.108x$$

$$\sum_{i=1}^{17} (Y_i - \bar{Y})^2 = 487.6126, \quad SSE = 252.9039$$

- i) Test statistically the significance of regression.
- ii) The data used in the above fit has ten (1) distinct levels of x with repeat observations at five levels of x . With the above information complete the following ANOVA table, perform the lack of fit test and comment.

ANOVA TABLE

Source	SS	DF
Regression	*	*
Residual	*	*
(Lack of fit)	237.3407	*
(Pure error)	*	*
<hr/>		
TOTAL	*	*

- b) For the linear regression model given in part(a), define the i th residual $e_i = Y_i - \hat{Y}_i$.

- i) Show that the residuals have zero mean.
- ii) Give an estimate of the variance of the residuals and hence define standardized residuals.
- iii) Describe how the standardized residuals can be used to detect departures from normality assumption on errors.
- iv) Show by a rough graph, what type of plot of residuals against fitted values of response variable do you expect if the fitted regression model is adequate.

3. a) Express the linear regression model

$$Y_i = \beta_1 x_i + \varepsilon_i, \quad i = 1, \dots, n \text{ where errors } \varepsilon_i \text{ are independent identical and } N(0, \sigma^2) \text{ in the matrix form.}$$

- b) Using the matrix form of the model in part(a) find the least squares estimator of β_1 and show that it is unbiased for β_1 .

- c) Find the variance of the estimator found in part(b). Also state the distribution of the estimator.
- d) Suggest an unbiased estimator of σ^2 (proof is not required). Hence construct a $100(1-\alpha)\%$ confidence interval on β_1 .
- e) Suppose the above regression model was fitted to a set of 15 data points and the following information was obtained.

- i) Fitted line is $\hat{y} = 0.4026x$
- ii) $MSE = 0.0893$
- iii) $\sum x_i^2 = 4575.0$

Perform a statistical test on the hypothesis $H_0: \beta_1 = 0$ and comment on the significance of regression.

- f) The corresponding intercept model $Y = \beta_0 + \beta_1 x + \epsilon$ was fitted to the same data. Results obtained were:

- i) Fitted line was $\hat{Y} = -0.0938 + 0.4071x$.
- ii) The test statistic for testing

$H_0: \beta_0 = 0$ was $t_0 = -0.65$, with this information, state which of the two fitted lines $\hat{Y} = 0.4026x$ or $\hat{y} = -0.0938 + 0.4071x$ is a better fit.

- g) If the data used for regression model lie in a region of x -space remote from the origin, would you recommend a regression model without intercept? comment.

4. a) Let X be an n -dimensional random vector with mean vector μ and variance covariance matrix V . Show that

- i) $E(XX') = V + \mu\mu'$
- ii) $E(X'AX) = \text{trace}(AV) + \mu' A \mu$.

- b) Consider the linear regression model $Y = X\beta + \epsilon$, $E(\epsilon) = 0$, $V(\epsilon) = \sigma^2 I_n$, for which $\hat{\beta} = (X'X)^{-1}X'Y$ is the least squares estimator of β . Define SSE, the sum of the squares of the residuals and express it as a quadratic form of vector Y . Hence using the result of part a(ii), show that

$$E(SSE) = \sigma^2(n - \text{rank}(X)).$$

5. Consider the multiple linear regression model

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \epsilon.$$

Describe the test statistic for testing the hypothesis

$$H_0: \beta_1 = \beta_2; \beta_3 = \beta_4$$

- b) Explain briefly what is multicollinearity?
- c) For the linear regression model $Y = X\beta + \epsilon$ where Y is a $n \times 1$ vector of observations, X is a $n \times 4$ matrix of 0's and 1's (regressors are categorical variables) which is not of full column rank and $\epsilon \sim N(0, \sigma^2 I)$, answer the following with full explanation and working if required.
- Can we solve the normal equations

$$X'X\beta = X'y$$
 if yes, how?
 - How many degrees of freedom are associated with SSE in this model?
 - Define estimable functions of parameters vector β and construct any two contrasts of vector β which are estimable.
 - What are the BLUE of the contrasts given in part (iii).

6. a) Define Studentized Range Distribution.

- b) Four chemicals were used to combat plant lice on sugar beets. Four plots were used in the study and each chemical was applied to one-plot. Twenty five leaves were picked from each plot and the numbers of plant lice on each leaf was recorded. Let Y_{ij} denote the number of lice on the i th leaf from the j th plot, $i = 1, \dots, 25$; $j = 1, 2, 3, 4$. Preliminary calculations gave the following:

Chemical	$\sum_{i=1}^{25} Y_{ij}$	$\sum_{i=1}^{25} Y_{ij}^2$	$(\bar{Y}_{.j} - \bar{Y}_{..})^2$
I	300	4600	28.409
II	374	6922	5.617
III	459	9603	1.061
IV	600	15490	44.489

$$\sum_{j=1}^4 \sum_{i=1}^{25} (Y_{ij} - \bar{Y}_{..})^2 = 6582.110$$

Assume that $Y_{ij} = \mu + \alpha_j + \epsilon_{ij}$ where $\sum_{j=1}^4 \alpha_j = 0$ and $\epsilon_{ij} \text{ i.i.d. } (0, \sigma^2)$

- i) Fill in an ANOVA table and test at a 0.05 level whether differences exist among four chemicals.
- ii) Write down point estimates of the overall mean number of plant lice per leaf for the four chemicals and the mean number of lice per leaf for the first chemical.
- iii) Show that MSE is an unbiased estimator of σ^2 .
- iv) Find confidence intervals for all pairwise comparisons with the Tukey procedure, using a family confidence coefficient of 0.95 and analyze them.

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATIONS OCT/NOV/ 1994/95
M910- NUMERICAL ANALYSIS

TIME ALLOWED: 3 HOURS

INSTRUCTIONS: Answer ANY FIVE(5) questions.
INDICATE THE QUESTIONS ATTEMPTED
IN YOUR ANSWER BOOK

- Q1. a) Use the Newton-Raphson method (Newton's method) to approximate to within 10^{-4} the solution of $\sin x = e^{-x}$ in the interval $[0, \pi/4]$.
- b) Let $x = p$ be a solution of $x = g(x)$ and suppose that g is continuous in some interval $[a, b]$ containing p . suppose that g' exists in (a, b) with

$$|g'(x)| \leq k < 1 \text{ for all } x \in (a, b).$$

Show that the iteration process defined by $p_n = g(p_{n-1})$ converges for any x_0 in $[a, b]$.

2. Let the function f be given by the following table

x	1.0	1.1	1.2	1.3	1.4	1.5
$f(x)$	43.4	47.7	52.1	56.4	60.8	65.1

- a) Find the following derivatives
- i) $f'(1.0)$ ii) $f'(1.5)$ iii) $f''(1.2)$
- b) Approximate $f(1.15)$ using the langrange interpolating polynomial of degree 5
-

3. a) Let f be a function defined on the interval $[a,b]$.

Derive Simpson's rule for approximating $\int_a^b f(x)dx$

- b) Use Simpson's Rule to approximate $\int_{1.8}^{2.6} xe^{-x}dx$
with $h = 0.2$
- c) Find a bound for the Error.
-

- Q4. a) Find the first three iterations obtained by the power method applied to the matrix

$$\begin{pmatrix} 4 & 1 & 1 & 1 \\ 1 & 3 & -1 & 1 \\ 1 & -1 & 2 & 0 \\ 1 & 1 & 0 & 2 \end{pmatrix}$$

using $\bar{x}^{(0)} = (1,1,1,1)^t$.

- b) The linear system $A\bar{x} = \bar{b}$ is given by

$$\begin{aligned} 2x_1 + x_2 &= 6 \\ 3x_2 + 2x_3 &= -11 \\ x_1 + 2x_2 + 4x_3 &= 9. \end{aligned}$$

Use the Gauss-Jordan method to find the inverse, A^{-1} of the matrix A . Hence solve the system.

5. a) Use Euler's method with $h = 0.25$ for the initial value problem

$$y' = -y + t^2 + 1, \quad 0 \leq t \leq 1, \quad y(0) = -1$$

- b) Let $p(t)$ be the number of individuals in a population at a given time t , measured in years. If the average death rate d is proportional to the size of the population, then the growth rate of the population is given by the logistic equation

$$\frac{dp(t)}{dt} = b p(t) - k[p(t)]^2$$

Suppose $p(0) = 50,976$, $b = 2.9 \times 10^{-2}$ and $k = 1.4 \times 10^{-7}$. Find the population after two years using the Runge-Kutta method of order 4 with $h = 1$.

6. Given the initial value problem

$$y'' + 2y' + y = e^t, \quad 0 \leq t \leq 2, \quad y(0) = 1, \quad y'(0) = -1.$$

Use the Runge-Kutta method of order four with $h = 0.1$ to approximate the solution at $t = 1.1$

7. Consider a population table of a particular town. The year is given and the corresponding population in thousands e.g in 1940 the population was 131,669,000.

Year	1930	1940	1950	1960	1970	1980
Population	123,203	131,669	150,697	179,323	203,212	226,505

- a) Construct a divided difference table from the table above
- b) Using an appropriate divided difference method, approximate
 - i) The population in 1975
 - ii) the population in 2005

END OF EXAM

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

NR430

APPLIED ECOLOGY

TIME: THREE HOURS

ANSWER: FOUR QUESTIONS. QUESTION 1 AND ANY OTHER THREE. ALL QUESTIONS CARRY EQUAL MARKS.

THE USE OF AN APPROVED ATLAS IS ALLOWED. YOU ARE ENCOURAGED TO USE MAPS AND DIAGRAMS WHEREVER POSSIBLE TO ILLUSTRATE YOUR ANSWER.

1. (a) The Chitemene shifting cultivation is an extensive land use system which is an adaptation to the inherent soil fertility status in the areas in which it is practised. Discuss.

 (b) What are the advantages and disadvantages of agroforestry as an alternative landuse system to Chitemene?
2. Solid waste disposal is one of the many environmental problems of the city of Lusaka today.

 (a) assess the magnitude of this problem and its implications on the socio-economic environment of the city.

 (b) suggest waste management measures that must be practiced to minimize the problem.
3. Outline the major threats to biodiversity in Zambia today and state why it is important to conserve biodiversity.
4. (a) Explain how chemical resistance leads to pesticide treadmill in pest control.

- (b) What is Integrated Pest Management (IPM)? Explain the principle behind IPM and how can this help break the pesticide treadmill?
5. Outline the main wildlife utilization types in Southern and Eastern Africa and suggest management strategies for the resource to ensure wildlife based sustainable development in the region.
6. Describe the biotic and ^{abiotic} factors that affect the structure and composition of tropical forests. What are the threats to the normal functioning of tropical forests and how can they be protected?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - OCTOBER/NOVEMBER 1995

NR 435

NATURAL RESOURCES ECONOMICS

TIME: THREE HOURS

ANSWER: FOUR QUESTIONS - QUESTION ONE (1) AND ANY OTHER THREE

NOTE: USE OF AN APPROVED CALCULATOR IS ALLOWED

- Q1. (a) Define the term common property resource and characterize the tragedy of the commons.
- (b) By means of the yield effort curve, depict and explain the economic optimum, the biological equilibrium and the common property equilibrium.
- (c) Why is free-access equilibrium in the common property resource inefficient?
- Q2. Consider a project plan by an emergent farmer in Lusaka Rural to plant eucalyptus trees on his land. Suppose for simplicity, unpriced non-market impacts of this plan are ignored and the relevant costs are all resource-using activities associated with the plan. The following cost and benefit cash flows occur in the years given from the start of the project:

ITEM	YEAR	VALUE (in ZK)
1. Land clearing & ploughing	0	480,000.00
2. Planting	0	500,000.00
3. Fencing	0	650,000.00
4. 1st Weeding	3	190,000.00
5. Spraying	6	460,000.00
6. 2nd Weeding	9	200,000.00
7. 1st Pruning	16	150,000.00
8. Value of 1st Prunings	16	100,000.00
9. 2nd Pruning	30	250,000.00
10. Value of 2nd Prunings	30	315,000.00
11. Clear felling	45	570,000.00
12. Value of timber	45	5,515,000.00

- a) Calculate the Net Present Value (NPV) of the project at 6% discount rate. Does the project pass the NPV test?
 - b) What would be the NPV test result if the discount rate is reduced to 4%?
 - c) Given the assumptions of the project plan, comment on the validity of your results.
- Q3. Suppose that a forest stand is a National Park of old growth which is protected in order to conserve biological diversity, but because of human encroachment, the park is severely degraded. Discuss the strategies which public authorities can employ to protect the park whilst meeting the demands for economic development.
- Q4. (a) Characterize the growth function of the fisheries model and explain the meaning of critical depensation growth function of fish?
- (b) Explain the concepts of sustainable yield and maximum sustainable yield. Under what circumstances would the yield of fish be zero?
- (c) Compare and contrast the profit maximizing solution to the sustainable yield solution of the fisheries model. Why are both solutions unstable?
- Q5. Evaluate the Limits to Growth Model's predictions of the world economy against the current world economic order.
- Q6. Suppose you have been asked by Zambia National Tourist Board (ZNTB) to conduct a valuation exercise to provide an estimate of the economic value of South Luangwa National Park in the Luangwa Valley as an environmental asset.
- (a) Choose the most suitable valuation technique and explain how you would proceed with the valuation exercise.
- (b) What problems are you likely to encounter with the technique you have chosen in the valuation exercise?
- Q7. Discounting is performed by economics to calculate the present value of a stream of costs and benefits associated with a project or policy. What in your view are the justifications for natural resource economists to support discounting?

 END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
University Examinations - 1994/1995.
P-110 : Introductory Physics

Time : Three hours.

Maximum marks : 100

Answer any five questions.

All questions carry equal marks. The marks are shown in square brackets.

Note : Write clearly your computer number on the answer book. Indicate on the cover which questions you have attempted.

-----λ-----
Wherever necessary, use :

charge of electron, $e = 1.6 \times 10^{-19} \text{ C}$

mass of electron, $m_e = 9.11 \times 10^{-31} \text{ kg}$

permittivity constant, $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N.m}^2$

permeability constant, $\mu_0 = 4\pi \times 10^{-7} \text{ N}^2/\text{A}$

$g = 9.8 \text{ m.sec}^{-2}$

$k = 9 \times 10^9 \text{ N.m}^2/\text{C}^2$

density of water $= 1000 \text{ kg.m}^{-3}$

velocity of light, $c = 3 \times 10^8 \text{ m/s}$

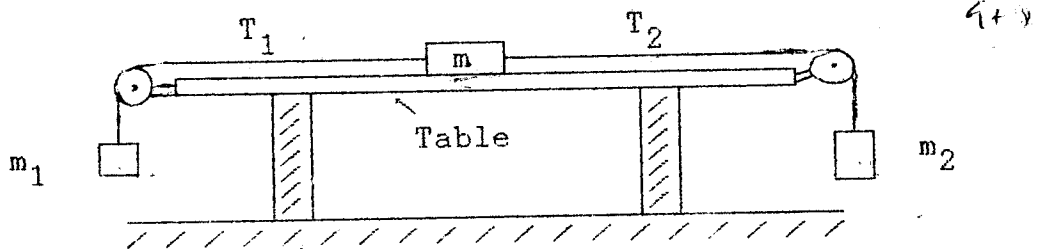
refractive index of water $= 1.33$

refractive index of air $= 1.00$

1 cal. $= 4.184 \text{ J}$

Gas constant R $= 8.314 \text{ J/mol.K}$

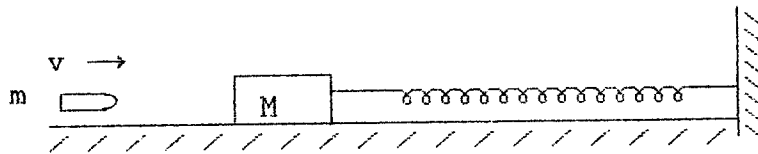
1. (a) The displacement of an object moving under uniform acceleration is some function of time and acceleration. Suppose we write the displacement as $s = ka^m t^n$, where k is a constant. Show by dimensional analysis that this expression is satisfied if $m = 1$ and $n = 2$. [4]
- (b) For the diagram shown below, if $m_1 = 1\text{kg}$, $m = 10\text{kg}$, and $m_2 = 3\text{kg}$,
- (i) Find the acceleration of the system and the tension in both the cords. Assume that the pulleys are massless, and that there is no friction. [3 + 2 + 2]
- (ii) If the coefficient of friction between the table and mass m is 0.1, find the acceleration of the system, and the tension in both cords. [3 + 3 + 3]



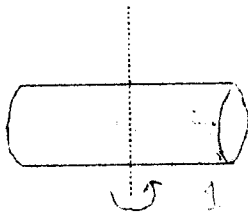
2. (a) In an elastic collision, kinetic energy is not conserved. Does this violate the law of conservation of energy? Explain. [1 + 1]
- (b) The bob of a 2m long pendulum has a mass of 0.5kg. The bob is pulled to a side until it makes an angle of 30° with the vertical. Calculate :
- (i) the change in potential energy,
- (ii) the work done in moving the bob, and
- (iii) the speed of the bob when it passes the lowest point after being released. [2 + 2 + 4]
- (c) A 20g bullet moving with a speed v becomes embedded in a block of mass 980g as shown. The block is tied to a spring that compresses 10cm. Find :
- (i) the final speed of the block-bullet combination,
- (ii) the initial speed of the bullet, and

(3).

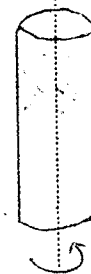
(iii) the kinetic energy lost in the collision.

(The spring constant is 1000N/m .) [3 + 3 + 4]

3. (a) The figures below show identical solid rods. The dotted lines show the axes of rotation. Explain which rod has greater moment of inertia. [4]



rod 1



rod 2

- (b) A pipe open at both ends has a fundamental frequency of 300Hz when the velocity of sound in air is 340m/s .
- what is the length of the pipe ?
 - what is the frequency of the second harmonic when the temperature of the air is increased so that the velocity of sound in the pipe is 351m/s ?

[3 + 3]

- (c) A flywheel, when slowed down from 60rev/min to 30rev/min , loses 100J of energy. What is

- its moment of inertia ? [5]
- the change in the angular momentum ? [5]

4. (a) Write short notes on :

- the first law of thermodynamics, and
- an isothermal process. [1 + 1]

- (b) One gram of water occupies a volume of 1cm^3 at the boiling temperature and atmospheric pressure of 101kPa . When this water is boiled, it becomes 1671cm^3 of steam. Calculate the change in internal energy for this process. What percentage of the heat goes into external work ? Heat of vaporisation of water is 540cal/g . [4 + 4]

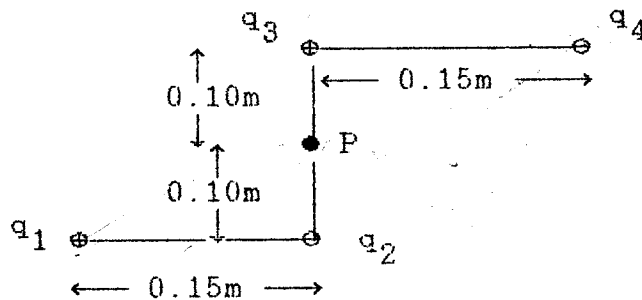
(4)

- (c) A certain amount of nitrogen gas is to expand adiabatically from its original pressure of $3.0 \times 10^6 \text{ Pa}$ and temperature of 27.0°C to such a volume that its temperature becomes -15°C .

Find the final volume as a function of the initial volume. ($C_p/C_v = \gamma = 1.4$ for nitrogen). [10]

- (5.) (a) A particle of charge q is travelling with a velocity v perpendicular to a uniform magnetic field \vec{B} . Relate the radius of its path to the kinetic energy of the particle. [4]

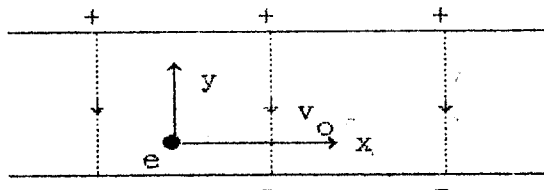
- (b) Calculate the electric potential at point P due to charges $q_1 = q_3 = 8\mu\text{C}$ and $q_2 = q_4 = -12\mu\text{C}$ as shown. [6]



- (c) An electron is shot along the x-axis with a velocity v_0 into a uniform electric field along the negative y-axis as shown in the figure.

Show that after a time t the coordinates of the electron are

$$y = - \left[\frac{e \vec{E}}{2mv_0^2} \right] x^2 \quad [7]$$



Hence or otherwise calculate the value of \vec{E} for $x = 0.5\text{m}$, $y = 0.10\text{m}$, and $v_0 = 1 \times 10^7 \text{ m/s}$. [3]

(5)

6. (a) Which two conservation laws are embodied in Kirchoff's rules for electric circuits ? [1 + 1]
- (b) Four 120V, 30W electric lamps are connected in parallel. The group is then connected in series with a coil of 80Ω resistance.
- (i) How much power is dissipated in each lamp, and in the coil when the combination is connected across a 120V battery ? [3 + 3]
- (ii) What are the voltages across the lamps, and across the coil ? [3 + 3]
- (c) A voltage source with a maximum output value of 110V and a variable frequency is connected in series with the following elements : $L = 156\text{mH}$, $C = 0.2\mu\text{F}$, and $R = 88\Omega$. Calculate
- (i) the resonance frequency of the circuit,
- (ii) the impedance of the circuit, and
- (iii) the average power delivered to the circuit when the frequency is 600Hz. [2 + 2 + 2]
7. (a) State the two conditions under which total internal reflection of light can occur. [2 + 2]
- (b) Derive the thin lens formula, $\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$, where p is the object distance, q is the image distance, and f is the focal length of the lens. [8]
- (c) An object is placed 12cm to the left of a diverging lens of focal length 6cm. A converging lens of focal length 12cm is placed at a distance d to the right of the diverging lens. For what value of d is the final image formed at infinity ? [8]
8. (a) Write short notes on :
- (i) near point of the eye, and
- (ii) astigmatism of the eye. [2 + 2]

(6)

(b) At what angle of incidence should a beam of light strike a still pond if the angle between the reflected and refracted rays is to be 90° ? [6]

(c) An alternative form of the lens and mirror equations is $s_i s_o = f^2$ where s_o is the distance of the object from the focal point, and s_i is the distance of the image from the focal point. Derive this relation. Show s_o and s_i in a sketch for a concave mirror. [8 + 2]

--- END OF EXAMINATION ---

Some equations you may find useful :

$$v = u + at$$

$$v^2 = u^2 + 2ax$$

$$x = vt + \frac{1}{2} at^2$$

$$f = \mu F_N$$

$$F = \frac{mv - mu}{t}$$

$$P = \frac{2}{3} N \frac{mv^2}{2}$$

$$\alpha = \frac{\omega_o - \omega_f}{t}$$

$$e = \omega_o t + \frac{1}{2} \alpha t^2$$

$$2\alpha e = \omega_o^2 - \omega_f^2$$

$$v_T = \omega r$$

$$F_C = \frac{mv^2}{r}$$

$$I = \sum_{i=1}^N m_i r_i^2$$

$$\gamma = \frac{F/A}{\Delta L/L_o}$$

$$B = - \frac{\Delta P}{\Delta V/V_o}$$

$$W_{app} = mg - F_B$$

$$W_{app} = W \left(1 - \frac{\rho_f}{\rho} \right)$$

$$P = \rho gh$$

$$F = kx$$

$$\left(\frac{1}{2} mv^2 \right)_{av.} = \frac{3}{2} kT$$

$$c = \frac{\Delta Q}{m \Delta T}$$

$$\alpha = \frac{\Delta L/L}{\Delta T}$$

$$\gamma = \frac{\Delta V/V}{\Delta T}$$

$$\Delta W = P \Delta V$$

$$\frac{\Delta Q}{\Delta t} = k \frac{A \Delta T}{\Delta L}$$

$$\Delta Q = \Delta U + \Delta W$$

$$a_{max} = \frac{kx_o}{m}$$

$$a_C = \omega^2 x_o$$

$$P.E. = \frac{1}{2} kx^2$$

$$\frac{1}{2} kx^2 + \frac{1}{2} mv^2 = \frac{1}{2} kx_o^2$$

$$a = - \frac{k}{m} x$$

$$\omega = \sqrt{\frac{k}{m}}$$

$$v = \pm \sqrt{\frac{k}{m} (x_o^2 - x^2)}$$

$$v = \sqrt{\frac{Y}{\rho}}$$

$$f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$

$$f = \frac{1}{2\pi} \sqrt{\frac{g}{L}}$$

(7)

$$v = \sqrt{\frac{T}{m/L}} \quad f_n = nf_1 \quad v = \sqrt{\frac{E}{\rho}} \quad v = \sqrt{\frac{\gamma RT}{M}} \quad I(\text{dB}) = 10 \log \frac{I}{I_0}$$

$$\frac{f'}{f} = \frac{1 - (v_L - v_v)}{1 - (v_s - v_v)} \quad qV = \frac{1}{2} mv^2 \quad W = qV_{AB} \quad \rho = \frac{RA}{L}$$

$$F = \frac{kq_1q_2}{r^2} \quad \vec{E} = q\vec{E} \quad V_{AB} = Ed \quad C = \frac{\epsilon_0 A}{d} \quad \Delta R = R_0 \alpha \Delta T$$

$$F = BIL \sin \theta \quad qvB = \frac{mv^2}{r} \quad B = \mu_0 nI \quad B = \frac{\mu_0 I}{2\pi r} \quad B = \frac{\mu_0 I}{2a}$$

$$F = \frac{\mu_0 I_1 I_2 L}{2\pi b} \quad \text{torque} = (\text{area})NIB \sin \theta$$

$$\Phi = BA \cos \theta \quad \text{emf} = N \frac{\Delta \Phi}{\Delta t} \quad W = \frac{1}{2} LI_f^2 \quad v = v_0 \sin(2\pi ft)$$

$$I = \frac{i_0}{\sqrt{2}} \quad v = \frac{v_0}{\sqrt{2}} \quad V = IZ \quad X_C = \frac{1}{2\pi fC} \quad X_L = 2\pi fL$$

$$Z^2 = R^2 + (X_L - X_C)^2 \quad \tan \phi = \frac{X_L - X_C}{R} \quad f_0 = \frac{1}{2\pi} \sqrt{\frac{1}{LC}}$$

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \quad n_1 \sin \theta_1 = n_2 \sin \theta_2 \quad \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$M_o = i_o \left(\frac{1}{f_c} - \frac{1}{f_o} \right) \quad n\lambda = d \sin \theta_n \quad M = 1 + \frac{\gamma}{f}$$

**UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT**

UNIVERSITY EXAMINATIONS - 1994/95

**-P250-
Classical Mechanics**

TIME: THREE (3) HOURS

MAXIMUM MARKS: 100

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

YOU MAY NEED THE FOLLOWING:

$$\mathbf{v} = v\boldsymbol{\tau}; \quad \mathbf{a} = \dot{v}\boldsymbol{\tau} + \frac{v^2}{\rho}\mathbf{n}$$

$$\mathbf{a} = (\ddot{r} - r\dot{\theta}^2)\hat{\mathbf{r}} + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\hat{\boldsymbol{\theta}} + \ddot{z}\hat{\mathbf{z}}$$

$$c_1 = 1.55 \times 10^{-4}D; \quad c_2 = 0.22D^2$$

$$x(t) = Ae^{-\gamma t} \cos(\omega t - \phi)$$

$$r = r_0 \frac{1+e}{1+e \cos \theta}$$

$$\int \sec^4 \theta d\theta = \frac{\tan \theta}{3}(2 + \sec^2 \theta) + C$$

$$\frac{d}{dt} \frac{\partial L}{\partial \dot{q}} = \frac{\partial L}{\partial q}; \quad \frac{\partial H}{\partial p} = \dot{q}; \quad \frac{\partial H}{\partial q} = -\dot{p}$$

$$x' = \frac{x - Vt}{\sqrt{1 - V^2/c^2}}; \quad t' = \frac{t - Vx/c^2}{\sqrt{1 - V^2/c^2}}$$

$$m = \frac{m_0}{\sqrt{1 - v^2/c^2}}; \quad v'_x = \frac{v_x - V}{1 - Vv_x/c^2}$$

$$g = 9.8 \text{ m/s}^2$$

- Q1. (a). Consider a ball thrown vertically up. Taking air resistance into account, would you expect the time during which the ball rises to be longer or shorter than the time during which it falls? Explain. (3)

(b). A metal block of mass m slides on a horizontal surface which has been lubricated with a heavy oil such that the block suffers a viscous resistance that varies as

$$F(v) = -cv^{3/2}$$

If the initial speed of the block is v_0 at $x = 0$, show that the block cannot travel farther than $2mv_0^{1/2}/c$. (7)

(c). (i) Show that the terminal speed of a falling spherical object is given by

$$v_t = [(mg/c_2) + (c_1/2c_2)]^{1/2} - (c_1/2c_2)$$

where both the linear and the quadratic terms in the drag force are taken into account. (5)

(ii) Use the result to calculate the terminal speed of a soap bubble of mass 10^{-7} kg and diameter 10^{-2} m. Compare with the value obtained by using $v_t = (mg/c_1)^{1/2}$ - the result obtained when only the linear term in the drag force is considered - and comment on your results. (5)

- Q2. (a). (i) Define simple harmonic motion. (2)

(ii) Show that the equation

$$x = a\sin(\omega t + \epsilon)$$

represents such motion and explain the meaning of the symbols x , a , ω , and ϵ . (5)

(iii) Draw with respect to a common time axis graphs showing the variation with time of the displacement, velocity, and kinetic energy of a heavy particle that is describing such motion. (4)

(b). (i) Show that for the damped harmonic oscillator, the time rate of change of the total energy is equal to the product of the damping force and the velocity. (3)

(ii) A block of mass 1.5 kg hangs from a spring of force constant $k = 8.0$ N/m. The block is pulled down a distance of 12.0 cm and released. Assuming the resisting frictional force is given by $-b dx/dt$, where $b = 0.23$ kg/s, find the number of oscillations made by the block during the time interval for the amplitude to fall to one-third of its initial value. (6)

Q3. (a). Consider the two force functions;

(i) $\mathbf{F} = x \mathbf{i} + y \mathbf{j}$ (ii) $\mathbf{F} = y \mathbf{i} - x \mathbf{j}$

Verify that (i) is conservative and that (ii) is non-conservative by showing that the integral $\int \mathbf{F} \cdot d\mathbf{r}$ is independent of the path of integration for (i) but not for (ii), by taking two paths in which the starting point is the origin (0,0) and the end point is (1,1). For one path take the line $x = y$. For the other path, take the x-axis out to the point (1,0) and then the line $x = 1$ up to the point (1,1). (12)

(b). The potential energy corresponding to a certain 3-dimensional force field is given by

$$V(x, y, z) = \frac{1}{2}k(x^2 + y^2 + z^2).$$

(i) Derive the force vector at each point in terms of the coordinates (x, y, z) of the point. (3)

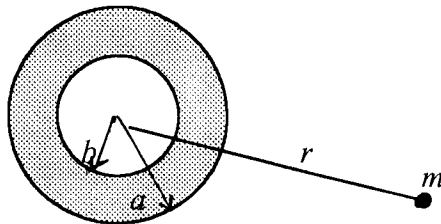
(ii) Derive the force vector at each point in terms of the spherical coordinates r, θ, ϕ of the point. (3)

(iii) Can you think of a physical model of such a force? (2)

Q4. (a). (i) Define gravitational field strength and gravitational potential, stating the relationship between them. (3)

(ii) Distinguish between the gravitational constant G and the acceleration due to gravity g . (3)

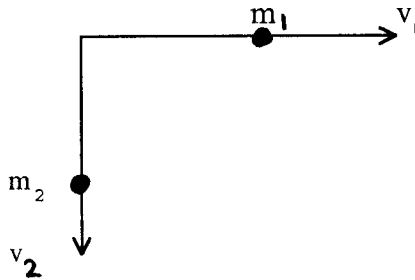
(b). A sphere of matter of mass M and radius a has a concentric cavity of radius b as shown in the figure below. (7)



Sketch the gravitational force F exerted by the sphere on a particle of mass m located a distance r from the center of the sphere as a function of r in the range $0 \leq r \leq \infty$, clearly showing the points $r = 0, b, a$, and ∞ . (7)

(c). How long will it take a comet, moving in a parabolic path, to move from its point of closest approach to the sun through an angle of 90° measured at the sun? Let the distance of closest approach to the sun be equal to the radius of the earth's orbit, r_e , assumed to be circular. (7)

- Q5. (a). Can a body have energy without having momentum? Explain. Can a body have momentum without having energy? Explain. (4)
- (b). A certain nucleus at rest disintegrates into three particles. Two of them are detected, with masses and velocities as shown in the figure below, where $m_1 = 17.0 \times 10^{-27} \text{ kg}$, $v_1 = 6.0 \times 10^6 \text{ m/s}$, $m_2 = 8.0 \times 10^{-27} \text{ kg}$ and $v_2 = 8.0 \times 10^6 \text{ m/s}$.



- (i) What is the momentum of the third particle of mass $m_3 = 12.0 \times 10^{-27} \text{ kg}$? (6)
- (ii) How much energy was involved in the disintegration process? (3)
- (c). Show that the kinetic energy of a two-particle system is given

$$T = \frac{1}{2}mv_{\text{cm}}^2 + \frac{1}{2}\mu v^2$$

where $m = m_1 + m_2$, v is the relative speed, and μ is the reduced mass. (7)

- Q6 (a). Describe how you would experimentally determine the moment of inertia of a rigid wheel about its usual axis of rotation. (6)
- (b). Show that the moment of inertia of a rectangular plate of sides a and b about an axis perpendicular to the plate through the center is

$$I = \frac{1}{12}M(a^2 + b^2)$$

where M = mass of the plate. (7)

- (c). A wheel is rotating with an angular speed of 800 rev/min on a shaft whose moment of inertia is negligible. A second wheel, initially at rest and with twice the moment of inertia of the first, is suddenly coupled to the same shaft.

- (i) What is the angular speed of the resulting combination? (4)
- (ii) Account for any changes in the kinetic energy of the system. (3)

Q7. (a). What do you understand by the terms

- (i) generalized coordinates, and (3)
(ii) generalized force? (3)

(b). Two books of equal mass m are connected by a flexible cord. One book is placed on a smooth horizontal table, the other book hangs over the edge. Find the acceleration of the system using Lagrangian mechanics assuming the mass of the cord is negligible. (7)

(c). Find the Hamilton canonical equations for a particle of mass m sliding down a smooth inclined plane, where the plane makes an angle θ with the horizontal. (7)

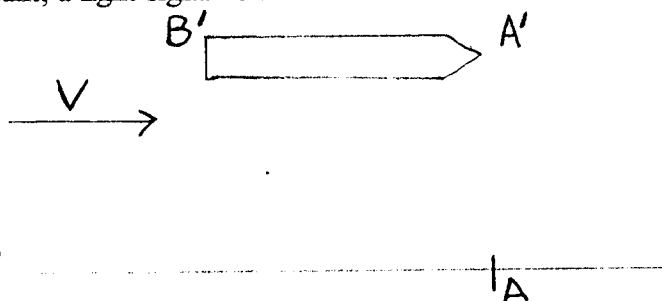
Q8. (a) State the two fundamental postulates on which the special theory of relativity is based. (2)

(b) Two neutrons A and B are approaching each other along a common straight line. Each neutron has a constant speed βc as measured in the laboratory, where c is the speed of light. Show that the total energy of neutron B as observed in the rest frame of neutron A is

$$E = \frac{1 + \beta^2}{1 - \beta^2} m_0 c^2$$

where m_0 is the rest mass of the neutron. (8)

(c) A rocketship of proper length l_0 travels at constant velocity v relative to a frame S (as shown in the figure below). The nose of the ship (A') passes the point A in S at time $t=t'=0$, and at this instant, a light signal is sent out from A' to B' .



(i) When by rocketship time t' does the signal reach the tail B' of the ship? (2)

(ii) At what time as measured in S does the tail of the ship pass the point A? (3)

(iii) Show that as measured in S, the signal reaches the tail of the ship at time

$$t = \left[\frac{1 - v/c}{1 + v/c} \right]^{1/2} \frac{l_0}{c}.$$

(5)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS
1994 / 95 ACADEMIC YEAR
COURSE CODE: P 260

ELECTRICITY AND MAGNETISM / ATOMIC PHYSICS

TIME ALLOWED : THREE (3) HOURS

INSTRUCTIONS: Answer any FIVE (5) questions only; at least TWO(2) from each section. All questions are of equal marks.

TOTAL MARKS : 100

The following data and formulas can be used where-ever necessary:

$$\text{speed of light } c = 3.0 \times 10^8 \text{ m/s}$$

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

$$\text{electronic charge } e = 1.6 \times 10^{-19} \text{ C}$$

$$\text{electronic mass } m_e = 9.1 \times 10^{-31} \text{ Kg}$$

$$1 \text{ atomic mass unit, } u = 931.3 \text{ MeV}$$

$$\text{Avogadro's constant } N_A = 6.02 \times 10^{23} / \text{mole}$$

$$\text{Planck's constant } h = 6.625 \times 10^{-34} \text{ Js}$$

$$\text{Photon energy } E = h\nu$$

$$1 \text{ Angstrom } 1 \text{ \AA} = 10^{-10} \text{ m}$$

$$e^x = 1 + x, \quad x \ll 1$$

$$I = I_0 (1 - e^{-t/\tau})$$

$$\cos^2(\theta) = \frac{\cos(2\theta) + 1}{2}$$

$$\text{Rayleigh - Jean's law} = I(\lambda)d\lambda = 8\pi kT \frac{d\lambda}{\lambda^4}$$

$$\text{Wien's formula} = I(\lambda)d\lambda = \frac{C_1 \lambda^{-5} d\lambda}{e^{C_2/\lambda T}}$$

SECTION A: ELECTROMAGNETISM

Q1 (a) If the net electric field at a point in space is zero, can we say that the net electric potential at the same point is also zero? Is the converse statement true? Give reasons for your answer. [6]

(b) A charge q is uniformly distributed on a ring of radius a . Derive an expression for the electric field, E for the points on the axis of the ring as a function of the distance x from the ring's centre. [8]

(c) Verify that the expression for E obtained in part (b) reduces to expected results for $x = 0$ and $x \gg a$. What is the physical meaning of these results? [6]

Q2 (a) A copper wire is specified to have a cross-sectional area of $2.082 \times 10^{-6} \text{ m}^2$. Find the magnitude of the drift velocity of the charge carriers when the wire is carrying a current of 15 A. [7]

Data: molar mass of copper = 63.5 gram/mole
density of copper = 8.9 gram/cm^3

(b) Find the magnitude of the internal electric field that drives the current in the wire cited in part (a) given that the resistivity of copper at room temperature $\rho_{20^\circ\text{C}} = 1.77 \times 10^{-8} \Omega\text{m}$ [4]

(c) The circuit illustrated below is called the potentiometer.

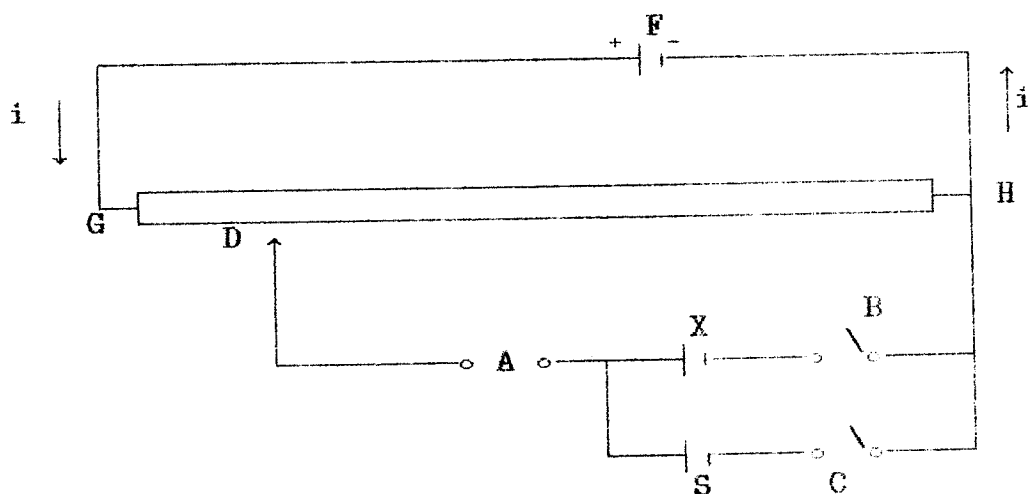


Figure 1.

(2)

A steady current i supplied by an auxiliary battery E flows in a uniform wire GH . The battery labelled X whose emf is to be determined is compared with S a standard battery of known emf. Switch C is opened and B is closed. The pointer D is then slid along GH until ammeter A reads zero. The length L_x between balance point and H , is then noted. B is now opened and C is closed. A new position is found to give a zero reading and the length L_s between the new balance point and H is measured.

- (i) If the resistance per unit length of wire GH is λ , write the voltage equation for loop $DHBXD$ when ammeter A reads zero. [2]
- (ii) Do the same for loop $DHCSD$ when X is replaced by S (i.e when switch C is closed and B is open). [2]
- (iii) Write the equation for the calculation of the emf of battery X . [2]
- (iv) Why is the calculated value an emf and not a terminal voltage [3]

Q3 (a) The statement $\int_{CS} \mathbf{B} \cdot d\mathbf{S} = 0$ is sometimes referred to as Gauss's law for magnetic fields. Compare and contrast this with the same law for electric fields defined as $\int_{CS} \mathbf{E} \cdot d\mathbf{S} = \frac{\sum q}{\epsilon_0}$. [4]

(b) A long straight thick walled metal tube has inner and outer radii of r_1 and r_2 respectively. A current I flows along it, the current density being the same every-where within the body of the tube.

- (i) Show that the magnetic field inside the body of the tube at distance r from its axis has the value given by

$$B = \frac{\mu_0 I}{2\pi r} \left(\frac{r^2 - r_1^2}{r_2^2 - r_1^2} \right) \quad [8]$$

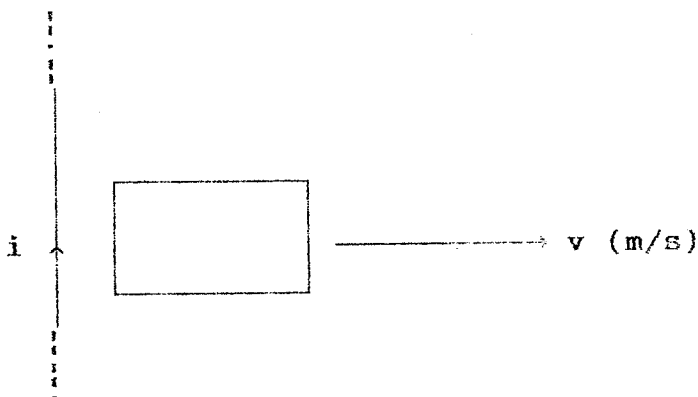
- (ii) Write expressions for B in the regions $0 < r < r_1$ and $r_2 < r$ [4]

- (iii) Make a sketch of B versus r for the region $0 < r < r_2$. [4]

(3)

- Q4 (a) The rectangular loop of wire shown below (see figure 2) is being pulled to the right, away from the long straight wire through which a steady current i flows upward. Does current in the loop flow in the clockwise or anti-clockwise sense ? Give reasons for your answer. [4]

Figure 2



- (b) The magnetic flux through the loop perpendicular to the plane of the coil and directed into the paper is varying according to the relation

$$\Phi_B = 6t^2 + 7t + 1 \quad \text{where } \Phi_B \text{ is in milliwebers and } t \text{ is in seconds.}$$

Find the induced emf in the loop when $t = 2.0$ secs. [4]

- (c) (i) The current in an LR circuit builds up to one third of its steady value in 5 seconds. What is the inductive time constant [5]

- (ii) What is meant by the term " root-mean-square " of an alternating voltage ? [2]

- (iii) For a sinusoidal voltage given by $V = V_0 \cos \omega t$, show that the root-mean-square (V_{rms}) of this voltage is given by [5]

$$V_{rms} = \frac{V_0}{\sqrt{2}} \quad \text{where } V_0 \text{ is the voltage amplitude}$$

END OF SECTION A

(4)

SECTION B: ATOMIC PHYSICS

Q5 (a) What do you understand by the term "ultra-violet catastrophe" as applied to black-body radiation ? [2]

(b) Planck's radiation law for the distribution of intensity of radiation in the spectrum of the black-body is stated as

$$I(\lambda)d\lambda = \frac{8\pi hc}{\lambda^5} \frac{d\lambda}{e^{hc/\lambda kT} - 1}$$

Show that this expression reduces to Rayleigh - Jean's law at long wave lengths and to wien's law at short wave-lengths.

[8]

(c) An experiment on the photoelectric effect of cesium gave the following results: stopping potentials for $\lambda = 4358$ and $\lambda = 5461 \text{ \AA}$ were 0.95V and 0.38 V respectively. From these data, find the Planck's constant h , the threshold frequency ν_0 , and the work-function of cesium. [10]

Q6 (a) Bohr's theory is a mixture of classical physics and the energy quantization ideas introduced by Planck. Infact, it is sometimes referred to as a semi-classical theory. Show that this is so by considering Bohr's second postulate and the centripetal force on the orbital electron in the hydrogen atom.

(b) (i) What is the essential difference between "ionization" and "excitation" potentials ? [6]
[4]

(ii) In sodium, the wave-length at which there is transition of an electron from the first excited state to the ground state is 5896 \AA . The ionization potential of sodium is 5.1 volts. According to the Franck-Hertz experiment, at what wavelengths should we expect drops in the current I_p ? [6]

(c) Calculate the de Broglie's wavelength associated with an electron moving with a kinetic energy of 10 eV. [4]

(5)

Q7 (a) Radio-carbon dating is a method that is used to determine the age of organic relics. Describe the natural physical processes that form the basis of this method. [8]

(b) An Archeologist finds a piece of wood in an excavated house which he knows to be of great antiquity. He brings the wood to you to examine. It is found to weigh 50 grams and shows C-14 activity of 320 disintegrations per minute. Estimate the length of time which has elapsed since the wood was part of a living tree, assuming that living plants show a C-14 activity of 12 disintegrations per minute per gram. Half-life of C-14 is 5730 years. [12]

Q8 (a) What are "nuclear reactions"? Discuss how these reactions differ from "chemical reactions" taking the following into account:

- (i) amount of energies involved;
- (ii) the particles involved; [9]
- (iii) atomic and nuclear changes involved.

(b) (i) Atomic and molecular reactions also involve binding energies. Why didn't the nineteenth century chemists observe mass deficiencies in these reactions? [4]

(ii) How much energy in MeV would have to be supplied to a nucleus of $^{52}_{24}\text{Cr}$ in order to split it into two identical fragments? [7]

The atomic mass of $^{52}_{24}\text{Cr}$ is 51.94051u

and that of $^{26}_{12}\text{Mg}$ is 25.9826u

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS-1995
P-302
(Computational Physics-I)

Time: Three Hours.

Max. Marks: 100

Answer: (i) Question One is Compulsory.

(ii) Any Three Questions from 2,3,4,5 and 6.

All Questions Carry Equal Marks.

(Marks are shown in the Square Brackets)

INSTRUCTION: Whenever necessary, use the information given in the Appendix.

Q.1. (A) Identify the errors if any in the following

[8]

- (i) NAME=UNZA\$
- (ii) DIM(5,6)
- (iii) DEF FNZ(Y)=X*X+2*X+1
- (iv) PRINT 'NAME OF THE SCHOOL'
- (v) IF (J=0) THEN
PRINT K
IF(K=0) THEN
PRINT J
ENDIF
- (vi) FOR L%=1 TO 10
P=P+1
FOR K%=5 to 10
X=X+1
NEXT L%
NEXT K%
- (vii) OPEN 'FILE1' FOR OUTPUT AS # 1
- (viii) READ#2,X,Y,A+B

(B) The following segment of the program is intended to calculate $N!$.

[2]

Does it achieve the intended purpose?

```
M=1
FOR I=1 TO N-1
M=M*I
NEXT
```


(C) Write a program to read and print [2]
 x_i and y_i for $i = 1, 2, \dots, 10$.

(D) Translate the following into BASIC expressions [3]

(i) $\frac{xy}{z+1}$ (ii) $(2-z)^{n+1}$ (iii) $(a^b)^c$

(E) Translate the following into BASIC using FOR loops [5]

(i) $S = \sum_{i=1}^{10} a_i x_i$

(ii) $C_{ij} = \sum_{k=1}^{10} a_{ik} b_{kj}$ for $i, j = 1, 2, \dots, 10$.

(F) Given a two dimensional array A of size 10 x 10 , write a sequence [5]
of statements in BASIC which could replace all except diagonal elements
by zeros.

Q.2. You are given an input file with the name XY.DAT containing the following [25]
data corresponding to variables (x_i, y_i) for $i = 1, 2, \dots, 5$. The data are
available in the data file as shown, the first column being for x_i and the
second for y_i .

0.1 , 0.5
0.2 , 0.7
0.3 , 0.95
0.45, 1.12
0.78, 2.14

Write a program

- (i) to read the given data from the input file,
- (ii) to write on an output file XY.OUT with headings X(I) and Y(I),
- (iii) to calculate following sums

$$\sum x_i, \sum x_i^2, \sum y_i, \sum y_i^2, \sum x_i y_i$$

and to write them into an output file.

(iv) to calculate the following sums so as to have reduced truncation errors

$$\sum \frac{1}{x_i}, \quad \sum \frac{1}{y_i}$$

Q.3. The major natural satellites of the first five planets from the sun are

[25]

Planet No.	Name	Name of Satellites (in order of increasing orbital radius)
1	Mercury	none
2	Venus	none
3	Earth	Moon
4	Mars	Phobos, Deimos
5	Jupiter	Io, Europa, Ganymede, Callisto

Write a program

- (i) that stores the above information in a suitable form in an input file,
- (ii) that lists all the satellites(if any) of a planet chosen by the user through the default input device,
- (iii) that displays the name of the planet, given the name of the satellite through the default input device.

Q.4. Suppose a body of mass m is travelling vertically upward starting at the surface $x = R$ of the earth, where R is the radius of the earth. If all resistance except gravity is neglected, then the escape velocity v is given by

[25]

$$v^2 = 2GR \int_1^{\infty} z^{-2} dz \quad \text{where } z = x/R$$

G = gravitational field strength = $6.672 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$

R = radius of the earth = $6.4 \times 10^6 \text{ m}$

Write a program

- (i) that calculates the escape velocity,
- (ii) that writes the output to an output file.

Hint: Change the variable z so as to make the integration range finite.

Q.5. The Van der Waals equation for an imperfect gas is given by

[25]

$$p = \frac{8t}{3v-1} - \frac{3}{v^2}$$

where $p = P/P_c$, $t = T/T_c$ and $v = V/V_c$.

Here P_c , T_c and V_c are values of pressure, temperature and volume respectively at the critical point.

For CO_2 ,

$$T_c = 304.26 \text{ K} , P_c = 7.40 \times 10^6 \text{ Pa} \text{ and } V_c = 2.02 \times 10^{-5} \text{ m}^3/\text{mole}$$

Write an algorithm in pseudo-code to compute enough values of p to plot four isotherms (p - v graph at constant temperature) at temperatures

$$t = 0.7 , 0.9 , 1.0 \text{ and } 1.2$$

$$v = \text{from } 0.5 \text{ to } 1.5 \text{ and } p = \text{from } 0 \text{ to } 1.5 .$$

Q.6. A body of mass m moves along the elliptical path given by

[25]

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 .$$

Assume that acceleration is parallel to the y -axis and the initial conditions at $t = 0$ are

$$x(t=0) = 0 , y(t=0) = b$$

and

$$\text{x-component of velocity } v_x(t=0) = \frac{v_0}{\sqrt{2}}$$

$$\text{y-component of velocity } v_y(t=0) = \frac{v_0}{\sqrt{2}} .$$

The force acting on the body at every point of the path is

$$F_x = 0 \quad , \quad F_y = \frac{m v_0^2 b^4}{a^2 y^3} \quad .$$

where F_x and F_y are x- and y- components respectively. This leads to the equation

$$\frac{dv_y}{dt} = \frac{v_0^2 b^4}{a^2 y^3}$$

Assume that a , b , v_0 and m are given and

$$x(t + \Delta t) = x(t) + v_x(t)\Delta t$$

$$y(t + \Delta t) = y(t) + v_y(t)\Delta t \quad .$$

Write an algorithm in pseudo-code

- (i) to find the velocity along the y-direction at
 $t = 0, 0.1, 0.2, \dots$ up to 1 second,
- (ii) to find the maximum velocity attained during the given period.

@@@ END OF EXAMINATION @@@

APPENDIX

1. Non-Linear Equations:

Newton-Raphson method:

$$x_n = x_{n-1} - \frac{f(x_{n-1})}{f'(x_{n-1})}$$

2. Integration:

(a) Trapezoidal Rule:

$$\int_a^b f(x) dx = 0.5 h \left[f(a) + f(b) + 2 \sum_{j=1}^{m-1} f(x_j) \right]$$

with $x_j = a + j h$ with $j = 1, 2, 3, \dots, m$.

(b) Simpson Rule:

$$\int_a^b f(x) dx = \frac{h}{3} [f(a) + f(b) + 4(f_1 + f_3 + f_5 + \dots + f_{2n-1}) + 2(f_2 + f_4 + f_6 + \dots + f_{2n})]$$

(c) Monte Carlo Method:

$$\int_a^b f(x) dx = \frac{(b-a)}{N} \sum_{i=1}^N f(x_i)$$

3. Solution of Differential Equation:

(a) First Order Differential equation with initial conditions:

$$\frac{dy}{dx} = f(x, y) .$$

Fourth Order RK-Method:

$$y_{i+1} = y_i + (k_1 + 2k_2 + 2k_3 + k_4)/6$$

where

$$k_1 = h f(x_i, y_i)$$

$$k_2 = h f(x_i + 0.5h, y_i + 0.5k_1)$$

$$k_3 = h f(x_i + 0.5h, y_i + 0.5k_2)$$

$$k_4 = h f(x_i + h, y_i + k_3)$$

(b) Second Order Differential Equation:

$$\frac{d^2y}{dx^2} + k^2(x)y = S(x)$$

Numerov Method:

$$\begin{aligned} & \left(1 + \frac{h^2}{12} k_{n+1}^2\right) y_{n+1} - 2 \left(1 - \frac{5h^2}{12} k_n^2\right) y_n + \left(1 + \frac{h^2}{12} k_{n-1}^2\right) y_{n-1} \\ & = \frac{h^2}{12} (S_{n+1} + 10S_n + S_{n-1}) \end{aligned}$$

.....@@@.....

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS 1994/5
P332
STATISTICAL PHYSICS AND THERMODYNAMICS

TIME: THREE HOURS

ANSWER: ANY FOUR QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

MAXIMUM MARKS 100

Useful information:

Stirling's formula: $\ln n! \approx n \ln n - n$

$$S = k \ln \Omega; \quad kT = \frac{1}{\beta}; \quad \beta = \frac{\partial \ln \Omega}{\partial E}$$

$$\int_{-\infty}^{\infty} e^{-\alpha x^2} dx = \sqrt{\frac{\pi}{\alpha}}$$

$$\int_0^{\infty} e^{-\alpha x^2} x dx = \frac{1}{2\alpha}$$

$$\int_0^{\infty} e^{-\alpha x^2} x^3 dx = \frac{1}{2\alpha^2}$$

$$C_v = \left(\frac{\partial \bar{E}}{\partial T} \right)_v = T \left(\frac{\partial S}{\partial T} \right)_v$$

The Maxwell relations:

$$\left(\frac{\partial T}{\partial V} \right)_s = - \left(\frac{\partial p}{\partial S} \right)_v; \quad \left(\frac{\partial T}{\partial p} \right)_s = \left(\frac{\partial V}{\partial S} \right)_p$$

$$\left(\frac{\partial S}{\partial V} \right)_T = \left(\frac{\partial p}{\partial T} \right)_v; \quad \left(\frac{\partial S}{\partial p} \right)_T = - \left(\frac{\partial V}{\partial T} \right)_p$$

The binomial distribution:

$$W(n) = \frac{N!}{n!(N-n)!} p^n (1-p)^{N-n}$$

1(a) A man is walking randomly in steps of equal length up and down a slope. Assuming that the motion of the man is one-dimensional, and that the probabilities of his taking a step down and up the slope are $3/4$ and $1/4$ respectively,

(i) what is the probability that his first five steps are all down the slope and the next five are all up the slope? (2)

(ii) What is the number of different ways in which he can order his steps so as to come back to the starting point after a total of 10 steps? (2)

(iii) What is the probability that he is found at the starting point after a total of 10 steps? (2)

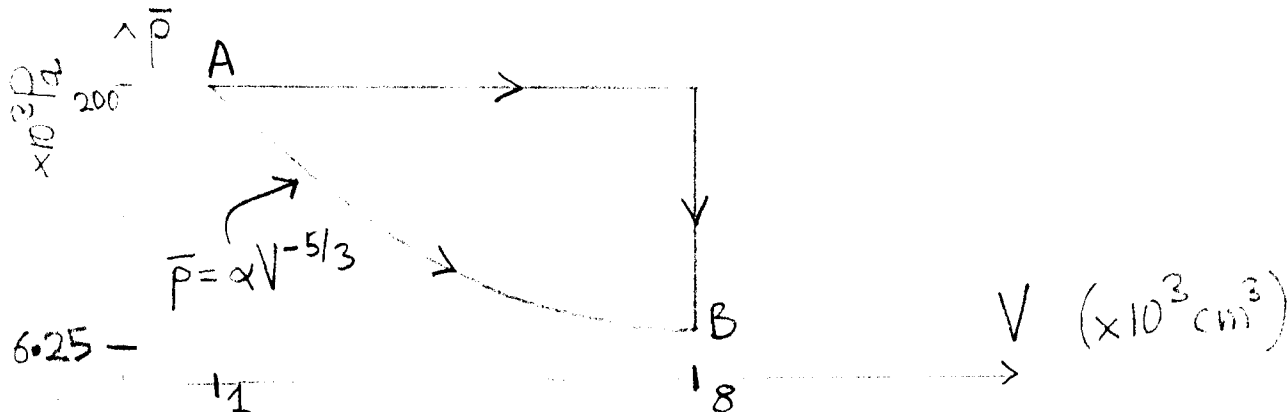
(iv) Calculate the expected position of the man after a total of 10 steps? (4)

(b)(i) Distinguish with examples the difference between a purely thermal and a purely mechanical interaction. (5)

(ii) In a quasi-static process $A \rightarrow B$ in which no heat is exchanged with the environment, the mean pressure of a certain amount of gas is found to change with volume according to the relation

$$\bar{p} = \alpha V^{-5/3}$$

where α is a constant. Find the quasi-static work done and the net heat absorbed by the system if the system is expanded to its final volume at constant pressure, and then the pressure reduced at constant volume to its final value, as illustrated in the diagram. (10)



2. Consider a system of N localised weakly interacting particles each of spin $1/2$ and magnetic moment μ located in an external magnetic field H . Consider the energy range between E and $E+\delta E$, where δE is small compared to E but is microscopically large, so that $\delta E \gg \mu H$.

(i) Show that the spacing of the energy levels of the system is $|dE| = 2\mu H$. (3)

(ii) Show that the total number of states $\Omega(E)$ lying in this energy range is

$$\Omega(E) = \frac{N!}{\left(\frac{N}{2} - \frac{E}{2\mu H}\right)! \left(\frac{N}{2} + \frac{E}{2\mu H}\right)!} \frac{\delta E}{dE} \quad (7)$$

(ii) Using Stirling's formula, show that

$$\ln \Omega(E) = N \ln N - \frac{N}{2} \ln \left(\frac{4N^2 \mu^2 H^2 - E^2}{4\mu^2 H^2} \right) + \frac{E}{2\mu H} \ln \left(\frac{2N\mu H - E}{2N\mu H + E} \right) + \ln \left(\frac{\delta E}{2\mu H} \right) \quad (6)$$

(iii) Show that the relation between the absolute temperature T and the total energy E of the system is

$$E = -N\mu H \tanh \left(\frac{\mu H}{kT} \right). \quad (6)$$

(iv) Show that the total magnetic moment of the system is

$$M = \mu N \tanh \left(\frac{\mu H}{kT} \right). \quad (3)$$

3(a) Two macroscopic systems A and A' with fixed volumes are in thermal contact and interacting weakly. The combined system A+A' is isolated and the total energy of the system is constant. Systems A and A' are in equilibrium with each other.

(i) Express the probability $P(E)$ of the system A having energy near E in terms of the number of states of the two systems. Show that the probability is maximum when the absolute temperature of the two systems is the same. (5)

(ii) Show that the condition for maximum probability is expressible as the condition that the total entropy is maximum. (3)

(b)(i) Using the first law of thermodynamics, show that

$$dH = Tds + Vdp$$

where $H=E+pV$ is the enthalpy. Describe one process in which the enthalpy is conserved. (5)

(c) (i) Starting from

$$dE = TdS - pdV,$$

show that for any substance

$$C_v = \left(\frac{\partial E}{\partial T} \right)_v$$

and

$$\left(\frac{\partial E}{\partial V} \right)_T = T \left(\frac{\partial p}{\partial T} \right)_v - p. \quad (5)$$

(ii) A van der Waals gas obeys the equation of state $(p + a/v^2)(v - b) = RT$, where $v = V/v$ is the molar volume and v is the number of moles. Show that its molar energy ϵ is given by

$$\epsilon = c_v T - a/v + \text{constant},$$

where c_v is the temperature-independent molar heat capacity. (7)

4(a)(i) What do you understand by the postulate of equal a priori probabilities? (2)

(ii) By considering a small system A in weak thermal interaction with a heat reservoir A', show that in equilibrium the probability of the system A being in a state r of energy E_r is given by

$$P_r = \frac{e^{-\beta E_r}}{\sum_r e^{-\beta E_r}}. \quad (10)$$

(b) A one-dimensional simple-harmonic oscillator has energy levels given by

$E_n = (n + \frac{1}{2}) \frac{h\omega}{2\pi}$, where ω is the characteristic (angular) frequency of the oscillator and where the quantum number n can assume the possible integral values $n=0,1,2,\dots$. Suppose that such an oscillator is in thermal contact with a heat reservoir at temperature T low enough so that $2\pi \frac{kT}{h\omega} \ll 1$,

(i) Find the ratio of the probability of the oscillator being in the first excited state to the probability of its being in the ground state. (3)

(ii) Assuming that only the ground state and the first excited state are appreciably occupied, find the mean energy of the oscillator as a function of the temperature T . (5)

(iii) Assuming that this oscillator is an atom in a solid, estimate its contribution to the heat capacity at constant volume. Obtain this heat capacity in the limit $2\pi \frac{kT}{h\omega} \ll 1$, and comment on it. (5)

5(a) According to Maxwell's velocity distribution, the mean number of molecules having their velocity components between v_x and $v_x + dv_x$, v_y and $v_y + dv_y$, and v_z and $v_z + dv_z$ is given by

$$f(\mathbf{v})dv_x dv_y dv_z = N \left(\frac{m}{2\pi kT} \right)^{3/2} \exp \left(-\frac{mv^2}{2kT} \right) dv_x dv_y dv_z$$

where the terms have their usual meaning.

(i) Obtain an expression for the mean number of particles having x component of velocity in the range between v_x and $v_x + dv_x$. (5)

(ii) Obtain an expression for the mean number of particles having their speed between v and $v+dv$. (5)

(iii) Calculate the average reciprocal speed $\overline{v^{-1}}$. (5)

(iv) Calculate the mean speed \bar{v} . (5)

(v) Show that the most probable speed of a molecule is $v_{\text{prob}} = \sqrt{\frac{2kT}{m}}$. (5)

6(a) Consider a system consisting of three indistinguishable particles each of which can be in any one of four quantum states of respective energies 0, E, 2E and 3E. The total energy of the system remains constant and is equal to 6E.

(i) Enumerate all the possible states of the system if it obeys

(1) Maxwell-Boltzmann statistics

(2) Bose-Einstein statistics

(3) Fermi-Dirac statistics (12)

(ii) For each type of statistics, find the probability

(1) that all the particles are found in the same state,

(2) that all the particles are found in different states. (5)

(b) The mean number of fermions in the quantum state s is given by the Fermi-Dirac distribution

$$\bar{n}_s = \frac{1}{\exp[\beta(\epsilon_s - \mu)] + 1}$$

where β , ϵ_s and μ have the usual meanings.

(i) Discuss how the occupancy \bar{n}_s varies with ϵ_s at low temperatures. What is the distribution at $T=0$? (8)

END OF P332 EXAMINATION

**THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATION - 1994/95**

**P340
(ELECTRONICS 1)**

TIME 3 HOURS

MAXIMUM MARKS 100

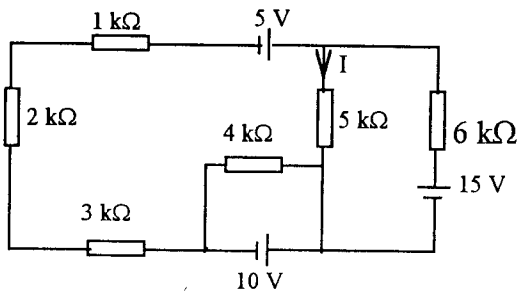
ANSWER 5 QUESTIONS

ANSWER AT LEAST ONE QUESTION FROM EACH SECTION

SECTION 1

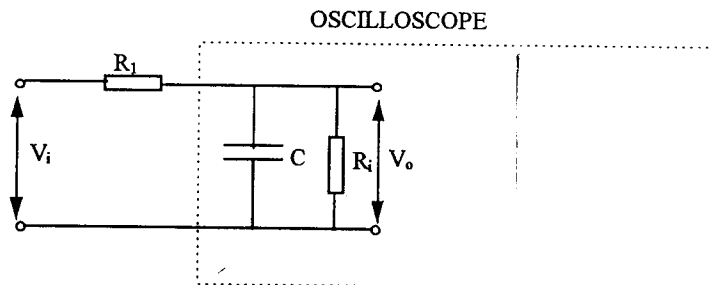
Q1. a) State Norton's theorem and show how a Norton equivalent circuit can be converted to a Thevenin equivalent circuit. [3]

- b)
- i) For the circuit below find the current I , using Thevenin's Law. [6]
 - ii) Confirm this result by finding the same current using the superposition principle. [6]
 - iii) If the resistor $R = 5\text{ k}\Omega$ was replaced by another resistor so as to achieve maximum power dissipation find the new value of the new resistor. What is the power dissipated in the new resistor. [5]



Q.2. i) Derive the complex form of the impedance of a capacitor. [2]

ii) From this show that the phase of an a.c. current through the capacitor always leads the phase of the voltage across it by $\pi/2$. [1]



The input impedance of the oscilloscope can be represented by a resistor in parallel with the capacitor as in the figure above. The value of C is given by the capacitance of the cable connected to the input. In order for a student to determine the input impedance, reductions in the input signals of d.c. and a.c. signals is measured.

Given that the data is

i) d.c. measurements

	$V_o(\text{without } R_1)$ volts	$V_o \text{ (with } R_1)$ volts
1	1.00	0.71
2	2.00	1.43

Table 1

ii) a.c. measurements

	Frequency kHz	V_o (without R_i) (RMS) volts	V_o (with R_i) (RMS) volts
1	10	1.00	0.70
2	100	1.00	0.62
3	1000	1.00	0.35

Table 2.

- From the above data determine the value of R_i . [1]
- Derive an expression for the transfer function of the input impedance with R_i included. [4]
- Using the transfer function determine the value of the capacitance at the frequencies given in table 2. [5]
- Derive an expression for the phase shift as a function of frequency. [3]
- Use this expression to determine the frequency when the imaginary term in the denominator of the transfer function is equal to the real term. Thus what is the Bandwidth of the oscilloscope? [3]
- What would be the ideal value of the R_i and C if an infinite bandwidth was to be achieved. [1]

Q.3. a) What is meant by the following terms?

- Intrinsic semiconductor [1]
- Extrinsic semiconductor [1]
- Doped semiconductor [1]
- Donor impurities [1]
- Depletion region of p-n junction [1]
- Space charge [1]

b) Explain briefly using the Energy Band diagrams the difference between an insulator, a semiconductor and a metal. [3]

c) i) Draw a schematic representation of a bridge rectifier circuit. [2]

ii) Explain briefly using voltage waveform diagrams how the circuit achieves rectification. [3]

iii) If a capacitor is placed across the load resistance sketch the waveform that appears across the capacitor. [2]

iv) If a 10V, 50 Hz peak to peak a.c. voltage is to be used at the input determine the capacitance needed to achieve a 0.1V ripple if a load resistance of 100 k Ω is used. [4]

SECTION 2

Q.4. Distinguish between,

- Active Region, Saturated region and cut off regions of the characteristics of an n-p-n transistor. [2]

ii) Minority and majority carriers in a transistors.

[2]

a) Determine whether the n-p-n transistor in the circuit below (figure 4a) is operating in the saturated or active regions. Thus find transistor currents I_b and I_c .

[8]

Assume that $V_{ce(sat)} = 0.2\text{V}$, $V_{be(\text{forward bias})} = 0.7\text{V}$.

b) Repeat part a) if a $2\text{ k}\Omega$ emitter resistor is added to the circuit as in figure 4b.

[8]

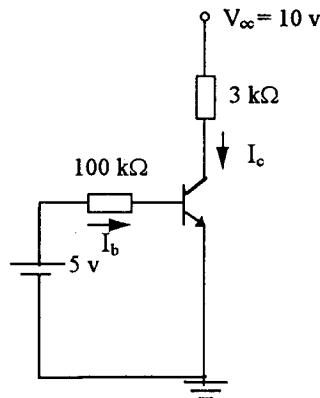


figure 4a

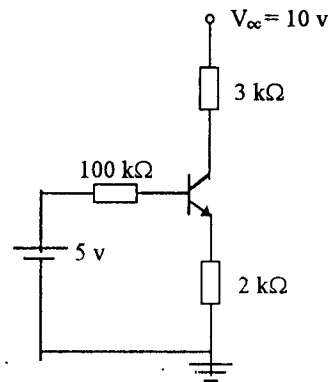
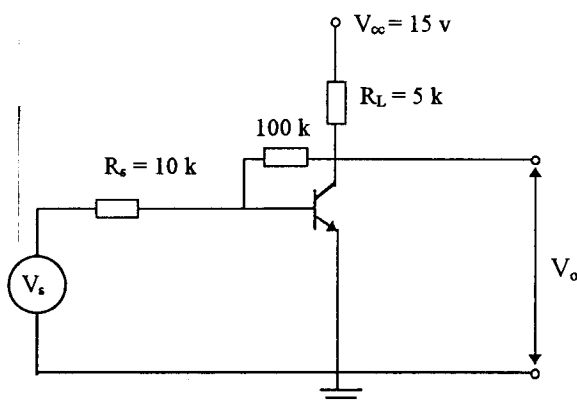


figure 4b

Q 5. The transistor used in the amplifier circuit shown below has the following hybrid parameters:

$$h_{ie} = 1\text{ k}\Omega; h_{re} = 0; h_{fe} = 100; h_{oe} = 0.$$



a) Determine the quiescent point of the amplifier.

[4]

b) Draw the equivalent circuit of the amplifier using the hybrid model of the transistor.

[4]

c) Calculate the voltage gain of the amplifier in dB.

[7]

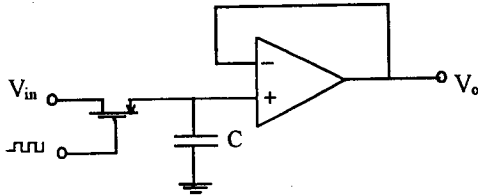
d) What is the maximum amplitude of V_s such that V_o is not distorted?

[5]

SECTION 3

Q.6. What is the effect of putting a feedback resistor in an op-amp amplification circuit on the Bandwidth of the amplifier. (Draw bode diagram) [2]

- a) Draw the circuit of a logarithmic amplifier using a diode. Derive the expression for V_o as a function of V_{in} . [6]
 b) Explain briefly how the sample and hold circuit below functions. [6]



c) Draw a summing amplifier using an op-amp and derive the output voltage as function of the input voltages. [6]

Q.7. a) Convert the decimal number 27.375 into a binary number. [2]

b) Use the two's complement method to subtract the binary equivalent of 13 (decimal) from 18 (decimal). [3]

c) Show that
 $(A + B + C) \cdot (A + B + \bar{C}) \cdot (\bar{A} + B + \bar{C}) = \bar{A} \cdot \bar{B} + B \cdot C$ [4]
 $A + \bar{A} \cdot B + \bar{A} \cdot \bar{B} \cdot C = A + B + C$

d) Show that a three gate implementation of the two input Exclusive-Or function is possible. [4]

e) A voting system is to be utilised by a three judge tribunal. The system is such that if 2 or more judges proclaim the defendant guilty then the verdict is "guilty", otherwise the verdict is "not guilty". If the verdict is to be electronic displayed, with the judges simply pressing the guilty (1) or not guilty (0) buttons in front of them, design a logic circuit that will display the result. [7]

Q.8. i) What is meant by the term "race around condition" in R-S flip flops. [1]

ii) How is this condition remedied using the J-K master slave flip flop. [3]

a) i) Draw a schematic diagram of a 4-bit S-R synchronous shift register. [4]

ii) Explain briefly how the Shift register performs,

- 1) Serial to parallel conversion [3]
- 2) Parallel to serial conversion [3]
- 3) Parallel to parallel conversion [3]
- 4) Ring counting [3]

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - 1994/1995

P421

Solid State Physics I

TIME: THREE HOURS
ATTEMPT: ANY FOUR QUESTIONS
(All Questions Carry Equal Marks)

Maximum marks: 100

Use the following wherever necessary:

Magnitude of electronic charge, $e = 1.60 \times 10^{-19}$ C
Electron rest mass, $m = 9.11 \times 10^{-31}$ kg
Reduced Planck's constant, $\hbar = 1.05 \times 10^{-34}$ J s
Boltzman constant, $k_B = 1.38 \times 10^{-23}$ J K⁻¹
Avogadro's number $N_A = 6.02 \times 10^{26}$ per kg mole
Permittivity of free space, $\epsilon_0 = 8.85 \times 10^{-12}$ F m⁻¹
1eV = 1.60×10^{-19} J

$$\int_{-\infty}^{\infty} \frac{x^2 e^x dx}{(e^x + 1)^2} = \frac{\pi^2}{3}$$

$$\int_0^{\theta_D/T} \frac{x^3 dx}{(e^x - 1)} = \frac{1}{4} \int_0^{\theta_D/T} \frac{x^4 e^x dx}{(e^x - 1)^2} = \frac{\pi^4}{15} \quad \text{at low temperatures}$$

$$= \frac{1}{3} \left(\frac{\theta_D}{T} \right) \quad \text{at high temperatures}$$

1. (a) Explain briefly what you understand by the following:

- (i) Lattice (2 marks)
- (ii) Basis (2 marks)
- (iii) Crystal structure (2 marks)
- (iv) Primitive cell (3 marks)
- (v) Miller indices (3 marks)

(b) Show two ways of arranging equal spheres into closed-packed structures that minimise interstitial volume. (7 marks)

(c) Determine what fraction of space is not occupied by atoms in a face-centred cubic crystal. Treat the atoms located at lattice points as hard spheres that are touching each other. (6 marks)

2 (a) State the four main types of interactions found in ionic crystals. (4 marks)

The interaction energy between two ions i and j in a crystal consisting of ions of charge Z_1e and Z_2e , respectively, separated by distance $r_{ij} = r\delta_{ij}$, where r is the nearest-neighbour distance, is given by

$$U_{ij} = \pm \frac{Z_1 Z_2 e^2}{4\pi\epsilon_0 r_{ij}} + be^{-\frac{r}{\rho}}$$

where the symbols have their usual meaning and b and ρ are constants.

(b) What is the interaction energy of the i -th ion with the other ions? (8 marks)

(c) (i) Find the cohesive energy of the crystal consisting of N ion pairs as a function of the equilibrium separation of the ions r_0 . (8 marks)

(ii) Calculate the cohesive energy, in eV, of an NaCl crystal per ion pair given that

Madelung constant, $\alpha = 1.8$, $Z_1 = Z_2 = 1$, $r_0 = 2.8 \text{ \AA}$, $\frac{r_0}{\rho} = 10$ (5 marks)

3. Consider a linear chain of atoms in which alternate atoms have mass m_1 and m_2 and only nearest neighbours interact with force constant β .

(a) Show that the dispersion relation for the normal mode is

$$\omega^2 = \frac{\beta(m_1 + m_2)}{m_1 m_2} \pm \frac{\beta(m_1^2 + m_2^2 + 2m_1 m_2 \cos ka)^{\frac{1}{2}}}{m_1 m_2} \quad (10 \text{ marks})$$

(Q. 3, Continued)

where k is the magnitude of the wavevector and a is the lattice parameter.

(b) Examine the limiting cases $ka \ll 1$ and $ka = \pm\pi$ and then sketch the dependence of ω on k for $m_1 > m_2$. (8 marks)

(c) Show how the dispersion relation in (b) above differs from that of a monatomic chain. (7 marks)

4. In the Debye approximation the density of states for each polarisation is given by

$$D(\omega) = \frac{V\omega^2}{2\pi^2 v_s^3}$$

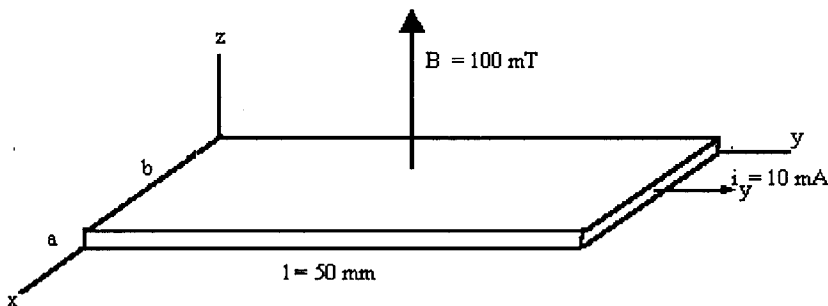
in the usual notation.

(a) Use this to obtain an expression for the heat capacity of solids. (5 marks)

(b) Show that at low temperatures the heat capacity is proportional to T^3 . (12 marks)

(c) Show that at high temperatures the Debye theory gives the Dulong-Petit value. (8 marks)

5. A copper sheet has dimensions $l = 50\text{mm}$, $b = 20\text{mm}$ and $a = 0.25\text{mm}$ as shown in the following diagram.



If an electric current $i_y = 10\text{mA}$ flows through the specimen, potential differences $V_y = 1.7\mu\text{V}$ and $V_x = 0$ are set up. If in addition a magnetic field $B = 100\text{mT}$ is applied along the z -direction, the potential difference, V_x , is increased to 0.5mV .

(Q. 5, Continued)

Calculate :

- (a) the Hall coefficient. (7 marks)
- (b) the electron concentration (5 marks)
- (c) the electrical conductivity (6 marks)
- (d) the electron mobility. (7 marks)

6. The concentration of electrons and holes in the conduction band are given, respectively, by

$$n = 2 \left(\frac{m_e k_B T}{2\pi\hbar^2} \right)^{\frac{3}{2}} e^{\frac{(\mu - E_g)}{k_B T}}$$

and,

$$p = 2 \left(\frac{m_h k_B T}{2\pi\hbar^2} \right)^{\frac{3}{2}} e^{-\frac{\mu}{k_B T}}$$

where m_e and m_h are the effective masses of the electrons and holes, respectively, μ is the chemical potential and E_g is the band gap.

(a) Show that the product np is independent of the Fermi level, μ .

Is the result applicable to both intrinsic and extrinsic semiconductors? Explain.

(8 marks)

(b) Show that the Fermi level of an intrinsic semiconductor is given by

$$\mu = \frac{1}{2} E_g + \frac{3}{4} k_B T \ln \left(\frac{m_h}{m_e} \right)$$

(12 marks)

(c) State the conditions that result in $\mu = \frac{1}{2} E_g$.

(5 marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS - 1994/1995
PHYSICS OF RENEWABLE ENERGY RESOURCES AND ENVIRONMENT
P485

TIME: 3 HOURS

MAX MARKS: 100

ATTEMPT ANY **FOUR** QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

You may use the following information:

Boltzman constant $k = 1.38 \times 10^{-23} \text{ JK}^{-1}$
Gas constant $R = 8314 \text{ J/kmol.K}$
1 electron volt $= 1.6 \times 10^{-19} \text{ J}$
Stefan's constant $\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4$
Sun's radius $R_s = 6.96 \times 10^8 \text{ m}$
Mean Earth-Sun distance $r_0 = 1.496 \times 10^{11} \text{ m}$
Solar constant $I_{sc} = 1367 \text{ Wm}^{-2}$
Earth's radius $R_e = 6.37 \times 10^6 \text{ m}$

In usual notation

$$E_0 = \left(\frac{r_0}{r} \right)^2 = 1 + 0.033 \cos \left(\frac{360 d_n}{365} \right)$$

$$\delta = 23.45 \sin \left[\frac{360}{365} (d_n + 284) \right]$$

$$\cos \theta_z = \sin \delta \sin \phi + \cos \delta \cos \phi \cos \omega$$

$$\cos \psi = \frac{\sin \alpha \sin \phi - \sin \delta}{\cos \alpha \cos \phi}$$

$$\omega_s = \cos^{-1}(-\tan \phi \tan \delta)$$

$$\text{Solar time} = \text{clock time} + 4(L_l - L_s) + \text{EOT}$$

$$\begin{aligned} \cos \theta &= (\sin \phi \cos \beta - \cos \phi \sin \beta \cos \gamma) \sin \delta \\ &+ (\cos \phi \cos \beta + \sin \phi \sin \beta \cos \gamma) \cos \delta \cos \omega \\ &+ \cos \delta \sin \beta \sin \gamma \sin \omega \end{aligned}$$

$$\lambda_{\max} T = 2898 \mu\text{m}\cdot\text{T}$$

The emissive power of a black body $B_\lambda(T)$ (in W/m^2 per unit wavelength range) is

$$B_\lambda(T) = \frac{2\pi h c^2}{\lambda^5 \left(e^{\frac{hc}{\lambda kT}} - 1 \right)}$$

Reflectance at normal incidence is given by

$$r = \left(\frac{n_r - n_i}{n_r + n_i} \right)^2$$

Reflectance at normal incidence for light of wavelength λ at an anti-reflecting coating which is designed for wavelength λ_0 is given by

$$r_\lambda = \frac{2p (1 + \cos \beta_\lambda)}{1 + 2p \cos \beta_\lambda + p^2}$$

$$\text{where } p = \left(\frac{n_f - 1}{n_f + 1} \right)^2; \quad \beta_\lambda = \frac{\pi \lambda_0}{\lambda}$$

Fresnel's equations

$$r_{\parallel} = \left[\frac{n_r^2 \cos \theta_i - n_i \sqrt{n_r^2 - n_i^2 \sin^2 \theta_i}}{n_r^2 \cos \theta_i + n_i \sqrt{n_r^2 - n_i^2 \sin^2 \theta_i}} \right]^2$$

$$r_{\perp} = \left[\frac{n_i \cos \theta_i - \sqrt{n_r^2 - n_i^2 \sin^2 \theta_i}}{n_i \cos \theta_i + \sqrt{n_r^2 - n_i^2 \sin^2 \theta_i}} \right]^2$$

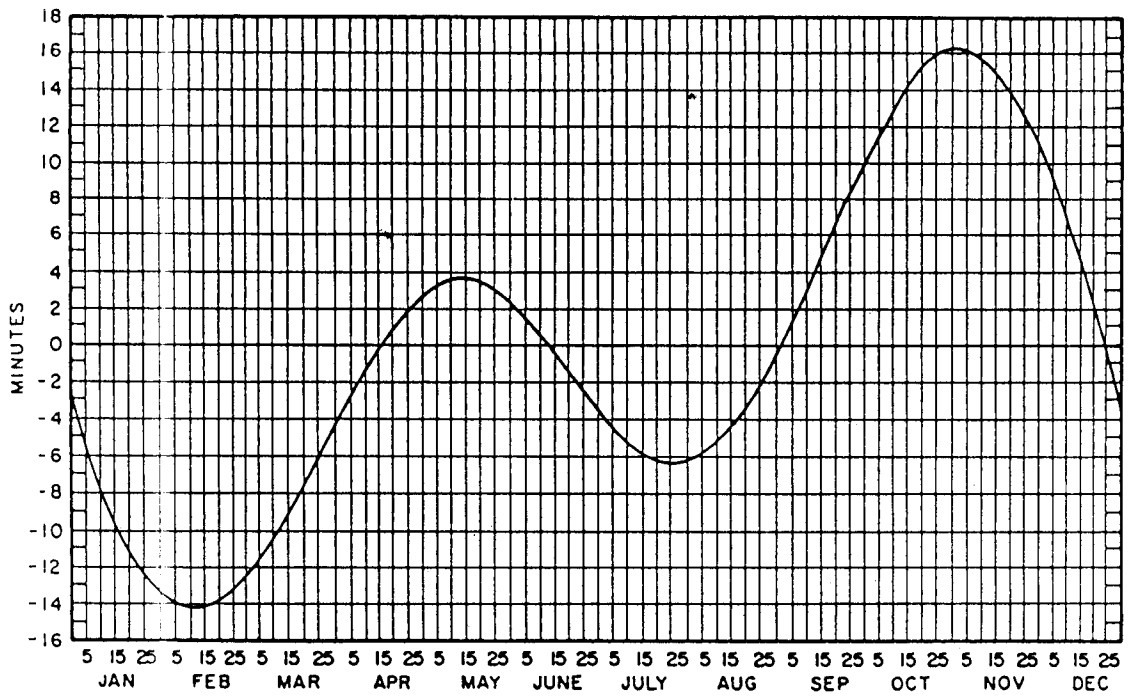
Carrier concentration for intrinsic semiconductor is

$$n_i = p_i = AT^{3/2} e^{-\frac{\epsilon_b}{2kT}}$$

Table for the function $f(x) = f(\lambda T)$

$x(\mu\text{ m-K})$	$f(x)$	$x(\mu\text{ m-K})$	$f(x)$	$x(\mu\text{ m-K})$	$f(x)$
1100	0.001	4600	0.580	8100	0.860
1200	0.002	4700	0.594	8200	0.864
1300	0.004	4800	0.608	8300	0.868
1400	0.008	4900	0.621	8400	0.871
1500	0.013	5000	0.634	8500	0.875
1600	0.020	5100	0.646	8600	0.878
1700	0.029	5200	0.658	8700	0.881
1800	0.040	5300	0.669	8800	0.884
1900	0.052	5400	0.680	8900	0.887
2000	0.067	5500	0.691	9000	0.890
2100	0.083	5600	0.701	9100	0.893
2200	0.101	5700	0.711	9200	0.895
2300	0.120	5800	0.720	9300	0.898
2400	0.140	5900	0.730	9400	0.901
2500	0.161	6000	0.738	9500	0.903
2600	0.183	6100	0.746	9600	0.905
2700	0.205	6200	0.754	9700	0.908
2800	0.228	6300	0.762	9800	0.910
2900	0.251	6400	0.770	9900	0.912
3000	0.273	6500	0.776	10000	0.914
3100	0.296	6600	0.783	11000	0.932
3200	0.318	6700	0.790	12000	0.945
3300	0.340	6800	0.796	13000	0.955
3400	0.362	6900	0.802	14000	0.963
3500	0.383	7000	0.808	15000	0.969
3600	0.404	7100	0.814	16000	0.974
3700	0.424	7200	0.819	17000	0.978
3800	0.443	7300	0.824	18000	0.981
3900	0.462	7400	0.830	19000	0.983
4000	0.483	7500	0.834	20000	0.986
4100	0.499	7600	0.840	30000	0.995
4200	0.516	7700	0.844	40000	0.998
4300	0.533	7800	0.848	50000	0.999
4400	0.549	7900	0.852		
4500	0.564	8000	0.856		

Yearly variation of the equation of time



Q.1 A solar panel with tilt $\beta = 20^\circ$ and $\gamma = 180^\circ$ is situated in Livingstone (Latitude = $17^\circ 49' \text{ S}$, Longitude = $25^\circ 49' \text{ E}$). The optical thickness of the atmosphere is $\tau = 2.0$ for the wavelength band 1.0 to $3.0 \mu\text{m}$ and $\tau = 0.2$ otherwise. Assuming the Sun to be a black body at temperature 6000 K and the standard meridian for Livingstone to be 30° , find the following at 11.00 a.m. clock time on 5 February.

- (i) solar declination (2 marks)
- (ii) solar time (4 marks)
- (iii) hour angle (2 marks)
- (iv) solar zenith angle (5 marks)
- (v) angle made by the direct beam with the normal to the inclined plane (5 marks)
- (vi) direct flux incident on the panel (7 marks)

Q.2 (a) Briefly describe the physical principles underlying the Greenhouse Effect. Distinguish between natural and "enhanced" Greenhouse Effect on our Earth. Which atmospheric gases play major roles in causing the Greenhouse Effect? Discuss the possible implications of Climate Change due to "enhanced" Greenhouse Effect, with particular reference to Zambia. What are the principal causes of the "enhanced" Greenhouse Effect and the practical measures necessary to check it? (15 marks)

(b) (i) Assuming that

the earth is a black body,
the reflectivity of the earth-atmosphere system is 0.30, and
the atmosphere does not absorb any radiation,

use the zero-dimensional model to calculate the earth's equilibrium temperature. (7 marks)

(ii) If some of the polar ice melts so as to decrease the reflectivity from 0.3 to 0.28, what will be the change in the equilibrium temperature? (3 marks)

Q.3 Assuming the air behaves as an ideal gas and is in hydrostatic equilibrium

(a) Obtain an expression for the density profile of the atmosphere. Assuming that the temperature does not change with height, obtain an expression for the density profile of an exponential atmosphere. (6+2 marks)

- (b) What do you understand by the scale height of an exponential atmosphere? Show that if the entire atmosphere were redistributed with a uniform density equal to its sea level value, it would extend only as high as the scale height. (2+4 marks)

- (c) Using the equation in (a) show that the density profile of an atmosphere with a temperature profile $T = T_0 - L Z$ is given by

$$\rho = \frac{\rho_0}{1 - \beta Z} \exp\left[\frac{\ln(1 - \beta Z)}{\beta H}\right] \quad \text{where } \beta = \frac{L}{T_0} ; H = \frac{RT_0}{Mg} .$$

(6 marks)

- (d) Using the expression in (c) above, find the density at an altitude of 10 km, given $T_0 = 300 \text{ K}$, $\rho_0 = 1.29 \text{ kg m}^{-3}$ and $L = 6 \text{ K/km}$. (5 marks)

- Q.4. (a) Use the law of heat conduction to show that under steady state the heat transfer coefficient per unit length for conduction between long concentric cylinders is given by

$$U_L = \frac{\dot{Q}}{L(T_1 - T_2)} = \frac{2\pi K}{\ln(r_2/r_1)} .$$

Hence show that for a long composite cylindrical shell consisting of n concentric layers, the overall heat transfer coefficient is given by

$$\frac{1}{U_L} = \frac{1}{U_{L1}} + \frac{1}{U_{L2}} + \dots + \frac{1}{U_{Ln}} .$$

(15 marks)

- (b) A 3m long plastic pipe ($K = 0.7 \text{ W/m } ^\circ\text{C}$) is carrying water at 70°C from a solar heating panel to a storage. The inner and outer radii are 1cm and 1.5cm, respectively. The pipe is wrapped with cylindrical sponge ($K_s = 0.05 \text{ W/m } ^\circ\text{C}$) insulation up to a radius of 3 cm. If the outer surface of the insulation is at 20°C , calculate the heat conduction rate from the pipe to the surroundings. (10 marks)

- Q.5 (a) Obtain the conditions of anti-reflecting coatings for normal incidence. (7 marks)

- (b) A glazing of index $n = 1.6$ is coated with a film to make it anti-reflective at normal incidence.

- (i) What should the film index be? (2 marks)
- (ii) What should its minimum thickness be if it is to produce zero reflection at $\lambda_0 = 600 \text{ nm}$? (4 marks)
- (iii) What will the surface reflection coefficient be for light of wavelength 400 nm at normal incidence? (5 marks)
- (c) (i) Show a qualitative plot of the emissivity/absorptivity vs wavelength for a non-selective, real selective and an ideally selective surface. (3 marks)
- (ii) A non-selective surface is exposed to an incident flux of solar constant. Neglecting back losses and convection losses, find the steady-state temperature of the surface. (4 marks)

The absolute thermoelectric power of two materials (A and B) varies with temperature as $\varepsilon_A = 6 \times 10^{-9} T$ and $\varepsilon_B = 4 \times 10^{-9} T$ where T is in Kelvin and ε_A and ε_B are in volts/Kelvin. The materials are joined to form a thermocouple whose hot and cold junctions are maintained at 300 and 10°C, respectively. The materials have a negligible electrical resistivity and thermal conductivity.

- (i) Find the emf produced by the thermocouple. (5 marks)
- (ii) If a current of $I = 0.5 \text{ A}$ is supplied to an external electrical device, find the power produced. (3 marks)
- (iii) Find the Peltier heat rates absorbed and rejected in materials A and B. (5 marks)
- (iv) Find the Thomson heat rates absorbed and rejected in materials A and B (5 marks)
- (v) Verify that the difference between the heat rates absorbed and those rejected is equal to the power produced in (ii). (3 marks)
- (vi) Find the efficiency of the system and compare it with a Carnot system operating between the same two temperatures. (4 marks)

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

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