

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATION - NOVEMBER/DECEMBER 1994
SCHOOL OF NATURAL SCIENCES

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BZ 110

INTRODUCTORY BIOLOGY THEORY

TIME: THREE HOURS

INSTRUCTIONS:

ANSWER: ALL QUESTION IN ANY ORDER

MARKS: ALL QUESTIONS CARRY EQUAL MARKS
CORRECT = 4 INCORRECT = -1 I DON'T KNOW = 0

NOTE: DEPOSIT THE QUESTION PAPER WITH THE EXAMINER.

CELL BIOLOGY

1. The first primitive cell was a

- (a) heterotrophic anaerobe
- (b) cell capable of carrying out photosynthesis
- (c) nitrogen fixer
- (d) heterotrophic fermenter
- (e) parasite in its nature of nutrition
- (f) I don't know

2. A repeat of the phenomenon which brought about life on earth is unlikely to occur again. This is because:

- (a) There are smaller quantities of the primitive gases in the atmosphere today
- (b) There is too much pollution in the environment in the present atmosphere
- (c) The chemical properties of water have drastically changed over the years.
- (d) the present atmosphere is an oxidizing one, and therefore organic molecules would get destroyed as soon as they formed
- (f) I don't know

The planet earth formed about

- (a) 20 million years ago
- (b) 30 million years ago
- (c) 8 million years ago
- (d) 15 billion years ago
- (e) 5 billion years ago
- (f) I don't know

The linkage of water molecules which makes it possible to make it a liquid at ordinary temperature and pressure is the formation of loose linkages between

- (a) Oxygen atoms
- (b) Hydrogen atoms
- (c) Oxygen and hydrogen atoms of different water molecules
- (d) dissolved ions in water
- (e) Oxygen and hydrogen atoms of the same water molecule
- (f) I don't know

Which of the following statements is correct

- (a) All carbohydrates are ketones or aldehydes and they contain several hydroxyl groups.
- (b) Carbohydrates have the general formula $C_n(H_2O)_n$.
- (c) Carbohydrates do not give off water when heated.
- (d) Carbohydrates are divided into two main classes of monosaccharides and polysaccharides.
- (e) All carbohydrates are reducing sugars.
- (f) I don't know.

When two glucose molecules combine, they normally form a disaccharide. Which one is this?

- (a) sucrose
- (b) maltose
- (c) lactose
- (d) amylase
- (e) maltase
- (f) I don't know

4. Identify the carbohydrate which is sweet, and can be translocated as a source of energy in an organism, and on hydrolysis it yields glucose and fructose molecules.

- (a) maltose
- (b) galactose
- (c) fructose
- (d) lactose
- (e) sucrose
- (f) I don't know

8. Which of the following statements is correct?

- (a) All reducing sugars are monosaccharides
- (b) Some polysaccharides are sweet
- (c) Among the disaccharides, some are reducing agents while others are not
- (d) All polysaccharides are disaccharides
- (e) All the disaccharides are non-reducing agents
- (f) I don't know

9. How many hydrogen atoms are contained in a dipeptide molecule?

- (a) four
- (b) two
- (c) eight
- (d) five
- (e) six
- (f) I don't know

10. Some bacterial cells bind firmly to dyes such as gentian violet. Such cells are said to be gram-positive. These cells are able to take the stain because ...

- (a) they lack a cell wall
- (b) they have a cell membrane which is stain positive
- (c) they lack the lipoprotein and lipopolysaccharide layers of the cell wall
- (d) they lack a peptidoglycan layer of the cell wall
- (e) their entire cell wall structure is gram positive
- (f) I don't know

11. The nucleus is in direct communication with the cytoplasm through special openings called ...

- (a) tubes
- (b) plasmamembrane
- (c) granules
- (d) nuclear pores
- (e) fibrils
- (f) I don't know

12. Two organelles in a cell share the responsibility of transporting and packaging organic molecules. These organelles are:
- (a) ribosomes and lysosome
 - (b) golgi bodies and endoplasmic reticulum
 - (c) vesicles and mitochondria
 - (d) the endoplasmic reticulum does both jobs
 - (e) the nucleus and its nucleolus
 - (f) I don't know
13. The chloroplast is the general site for photosynthesis. But the actual location of its activity is in the....
- (a) lumen of the thylakoid
 - (b) stroma
 - (c) thylakoid membrane
 - (d) whole chloroplast
 - (e) mitochondrial membrane
 - (f) I don't know
14. The by products of glycolysis (CO_2 and H_2O) are most likely to be found in
- (a) chloroplasts
 - (b) the golgi complex
 - (c) the rough endoplasmic reticulum
 - (d) mitochondria
 - (e) vacuoles
 - (f) I don't know
15. Which of the following body cells will contain a high density of the rough endoplasmic reticulum?
- (a) cells that line the nasal system
 - (b) cells that line the digestive system
 - (c) the gum cells of the mouth
 - (d) cells that line the tracheal system
 - (e) cells of the inner ear
 - (f) I don't know
16. Which of the structures in the cytoskeleton of a cell is involved in the movement of a cell such as an amoeba
- (a) microfilaments
 - (b) microtubules
 - (c) cytoplasm
 - (d) nucleus
 - (e) endoplasmic reticulum
 - (f) I don't know

17. The following are characteristics of a plant cell vacuole, EXCEPT ONE. Identify the one which is not.
- (a) A plant vacuole can occupy up to 90% of a mature cell's volume
 - (b) A plant vacuole is used for storage and maintenance of high water pressure and aids in plant support.
 - (c) Salts, sugars, pigments, etc. are present in some plant cell vacuoles
 - ☒ (d) A plant vacuole stores strong digestive enzymes similar to those in lysosomes.
 - (e) A plant cell vacuole has a tonoplast made up of a single membrane
 - (f) I don't know
18. During cell replication of mitosis, chromosomes come to lie at the equatorial plane of the cell during ...
- (a) interphase
 - (b) ☒ metaphase
 - (c) anaphase
 - (d) telophase
 - (e) at the end of telophase
 - (f) I don't know
19. Chiasma formation is a characteristic of meiosis I. This phenomenon takes place in the ...
- (a) metaphase stage
 - (b) leptotene phase of prophase I
 - (c) anaphase stage
 - (d) telophase stage
 - (e) pachytene phase of prophase I
 - (f) I don't know
20. What do you understand by the phrase 'energy of activation' as it relates to enzymes?
- (a) The energy given off during the formation of products
 - (b) The energy difference between the energy taken in by a reaction and the total energy given off by the same reaction
 - (c) The energy required to sustain the life processes of an organism during respiration
 - (d) The energy required to make substrates react
 - (e) All the above statements are wrong
 - (f) I don't know

GENETICS

- [Faint handwritten notes, possibly bleed-through from the reverse side.]*

5. Consider a cross of a true-breeding tall-stemmed pea plant with a true-breeding short-stemmed pea plant. Tall stem is completely dominant to short stem. One hundred and twenty (120) first filial (F₁) plants are produced and examined. How many of these plants are expected to be tall-stemmed and how many short-stemmed?
- (a) 60 tall-stemmed and 60 short-stemmed
 - (b) 80 tall-stemmed and 40 short-stemmed
 - ☒ (c) 120 tall-stemmed and none short-stemmed
 - (d) 90 tall-stemmed and 30 short-stemmed
 - (e) All are intermediates between the tall and the short parents
 - (f) I do not know
6. The F₁ plants in question 25 are self-pollinated. Of the 300 plants produced in the F₂ generation, how many are expected to be tall-stemmed and how many short-stemmed?
- ☒ (a) 225 tall-stemmed and 75 short-stemmed
 - (b) 150 tall-stemmed and 150 short-stemmed
 - (c) 200 tall-stemmed and 100 short-stemmed
 - (d) 300 tall-stemmed
 - (e) 75 tall-stemmed and 225 short-stemmed
7. In pea plants, the allele R for round seeds is dominant over r for wrinkled seeds and the allele Y for Yellow is dominant over the allele y for green seeds. If a plant that is heterozygous for both alleles is crossed with one that is homozygous dominant for both alleles, what would be the expected phenotypic ratio?
- (a) 2 round yellow : 2 round green
 - (b) 2 round yellow : 1 round green
 - (c) 9 round yellow : 3 round green : 3 wrinkled yellow : 1 wrinkled green
 - (d) 1 round yellow : 1 round green : 1 wrinkled yellow : 1 wrinkled green
 - ☒ (e) All round yellow
 - (f) I do not know
8. Considering the alleles in question 7, what would be the expected phenotypic proportions if a plant that is double heterozygous is crossed with one that is homozygous dominant for the R allele but homozygous recessive for the y allele?
- (a) 1/2 round yellow : 1/2 wrinkled green
 - (b) 1/2 round yellow : 1/2 round green
 - (c) 3/4 round yellow : 1/4 wrinkled green
 - (d) 1/2 round yellow : 1/2 round green
 - (e) 1/2 round yellow : 1/4 round green : 1/4 wrinkled green
 - (f) I do not know

Use the following information to answer questions 29 through to 32. Consider a human population where inability to taste phenyl-thio-carbamide (PTC) is caused by homozygosity for a recessive gene. Tasters are either homozygous dominant or heterozygous dominant. In this population, 84% of the individuals are tasters while the rest are non-tasters.

29. What is the frequency of the recessive allele in the population?

- (a) 0.4
- (b) 0.16 ✓
- (c) 0.32
- (d) 0.36
- (e) 0.6
- (f) I do not know

30. What is the frequency of the homozygous dominant genotype in the population?

- (a) 0.36
- (b) 0.6
- (c) 0.32
- (d) 0.4
- (e) 0.84 ✓
- (f) I do not know

31. What percentage of the population is heterozygous for the gene?

- (a) 36%
- (b) 10%
- (c) 52% ✓
- (d) 60%
- (e) 48%
- (f) I do not know

32. In humans, ability to roll the tongue is dominant to inability to roll the tongue. What are the probable genotypes of Mr and Mrs Banda who can both roll the tongue and have 5 children one of whom cannot roll the tongue?

- (a) RR and Rr
- (b) RR and rr
- (c) RR and RR
- (d) Rr and Rr ✓
- (e) Rr and rr
- (f) I do not know

Suppose the couple in question 32 decides to produce a 6th child, what chance is there that this child will not roll the tongue?

- (a) $5/6$
- (b) $1/6$
- (c) $1/5$
- (d) $1/4$ *
- (e) $3/4$
- (f) I do not know

Which one of the following genotypes results in the Klinefelters syndrome?

- (a) AA XXX
- (b) AA XO
- (c) AA XXY *
- (d) AAOY
- (e) None of the above
- (f) I do not know

What is the probability of a child having AB blood group if one of the parents is heterozygous for A blood and the other heterozygous for B?

- (a) $1/4$
- (b) $1/2$
- (c) 0
- (d) 1
- (e) $3/4$
- (f) I do not know

What other genotypes are possible from the couple in question 35?

- (a) **only** $I^A I^B$ genotype is possible
- (b) $I^A i$ and I^B
- (c) $I^A i$ and ii
- (d) $I^A i$, $I^B i$ and ii ✓
- (e) I^B and ii
- (f) I do not know

In a 3 coin-toss, what is the chance that 2 heads and 1 tail will be obtained simultaneously?

- (a) $2/3$
- (b) $1/2$
- (c) $1/4$
- (d) $1/8$
- (e) $3/8$
- (f) I do not know

$$\left(\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \right) = \frac{1}{8}$$

38. Quantitative inheritance involving two gene pairs determines the colour of grain in a variety of wheat. Alleles A and B each equally increase the redness of the seed while alleles a and b add no colour. In the cross AABB (deep red) x ~~Aa~~ Bb (medium red), what proportion of the total progeny will be medium red?

- (a) $1/2$
- (b) $1/3$
- (c) $1/4$
- (d) $3/4$
- (e) $3/8$
- (f) I do not know

39. In a large population of random mating animals, 0.84 of the individuals express the phenotype of the dominant allele (A-) and 0.16 express the phenotype of the recessive aa.

A constraint is imposed on the population which results in complete selection against the A phenotype. What proportion of AA, Aa and aa would be in the next generation?

- (a) 25% AA 25% Aa and 50% aa
- (b) No AA, 50% Aa and 50% aa
- (c) 25% AA, 59% Aa and 16% aa
- (d) 100% aa ✓
- (e) 25% Aa and 75% aa
- (f) I do not know

40. Multiple allele inheritance is:

- (a) the concept that a number of different gene pairs may combine forces to determine a characteristic
- (b) the concept that there are several different forms of a gene for a particular characteristic
- (c) the pattern of inheritance that follows Mendel's Laws
- (d) the multiple effects that a gene may have on the phenotype of an organism
- (e) when two pairs of genes are involved in determining a trait
- (f) I do not know

ABC

PLANT BIOLOGY

1. The process of grouping plants or animals into a hierarchy of classes is a taxonomic activity termed
 - (a) ecology,
 - (b) anatomy,
 - (c) identification +
 - (d) classification.
 - (e) nomenclature
 - (f) I do not know
2. The basic universal unit of classification is termed
 - (a) the class
 - (b) the division
 - (c) the family
 - (d) the genus
 - (e) the species.
 - (f) I do not know
3. The Kingdoms Animalia and Plantae are some of the groups included in the Superkingdom called
 - (a) Eukaryonta ✓
 - (b) Prokaryonta
 - (c) Protista
 - (d) Myreteeae
 - (e) Monera
 - (f) I do not know
4. An examination of the structure of the blue-green algae reveals presence of a nitrogen-fixing feature called a
 - (a) heterocyst ✓
 - (b) heterochromatin.
 - (c) heterothallism
 - (d) heterokaryon
 - (e) heteroptera
 - (f) I do not know
45. A fungal body constituted from a network of numerous hyphae is usually termed the
 - (a) myocyte
 - (b) myoblast
 - (c) mycorrhiza
 - (d) mycellium-
 - (e) mycoplasm
 - (f) I do not know

6. The class of fungi which includes the common edible mushrooms bears a tetrad of spores that are called
- (a) conidiospores
 - (b) conidia
 - (c) asci
 - (d) ascospores
 - (e) basidiospores
 - (f) I do not know
7. A vascular plant that is incapable of developing seeds but only known to reproduce by means of spores can be classed as the
- (a) Bryophyte
 - (b) ✓ Pteridophyte
 - (c) Spermatophyte
 - (d) Ascomycetes
 - (e) Zygomycetes
 - (f) I do not know
8. The branch of botany categorised as morphology is considered to be
- (a) the study of biology which deals with the internal structure of the plants, including the organs and their associated tissues. ✕
 - (b) the study which deals with the structure, function and life history of the cells. ✓
 - (c) the study which deals with the shape and arrangement of the organs and hence involves aspects of form and structure of an organism. ✓
 - (d) the study which deals with the internal processes and functions of plant parts. ✕
 - (e) a field of study which deals with the relation between plants and their environment. ✕
 - (f) I do not know
9. The dicotyledons are considered to be
- (a) a group of vascular plants which bear spores
 - (b) a group of non-vascular plants which bear spores
 - (c) a group of non-vascular plants which bear seeds
 - (d) ✕ a group of plants whose seeds possess two initial embryonic leaves
 - (e) a group of flowering plants whose seeds possess a single embryonic leaf
 - (f) I do not know

0. On the basis of habit the cassava plant is considered to be

- (a) a woody plant termed a herb
- (b) a woody plant termed a shrub
- (c) a woody plant termed a tree
- (d) a non-woody plant termed a tree
- (e) a herbaceous plant termed a liane
- (f) I do not know

1. The biological term referred to as a tissue is defined as

- (a) a unicellular organism performing all the functions associated with a living system
- (b) a group of unicellular organisms performing the same function in an ecosystem
- (c) a group of multicellular organisms found in the same community
- ~~(d)~~ (d) a group of cells made up of the same shape and size collectively performing the same function
- (e) a group of organelles that make up a whole plant cell
- (f) I do not know

2. The concept of totipotent implies that

- ~~(a)~~ (a) the meristematic cells are competent of developing into any type of plant cell
- (b) the mature sclerenchyma cells are capable of differentiating into parenchyma cells
- (c) the mature lignified cells of the vascular system are capable of differentiating into cortical parenchyma cells
- (d) The mature lignified xylem can differentiate into meristematic cells
- (e) none of the above statements is correct
- (f) I do not know

3. The companion cells originate from and are later known to be associated with
- (a) xylem cells
 - (b) sieve elements
 - (c) tracheids
 - (d) collenchyma cells
 - (e) epidemidal cells
 - (f) I do not know
4. The meristematic region found in the root tip where a group of cells form a hemisphere is termed
- (a) the active centre
 - (b) the quiescent zone
 - (c) the quinone centre
 - (d) the shoot apex
 - (e) the root cap
 - (f) I do not know
5. Whereas the limbs of vertebrate animals arise from the pectoral and pelvic girdles, in vascular plants the lateral branches and leaves arise from the
- (a) internum
 - (b) internode
 - (c) intine
 - (d) node
 - (e) nodule
 - (f) I do not know
56. In most tropical plants the region of the tree trunk that usually retains the capacity to conduct water and dissolved mineral salts is termed
- (a) the bark
 - (b) the heartwood
 - (c) the sapwood
 - (d) the cortex
 - (e) the phellogen
 - (f) I do not know
57. A shortened form of underground stem bearing fleshy scale leaves is a perennating organ called
- (a) the cladode
 - (b) the cladophyll
 - (c) the bulb
 - (d) the tuber
 - (e) the stolon
 - (f) I do not know

8. Leguminous plants are characterised by the possession of a pair of small appendages found at the base of the leaf and such small structures are known as

- (a) cotyledons
- (b) stipules
- (c) stipes
- (d) ligules
- (e) cataphylls
- (f) I do not know

9. A compound leaf is often described as

- (a) a plant organ whose blade is simple and entire
- (b) a plant organ whose blade is simple with toothed margins
- (c) a plant organ whose blade is subdivided into two or more leaflets
- (d) a plant organ with flowers consisting of many sepals and petals
- (e) a plant organ whose leaf blade extends into the tendril
- (f) I do not know

10. In reproductive systems of the angiosperm plants the essential parts of the flower are:

- (a) the pistils and stamens
- (b) the calyx comprised of sepals
- (c) the corolla comprised of petals
- (d) the receptacle on which all floral parts arise
- (e) the hypanthium
- (f) I do not know

11. It has been established that, in female gametogenesis,

- (a) all daughter cells resulting from meiotic division of the mother cell remain functional
- (b) only two of the four daughter cells resulting from meiotic division of the mother cell remain functional
- (c) only one of the four daughter cells resulting from meiotic division of the mother cell remains functional
- (d) an ovule that is ready for fertilization has a total of six nuclei
- (e) the egg apparatus located near the micropyle has a set of four nuclei
- (f) I do not know

62. In an ovary of the angiosperm plant the development of the ovules occurs on the tissue known as
- (a) the nucellus
 - (b) the integument
 - (c) the embryo sac
 - (d) the placenta
 - (e) the endosperm
 - (f) I do not know
63. The first event which leads to the germination of the seed has been noted as a process which involves
- (a) the inhibition of water
 - (b) the imbibition of water
 - (c) the synthesis of mRNA
 - (d) the synthesis of gibberellic acid
 - (e) the synthesis of abscisic acid
 - (f) I do not know
64. The potential ability of the gas, liquid or solid molecules to diffuse from an area of higher concentration to that of lesser concentration is briefly expressed as
- (a) osmotic potential
 - (b) osmotic pressure
 - (c) diffusion pressure
 - (d) independent diffusion pressure
 - (e) plasmolysis process
 - (f) I do not know
65. The structure of biomembrane has been elucidated as a form of a
- (a) glycoprotein
 - (b) lipoprotein
 - (c) polysaccharide
 - (d) oligosaccharide
 - (e) impermeable structure
 - (f) I do not know
66. A transpiration process is perceived as a physiological activity in which water will diffuse out of the stomatal pore to the atmosphere in the form of
- (a) a continuous jet of water
 - (b) condensed droplets of water
 - (c) a diffusion shell
 - (d) liquid oxygen
 - (e) all the above are correct
 - (f) I do not know

67. When the extracted chloroplasts are employed in ex situ in elucidating the photosynthetic event of the light reaction, the ferric salt which is used in the experiment is known to be
- (a) the electron acceptor ✓
 - (b) the electron donor
 - (c) the chlorophyll deactivating agent
 - (d) the carbon dioxide generator
 - (e) involved in the synthesis of water molecules
 - (f) I do not know
68. The C_4 pathway of photosynthesis is a biochemical process in which
- (a) the initial CO_2 acceptor is ribulose 1,5-diphosphate
 - (b) the initial CO_2 acceptor is phosphoenol pyruvate ✓
 - (c) malic acid and aspartic acid are the first products of the dark reaction
 - (d) 3-phosphoglyceric acid is the first product of the dark reaction ✓
 - (e) 3-phosphoglyceraldehyde is the first product of the dark reaction
 - (f) I do not know
69. The enzyme involved in the initial stage of CO_2 fixation in a C_3 pathway is called
- (a) amylase
 - (b) malic enzyme
 - (c) ~~ribulose diphosphate~~ carboxylase ✓
 - (d) phosphoenol pyruvate carboxylase
 - (e) phosphotriose isomerase
 - (f) I do not know
70. In leaves of most tropical grasses the occurrence of the C_4 photosynthetic pathway can be predicted by noting the presence of such anatomical syndrome as
- (a) the sunken stomata
 - (b) the bulliform cells ✓
 - (c) the transfusion tissue
 - (d) the non-Kranz anatomy
 - (e) the Kranz anatomy ✓
 - (f) I do not know

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ANIMAL BIOLOGY

71. Choose in order of complexity from least complex to most complex.
- (a) cell, tissue, organ, organism ✓
 - (b) tissue, cell, organism, organ
 - (c) organism, tissue, cell, organ
 - (d) cell, organism, organ, tissue
 - (e) organism, macromolecule, cell, system
 - (f) I do not know
72. Smooth muscles are sometimes referred to as:
- (a) ☒ involuntary ✓
 - (b) voluntary
 - (c) fast acting
 - (d) attached to bones
 - (e) found in vertebrates only
 - (f) I do not know
73. The capacity of an organism to detect stimuli is termed:
- (a) metabolism
 - (b) responsiveness ✓
 - (c) ~~reproduction~~
 - (d) feed back
 - (e) co-ordination ✓
 - (f) I do not know
74. Which of the following is an example of an exocrine gland
- (a) pituitary gland
 - ✓(b) salivary gland ✓
 - (c) ovary
 - (d) testis
 - (e) none of the above
 - (f) I do not know
75. The term "TISSUE" can be applied to
- ✓(a) any structure in an organism
 - (b) a copulatory structure
 - ✓(c) a group of similar cells organized into a structural and functional unit ✓
 - (d) all of the above
 - (e) I do not know

76. In insects the process of excretion is carried out through the:
- (a) spiracles
 - (b) small intestine
 - (c) malpighian tubules
 - (d) trachea
 - (e) none of the above
 - (f) I do not know
77. The zygote of a mammal develops inside a specialised structure called a:
- (a) placenta
 - (b) uterus
 - (c) fallopian tube
 - (d) vagina
 - (e) ovary
 - (f) I do not know
78. The tendency of an organism to maintain constancy of the internal environment is known as:
- (a) homeostasis
 - (b) adaptation
 - (c) responsiveness
 - (d) excretion
 - (e) secretion
 - (f) I do not know
79. The brain and spinal cord of mammals make up the:
- (a) central nervous system
 - (b) autonomous nervous system
 - (c) sympathetic nervous system
 - (d) reflex arch
 - (e) parasympathetic nervous system
 - (f) I do not know
80. The structure through which gas exchange actually takes place is:
- (a) sinuses
 - (b) larynx
 - (c) alveoli
 - (d) epiglottis
 - (e) pleural membrane
 - (f) I do not know

81. The structure in which protein digestion begins is called:
- (a) duodenum
 - (b) stomach
 - (c) liver
 - (d) large intestine
 - (e) none of the above
 - (f) I do not know
82. Which of the following organ is equipped with valves
- (a) capillary
 - (b) artery
 - (c) vein
 - (d) aorta
 - (e) all of the above
 - (f) I do not know
83. The function of plateletes is to:
- (a) transport oxygen
 - (b) initiate clotting
 - (c) seek out and ingest bacteria
 - (d) become macrophages
 - (e) transport carbon dioxide
 - (f) I do not know
84. Whether it is the long neck of the giraffe or the short neck of the cat, the number of cervical vertebrae in all mammals is
- (a) seven
 - (b) five
 - (c) four
 - (d) twelve ✓
 - (e) ten
 - (f) I do not know
85. Which of the following is NOT a function of the liver
- (a) Bile secretion ✓
 - (b) Homeostasis maintenance ✓
 - (c) water balance ✓
 - (d) synthesis of glucose to glycogen ✓
 - (e) none of the above ✓
 - (f) I do not know

86. The duodenum receives'

- (a) food from the stomach through the pyloric sphincter
- (b) digestive enzymes from the appendix
- (c) bile salts from the pancreas
- (d) all of the above
- (e) none of the above
- (f) I do not know

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

- (a) 4.0
- (b) 7.0
- (c) 8.0
- (d) 14.0
- (e) none of the above
- (f) I do not know

2.5

3.5

7.5

88. The heart empties itself and blood pressure reaches a maximum during:-

- (a) diastole
- (b) systole
- (c) heart beat
- (d) exercise
- (e) rest
- (f) I do not know

1 - 2 Aick

89. Which of the following is NOT a tissue?

- (a) bone
- (b) nerve
- (c) cartilage
- (d) stomach
- (e) epithelium
- (f) I do not know

help us how can it be?

90. The number of ureters in the mammalian body is

- (a) one ✓
- (b) two ✓
- (c) four
- (d) several thousand
- (e) ten
- (f) I do not know

91. The structure in a cockroach that can be considered analogous to a mammalian kidney is the
- (a) fat body
 - (b) intestinal caeca
 - (c) malpighian tubules
 - (d) tracheal system
 - (e) haemocoel
 - (f) I do not know
92. Which of the following bones is found in a mammalian leg?
- (a) humerus
 - (b) radius
 - (c) femur
 - (d) ulna
 - (e) scapula
 - (f) I do not know
93. Peristalsis
- (a) stops food from getting into the trachea
 - (b) is the enzyme that hydrolyses starch
 - (c) destroys bacteria that reach stomach
 - (d) is the movement that pushes food material down the gullet
 - (e) Is a finger like process in the small intestine.
 - (f) I do not know
94. Which of the following organs is the MOST important.
- (a) Spleen
 - (b) Heart
 - (c) Lungs
 - (d) Brain
 - (e) Kidneys
 - (f) I do not know
95. The products of protein digestion are
- (a) fatty acids
 - (b) simple sugars
 - (c) amino acids
 - (d) nucleic acids
 - (e) vitamins
 - (f) I do not know

96. Most carbon dioxide in the body is transported as
- (a) a dissolved gas in the blood
 - (b) ~~a~~ binding to haemoglobin in the blood
 - (c) carbonic acid
 - (d) bicarbonate salt
 - (e) as carbohydrates
 - (f) I do not know
97. In human beings the circulatory system is....
- (a) divided by the septum
 - (b) open
 - (c) closed
 - (d) intermediate
 - (e) none of the above
 - (f) I do not know
98. The carrier of oxygen in the blood is....
- (a) myoglobin
 - (b) haemoglobin
 - (c) fibrin
 - (d) thrombin
 - (e) prothrombin
 - (f) I do not know
99. A specialised cell that distinguishes a nervous system from other communication systems is called:
- (a) the neuron
 - (b) the nephron
 - (c) a glial cell
 - (d) a muscle cell
 - (e) an erythrocyte
 - (f) I do not know
100. Which of the following types of blood-cells is NOT nucleated
- (a) erythrocyte
 - (b) lymphocyte
 - (c) eosinophil
 - (d) neutrophil
 - (e) thrombocyte
 - (f) I do not know

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 210

BIOLOGY OF CELLS AND SYSTEMS

PRACTICAL PAPER I

TIME: THREE HOURS

ANSWER: ALL QUESTIONS IN SECTIONS A AND B.

SECTION A

CELL MOLECULAR BIOLOGY

Analyse the data provided on the effect of temperature on two enzyme catalysed reactions. Compare the results and explain the Data.

SECTION B

PLANT PHYSIOLOGY

You have been provided with serial dilutions of sucrose solution marked A1 to A6 whose molarity is 0.15 M to 0.40 M, respectively, and six lots of tissue B.

Use the sucrose solutions to determine the water potential of tissue B.

- a. State the method, as well as, the theoretical basis for the method you have used.
 - b. Report your results in the form of tables and/or graphs.
 - c. Analyse the results to determine the water potential of tissue B, stating any assumptions which you have made and.
 - d. Draw appropriate conclusions.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF BIOLOGY

UNIVERSITY EXAMINATIONS - DECEMBER 1994

CELL MOLECULAR BIOLOGY

Q1(a) A traditional healer claiming to have found a cure for AIDS submitted his preparation to Scientists. Paper chromatography studies gave the following data.

UNKNOWN	RATIO OF FRONTS	STANDARD	RATIO OF FRONTS
A	0.05	Alanine	0.950
		Glycine	0.995
B	0.152	Phenylalanine	0.785
C	2.000 0.200	Valine	0.005
D	0.795	Cysteine	0.051
E	0.945	Serine	0.201
		Threonine	0.150

- (a) Interpret the data
(b) Make appropriate conclusions

Q2. Study the following data. The enzyme Lactic dehydrogenase was extracted from two species of water bugs, and the activities of the two extracts were compared at constant pH, Enzyme and substrate concentration. The following data was obtained.

TEMPERATURE °C	MOLES OF SUBSTRATE HYDROLYSED	
	SPECIES A	SPECIES B
5	0.0	0.0
15	0.15	0.0
25	1.36	0.0
35	2.75	0.0
45	1.04	0.10
55	0.25	0.21
65	0	0.40
85	0	0.80
105	0	0.25

- (a) State the aim of the experiment.
(b) Interpret the data with the aid of a graph.
(c) Make appropriate conclusions, and comment on the possible habitats of the two species of beetles.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 210

BIOLOGY OF CELLS AND SYSTEMS

THEORY PAPER I

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 SECTION.

SECTION A

CELL MOLECULAR BIOLOGY

1. Discuss the structural and functional relationship of striated muscle at the molecular level.
2. Proteins are the only macromolecules with enough specificity to carry out key cellular functions. Discuss.
3. Describe the following macromolecules:
 - a. Cellulose
 - b. Glycogen
 - c. Haemoglobin
 - d. Steroids
 - e. Vitamin A
4. Discuss factors that affect enzyme catalysed reactions.

SECTION B

PLANT PHYSIOLOGY

Give a detailed account of C-3 pentose reduction cycle, indicating the three major steps in the cycle, the carboxylation, reduction and regeneration phases, as well as, the enzymes catalyzing the various reactions.

Discuss the mechanism of phloem transport in vascular plants in relation to the ultrastructure of the phloem elements.

Write on one of the following:

- a. The mechanism of stomatal opening and closure.
- b. The physiological roles of micronutrient elements in plants.

Discuss the role of plant hormones in the physiological regulation of root growth.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 210

BIOLOGY OF CELLS AND SYSTEMS

PRACTICAL PAPER, II

TIME: THREE HOURS

ANSWER: ALL QUESTIONS IN SECTION A AND B

SECTION A

GENETICS

For each of the following hypothetical sequences of nitrogenous bases on a sugar-phosphate strand of DNA:

- Determine the sequence of nitrogenous bases on the complementary sugar-phosphate strand of the DNA molecule.
- Write down the sequence of nitrogenous bases of the mRNA to be transcribed.
- How many proteins are coded for by the sequence?
- How many proteins would be coded for by the complementary sugar-phosphate strand of the DNA molecule.
- How many amino acids will each protein produced have? and,
- List the amino acids encoded by the sequence in the order in which they would be assembled at the ribosome.

SEQUENCES

- 5'- TACAGAGGTTGACGGCGGCTTCAACAT TAGCGTGACTATTTATT GTAAATTC-3'
- 5'- CACTGAATGAAAAAGGATGAAGAGGGTGCGATCTAA-3'

Rank the genetic maps whose particulars are indicated in the table below in order of severity of interference in crossing-over among their genes or alleles. Show your work.

Genetic Map	Linked Genes	Region 1 distance (m.u)	Region 2 distance (m.u)	Observed Frequency of double crossovers
1	cv-ct-v	cv+ct=6.42	c+ v=13.19	0.55%
2	ec-cv-ct	ec+cv=10.27	cv+ct=8.42	0.15%
3	sc-ec-cv	sc+ec=7.57	ec+cv=9.70	0.00%
4	sc-ec-vg	sc+ec=5.56	ec+vg=49.80	2.58%

SECTION B

ANIMAL PHYSIOLOGY

- a.
 - i. How can you test for starch?
 - ii. How can you tell the presence of limit dextrins in your reaction mixture?
 - iii. Which enzyme digests starch?
 - b.
 - i. What are the products of sucrose digestion?
 - ii. What property do these products have which is used in the Benedict's test?
 - c. Briefly describe the procedure you would use to test for proteases.
 - d. Of what value is one knowledge of enzymology to the Doctor in the treatment of infections?
-
- a. Identify the specimens A-E.
 - b. What is the approximate age of each specimen in hours?
 - c. Draw and label the major parts of each specimen.

- d. How does gas exchange take place in bird eggs?
 - e.
 - i. What is the main waste product of the growing embryo in the shell?
 - ii. What is the advantage of that?
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 210

BIOLOGY OF CELLS AND SYSTEMS

THEORY PAPER II

ME: THREE HOURS

SWER:

VE QUESTIONS: TWO QUESTIONS FROM EACH SECTION AND THE
ST QUESTION FROM EITHER SECTION. ALL QUESTIONS CARRY EQUAL
RKS. USE SEPARATE ANSWER BOOKS FOR EACH SECTION.

SECTION A

GENETICS

In terms of the structure of the DNA molecule, define a gene. How do genes operate to **produce** observable phenotypes and in your answer explain the roles played by enzymes in the process.

Discuss factors that govern the ultimate equilibrium attained by alleles in large natural populations of organisms and explain how this equilibrium can be expressed mathematically, giving an example.

What contributions have the following techniques of Genetic engineering made to our understanding of gene action and the inheritance of traits from parents to the offsprings?

- a. Gene Splicing
- b. Nuclear Transplantation

Explain how an Operon system regulates gene action in a cell and give the evidences that are in existence pointing to such regulation.

SECTION B

ANIMAL PHYSIOLOGY

1. Compare the patterns of osmoregulation between aquatic freshwater organisms and those that live in the sea.

2. Describe various methods used by various animals to obtain their food.

What do you understand by the term, "Spermatogenesis"? Explain with the aid of suitable diagrams.

Write short notes on any four of the following;

- a. Extraembryonic membranes
- b. Parthenogenesis
- c. Patterns of cleavage
- d. Bohr effect
- e. Aestivation

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 310

BIOMETRY, ECOLOGY AND EVOLUTION

PAPER I

THEORY

TIME: THREE HOURS

ANSWER:

QUESTION ONE AND FOUR OTHERS.
ILLUSTRATE YOUR ANSWERS WHERE NECESSARY.

What are the differences between stratified and completely randomized block experimental designs.

Succession can be explained by either the "facilitation model" or the "initial floristic composition model". In what ways are these two models different.

Discuss the role of tropical deforestation and wood biomass burning in the global carbon build-up.

Discuss the usefulness of capture-recapture technique in estimating animal populations.

Explain how miombo woodland trees minimize loss of nitrogen and phosphorus loss through leaf fall.

With the use of Zambian examples, explain the differences between zonal and azonal soils.

The fig and the fig wasp represent one of the most specialised inter-specific interactions. Discuss.

How useful is the niche concept in explaining competition within and between species.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 310

BIOMETRY, ECOLOGY AND EVOLUTION

PAPER II

THEORY

ME: THREE HOURS

SWER:

QUESTION ONE AND FOUR OTHERS.
ILLUSTRATE YOUR ANSWERS WHERE NECESSARY

What is the difference between a t-test and analysis of variance (ANOVA).

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

Write short notes on any four (4) of the following:

- (i) Aneuploids
- (ii) Sexual selection
- (iii) Altruism
- (iv) Criterion of demarcation
(as in philosophy of science)
- (v) Teleology
- (vi) Homo habilis

In your notes, stress the relationship of each topic to evolution.

Define the Hardy-Weinberg law, and discuss its practical problems associated with it.

Compare and discuss any two (2) of the following:

- (i) Kin selection and group selection
- (ii) Darwinism and Lamarckism
- (iii) Batesian mimicry and Mullerian mimicry
- (iv) Sympatric and allopatric species

Explain the mechanism of genetic drift and its significance to the concept of evolution.

Suppose a survey of four district hospitals gave the following data on the occurrence of sickle cell anaemia in parts of Zambia;

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

On the basis of these data, discuss

- (i) the distribution of the gene responsible for sickle cell anaemia.
- (ii) since heterozygous in this gene are resistant to malaria and since malaria is endemic in Zambia, do you think the selection for this gene is advantageous to the Zambian population?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 310

BIOMETRY, ECOLOGY AND EVOLUTION

PAPER III

PRACTICAL

THREE HOURS

ALL FIVE QUESTIONS

EITHER

A researcher grew Afzelia guanzensis seedlings and harvested a sample for oven-dry mass determination at regular intervals. The results were as follows:

Age of seedlings (weeks)	Above-ground biomass (g/sample plant)			
	1	2	3	4
3	0.882	0.417	0.400	0.420
7	1.437	0.441	1.653	0.363
11	2.462	0.901	0.520	1.899
15	1.217	2.191	1.726	-
19	1.417	0.336	4.125	0.390

Do these results show any correlation between age and mean biomass of seedlings. If so, develop a mathematical model that can be used to determine biomass from the age of seedlings.

OR

A researcher measured the girth (cm) at 1.3m above ground of four marked Brachystegia spiciformis trees in March of each year from 1991 to 1994 and obtained the following results:

Tree	Girth (cm) in March			
	1991	1992	1993	1994
1	38.5	38.0	38.0	39.0
2	61.0	61.0	65.5	63.0
3	30.5	30.5	32.0	33.0
4	79.5	79.0	80.5	80.0

Did the trees show any significant differences among the years. What is the basis of your answer.

EITHER

Calculate the probability of three children born to the same parents being male.

OR

Calculate the variance and standard deviation of the mean germination rate of Acacia polyacantha given that in an experiment 66 out of 88 seeds germinated.

Briefly explain the evolutionary principles or mechanisms that each of the specimens A, B, C, and D illustrate.

Classify specimens E, F, G, H and I according to Raunkiaer's Life Forms.

Classify specimens J, K, L, M and N by their respective leaf arrangement.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 320

PRACTICAL PAPER

THREE HOURS

ER: ALL QUESTIONS IN SECTION A AND SECTION B.

SECTION A

You are provided with 3 lots of cereal grain seeds germinating for 1, 2 and 3 days. Weigh approximately 5 grammes of the seeds and using a pestle and mortar homogenize them separately with 10 ml of distilled water, then centrifuge at 15 000 x g for ten minutes. Transfer the clear supernatant to a graduated measuring cylinder and make up the volume to 15 ml with distilled water. Label each extract appropriately.

Place 5 ml of 5% (~~W~~) starch solution in each of 3 test tubes labelled A, B, C and to each add 2 drops of iodine solution. Now add 2 ml of the seed extract to tubes A, B and C, one at a time.

Mix the contents quickly and note the colour reaction. Using a stop watch note the time lapse between the initial colour reaction and when observable colour change (colour disappearance) takes place. Do this for each of tubes A, B and C.

- (a) Record your observations.
- (b) State the aim of the experiment.
- (c) Which seed sample produced the fastest reaction and which had the slowest reaction?
- (d) Explain the reaction between starch and the seed extract and the differences in the results.
- (e) What conclusions can you draw regarding the germination status of the seeds and observed activity?

SECTION E

The amount of amylase present in the saliva of three groups of people living in Zambia was compared, the activity of amylase being expressed in units per cubic centimeter of saliva.

Group I

Their diet consisted mainly of millet and maize with irregular small amounts of meat, milk, fruit and vegetables in season.

66 people were examined.

Group II

Their diet consisted of potatoes, meat and vegetables. 34 people were examined.

Group III

Their diet was mainly milk, beef and chickens. 17 people were examined.

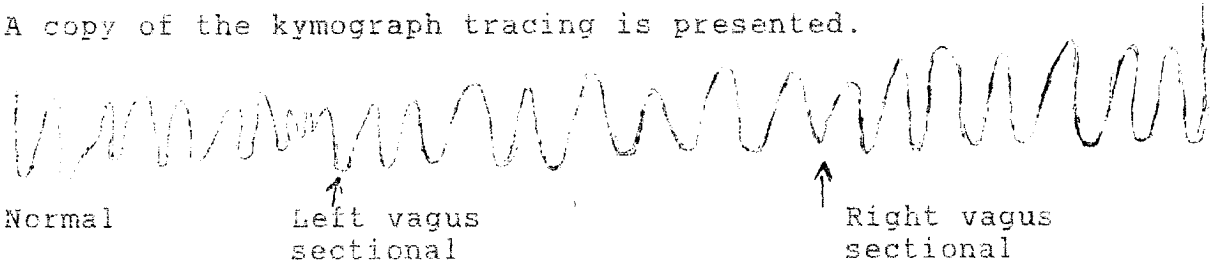
The results of the investigation are tabulated below:

	Mean activity of salivary amylase in units per cm	Standard deviation
Group I	250	60
Group II	115	30
Group III	35	10

- What was the hypothesis tested in this investigation?
- Analyse the data by means of t-test
- Do the results support your hypothesis and if so how?
- How do you find out whether the differences in amylase activity is an inherent characteristic or an environmentally caused characteristic?

Effects of vagiectomy on the breathing pattern of the rat was studied.

A copy of the kymograph tracing is presented.



- (a) Describe the experimental procedure involved in performing the experiment.
- (b) State the hypothesis which was being tested in this experiment.
- (c) From the tracing what effects were observed on the breathing pattern?
- (d) Giving reasons, would you consider the hypothesis to be valid or not?
- (e) What other mechanism could be involved in the regulation of breathing?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 320

THEORY PAPER

ME: THREE HOURS

SWER:

VE QUESTIONS. TWO FROM EACH SECTION AND ONE FROM
Y SECTION.

SECTION A

PLANT PHYSIOLOGY

Discuss the roles of IAA and Gibberellic acid 1 in regulating stem elongation growth in plants.

Discuss photosynthetic electron transport between photosystem II and photosystem I.

Discuss photorespiration in leaves.

Give an account of the biochemical processes of nitrogen fixation in legumes and nitrate assimilation in non-legumes. How are the two major export forms of nitrogen, glutamine and asparagine produced?

SECTION B

ANIMAL PHYSIOLOGY

Discuss the changes in circulation that occur at birth in the mammalian foetus.

Discuss the range of extrarenal osmoregulatory organs found in the vertebrates and the environmental adaptations associated with each structure.

What systems and mechanisms have insects evolved in order to avoid the transportation of gases in the blood?

Discuss antagonism in hormone action, giving appropriate examples in your answer.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 410

ECOLOGY

PAPER I

ME: THREE HOURS

ANSWER:

VE QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY.

How would you construct a Leopold Matrix to record the interactions between environmental components and charcoal production activities in Zambia.

With the use of examples, discuss the usefulness of the transect in field ecological studies.

Why are late dry season savanna fires more destructive than early dry season fires.

How would you study primary production and the effect of herbivory in a savanna grassland.

Explain how you would go about constructing a life table for a mammal species inhabiting a conservation area. Indicate whether you would choose to construct a dynamic or static life table and why.

The following data were collected by using the King census method on Impala population in Luangwa valley.

Habitat Type	Flushing Distance (meters)	Length of Transect (Km)	Numbers of Impalas Flushed
Mopane	100	5	150
Combretum	55	2	200
Savanna	200	2	50
Acacia	25	3	100

The area of study is given as 50 km².

- (i) Estimate the population of the species
- (ii) Discuss the advantages and limitations of this census method.

How useful is the concept of 'r' and 'k' selection strategies in population ecology.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 420

ENTOMOLOGY AND PARASITOLOGY

THEORY PAPER I

ME: THREE HOURS

SWER: FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

Is it really necessary for an insect to have two pairs of wings in order to fly? Describe situations in Class Insecta where flight is affected by a single pair of wings and explain the roles played by the other pair.

Write an essay on the potential of using Biological control in controlling a named arthropod pest in Zambia.

Leg modifications in insects are correlated to the types of habitats the insects occupy. Describe the major types of leg modifications exhibited by members of Class Insecta and name specialized structures that occur on some insect legs.

Write short notes on five of the following terms and concepts:

- a. Entomology as a science
- b. Indirect pest
- c. Economic Injury Level
- d. Insecticides
- e. Exponential growth
- f. Relative method

Distinguish the types of mouthparts exhibited by the following insects and in your answer show which parts of the generalized chewing and biting type of mouthparts gave rise to them.

- a. Mosquito
- b. Honey bee
- c. Butterfly

Despite being one of the major characteristics that led to the evolutionary success of insects, possession of the cuticle in the insect's body wall limits growth. Discuss how this limit is overcome and the processes involved in the life cycle of a named insect.

Describe how the concept of the 'Intermediate' strategy pest is useful in the practice of Biological control.

Insecticides have been used to control insects for some time now. Describe the merits and demerits of using insecticides in an agro-ecosystem.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 420

ENTOMOLOGY AND PARASITOLOGY

THEORY PAPER II

THREE HOURS

FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

Write short notes on the diagnosis and control of the following parasites:

- a. Entamoeba histolytica
- b. Leishmania donovani
- c. Necator americanus
- d. Oncorcerca volvulus
- e. Strongyloides stercoralis

Environmental pollution increases the prevalence of parasitic infections. Discuss.

Discuss the Life Cycle of either Taenia solium or Toxoplasma gondii and discuss means of controlling the infection.

What is zoonosis? Discuss.

Contrast African trypanosomiasis from American trypanosomiasis.

Write an essay on how to control malaria.

Define the following terms and concepts:

- a. Parasite
- b. Symbiosis
- c. Prepatent period
- d. Espundia
- e. Five Fs
- f. Polyembryony
- g. charcot-leyden Crystals
- h. Mazzoti test
- i. Ecological host
- j. Missirori principle

Discuss the control of Schistosomiasis in Zambia.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 470

TRACHEOPHYTE BIOLOGY

THEORY PAPER

E: THREE HOURS

WER:

FIVE QUESTIONS. ILLUSTRATIONS MAY ENHANCE YOUR ANSWER.

Give an account of some floristic procedures used in characterising a Miombo woodland.

Describe the floral features which can be employed to subdivide the Leguminosae into such lower taxa as the Caesalpinioideae, Mimosoideae and Papilionoideae.

Explain some aspects of ex situ and in situ conservation applicable in plant genetic resources.

EITHER support or challenge the perception that Colophospermum mopane is a neo-endemic taxon in Southern Africa.

Write brief notes on any FOUR of the following concepts:

- (a) geocarpic fruit
- (b) Age and Area concept
- (c) cyanogenic glycosides in Cassava
- (d) botanical interpretation of commercial cotton
- (e) alien plants
- (f) plant domestication
- (g) hypogenous seedlings
- (h) nodulations in Leguminosae

Provide evidence that would uphold the view that a eustele anatomy of the herbaceous stem is a derivation of the ectophloic siphonostele.

Discuss features of botanical interest found in a species belonging to any ONE of the following families:

ANACARDIACEAE, EUPHORBIACEAE, GRAMINEAE.

What floristic information would best characterise the African phytochorion known as the Sudanian-Zambezian Region?

Compare and contrast the reproductive structures of the male and female cones of the genus Pinus.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 470

TRACHEOPHYTE BIOLOGY

PRACTICAL PAPER

: THREE HOURS

ER: ALL QUESTIONS IN ANY ORDER.

You are provided with wood shavings of specimens A and B, one of which is alleged to have been used in the murder case that is pending a hearing in the Court of Law. The only clue provided by the Police is that the killer weapon happen to be an angiosperm woody stick. Use the reagents provided and carry out the "Maule Test" in the identification of the killer weapon.

Use the diagnostic botanical key provided to identify the woodland taxa labelled C, D and E. Indicate steps taken to arrive at your determination. The key is given separately as Data sheet 1.

Identify specimens F, G, H, I and J to their respective plant groups.

Examine a set of flowers labelled as specimens K, L, M, N and O and use the characters scored to construct a dichotomous key.

A floristic study was conducted on two different woodland types. One woodland type termed Kalahari woodland is located on Kalahari sand in Senanga District and another type called Miombo occurs on the main plateau in Mbala District. The floristic composition which forms the canopy cover of each of these two vegetation types is presented separately as Data Sheet 2.

Study the lists of taxa and calculate the Demarcation Knot. Comment on your findings.

END OF EXAMINATION

BZ470
PRACTICAL PAPER

DATA SHEET 1. Key to the woody plants of the Campus

-
1. Stems, leaves or both parts armed with prickles.....2
 1. Stems, leaves unarmed.....13
 2. Leaves simple.....3
 2. Leaves compound.....7
 3. Spines borne singly or in form of spinescent stems.....4
 3. Spines borne in pairs.....5
 4. Leaves usually 9 cm long, leaf blade margin crenate (toothed).....*Flacourtia indica*
 4. Leaves up to 3 cm long, leaf blade margin entire (smooth).....*Securidaca longipedunculata*
 5. Leaves opposite, leaf blade margin entire; pair of spines both curved.....*Strychnos cocculoides*
 5. Leaves alternate, leaf blade margin crenate; pair of spines one straight, another curved.....6
 6. Leaf base weakly asymmetric; abaxial surface white tomentose (matted hairs).....*Ziziphus mauritianus*
 6. Leaf base strongly asymmetric; abaxial surface glabrous or with brownish hairs.....*Ziziphus mucronata*
 7. Leaves trifoliate, petiole armed.....*Erythrina abyssinica*
 7. Leaves binnate, petiole unarmed.....8
 8. Spines borne singly as modified stems; inflorescence purple tinged.....*Dichrostachys cinerea*
 8. Spines borne in pairs as modified stipules; inflorescence completely white or yellow.....9
 9. Rachis 11-20 cm long; pair of spines all curved.....*Acacia polyacantha*
 9. Rachis up to 10 cm long or less; pair of spines straight or a mixture of straight and curved forms.....10
 10. Spines small, up to 1.5 cm long; leaflets usually 9 mm long.....*Acacia albida*
 10. Spines more than 3 cm long; leaflets up to 5.5 mm long or less.....11
 11. Leaves alternate, well spaced out; pinnae more than 10 pairs; leaflets 4 mm long.....*Acacia sieberana*
 11. Leaves clustered at the nodes; pinnae up to 10 pairs; leaflets 5-5.5 mm long.....12
 12. Rachis 4 cm long, with 2-7 pairs of pinnae; flowers yellow.....*Acacia karroo*
 12. Rachis 6-10 cm long, with 4-10 pairs of pinnae; flowers white.....*Acacia gerrardii*
 13. Leaves simple.....14
 13. Leaves compound.....26
 14. Leaf apex bilobed.....15
 14. Leaf apex entire, not lobed.....16
 15. Leaf blade up to 6.5 cm wide; nerves 3-4 per lobe, indistinctly raised.....*Bauhinia petersiana*
 15. Leaf blade 8-15 cm long; nerves 5-6 per lobe, prominently raised.....*Piliostigma thonningii*
 16. Plant's sap with latex.....17
 16. Plant's sap clear without latex.....18

17. Leaves opposite, glabrous; leaf base acute.....*Diplorhynchus condylocarpus*
17. Leaves alternate, hairy; leaf base cordate or rounded.....*Ficus sycomorus*
18. Leaves opposite or 3-verticillate (whorled).....19
18. Leaves alternate.....20
19. Leaves opposite, blade glabrous.....*Syzygium guineense*
19. Leaves 3-verticillate, blade hairy.....*Combretum fragrans*
20. Leaves sessile, blade lanceolate.....*Protea gaguedi*
20. Leaves petiolate, blade either elliptic obovate or ovate.....21
21. Leaf blade 10-20 cm wide, obovate.....*Uapaca kirkiana*
21. Leaf blade up to 10 cm wide or less, elliptic or ovate.....22
22. Leaf margin markedly toothed or wavy to bluntly toothed.....23
22. Leaf margin entire.....24
23. Plant a suffrutex; leaf blade margin markedly toothed, lamina covered with yellowish hairs.....*Triumfetta heliocarpa*
23. Plant a tree; leaf blade margin wavy to bluntly toothed, lamina glabrous.....*Bridelia micrantha*
24. Leaves ovate.....*Pseudolachnostylis maprouneifolia*
24. Leaves elliptic.....25
25. Petiole up to 1 cm long; leaf blade up to 4 cm wide, venation reticulate.....*Parinari curatellifolia*
25. Petiole more than 3 cm long; leaf blade 4-10 cm wide, venation reticulate.....*Terminalia mollis*
26. Leaves opposite.....26
26. Leaves alternate.....27
27. Tree large, to 15 m high; leaves usually 50 cm long, clustered at branch end; flowers yellow; fruit up to 18 cm diameter.....*Kigelia africana*
27. Tree small, up to 10 m high; leaves up to 25 cm long, widely separated; flowers purple; fruit up to 1 cm diameter.....*Stereospermum kunthianum*
28. Leaves pinnate.....28
28. Leaves bipinnate.....29
29. Leaflet margin with fringe of whitish hairs.....*Julbernardia globiflora*
29. Leaflet margin entire, without fringe of hairs.....30
30. Leaflets 2-5 pairs, widely spaced, distal pair larger, glossy.....*Brachystegia spiciformis*
30. Leaflets 13-24 pairs, closely spaced, more or less uniform in size, slightly hairy.....*Brachystegia boehmii*
31. Pinnae 2-6 pairs per leaf.....31
31. Pinnae 12-40 pairs per leaf.....32
32. Leaflets obliquely obovate, densely tomentose (hairy) beneath.....*Albizia versicolor*
32. Leaflets oblong, glabrous and blue-green beneath.....*Albizia antunesiana*
33. Leaflets 30-40 pairs per pinna; midrib diving blades into two equal halves.....*Albizia amara*
33. Leaflets 12-15 pairs per pinna; midrib dividing blades into two unequal halves.....*Entada abyssinica*

BZ470
PRACTICAL PAPER

DATA SHEET 2. List of floristic composition of the canopy species recorded in Kalahari and Miombo woodlands. Source: D.B. Fanshawe (1971). *The Vegetation of Zambia*.

Kalahari Woodland

Acacia giraffae
Amblygonocarpus andongensis
Baikiaea plurijuga
Brachystegia floribunda
Brachystegia longifolia
Burkea africana
Combretum mechowianum
Cryptosepalum exfoliatum
Dialium engleranum
Erythrophleum africanum
Guibourtia coleosperma
Isoberlinia angolensis
Julbernardia globiflora
Julbernardia paniculata
Parinari curatellifolia
Pteleopsis anisoptera
Pterocarpus angolensis
Ricinodendron rautanenii
Syzygium guineense
Terminalia sericea

Miombo Woodland

Anisophyllea pomifera
Brachystegis allenii
Brachystegia boehmii
Brachystegia bussei
Brachystegia floribunda
Brachystegia glaberrima
Brachystegia longifolia
Brachystegia manga
Brachystegia spiciformis
Brachystegia taxifolia
Brachystegia utilis
Brachystegia wangermeeana
Erythrophleum africanum
Faurea saligna
Isoberlinia angolensis
Isoberlinia tomentosa
Julbernardia globiflora
Julbernardia paniculata
Marquesia macroura
Parinari curatellifolia
Pericopsis angolensis
Pterocarpus angolensis
Syzygium guineense

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

BZ 910

MYCOLOGY AND PLANT PATHOLOGY

THEORY

ME: THREE HOURS

ANSWER:

VE QUESTIONS. TWO FROM SECTION A AND TWO FROM SECTION
AND ONE QUESTION FROM EITHER SECTION A OR B. ALL
QUESTIONS CARRY EQUAL MARKS.

SECTION A (MYCOLOGY)

"The exact position of fungi relative to other organisms is a subject of much debate". Do fungi deserve to have a kingdom of their own in the classification of organisms? Discuss your opinion giving reasons for your arguments.

The hyphal tip is a dynamic constituent of a hypha in a mycelium. Explain its significance in fungal growth, making particular reference to the role played by vesicles in the process.

Describe how rhizomorph in fungi is formed and give an outline of its structure. What is the significance of this structure in a fungus such as Armillaria mellea?

Give a diagrammatic representation of the life cycle in any TWO of the following subdivisions.

- i. Mastigomycotina
- ii. Zygomycotina
- iii. Ascomycotina
- iv. Basidiomycotina

SECTION B (PLANT PATHOLOGY)

Discuss the role of enzymes in plant disease.

Compare rusts and smuts with respect to mode of infection and symptoms giving two examples for each case. What control measures would you recommend if there was a serious outbreak of these diseases in Zambia?

What is the incitant of late blight of potatoes? How does this disease reoccur and how does it spread in Zambia. Briefly describe the symptoms and the control of this disease.

Write detailed notes on any TWO of the following:

- i. Vascular wilts
- ii. Powdery mildews
- iii. Parasitic angiosperms
- iv. Viroids
- v. Necrotrophs

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF BIOLOGY

UNIVERSITY EXAMINATIONS, DECEMBER, 1994

BZ 910

MYCOLOGY AND PLANT PATHOLOGY

PRACTICAL

TIME: THREE HOURS

ANSWER: ALL QUESTIONS

1. You have been provided with two fungi, A and B. Compare their growth rate by measuring the length of a hypha at different intervals over a period of 30 minutes.

Show your results in graphic form.

N. B. Note that you are required to calibrate your microscope and show how you arrive at your calibration figures. (25 marks)

2. You have been provided with a fungus which has been grown in an agar medium supplemented with either glucose or starch whereas the third culture was grown in a medium deficient of nitrogen.

(25 Marks)

Comment with reasons on the growth type of the fungus with regards to:

- (a) fungus texture (morphological quality)
- (b) carbohydrate utilization by the fungus in culture media A and B.
- (c) the effects of nitrogen deficiency to the culture in medium C. (25 marks)

3. Compare and contrast symptoms of D1 and D2 and in each case identify the;

- (a) causal organism
- (b) common name of the disease
- (c) nature of the pathogen (bio-or necrotroph)

(25 marks)

4. Examine specimens F1 - F10 and identify the host and pathogen in each case giving their scientific name.

(25 marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS-NOV/DEC 1994

C110

INTRODUCTORY CHEMISTRY

PUTER NUMBER: _____

TUTORIAL GROUP: _____

E: 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 No. and TUTORIAL GROUP NUMBER on your answer booklet
- (iii) Attempt 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

AL MARK

TION A

--

C110

USEFUL INFORMATION

Avogadro's Number (L, N_A) = 6.02×10^{23} per mol

Speed of light in vacuum = 3.0×10^8 ms⁻¹

Gas constant, (R) = 8.314 JK⁻¹mol⁻¹

= 0.082 dm³.atm.K⁻¹mol⁻¹

Planck's constant, (h) = 6.63×10^{-34} Js

Faraday's constant, (F) = $96\,500$ Cmol⁻¹

Rydberg constant, (R) = $109\,678$ cm⁻¹

Molar Volume at STP = 22.414 dm³mol⁻¹

1 torr = 1 mmHg = 133.32 Pa

RELATIVE ATOMIC MASSES

$^1_1\text{H} = 1.01$ $^{12}_6\text{C} = 12.01$ $^{14}_7\text{N} = 14.01$ $^{16}_8\text{O} = 16.00$ $^{19}_9\text{F} = 19.00$

$^{20}_{10}\text{Ne} = 20.18$ $^{23}_{11}\text{Na} = 23.01$ $^{24}_{12}\text{Mg} = 24.31$ $^{31}_{15}\text{P} = 31.00$

$^{32}_{16}\text{S} = 32.06$ $^{35}_{17}\text{Cl} = 35.45$ $^{39}_{19}\text{K} = 39.10$ $^{48}_{22}\text{Ti} = 48.00$

$^{52}_{24}\text{Cr} = 52.00$ $^{55}_{26}\text{Fe} = 55.85$ $^{108}_{47}\text{Ag} = 108.00$ $^{122}_{52}\text{Sb} = 122.00$

STANDARD REDUCTION POTENTIALS (E°) at 25°C

$\text{Na}^+(\text{aq}) + \text{e}^- \longrightarrow \text{Na}(\text{s})$ $E^\circ = -2.71\text{v}$

$\text{F}_2(\text{g}) + 2\text{e}^- \longrightarrow 2\text{F}^-(\text{aq})$ $E^\circ = +2.87\text{v}$

$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Cu}(\text{s})$ $E^\circ = +0.34\text{v}$

$\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \longrightarrow 2\text{H}_2\text{O}(\text{l})$ $E^\circ = +1.23\text{v}$

$2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \longrightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$ $E^\circ = -0.83\text{v}$

$2\text{H}^+(\text{aq}) + 2\text{e}^- \longrightarrow \text{H}_2(\text{g})$; SHE $E^\circ = 0.00\text{v}$

SECTION A

1. Sodium chromate is added to a solution in which the original concentration of Sr^{2+} is $1.0 \times 10^{-3}\text{M}$. Assuming $[\text{Sr}^{2+}]$ stays constant, will a precipitate form when the concentration of CrO_4^{2-} is $5.0 \times 10^{-2}\text{M}$?

$$K_{\text{sp}}(\text{Na}_2\text{CrO}_4) = 3.6 \times 10^{-6}$$

2. A clay contains 45% silica and 10% water. What is the % of silica in the clay on a "dry basis"?

C110

For the following set of quantum numbers (n, l, m_l, m_s)

for electrons, indicate those which could NOT occur and state why?

(3, 2, 2, $\frac{1}{2}$)

(2, -1, 0, $\frac{1}{2}$)

(2, 0, -2, $-\frac{1}{2}$)

(4, 1, 1, 0)

4. Calculate the pressure exerted by 1.00 mol of methane, CH_4 , in a 0.500 dm^3 vessel at 25°C assuming a non-ideal behaviour. (Van der Waals constants for CH_4 are:

$$a = 2.25 \text{ (dm}^3\text{)}^2 \cdot \text{atm} \cdot \text{mol}^{-2}; \quad b = 0.0428 \text{ dm}^3 \cdot \text{mol}^{-1}.$$

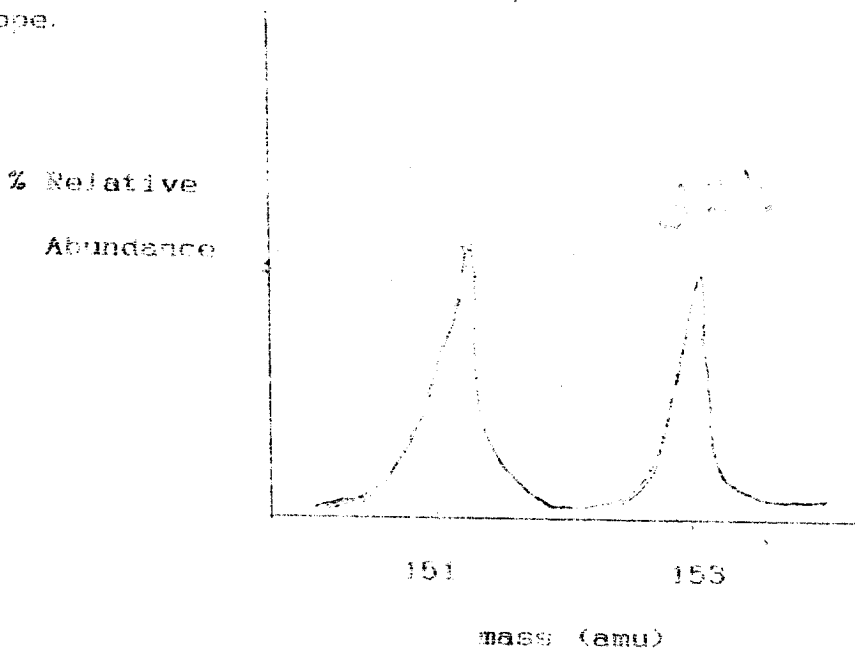
TOTAL MARK ON PAGE: _____

C110

5. Predict the relative solubility of bromine in benzene

($\mu = 0.00$) and in water ($\mu = 1.870$).

6. The following is a mass spectrum of the +1 charged ions of Europium (At Wt = 151.96) which has two isotopes. Calculate the relative percent abundance of each isotope.



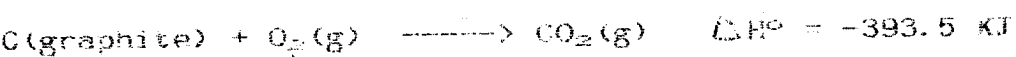
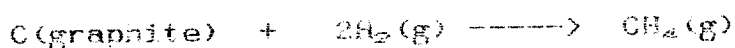
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C110

Give the structural formula for each of the following functional groups

- a) Carbonyl
- b) Carboxyl
- c) Nitrile
- d) Nitro

Use the thermochemical equations given below to determine ΔH° at 25°C for the following reaction



$$\Delta H^\circ = 890.3 \text{ kJ}$$

9. The wavelength of the green light from a traffic signal is centred at 522 nm. What is the frequency of this radiation?

TOTAL MARK ON PAGE: _____

C110

1. Calculate the pH at the equivalence point when a solution of 0.10M HP is titrated with a solution of 0.10M NaOH. $K_a(HP) = 3.53 \times 10^{-4} M$

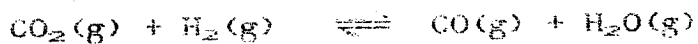
2. An ore, of mass 5.0g, containing silver was dissolved in HNO_3 solution and the latter was made up to 250 ml. Exactly 25 ml of the resulting solution was titrated with 11 ml of 0.10M KSCN solution. $Fe(NO_3)_3$ solution was used as indicator. Calculate the percent by mass of silver in the ore.

TOTAL MARK ON PAGE: _____

C110

2. A volatile liquid of mass 0.50g was introduced into a globe of 1000ml capacity. The globe was heated to 91°C so that all liquid vaporised. Under these conditions the vapour exerted a pressure of 190mmHg. What is the relative molecular mass of the liquid?

3. For a system



$K_p = 0.64$ at 900K. Originally, only CO_2 and H_2 are present each at a partial pressure of 1.00 atm. What are the equilibrium partial pressures of the species?

TOTAL MARK ON PAGE: _____

Calculate the molecular weight of a solid weak acid of unknown composition. The acid donates one proton per molecule. When a 1.02g sample of the acid is dissolved in water, the resulting solution requires 48.0 ml of a 0.241M solution of NaOH for neutralisation.

Dry air near sea level has the following composition by volume: N_2 , 78.1%; O_2 , 20.9%; and Ar, 1.0%. The atmospheric pressure is 1.00atm. Calculate the partial pressure of oxygen in the mixture.

SECTION B

ATTEMPT ANY FOUR (4) QUESTIONS

USE ANSWER BOOKLETS

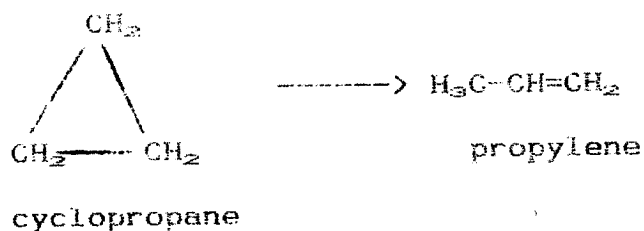
(a) The "life" of a certain voltaic cell is limited by the amount of Cu^{2+} in solution available to be reduced. If the cell contains 25cm^3 of 0.175M CuSO_4 , what is the maximum amount of electrical charge this cell could generate?

(b) What reactions and products would you expect at the electrodes in the electrolysis of aqueous NaF ? Explain clearly.

(a) We construct a cell in which identical copper electrodes are placed in two solutions. Solution A contains 0.80M Cu^{2+} . Solution B contains Cu^{2+} at some concentration known to be lower than that of Solution A. The potential of the cell is observed to be 0.045 volts. What is $[\text{Cu}^{2+}]$ in Solution B?

(b) A solution containing 11.2g of a non volatile solute in 250g of CCl_4 boils at 78.56°C . The boiling point of pure CCl_4 is 76.80°C . Calculate the molecular mass of the solute. K_b for CCl_4 is 5.02 .

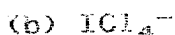
a) At 300°C the rate constant for the reaction



is $2.41 \times 10^{-10} \text{ s}^{-1}$. At 400°C, k equals $1.16 \times 10^{-6} \text{ s}^{-1}$.

Calculate the value of activation energy in kilojoules per mole for this reaction.

b) (i) Write Lewis structures of the following



[Note: central atom is written first.]

(ii) For each of the above molecules use the VSEPR theory to predict the geometric shape.

(a) Lactic acid, $\text{C}_3\text{H}_5\text{O}_3$ (=HLac), is a weak organic acid present in both sour and butter milk. It is also a product of carbohydrate metabolism and is found in the blood after vigorous muscular activity. A buffer is prepared by dissolving 1.00ml of lactic acid, HLac ($K_a = 1.4 \times 10^{-4}$) and 1.00ml of sodium lactate, NaLac, in enough water to form 550ml of solution. Calculate $[\text{H}^+]$ and the pH of the buffer.

b) Calcium phosphate, $\text{Ca}_3(\text{PO}_4)_2$, is a water insoluble mineral large quantities of which are used to make fertilizers. Taking its K_{sp} value as 1×10^{-33} , calculate the concentration of PO_4^{3-} in equilibrium with the solid, if $[\text{Ca}^{2+}] = 1 \times 10^{-9} \text{M}$.

(a) What is meant by petroleum cracking? 1

(b) During the process of cracking three products having the formula C_4H_8 were obtained from petroleum. Provide a structure for each of the products obtained

(c) When the three products obtained in (b) above are treated with HBr new products are formed. Write down the reaction in each case and provide a structural formula and IUPAC name for each of the new products.

(d) Why has methane got bond angles each equal to 109.5° ?

XX

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS-DECEMBER 1994

C220

PHYSICAL/ANALYTICAL/INORGANIC CHEMISTRY

TIME: THREE HOURS

ANSWER: ANY TWO QUESTIONS FROM SECTION A

QUESTION (1) AND ANY OTHER TWO QUESTIONS FROM SECTIONS B AND C

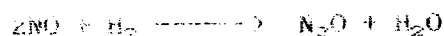
ELECTRONIC CALCULATORS ARE ALLOWED

SECTION A: PHYSICAL CHEMISTRY

ANSWER: ANY TWO QUESTIONS FROM THIS SECTION

QUESTION 1

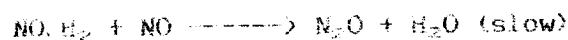
a) For the reaction between nitric oxide and hydrogen



It is found that doubling the concentration of both reactants increases the rate eightfold, but doubling the hydrogen concentration alone doubles the rate.

What is the order of the reaction with respect to nitric oxide and hydrogen?

b) Given that the mechanism of the reaction in (a) is as follows



Derive the steady state rate law for the mechanism and show under what condition the rate law reduces to the deduction in (a).

Penicillin is hydrolysed and thereby rendered inactive by

Penicillinase, an enzyme present in some resistant bacteria. The rate of hydrolysis was monitored at 298K and pH= 7.2. $1/V$ versus $1/(S)$ graph plot gave a slope of $7.6 \times 10^9 \text{ min mol}^{-1}$

Determine V_{max} and K_m for the hydrolysis.

QUESTION 2.

Define the term 'adiabatic process'.

One mole of an ideal gas at 20°C is compressed adiabatically so that the temperature rises to 50°C. Calculate the ΔU , q , w and ΔH for the process. C_v for the gas is $(3/2)R$.

(i) Derive the relation between conductance and conductivity.

(ii) From the following equivalent conductances at infinite dilution and 18°C. Calculate the molar conductivity at infinite dilution for NH_4OH .

Molar conductivity at infinite dilution for:

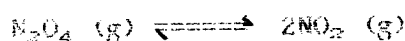
$$\text{Ba}(\text{OH})_2 = 228.8 \times 10^{-4} \text{ ohm}^{-1} \text{ m}^2 \text{ equivalent}^{-1}$$

$$\text{BaCl}_2 = 120.3 \times 10^{-4} \text{ ohm}^{-1} \text{ m}^2 \text{ equivalent}^{-1}$$

$$\text{NH}_4\text{Cl} = 129.8 \times 10^{-4} \text{ ohm}^{-1} \text{ m}^2 \text{ equivalent}^{-1}$$

QUESTION 3.

For the equilibrium reaction



The following data is given

	ΔH°	ΔG°
	(KJ mol ⁻¹)	(KJ mol ⁻¹)
$N_2O_4(g)$	9.16	97.8
$NO_2(g)$	33.18	51.30

Calculate the equilibrium constant for the reaction.

Calculate the equilibrium constant for the reaction at 343K.

By deriving the equation used in (b), state any assumption(s) in the calculations of the equilibrium constant at 343K.

ION B: ANALYTICAL CHEMISTRY

ER: TWO QUESTIONS INCLUDING QUESTION ONE

TION 1.

Calculate K_c for the reaction



at 200°C if 4.20 moles PCl_5 originally put in a 3.00l container were reduced to 1.00 mole at equilibrium?

Calculate the pH of the solution after mixing 50ml 0.010M

$Ba(OH)_2$ and 150ml of 0.010M HNO_3 .

) Calculate the pH of 0.10M barium acetate (BaA_2)

($A = CH_3COO^-$, K_a of $CH_3COOH = 1.75 \times 10^{-5}$)

Calculate the pH of the solution obtained by mixing 0.10 moles of

$NaOH$, 0.20 moles of acetic acid and 1.0 litre of water. K_a of

$CH_3COOH = 1.75 \times 10^{-5}$.

Calculate the solubility of silver sulphate, Ag_2SO_4 in moles per litre given that $K_{sp} = 1.2 \times 10^{-5}$.

Analysis of sodium in a sample gave the following readings (mg)
139.2 , 139.8 , 140.1 , 139.4

What is the range within which the true value lies at 95 % confidence level?

QUESTION 2.

Tartaric acid, H_2T is a weak diprotic acid $K_1 = 9.20 \times 10^{-4}$
 $K_2 = 4.31 \times 10^{-5}$

derive the expression of fractional equilibrium species , in terms of K_1 , K_2 , and $[\text{H}^+]$.

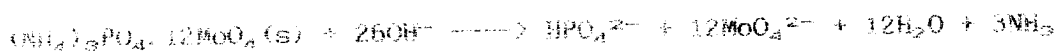
Hence calculate , at $\text{pH} = 3$ and its corresponding equilibrium concentration of the species for a 0.050M H_2T solution.

QUESTION 3.

Calculate the pH after addition of 0.0 , 15.0 , 50.0ml of 0.100M HCl in the titration of 50.0ml of 0.100M NH_3 K_b of $\text{NH}_3 = 1.75 \times 10^{-5}$

QUESTION 4.

A 0.141g sample containing Phosphorous was digested in strong acids to give Phosphoric acid (H_3PO_4) as the only Phosphorous containing product. The Phosphoric acid was completely precipitated out of solution as $(\text{NH}_4)_3\text{PO}_4 \cdot 12 \text{ MoO}_4$. The precipitate, after filtering, washing and drying was dissolved in excess NaOH (50.0ml, 0.200M).



The excess NaOH was back-titrated with HCl (14.17ml, 0.2000M).

With this data, determine the percentage Phosphorous in the sample.

N = 14.0 , P = 31.0 , O = 16.0 Mo = 95.9

QUESTION 5.

National Council for Scientific Research is currently involved in Uranium extraction from the local ores. The results (ppm) for the Uranium content of two sample ores :

Sample 1 : 10.32 , 10.39 , 10.19 , 10.21

Sample 2 : 10.45 , 10.41 , 10.51 , 10.36 , 10.34 , 10.39

By applying statistical analysis, deduce whether or not the two samples are significantly different at the 95% confidence level?

QUESTION 6.

A solution that is 0.010M Ca^{2+} and 1.0M EDTA is prepared. What will be the equilibrium concentration of Ca^{2+} ?

$$K_{eq} = 5.0 \times 10^{10}$$

10.0ml of 0.100M $AgNO_3$ were added to 50.0ml of 0.0500M NaCl

during titration. Calculate the chloride and silver ion concentration in the resulting solution. $K_{sp}(AgCl) = 1.75 \times 10^{-10}$

A mixture of 0.500g of $KClO_4$ and KCl was dissolved in water and the ClO_4^- converted into Cl^- . If the total Cl^- required 32.0ml of 0.138M $AgNO_3$, determine the percentage of $KClO_4$ and KCl in the sample. K = 39.1 , Cl = 35.5 , O = 16.0

ION C: INORGANIC CHEMISTRY

ER: TWO QUESTIONS INCLUDING QUESTION ONE

TION 1.

Give an equation relating the energy of a photon and the kinetic energy of an emitted electron and define the symbols used.

Write down one form of the Schrodinger equation and define its symbols.

Sketch the distribution functions of a 5p atomic orbital.

Deduce the period and group of an atom whose atomic number is 33.

Who derived an equation that relates the wavelength and the velocity of a particle? Write down the equation and define its symbols.

For each of the following pairs, choose one that is bigger giving reason(s).

(a) $_{12}\text{Mg}$, $_{20}\text{Ca}$

(b) $_{15}\text{P}$, $_{16}\text{S}$

Account for the following ionization energy (kJ mol^{-1}) observations

(a) First ionizations

$_{13}\text{Al}$ 577.6 , $_{12}\text{Mg}$ 737.7

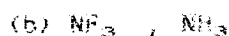
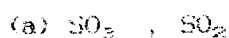
(b) First ionizations

$_{15}\text{P}$ 1012 , $_{17}\text{Cl}$ 1251

(c) First, second, third and fourth ionizations

$_{11}\text{B}$ 800, 2 430, 3 659, 25 020

With reasons choose a molecule which is more polar



Electronegativity numbers

S 2.5 , O 3.5

N 3.0 , F 4.0 , H 2.1

What is the hybridisation scheme around the central atoms in



Atomic numbers Be = 4 , F = 9 , N = 7 , O = 8

An example of

(a) Bidentate ligand

(b) Hexadentate ligand

QUESTION 2.

Briefly discuss how the photon concept explained the 'mystery' of the photoelectric effect.

Calculate the work function of a strontium metal in J mol^{-1} if an electron travels with a speed of $3.36 \times 10^7 \text{ cm/s}$ when the light of wavelength 405nm falls on it.

$$h = 6.63 \times 10^{-34} \text{ J.s} , m = 9.11 \times 10^{-31} \text{ Kg} , c = 3.00 \times 10^8$$

$$\text{J} = \text{Kg. m}^2\text{s}^{-2} , h_{\text{av}} = 6.02 \times 10^{23}$$

Strontium has the atomic number 38. Write the formulae of its oxide, chloride, hydride, hydroxide and carbonate.

QUESTION 3.

Draw the shapes (angular wave functions) of the atomic orbitals associated with the principal quantum number $n = 3$.

Draw a molecular orbital energy level diagram of CN^- . Using the diagram determine the bond order of CN^- and deduce its magnetic properties.

$N = 7$, $C = 6$

QUESTION 4.

What is the full name of VSEPR ?

Using VSEPR predict the shapes of the following species

(i) OF_2 (ii) PF_4^+ (iii) SF_4 (iv) BrF_4^- (v) BrF_4^+

discuss the nature of hybridization around the central atom in BF_3 .

$O = 8$, $F = 9$, $P = 15$, $S = 16$, $\text{Br} = 35$, $B = 5$

QUESTION 5.

Classify the following into covalent or ionic

H_2S , CaF_2 , HF , CF_4 , NaH

For the ionic ones indicate the charges and for covalent ones state whether polar or non polar.

Electronegativity numbers

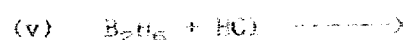
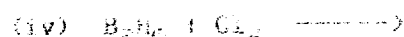
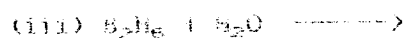
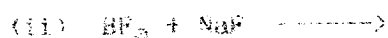
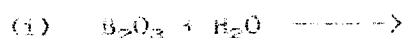
$H = 2.1$, $S = 2.5$, $Ca = 1.0$, $F = 4.0$, $C = 2.5$, $Na = 0.9$

Draw the shapes of the following chemical species:

(i) Al_2Cl_6 (ii) B_2H_6 (iii) C_2H_6 (iv) $[\text{Al}(\text{OH})_6]^{3-}$

Atomic numbers: $\text{Al} = 13$, $\text{Cl} = 17$, $B = 5$, $C = 6$, $O = 8$, $H = 1$

Complete and balance the following equations



SECTION B

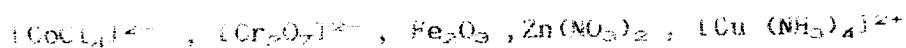
Zambia is an exporter of copper, cobalt and zinc whereas Zimbabwe exports chromium and steel (iron component).

(i) Write down the electron configurations of Copper (29),

Cobalt (27), Zinc (30), Chromium (24) and Iron (26)

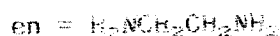
(ii) Assign groups to chromium, iron, and zinc.

(iii) Determine the oxidation states of the metal atoms in



Draw the shapes of

(i) the geometrical isomers of $[Co(en)_2Cl_2]^+$



(ii) $[Ni(NH_3)_6]^{2+}$

Using crystal field theory, account for the purple colour in

$[Ti(OH_2)_6]^{3+}$ complex. $Ti = 22$.

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

oct '94.

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

C 240

TIME: 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.

SECTION A

TIME: 1 HOUR

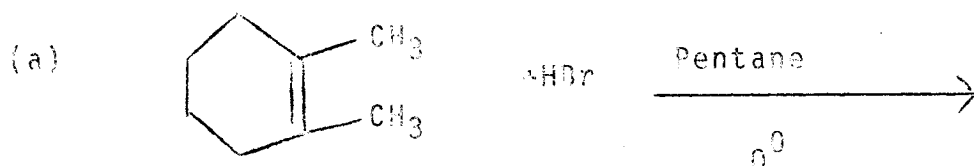
ANSWER ANY 3 OUT OF 4 QUESTIONS

TIME: . . .

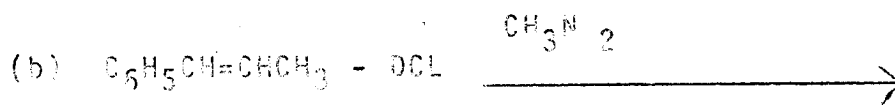
our

- (i) Treatment of meso-2, 3-dibromobutane [the 2R,3S diastereomer] with Potassium hydroxide (KOH) in ethanol gives a mixture of 3-bromo-1-butene and one of the isomeric 2-bromo-2-butenes. What is the stereostructure of the latter product?

- (ii) Indicate the stereoproducts of the following reactions?



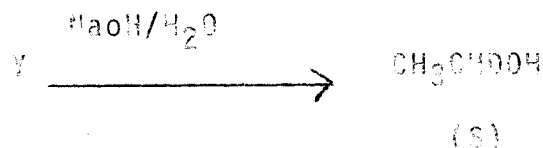
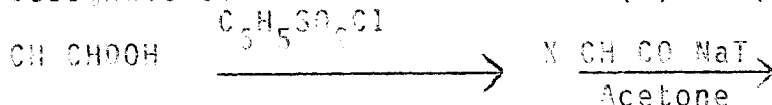
Z-1,2-dimethylcyclohexene



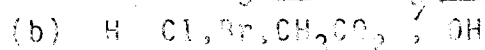
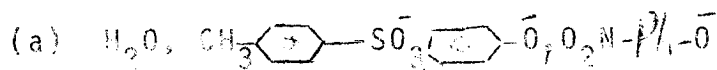
E-1-Phenyl-1-propene

- (i) Draw three-dimensional structures for the four compounds involved in the conversion of (R)-1-deuteroethanol to (S)-1-deuteroethanol depicted below.

Designate compounds X and Y as (R) or (S)



- (ii) Arrange the following sets of ions in decreasing order as leaving groups in nucleophilic substitution.



(i) Indicate which reagent in each pair is expected to be more nucleophilic towards CH_3Br in ethanol

- (a) $(\text{CH}_3)_3\text{B}$ or $(\text{CH}_3)_3\text{P}$
- (b) CH_3NH_2 or $(\text{CH}_3)_2\text{NH}$
- (c) $n\text{-C}_4\text{H}_9\text{O}^-$ or $t\text{-C}_4\text{H}_9\text{O}^-$
- (d) $\text{C}_6\text{H}_5\text{O}^-$ or $\text{C}_6\text{H}_5\text{OH}$
- (e) CH_3SH or CH_3OH
- (f) $p\text{-CH}_3\text{C}_6\text{H}_4\text{O}^-$ or $p\text{-NO}_2\text{C}_6\text{H}_4\text{O}^-$

(ii) 1-propyl halides undergo the S_N^2 reaction only, about only about 40% as fast as ethyl halides.

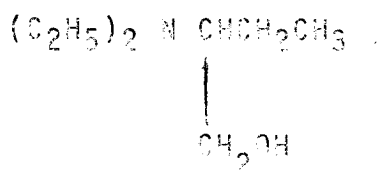
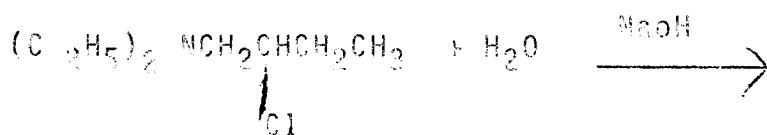
Draw three dimensional diagrams to account for these results.

Consider the Table below showing the effects of the medium on the rates of Nucleophilic (Nu) substitution

Mechanism	Reaction	Effect of Increasing Solvent Ionizing Power
S_N^2	$\text{Nu}^- + \text{R}-\text{L} \longrightarrow \text{R}-\text{Nu} + \text{L}^-$	Large acceleration
S_N^1	$\text{R}-\text{L} \longrightarrow \text{R}^+ + \text{L}^-$	Large acceleration
S_N^2	$\text{Nu} + \text{R}-\text{L} \longrightarrow \text{R}-\text{Nu} + \text{L}$	Large deceleration
S_N^1	$\text{Nu} + \text{R}-\text{L} \longrightarrow \text{R}-\text{Nu} + \text{L}^-$	Small deceleration

- . Draw the rate controlling transition state for each of the reactions above. Explain the observed solvent effect on the reaction rate.

(ii) Suggest a mechanism for the following reaction

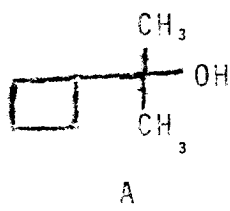


SECTION B

TIME: ONE HOUR

ANSWER ANY THREE OUT OF FOUR QUESTIONS.

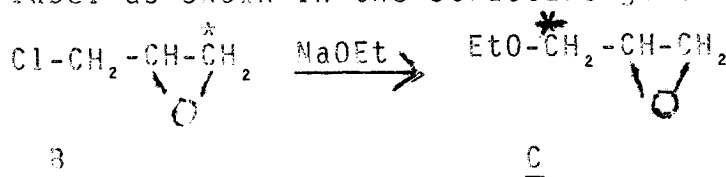
- a) Compound A reacted with HCl to give 1,1-dimethyl-2-chloro-cyclopentane as the major product. Suggest a stepwise mechanism for this reaction.



- b) Show clearly how the following transformation may be achieved in good yield. Reaction mechanisms are not required.



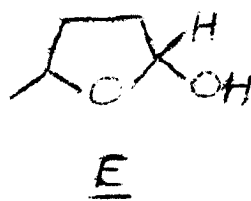
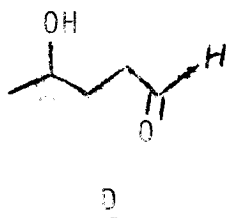
- c) When sodium ethoxide reacts with epichlorohydrin B, labeled with ^{14}C at the carbon shown by an asterisk, *, the major product is an epoxide C bearing the ^{14}C label as shown in the structure given below.



NOTE: * represents the isotopic carbon ^{14}C

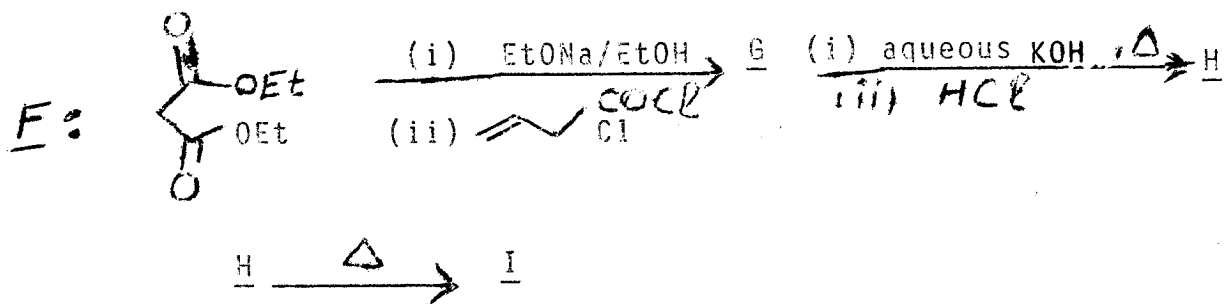
Provide a mechanistic explanation for this experimental result.

- a) Somewhat unexpectedly, attempted preparation of 2-oxo-2-pentanal by chromic acid oxidation of 1,4-pentanediol gave a compound E. Spectroscopic studies indicated that this reaction proceeded via an intermediate D



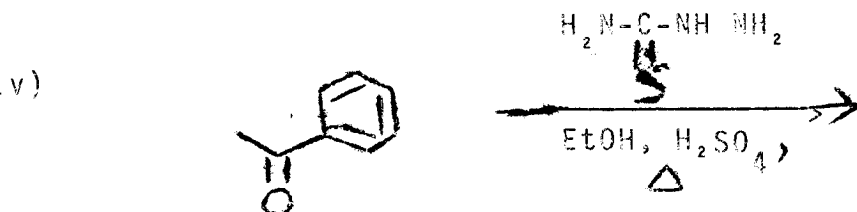
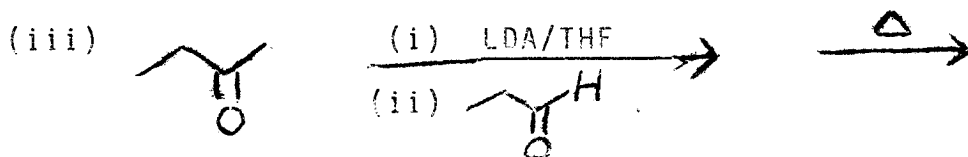
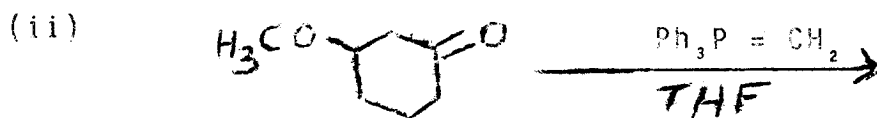
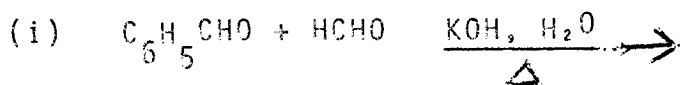
On this basis propose a mechanism to explain the formation of the unexpected product E from D.

- b) (i) Identify compounds G, H and I in the following synthetic scheme.

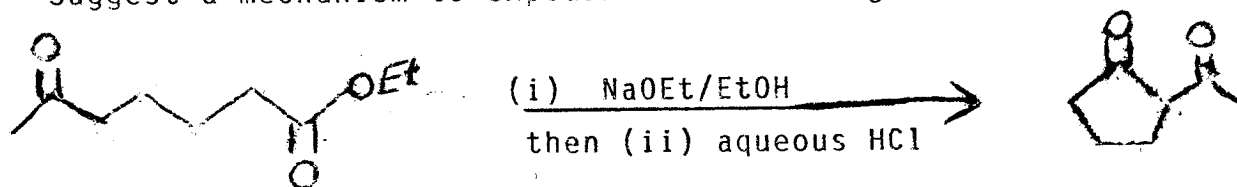


- (ii) Give mechanisms of the reactions involved in the formation of: (1) G from F and (2) I from H.

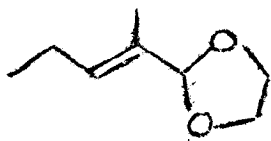
Predict the products and give mechanisms of Any Three of the following reactions.



a) Suggest a mechanism to explain the following reaction.



b) Suggest a stepwise synthesis of the following compound from alcohols containing FIVE OR FEWER carbon atoms and any other needed reagents.



SECTION 3

240/CAS10 BIOCHEMISTRY

Answer any FOUR questions

1. Explain what is meant by the following terms or phrases;

- (a) reducing sugar
- (b) nucleotide
- (c) non-competitive inhibition
- (d) buffering capacity

	<u>Gly</u>	<u>Lys</u>	<u>Asp</u>
pK'a ₁	2.34	2.18	2.09
pK'a ₂	9.6	8.95	9.82
pK'a ₃	-	10.53	3.86

Using the above information

(10) What are the predominant structures of the three amino acids at pH 1? pH 7?

(11) (a) What would be the most likely structure of the following tripeptide at pH 1? pH 7?

Gly-Lys-Asp

(b) What would be the net charge of the same peptide at pH 7?

3. (a) Calculate the $[H^+]$ of blood plasma pH 7.8

(b) If lactic acid (pK'a=3.86) and its salt are used to make a 0.49M buffer pH 4.0, what are the molar conc. of the acid and its salt in the buffer?

4. (a) Why is there no free rotation about a peptide bond?

(b) Briefly describe the four levels of protein structure.

- (a) Enzymes are biological catalysts. How do they speedup biochemical reactions?
- (b) What determines an enzyme's specificity?
- (c) What are the two types of enzyme inhibition?
- (d) Rearrange the M-M equation to give v as a function of $v / [S]$.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER, 1994

C310

BIOCHEMISTRY PAPER I

TIME: THREE HOURS

INSTRUCTIONS:

1. Answer ALL Questions in Section A.
 2. Answer any TWO Questions in Section B.
-

Section A

- Q1. What is the use of the following reagents in protein chemistry
- (a) Dabsyl Chloride and
 - (b) Chymotrypsin?
- Q2. Briefly explain why gluconeogenesis is not just a simple reversal of glycolysis. (5 sentences maximum)
- Q3. If formic acid ($pK_a = 3.75$) and its salt are used to prepare a 0.5M buffer solution, pH 4.0, What would be the Molar Concentrations of the acid and its Anion in the buffer solution?
- Q4. Where do the following processes take place in the cell?
- (a) TCA cycle.
 - (b) Oxidative phosphorylation
 - (c) Pentose monophosphate shunt
 - (d) Glycolysis

For the next set of Questions (5 - 10), answer TRUE or FALSE, if false explain why.

- Q5. When oxygenated the 3-D structure of Hb in vivo losses much of its α - helical conformation.
- Q6. Thiamine pyrophosphate (TPP) is a part of the following enzymes. Pyruvate Dhase, α - ketoglutarate Dhase, and Hexokinase.

Q7. The Michaelis - Menten Constant, K_m :

- (a) represents the substrate concentration at which the reaction rate is half V_{max} .
- (b) of some enzymes may be altered by the presence of metabolites structurally unrelated to the substrate.

Q8. There is free rotation about a peptide bond.

Q9. P680 donates an electron directly to $NADP^+$ upon photoexcitation.

Q10. Cyclic photophosphorylation involves both photosystem I and II.

Section B

Q11.(a) (i) Outline the rxns constituting glycolysis giving the structures, and names of the compounds involved as well as enzymes and cofactors.

(ii) What is the major control point in glycolysis and how is it controlled?

(b) How many ATP molecules are made from one glucose molecule when it passes through glycolysis?

Q12. (i) Distinguish between oxidative phosphorylation and substrate level phosphorylation.

(ii) (a) Explain the transfer of electrons from NADH to O_2 ; giving the names of the enzyme complexes and also the mobile carriers.

(b) How is the oxidation of NADH coupled to the synthesis of ATP?

(c) Why is cyanide a poison?

Q13. (i) What are C_3 and C_4 plants? Give an example of each.

(ii) What purpose is achieved by the light reactions in photosynthesis?

- (iii) Explain how hexose is made by the Calvin Cycle?
- (iv) Explain briefly what is meant by the term "Photorespiration".

Q14.(i) The absorbance of a protein solution containing 1mg/ml albumin was measured using a 1cm light path and was found to be 0.550 and 0.199 absorbance units at 279nm and 290nm respectively. Assuming that tyrosine and tryptophan residues are the a.a's which have appreciable absorbances at these wavelengths, calculate the number of the two a.a's residue in a molecule of the protein given that:

- (a) MW of the albumin is 65kd
- (b) The molar extinction coefficient to tyrosine is 1.1×10^3 l/mole cm at 279nm and 0.28×10^3 l/mole cm at 290nm.
- (c) The molar extinction coefficient of tryptophan is 5.2×10^3 l/mole. cm at 279nm and 4.3×10^3 l/mole.cm at 290nm.

- (ii) In an experiment on a certain enzyme and its inhibitor the following information was obtained:

(S) (mM)	V-noinhibitor (μ mole min ⁻¹ mg ⁻¹)	V-inhibitor present (μ mole min ⁻¹ mg ⁻¹)
3.0	2.2×10^3	1.83×10^3
5.0	3.20×10^3	2.56×10^3
7.0	3.86×10^3	3.09×10^3
9.0	4.36×10^3	3.49×10^3
11.0	4.75×10^3	3.80×10^3

- (i) Draw the lineweaver - Burks Plots
- (ii) What are the Km and Vmax values of the
- Uninhibited reaction and of the
 - inhibited reaction
 - Is the inhibitor competitive or noncompetitive?

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - NOVEMBER 1994
C310 PAPER II

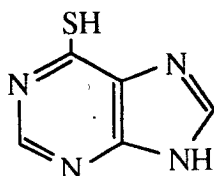
TIME : THREE HOURS

ANSWER : FIVE QUESTIONS

ALL QUESTIONS HAVE EQUAL MARKS

1. (a) What α -keto acids (structure and name) are formed from the transamination reactions involving the following amino acids:
 - (i) Alanine
 - (ii) Aspartate
 - (iii) Tyrosine
- (b) Show how glutamate may be converted to an intermediate in gluconeogenesis.
- (c) Show how serine can be made from 3-phosphoglycerate.
2. A once popular but controversial diet for losing weight rapidly is high in protein and lipid but lacks carbohydrates almost entirely. Its proponents claim that on this diet, you can eat as much protein and lipid rich food as you wish but nevertheless lose weight. Patients on the diet often complain of bad breath.
 - (a) Give a plausible metabolic explanation for why this diet is effective
 - (b) Discuss the claim that there is no limit to the amount of protein and lipid you can eat and still lose weight.
3. Give a detailed account of the β oxidation of palmitic acid in animals.

4. One of the drugs used for cancer chemotherapy is 6-mercaptopurine (structure shown below) which must be converted to a nucleotide before it can have any effect on the rate of purine synthesis.



- (a) What enzyme is used to convert 6-mercaptopurine to its nucleotide and why?
 - (b) Why is 6-mercaptopurine administered instead of its nucleotide?
 - (c) Suggest three ways in which the nucleotide derived from 6-mercaptopurine can inhibit *de novo* purine synthesis.
5. With reference to the *lac* operon, describe the mechanism of regulation of gene activity in *E. Coli*.
6. *E. Coli* ribonuclease contains 104 amino acid residues. Assuming the reaction begins with free amino acids, tRNAs, aminoacyl-tRNA synthetase, GTP, ATP, ribosomes, and the factors required for protein synthesis, how many high-energy phosphate bonds are used to translate the mRNA of ribonuclease once? Explain your answer.
7. Somogyi-blood filtrates are prepared as follows: Blood, 0.1 ml is combined with 3.5 ml water, 0.4 ml 0.5 M barium hydroxide, and 0.4 ml 5% zinc sulfate. Precipitated proteins are removed by centrifugation.

Blood sugar is determined by mixing 2 ml of the Somogyi-blood filtrate and 1.0 ml alkaline copper reagent. This is heated in a boiling water bath for 20 min, then cooled, and 1.0 ml arsenomolybdate color reagent added. The sample is diluted to 12.5 ml and the optical density at 540 nm ($OD_{540\text{ nm}}$) measured against a water blank.

- (a) What part of the original 0.1 ml of blood is actually used in the blood sugar measurement?
- (b) A blood sample taken from patient A gave an $OD_{540\text{ nm}}$ of 0.30. If a standard tube containing a known amount of glucose (0.1 ml of a 0.05% glucose solution) also gave an optical density of 0.30, what is the concentration of glucose in blood (mg/100 ml)?
- (c) If you make a mistake in dispensing the alkaline copper reagent (added 2 ml to all tubes instead of 1 ml), what effect would this have on the final result?

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

C 320

PAPER I

E: THREE HOURS

WER: ANY FOUR QUESTIONS

(a) Complete the following table:

	λ [cm]	ν [sec ⁻¹]	$\tilde{\nu}$ [cm ⁻¹]
i.		2.0×10^{10}	
ii.			2.0×10^5

(b) Complete the following table:

[M.M. = 420, where there is need]

	A	T%	b (cm)	ϵ (l/mol. cm)	x [M]
i.		92		4765	3.8×10^{-6}
ii.	0.167		1.0		2.5×10^{-2}

- (c) i. Calculate the energy in kJ at 420 nm and 750 nm per mole respectively.
- ii. What are the wave numbers at 420 and 750 nm respectively?
[$h = 6.62 \times 10^{-34}$, $N_A = 6.02 \times 10^{23}$, $c = 3.0 \times 10^8$ m/s]

- (d) A 1.28×10^{-4} M solution of potassium permanganate has a transmittance 70% at 525 nm in 2.00 cm cell.
[M.M. $\text{KMnO}_4 = 158.04$]

- i. What is the absorbance and molar absorptivity of this solution?
- ii. If the concentration were doubled, what would be transmittance and absorbance respectively?
- iii. What concentration would have a transmittance of 0.5 in this cell?

- (e) The molar absorptivity of acetone (M.M. = 58) in hexane solvent is 900 at 188 nm.
Calculate the maximum concentration (g/l) that could be used in 2.0 cm cell, so that absorbance will not exceed 0.9.
- (a) A 1.560 g steel sample is dissolved, and Mn in the sample is oxidized to permanganate by periodate using Ag^+ as a catalyst. After the sample is diluted to 500 ml, the absorbance is found to be 0.393 at 540 nm in a 2.00 cm cell. The molar absorptivity for permanganate at 540 nm is 2025. Calculate the percentage of Mn in the steel sample.
[Mn = 54.938]
- (b) A 0.300 g sample containing Cu is dissolved, and a diethyldithio-carbamate colored complex is formed in the presence of EDTA. The solution is then diluted to 50.0 ml and the absorbance measured as 0.260. A 0.800 g sample containing 0.240% Cu is treated in the same manner, and the resulting solution has an absorbance of 0.600. Calculate the percentage of Cu in the sample. [Cu = 63.54]
- (c) Titanium and vanadium form colored complexes with hydrogen peroxide. Separate solutions containing 10.0 mg of these metals were treated with perchloric acid and hydrogen peroxide and diluted to 100 ml. A third solution was prepared by dissolving 2.500 g of alloy (containing Ti and V but not other interfering metals) and treating in the same manner as the standard solutions. The absorbances of the three solutions were measured at 410 and 460 nm in 2 cm cell.
Calculate % V and % Ti in the alloy. [Ti = 47.90, V = 50.9415]

Solution	A_{410}	A_{460}
Ti	0.760	0.513
V	0.185	0.250
Alloy	0.715	0.657

(d) Bilirubin in blood serum absorbs strongly at 461 nm but not at cell at 551 nm. On the other hand, the absorbance due to hemoglobin and solution turbidity is about the same at both wavelengths. Thus a simple method for determining bilirubin is based on the difference in absorbance at the two wavelengths. A 20.0 microliter sample of blood serum, diluted to 1.0 ml with sodium citrate buffer of pH 8.8, had absorbances of 0.871 and 0.637 at 461 nm and 551 nm respectively. When 20.0 microliter of a bilirubin standard (50.0 µg/ml) was treated similarly, the absorbance were 0.337 and 0.014 at 461 and 551 nm respectively. Calculate the concentration of bilirubin in units of µg/ml in the serum.

- (a) Explain principle of IR - spectroscopy and Raman spectroscopy respectively.
- (b) What type of bending vibrations do you know? Sketch them.
- (c) What are the differences between sources, monochromators, cells and detectors in UV + VIS and IR spectroscopy respectively.
- (d) Explain different sample handling techniques in IR - spectroscopy.
- (e) Calculate the wavenumber and wavelength of the fundamental absorption peak due to stretching vibration of a $C \equiv N$ group.
 $[C = 12, N = 14, k = 1.5 \times 10^3 \text{ N/m}, C = 3.0 \times 10^8 \text{ m/s}, N_A = 6.02 \times 10^{23}]$

- (a) Explain principle of ^1H NMR spectroscopy.
- (b) What are basic differences between NMR and ESR spectroscopy methods?
- (c) Explain ^{13}C NMR spectroscopy and their advantages comparing to ^1H NMR.
- (d) Explain chemical shift and spin-spin splitting for ^1H NMR.
- (e) What are the advantages for using Fourier Transformation technique in NMR - spectroscopy.

- (f) ^1H NMR spectrum of organic compound are three signals with the frequencies from TMS 192, 554 and 924 Hz.
- Calculate their chemical shifts, if the spectrum were measured with apparatus with $\nu_0 = 80$ MHz.
 - At which frequencies from TMS can we find the signals, if we use apparatus with $\nu_0 = 350$ MHz?
- (g) Write a ^1H NMR spectrum of compounds:
- $$\begin{array}{c} \text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_3 \\ | \\ \text{I} \\ | \\ \text{Cl} \end{array}$$
 - $\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_2-\text{NO}_2$
- (a) Explain principle of emission spectroscopy.
- (b) What are basic differences between emission spectroscopy and atomic absorption spectroscopy respectively.
- (c) Describe type of sources for emission spectroscopy and AAS respectively.
- (d) Explain Inductively Coupled Plasma source. Sketch a diagram.
- (e) Outline briefly fluorescence method.
- (f) Explain standard addition method for AAS.
- (g) A 2.00 ml sample of cow's milk was diluted to 50 ml and analyzed for Zn, using AAS. The absorbance was 0.106. A second 2.00 ml aliquot was spiked with 12 μg of Zn before dilution to 50 ml. The absorbance was 0.245. Calculate Zn concentration in the milk as part per million. [Zn = 65.38]
- (h) Magnesium in blood serum can be determined by AAS. A 2.00 ml serum sample is diluted to 100 ml, and its absorbance is 0.125. A standard containing $2.0 \times 10^{-5} \text{ M Mg}^{2+}$ gives an absorbance of 0.187. Calculate Mg concentration in the blood as milligram percent (mg/100 ml). [Mg = 24.305]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

C 320
PAPER II

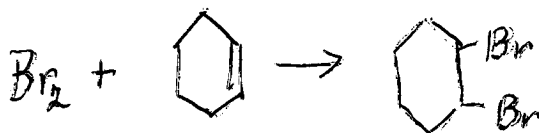
TIME: THREE HOURS

ANSWER: ANY FOUR QUESTIONS

- (a) Explain briefly potentiometric titration.
- (b) Explain asymmetry potential in glass electrode.
- (c) What is a junction potential?
- (d) Explain acid error and alkaline error in glass electrode.
- (e) What type of indicator electrodes can you use for:
- (i) neutralization potentiometric titrations
 - (ii) acido-reduction potentiometric titrations
 - (iii) precipitation potentiometric titrations
- (f) (i) Estimate E_{SCE} from the solubility of KCl, which is 4.18 M at 25°C, neglecting activity coefficients.
[$E^{\circ}_{SCE} = +0.268$ V]
- (ii) The actual value of E_{SCE} is +0.242 V vs. NHE.
Calculate the activity of chloride ion and its activity coefficient.
- (g) A 100.0 ml solution containing 0.100 M NaCl was titrated with 0.10 M $AgNO_3$, and the voltage of the cell was monitored.
Calculate the voltage after the addition of 65.0, 100.0 and 103.0 ml of $AgNO_3$.
[$E^{\circ}_{Ag} = +0.799$ V, $K_{sp} AgCl = 1.8 \times 10^{-10}$]
- (a) Explain principle of coulometric method.
- (b) A solution containing 75.0 mg of copper was electrolyzed at a constant current of 0.250 A, causing metallic copper to deposit on a platinum cathode.
What was the percentage of copper remaining in the solution after 15 min?
[Cu = 63.54]

- (c) Copper in a brass sample was determined by coulometric titration with constant 35.0 mA. If a 15.0 mg sample requires 470 sec, what is the % Cu in the sample?
[Cu = 63.54]

- (d) A 2.00 ml volume of solution containing 0.6113 mg of cyclohexene/ml is to be titrated coulometrically. If the coulometer is operated at a constant current of 4.825 mA, how much time will be required for complete titration?
Reactions:



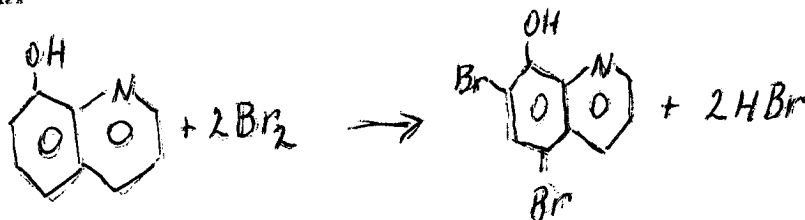
[F = 96,500 C]

- (e) A 408.1 mg sample containing aluminium was dissolved and treated with 25.0 ml of 0.0200 M 8-hydroxyquinoline. The precipitated AlQ_3 (Q = 8-hydroxyquinolate) was removed by filtration and discarded. The 8-hydroxyquinolate remaining in the solution was titrated with electrogenerated bromine at a constant current of 35.0 mA, requiring 131 sec. to reach the equivalence point.

Calculate the percentage of Al_2O_3 in the sample.

[M.M. Al_2O_3 = 101.97]

Reaction:



- (a) Explain principle of DC-polarographic method.
 - (b) Explain capacitance (or charging) current in polarography.
 - (c) (i) Write the principle of pulse and differential pulse polarography.
(ii) Why is differential pulse more sensitive than DC-polarography?
 - (d) The drug Librium gives a polarographic wave with $E_{1/2} = -0.265V$ in $0.05 M H_2SO_4$. A $50.0 ml$ sample containing Librium gave a wave height of $0.37 \mu A$. When $2.00 ml$ of $3.00 mM$ Librium in $0.05 M H_2SO_4$ was added to the sample, the wave height increased to $0.80 \mu A$.
Find the molarity of Librium in the unknown.
 - (e) The differential pulse polarogram of $3.00 ml$ of solution containing the antibiotic tetracycline in $0.1 M$ acetate, $pH = 4$, gives a maximum current of $152 nA$ at a half-wave potential of $-1.05 V$. When a $0.50 ml$ containing $2.65 ppm$ of tetracycline was added, the current increased to $206 nA$. Calculate the parts per million of tetracycline in the original solution.
 - (f) What is relative decrease of concentration of Zn^{2+} ion in percentage after electrolysis on the mercury drop electrode which last $3 min$. Electrolysis is provided on the potential of the limit diffusion current. Suggest the current of the electrolysis is constant. [$Zn = 65.39$]
[80 drops fallen down from capillary after $4.0 min$., weight $0.480 g$ of mercury; diffusion coefficient, $D = 9.0 \times 10^{-6} cm^2/s$; $C = 0.6 mM$ and $V = 20 ml$].
4. (a) Explain partition coefficient, retention time and relationship between them.
- (b) Explain plate height and number of theoretical plate in chromatographic column.
- (c) Describe efficiency of chromatographic columns.

- (2) In a 1000 cm wall coated open tubular column of 0.25 mm bore, the helium carrier gas velocity is 37 cm/sec. The retention time t_R for decane is 1.27 min; peak width at half height is 0.88 sec. What is the retention time for a nonretained compound t_M , partition ratio k' , number of effective plates N , and plate height H .
- (e) (i) In the column 122 cm long, operated at 160°C, these retention times (in minutes) were obtained: air peak 0.90; heptane 1.22; and octane 1.43. The base widths of the bands were 0.14 for heptane and 0.20 for octane. What are the relative retention and the resolution for these bands?
- (ii) Because the separation of heptane and octane is less than the baseline width of the bands, how much should the column be lengthened from the original 122 cm length?
- (a) Explain Eddy diffusion, Longitudinal diffusion and Mass transfer respectively.
- (b) Explain Peak area Integration.
- (c) What are the basic components of gas-liquid chromatograph? Sketch them.
- (d) Explain detectors for gas-liquid chromatographs.
- (e) What are the basic components of HPLC. Sketch them.
- (f) ~~Explain Ion Exchange Chromatographic Method.~~
- (g) Consider a 50 cm column with a plate height of 1.5 mm that provides a theoretical plate number of 333 at a flowrate of 3 ml min^{-1} , $V_m = 1.0 \text{ ml}$.
- (i) What are the solute retention time and retention volume when k' is 1, 5 and 10?
- (ii) What is the baseline peak for each of the foregoing values of k' ?

END OF EXAMINATION

$$W = 4(t_R - t_M) \sqrt{\frac{N}{12}}$$

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS NOVEMBER/DECEMBER 1994

CH40

INORGANIC CHEMISTRY

PAPER I

TIME : THREE (3) HOURS

INSTRUCTIONS

- (i) This examination has SIX (6) questions.
 - (ii) Attempt ANY FOUR (4) questions.
 - (iii) Answer each question in a separate Answer Book.
 - (iv) Each question carries Twenty Five (25) marks.
 - (v) A Tidy and Orderly presentation is a must.
-

(a) Describe in detail by using flow sheet diagram, the manufacture of Sodium Carbonate by Solvay Process. State the principles involved in this process.

(b) Write balanced equations for the chemical reactions, when:

- (i) Potassium dichromate reacts with potassium iodide in the presence of sulphuric acid.
- (ii) A mixture of sodium sulphide, sodium sulphite and iodine is heated.
- (iii) Calcium phosphate reacts with phosphoric acid.
- (iv) Carbon dioxide gas is passed through lime water for a long time.

(v) Sodium bicarbonate is heated.

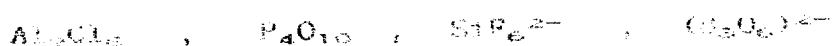
(b) Explain borax bead test for the identification of chromium.

(c) Give three commercial uses of each of the following:

(i) Aluminium

(ii) Phosphates

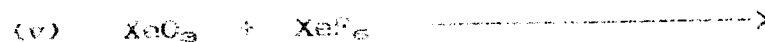
(d) Draw the structures of the following species.



(e) Write balanced equations for the chemical reactions between lithium aluminium hydride and

(i) Ammonia, (ii) Methylamine, (iii) Acetylene

(f) Complete and balance the following reactions.



(g) How would you obtain the following?

(i) Arsine from Arsenic trichloride.

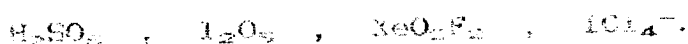
(ii) Hydrogen peroxide from barium peroxide.

(h) Describe the conversion of bauxite ore of aluminium ^{into pure alumina} by Bayer's process.

What happens when:

- (i) A mixture of boron oxide, sodium fluoride and conc. sulphuric acid is heated.
- (ii) Sulphurous acid reacts with potassium permanganate.
- (iii) Ozone reacts with potassium iodide in aqueous medium.
- (iv) A mixture of mercuric cyanide and mercuric chloride is heated.

Draw the structures of the following



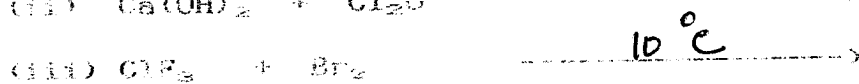
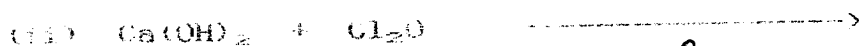
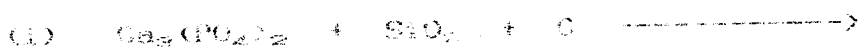
How are the following compounds prepared?

- (i) Ethylmagnesium iodide, (ii) Aluminium Hydroxide.

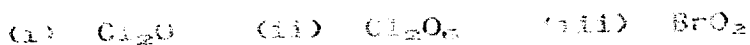
How is nitric acid manufactured by the Ostwald process?

Write concise notes on interhalogen compounds.

Complete and balance the following chemical reactions:



Write balanced equations for the reactions between sodium hydroxide and the following.



- (a) Give a generalised comparison of lanthanides with first row of transition metals.
- (b) Give three commercial uses of each of the following:
(i) Sulphuric acid (ii) Borates
- (c) Work out the ground state spectroscopic terms and their corresponding magnetic moments (μ_T) for the following ions:
(i) $_{65}\text{Nd}^{3+}$ (ii) $_{81}\text{Tm}^{3+}$
- (d) (a) Draw the structure of $\text{U}(\text{acac})_3$ and $\text{UO}_2(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O}$ and determine the coordination number of uranium.
(b) Compare magnetic and spectral properties of lanthanides and actinides.
(c) Write balanced chemical reactions when thorium oxide reacts with
(i) CCl_4 (ii) CO_2 (iii) H_2O

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATION - NOVEMBER/DECEMBER 1994

CS40

INORGANIC CHEMISTRY

PAPER II

TIME : THREE (3) HOURS

INSTRUCTIONS

- (i) This examination has SIX (6) questions.
- (ii) Attempt ANY FOUR (4) questions.
- (iii) Answer each question in a separate Answer Book.
- (iv) Each question carries Twenty Five marks.
- (v) A Tidy and Orderly presentation is a must.

1. The Stoichiometry and Stability of organometallic complexes tends to be governed by the 18-electron rule. Discuss the applicability of the 18e rule with special reference to the following organotransition - metal complexes:

$[\text{Co}(\text{NH}_3)_6]^{3+}$, metal carbonyls $\text{Fe}_3(\text{CO})_{12}$, $\text{V}(\text{CO})_6$, $\text{Mn}(\text{CO})_5$,

$\text{Mn}(\text{C}_2\text{H}_5)(\text{CO})_4$ and $[\text{Ir}(\text{CO})(\text{PPh}_3)_2(\text{NO})]$.

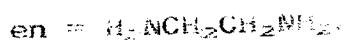
2(a) A spectrum of $[\text{Cr}(\text{NH}_3)_6]^{3+}$ in aqueous solution gives absorption maxima at $21,500 \text{ cm}^{-1}$, $28,500 \text{ cm}^{-1}$ and $40,000 \text{ cm}^{-1}$.

(i) Draw an energy level diagram for this complex to show the transitions and splitting occurring in the ground and excited states.

(ii) Calculate D_q in this ligand environment.

(iii) Calculate the interelectron repulsion parameter B for the complex.

(b) Given the complex $(Co(en)(NH_3)_2Cl_2)Cl$. Name and write down all possible isomers arising from the complex.



(a) While the d electrons in many transition metal compounds may not be involved directly in bond formation, they nevertheless exert a considerable influence on structure. Explain.

(b) An octahedral Cobalt(III) complex shows a magnetic moment of $0.0 \mu_B$. What is its electronic configuration? Comment on why the orbital contribution to the overall magnetic moment is zero.

(a) Ferro- and antiferromagnetism arise from a "cooperative phenomena". Explain.

(b) Explain why the molecular orbital theory (MOT) is regarded superior to crystal field theory (CFT) in explaining bonding between transition metal elements and ligands.

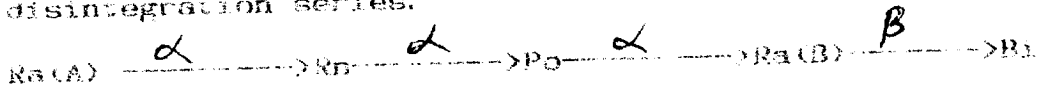
5(a) What is meant by: (i) half life period, and (ii) average life period of radioactive element.

(b) The atomic mass of $^{127}_{53}\text{I}$ is 126.9004 amu. Calculate the total nuclear binding energy for this nucleus and the corresponding energy per nucleon in Mev.

(c) One gram of ^{99}Mo decays by β emission to 0.125 gram in 200 hours. What is the half life period of ^{99}Mo ?

6(a) How many α and β particles will be emitted by $^{218}_{84}\text{Ra}$ in changing to a stable isotope of lead ($^{206}_{82}\text{Pb}$)?

(b) Calculate the mass number, atomic number and position in the periodic table for Bismuth (Bi) in the following disintegration series.



Mass No. of Ra(A) = 226; Atomic No = 88; Position in the periodic table = IIA group.

(c) One gram of a radioactive isotope of sodium decays to 0.25g in one day and six hours. How much time will it take for the radioactivity to fall to one tenth of its original value.

USEFUL INFORMATION AND PHYSICAL CONSTANTS

Mass of proton = 1.007838 amu

Mass of neutron = 1.008665 amu

Mass of $^{127}_{53}\text{I}$ = 126.9004 amu

Velocity of light = 3.00×10^8 m/sec

1 eV = 6.25×10^{12} MeV

1 amu = 1.66×10^{-27} kg

Atomic number:

V = 23; Cr = 24; Mn = 25; Fe = 26; Co = 27; Ir = 77

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER, 1994

C350

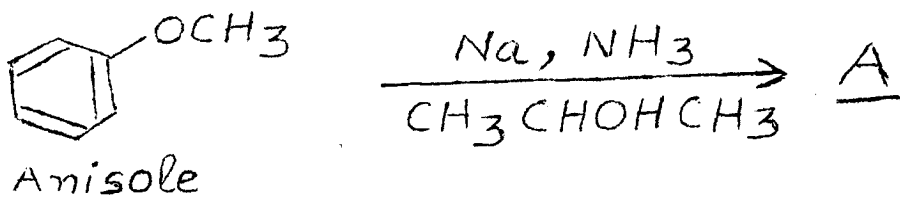
ORGANIC CHEMISTRY

PAPER I

TIME: THREE HOURS

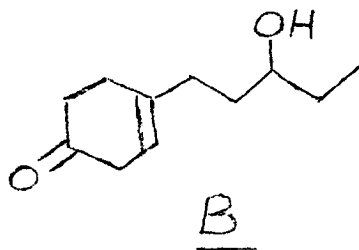
ANSWER: ANY FOUR QUESTIONS

1. (a) (i) Predict the major organic product and give mechanism of the following reaction.

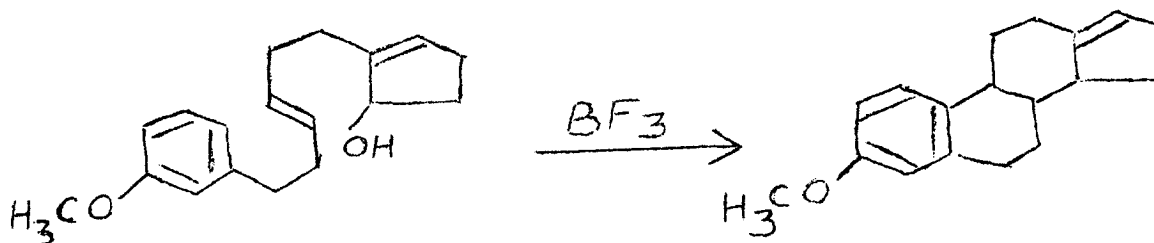


- (ii) Treatment of A with dilute hydrochloric acid gives 3-cyclohexenone. Suggest a mechanism for this transformation.

- (b) On the basis of the information in 1 (a) above, devise an efficient synthesis of compound B from anisole and any other readily available materials.



- (c) Propose a reasonable mechanism for the following transformation.



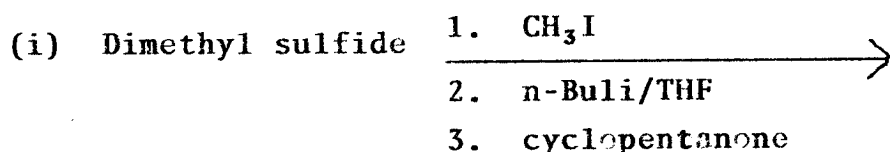
2. A biologically active compound X, $C_{13}H_{20}O_2N_2$, was found to be insoluble in water and dilute sodium hydroxide, but soluble in dilute hydrochloric acid. Upon treatment of X with sodium nitrite and aqueous hydrochloric acid and then with beta-naphthol, a highly coloured solid C was formed.

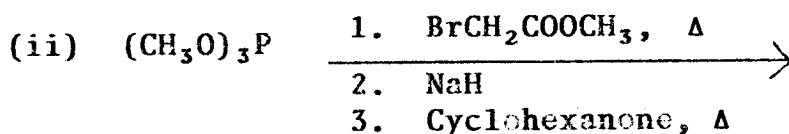
When X was boiled with aqueous sodium hydroxide, it slowly dissolved. The solution was allowed to cool, extracted with ether, and the layers were separated.

Acidification of the aqueous layer with concentrated HCl gave a white solid D which redissolved on continued addition of the acid. Upon isolation, D was found to have a melting point of $185^{\circ}C$ and molecular formula $C_7H_7O_2N$. I.R. and 1H NMR spectrum of D indicated the presence of a para disubstituted benzene.

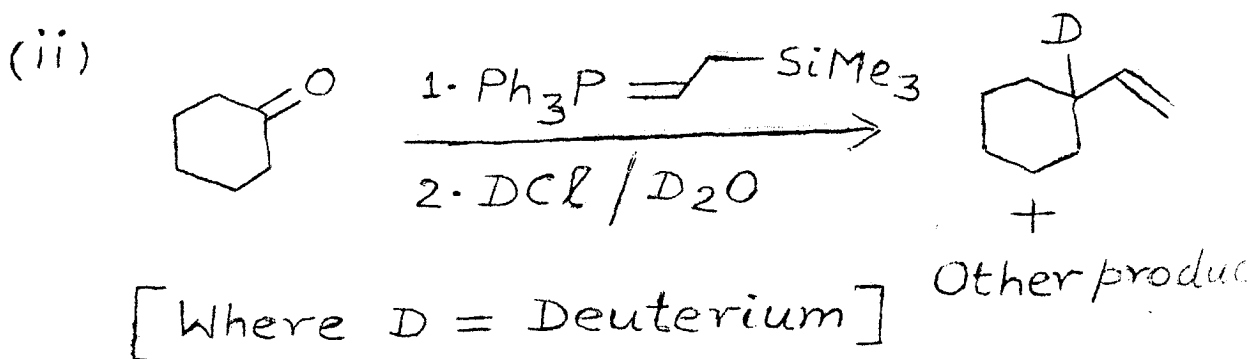
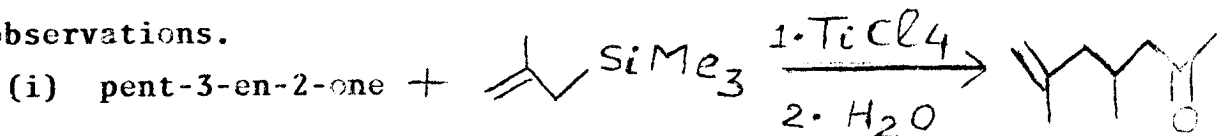
Evaporation of the ether layer gave a liquid E, $C_6H_{15}ON$, which dissolved in water, and aqueous solution of E turned red litmus blue. E was found to be identical with the compound formed by the action of diethylamine on ethylene oxide.

- (i) Deduce the structure of X from the above information. Show your reasoning.
- (ii) What is C? Give mechanisms of the reactions involved in the formation of C from X.
- (iii) Suggest a synthetic scheme for X starting from benzene or a mono-functionalised benzene and any other readily available reagents.
3. (a) Predict the products and give mechanisms of the following reactions.





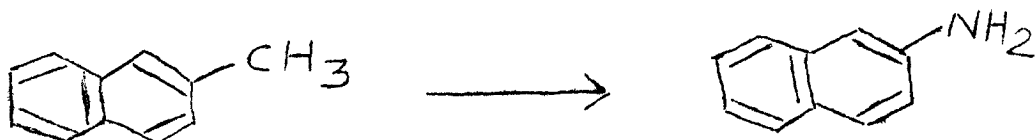
(b) Provide a mechanistic rationale for each of the following observations.



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



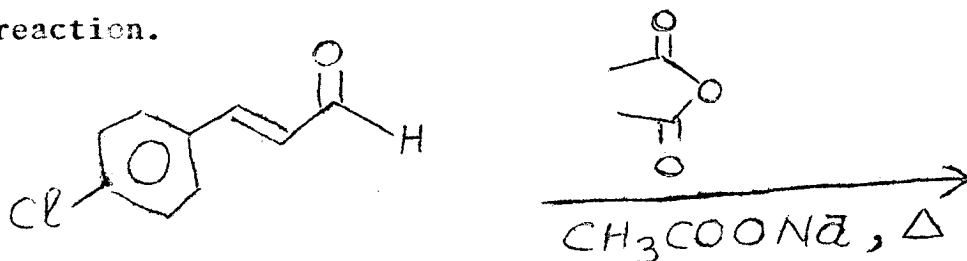
(ii)



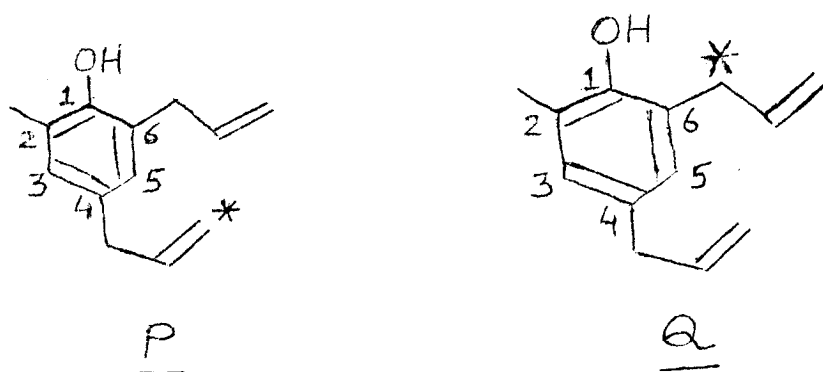
(b) When a trace of KNH_2 is added to a solution of chlorobenzene and potassium triphenylmethide, $(\text{C}_6\text{H}_5)_3\text{CK}$, in liquid ammonia, a rapid reaction takes place to yield a product F, $\text{C}_{25}\text{H}_{20}$.

What is F? What is the role of KNH_2 and why is it needed?

(c) Predict the product and give mechanism of the following reaction.

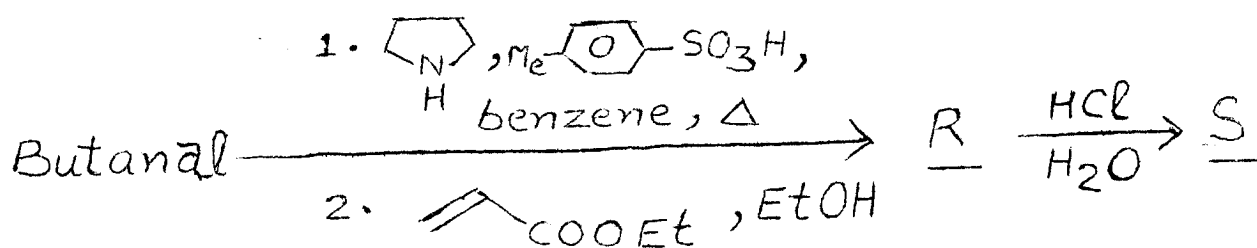


5. (a) Allyl chloride, $^*\text{CH}_2=\text{CHCH}_2\text{Cl}$, labeled with ^{14}C at the position shown by the asterisk, $*$, was allowed to react with the anion derived from 2-methyl-6-allylphenol to form the corresponding ether G. Upon heating, G gave a mixture of products P and Q which were found to contain ^{14}C label in the allyl group at positions shown;

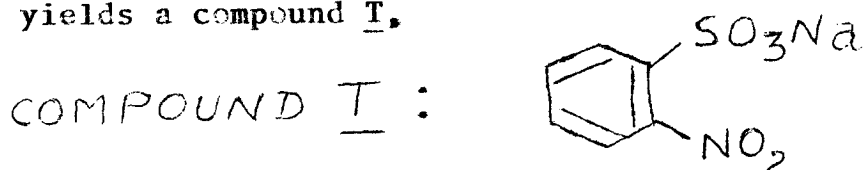


Suggest a mechanistic explanation for these experimental results.

- (b) Identify compounds R and S in the following reaction and write mechanisms of the reactions involved in the formation of R from butanal.



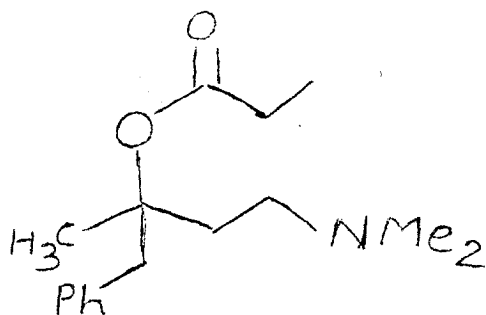
- (c) Treatment of ortho-chloro-nitrobenzene with aqueous sodium sulfite yields a compound T.



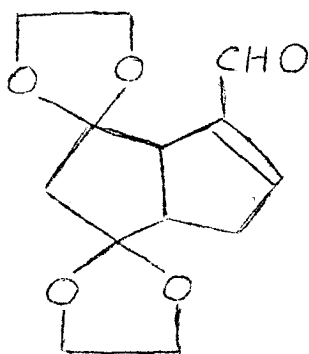
- (i) Outline all steps in the most likely mechanism of this reaction.
- (ii) Could this reaction be used for preparation of benzene-sulfonic acid from benzene? Justify your answer.

6. Using the disconnection approach devise an efficient synthesis of THREE of the following compounds from readily available starting materials and reagents. Show your analysis.

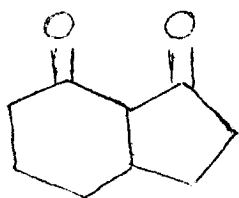
(i)



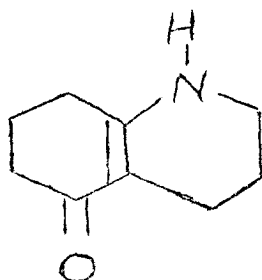
(ii)



(iii)



(iv)



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THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS NOVEMBER/DECEMBER 1994

C 350

ORGANIC CHEMISTRY

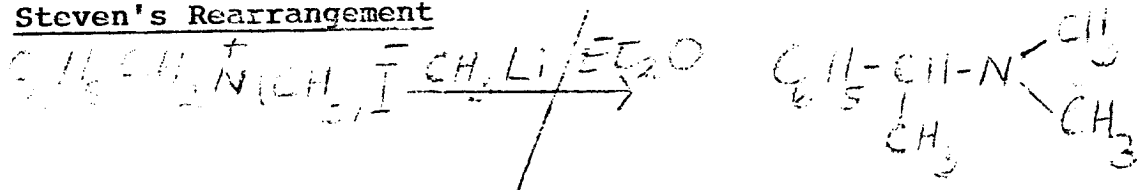
PAPER II

TIME: THREE HOURS

ANSWER: ANY FOUR QUESTIONS.

1. (a) A group of reactions known as 1,2-anionic rearrangements involving movement of migrating group to an adjacent anionic atom include the:
- (1) Steven's rearrangement of quaternary ammonium salts
 - (2) Wittig rearrangement of ethers and
 - (3) Meisenheimer rearrangement of amine oxides.

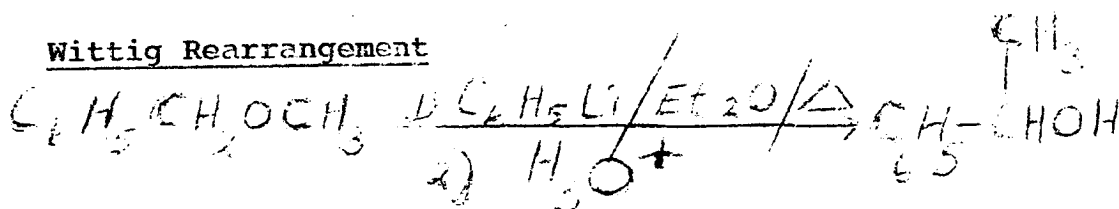
Steven's Rearrangement



N,N-Dimethylbenzylammonium
Iodide

2,N,N - Trimethyl
benzylamine

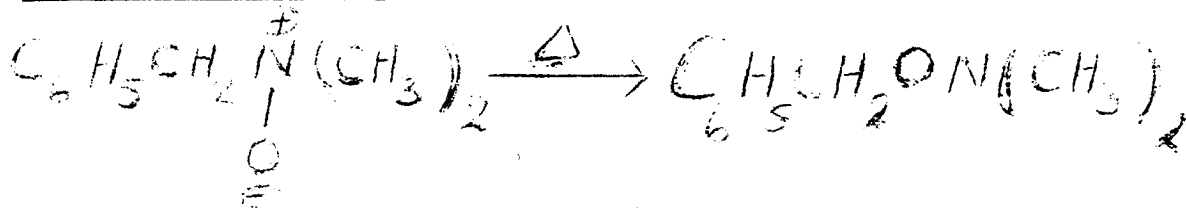
Wittig Rearrangement



Benzyl methyl ether

1-phenyl-
ethanol

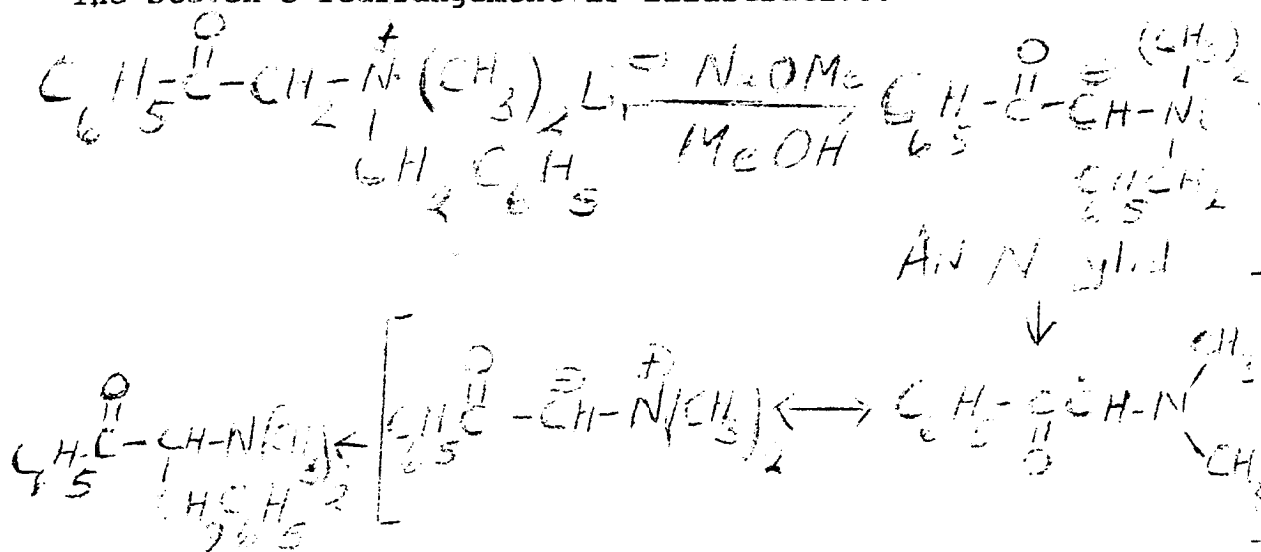
Meisenheimer Rearrangement



N,N-Dimethyl benzylamine
oxide

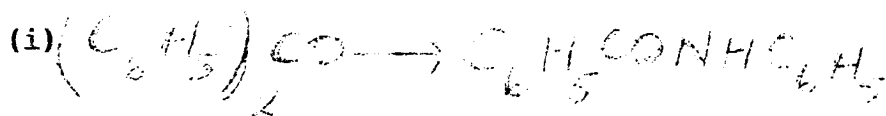
N-Benzyloxymethyl
amine

The mechanisms of these rearrangements has attracted considerable interest. A pathway involving heterolytic had been accepted for many years. More recent evidence suggests a homolytic process involving free radical intermediates. The Steven's rearrangement is illustrative.

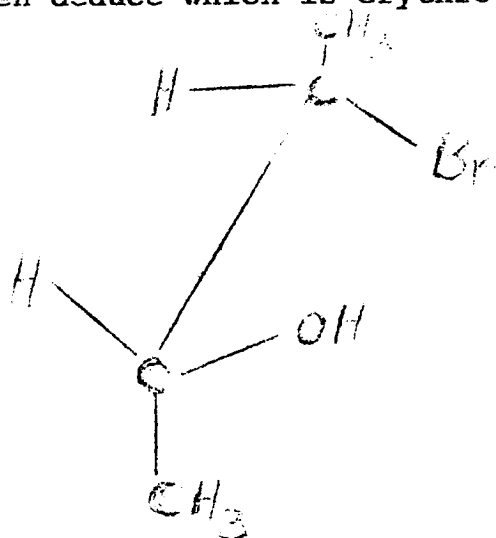
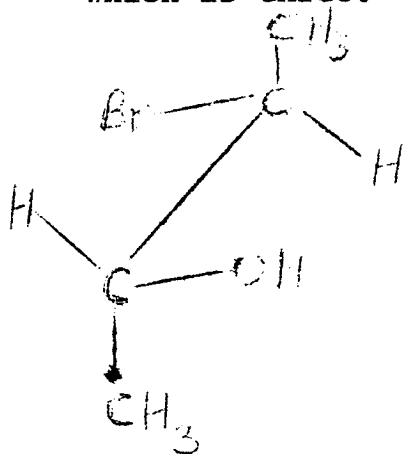


- (i) Why is it proper to depict the radical-pair intermediate of the proposed Steven's rearrangement mechanism by two resonance structures?
- (ii) Propose free radical mechanisms for the Wittig and the Meisenheimer rearrangements.

- (b) Show how each of the following conversions could be accomplished by using a sequence involving a rearrangement reaction.

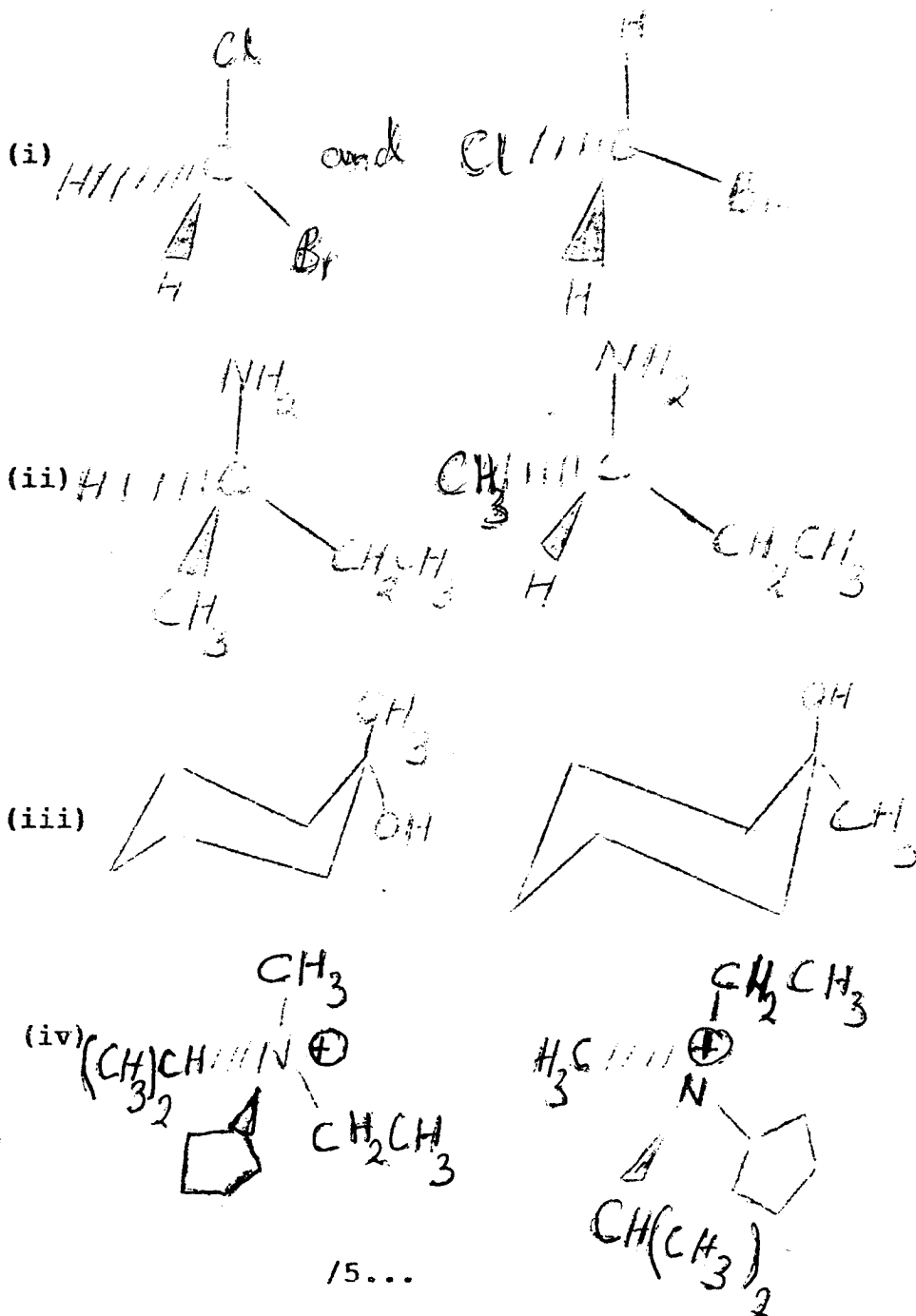


- (a) Draw Fischer projection of the structures below of 3-bromo-2-butanol and then deduce which is erythro-and which is threo.



- (b) Listed below are several pairs of molecules (molecular conformations). Pick from the following list the word that best describes each pair : enantiomers, diastereomers, conformational isomers, OR identical.

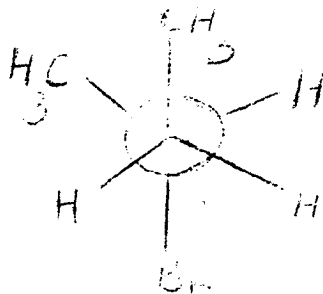
Which of the structures are capable of showing optical activity?



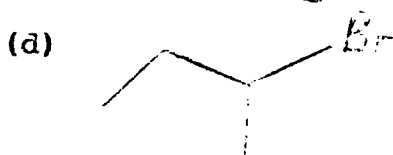
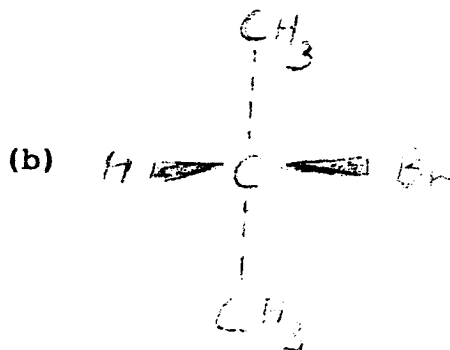
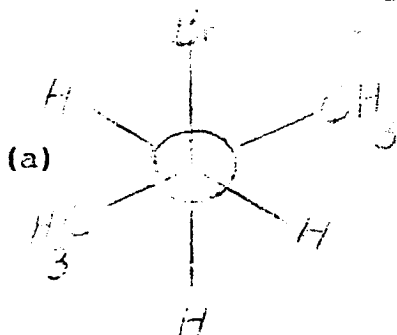
3. Optically active threo- and erythro - 3-phenyl-2-butyl tosylate were each allowed to solvolyze in acetic acid until about 60 percent had been converted to products. Chemically unchanged starting material was then recovered and it was found that threo - tosylate was 94 per cent racemized by erythro - tosylate was optically pure.

Show how these results support the phenonium ion intermediate.

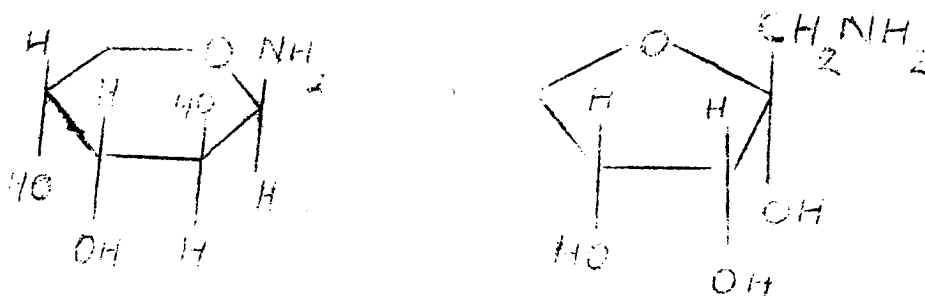
4. (a) Given the Newman projection:



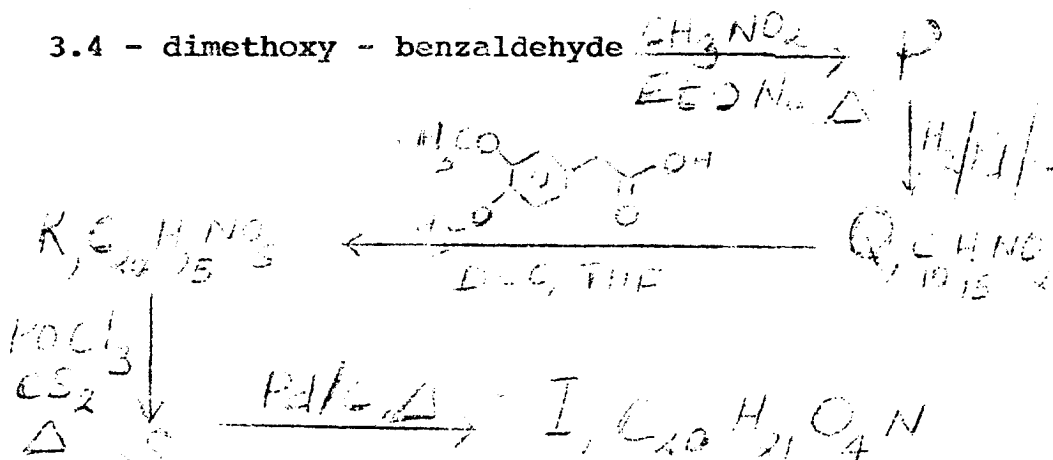
Is this structure R or S? Determine whether each of the following structural symbol is equivalent to the above Newman projection or to its enantiomer.



4. (b) Propose a plausible mechanism for the Amadori rearrangement.



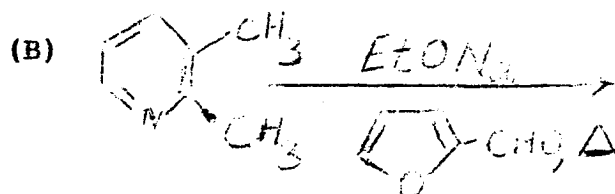
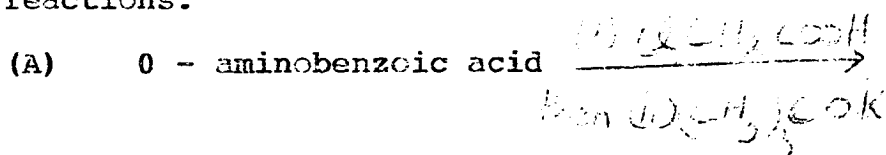
5. (a) The structure of an alkaloid I was confirmed by the following synthesis.



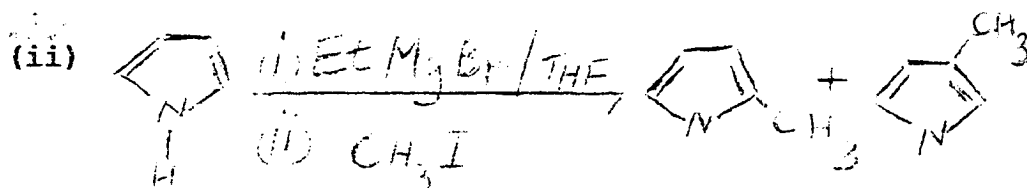
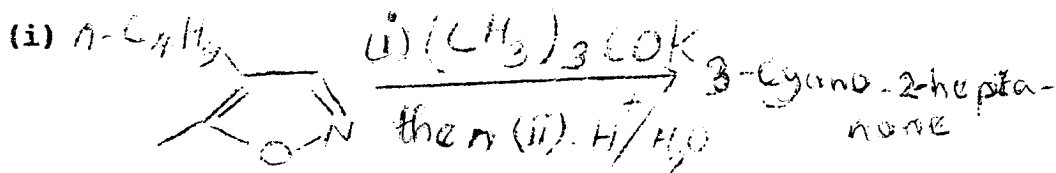
- (i) Identify compounds P to I in the above synthesis.
- (ii) Give mechanisms of the reaction involved in the formation of S from R.
5. (b) (i) Show all steps in the Skraup synthesis of 7 - chloro - quinoline.
- (ii) How would you obtain 4-amino-7-chloro quinoline from 7-chloro quinoline?

6. (a) (i) Pyridine N-oxide reacts with benzyl bromide to give N - benzyloxypyridinium bromide. Treatment of this salt with a strong base such as sodium hydride. Rationalize these experimental results with a reasonable mechanism.

- (ii) Predict the major products of the following reactions.



- (b) Suggest a mechanistic explanation for each of the following reactions.



THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

C360
PHYSICAL CHEMISTRY

PAPER 1

THREE HOURS

ANSWER ANY FOUR QUESTIONS

QUESTION 1.

Define the terms

- (i) Mean free path
- (ii) Collision frequency

One mole of hydrogen gas is confined in a compartment at a pressure of 10^{-6} atm and 0°C .

- (i) Calculate the mean free path of the hydrogen molecules
- (ii) If the confined gas is allowed to effuse into an evacuated compartment through a pinhole of diameter 10^{-6}m , how long will the effusion take.

QUESTION 2.

The Maxwell-Boltzmann distribution equation is given as follows

$$F(c)dc = (cN_c/N) = 4\pi(m/2\pi kT)^{3/2} e^{-cm^2/2kT} c^2 dc$$

Derive the expression $c^* = (2kT/m)^{1/2}$ for the most probable velocity of the molecules. All the terms have their usual meaning.

- (i) What is a thermodynamic isothermal reversible process.

(ii) The values of $\Delta H^\circ_{f,298}$ and S°_{298} for CaCO_3 (Calcite) and CaCO_3 (Aragonite) are given in the table below. Predict the thermodynamically stable form of CaCO_3 at 298K for the CaCO_3 (calcite) \rightleftharpoons CaCO_3 (Aragonite)

	Calcite	Aragonite
$\Delta H^\circ_{f,298}$ (KJ mol ⁻¹)	-1207.7	-1207.9
S°_{298} (KJ mol ⁻¹ K ⁻¹)	92.88	83.70

ION 3.

Define the term compressibility factor and explain its significance. At high pressure and temperature the equation of state for a real gas is given as $P(V-b) = RT$ where b is a van der waals constant.

Calculate the compressibility factor, Z , for the gas at 200K and pressure $1.0 \times 10^6 \text{ Nm}^{-2}$ given that b is $4.0 \times 10^{-6} \text{ m}^3 \text{ mol}^{-1}$.

Develop an equation for the work done in an isothermal reversible expansion from V_1 to V_2 with equation of state

$$PV = nRT + (nbRT - n^2a)(1/V)$$

a and b are van der Waals constants, P, V, T and n have their usual meaning.

ION 4.

Iodine boils at 183.0°C ; the vapor pressure of the liquid at 116.5°C is 100 mmHg. If $\Delta H^{\circ}_{\text{fusion}} = 15.65 \text{ kJ mol}^{-1}$ and the vapor pressure of the solid is 1 mmHg at 38.7°C ,

Calculate

(i) the triple point temperature and pressure.

(ii) $\Delta H^{\circ}_{\text{vap}}$, and $\Delta S^{\circ}_{\text{vap}}$

(iii) ΔG°_f ($\text{C}_{25.5}$)

Two grams of benzoic acid dissolved in 25g of benzene,

$K_f = 4.90 \text{ K kg mol}^{-1}$, produced a freezing point depression of 1.62K. Calculate the molar mass.

ION 5

Define the transference number and explain how it may be measured using the moving boundary method.

A moving boundary experiment is done with 0.01M LiCl in a tube having a cross section area of 0.125 cm^2 , the boundary moves 7.3 cm in 1490 seconds using a current of $1.80 \times 10^{-2} \text{ A}$. Calculate t_+ .

Given that $\lambda_+ = 38.68$ and $\lambda_- = 50.10$. Calculate t_+ .

Comment on any differences in the values obtained in (b) and (c) and give the value of t_- .

Define the terms activity and activity coefficient of an electrolyte.

Briefly explain how activity and activity coefficient of an electrolyte of your choice may be determined from Emf measurements.

Given that in the measurement of the mean activity coefficient of H^+

and Cl^- the following cell was considered

$Pt / H_2(g) (1 atm) / HCl (0.124M) / AgCl(s) / Ag$

and under the given conditions

$$E = E^\circ - (0.05915/1) \log \{ (a_{H^+})(a_{Cl^-}) / P_{H_2}^{1/2} \}$$

Show that

$$E = 0.1183 \log c = E^\circ - 0.1183 \log \gamma_{\pm}$$

$$\gamma_{\pm} = \left(\sum_i \sum_j \nu_i \nu_j \right)^{1/2} \quad c = [H^+] = [Cl^-]$$

Given that $E^\circ = +0.2225V$ and $E = 0.3420V$. Calculate γ_{\pm}

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

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - DECEMBER, 1994

C 360

PHYSICAL CHEMISTRY

PAPER II

TIME: THREE HOURS

ANSWER: ANY FOUR QUESTIONS

Gas Constant $R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$

Faraday Constant $= 96485 \text{ C mol}^{-1}$

Avogadro's number $= 6.02 \times 10^{23} \text{ mol}^{-1}$

Planck's Constant $= 6.62 \times 10^{-34} \text{ Js}$

Speed of light $= 3 \times 10^8 \text{ ms}^{-1}$

- (a) Define adsorption and state two of its industrial applications.
- (b) Explain the meaning of Physical adsorption and chemisorption.
- (c) This question is based on an experiment from laboratory manual:

Into three conical flasks were placed 100 mls, 60 mls and 20 mls of 0.25 M oxalic acid. Distilled water was added in two flasks to make up the volume to 100 mls. 2 grams of charcoal (adsorbate) was added to each flask and the three shaken for two hours.

Each of the mixtures were then filtered and 5.00 mls samples titrated with 0.091 N NaOH. The following were the results.

FLASK	100 mls	60 mls	20 mls
Volume of 0.091 N NaOH used.	25.70 mls	15.00 mls	4.80 mls

- (i) Calculate the final concentration of each solution C_s in mol dm^{-3} .

- (ii) Calculate the weight of Oxalic acid adsorbed per gram of charcoal, and the moles of adsorbate per Kg of adsorbent x/m .

- (d) Given that the data in (c) conforms to Freundlich isotherm i.e. $x/m = K C_s^{1/n}$ Use the 60 mls and 20 mls data to calculate values of K and n. (A graph plot is not required)

(a) Give the Collision theory and Activated Complex theory of reaction rates.

(b) Why are the reactions of higher orders not probable?

(c) What are the characteristics of a Catalyst? Discuss the different theories of Catalysis.

(a) Define and explain 'Order of reaction'. How does it differ from 'Molecularity'?

(b) What are the different methods for the determination of the 'Order of reaction'? Explain one of these in detail.

(c) Discuss the kinetics of the Opposing reactions when both reactions are of the first order.

(d) How can you evaluate the Energy of activation of a reaction by the knowledge of the rate constants at two different temperatures?

(a) What are the characteristics of Chain reactions?

(b) Discuss the kinetics of the Chain reaction between Hydrogen and Bromine and derive the rate equation

$$\frac{d[\text{HBr}]}{dt} = \frac{k_a [\text{H}_2][\text{Br}_2]^{1/2}}{k_b + [\text{HBr}][\text{Br}_2]}$$

where k_a and k_b are constants.

- (a) What is the difference between a Thermal or Dark reaction and a Photochemical reaction?
- (b) In the photobromination of Cinnamic acid to dibromocinnamic acid, using blue light of 435.8 nm at 30.6°C, a light intensity of $1.4 \times 10^{-3} \text{ J s}^{-1}$ produced a decrease of 0.075 millimole of Br_2 during an exposure of 1105 s. The solution absorbed 80.1 % of the light passing through it. Calculate the Quantum yield.
- (c) State Einstein's Law of photochemical equivalence. How do you account for the deviations from this law?
- (a) Discuss the kinetics of the photochemical reaction between Hydrogen and Chlorine.
- (b) What are Photosensitized reactions? Explain by giving suitable examples.
- (c) Explain the phenomenon of Luminescence.
- (d) Give the mechanism of Photolysis of Ammonia.

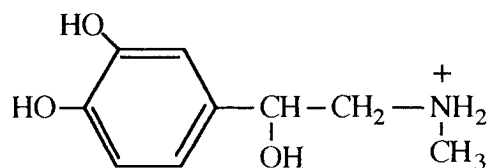
THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - DECEMBER 1994
C410 PAPER I

TIME : THREE HOURS

ANSWER : FIVE QUESTIONS

ALL QUESTIONS HAVE EQUAL MARKS

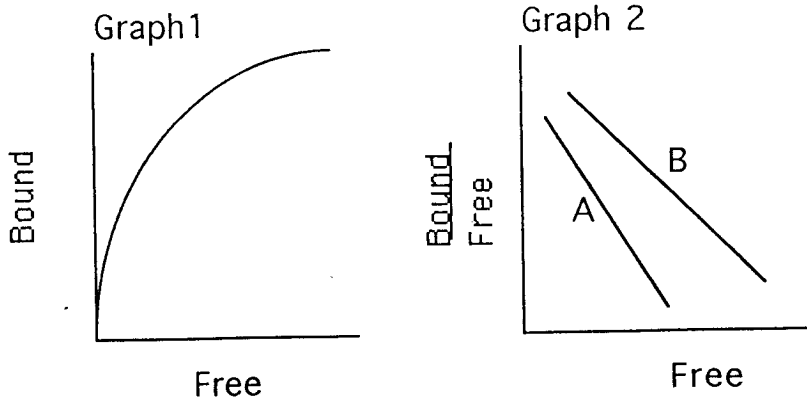
1. Write short notes on each of the following and give specific examples for each term:
 - (a) Voltage gated channels
 - (b) Signal transduction
 - (c) Acetylcholine receptor
 - (d) Amphiphile
 - (e) Symport
2. Discuss the physico-chemical factors which influence the growth of microorganisms.
3. Upon binding of a hormone to a receptor, most membrane associated hormone receptors generate a diffusible signal (second messenger). Given below is the structure of the hormone epinephrine.



- (a) What is the most likely starting compound in epinephrine biosynthesis?

- (b) How does the binding of epinephrine to the β -adrenergic receptor regulate glycogen metabolism?
4. Outline the biosynthesis of the aromatic ring (Shikimic acid pathway) in plants. Show the structures and the names of all the intermediates.
5. Discuss the events leading to the contraction of a striated muscle (begin with events following the arrival of a signal on the membrane around the myofibril).
6. (a) Briefly outline the principles behind sodium dodecyl sulfate gel electrophoresis (SDS-PAGE). What is the use of β -mercaptoethanol in this technique?
- (b) An enzyme has been extensively purified. By a variety of criteria, it is thought to be pure - that is, it shows a single peak when chromatographed, electrophoresed or centrifuged in a variety of ways. When subjected to SDS-PAGE, two bands result, one twice the area of the other. What information does this give about the protein?
7. The K_D (dissociation constant) for a particular neurotransmitter is $5 \times 10^{-7}M$.
- (a) Calculate the fraction of occupied receptor sites (relative to unoccupied sites) when the neurotransmitter concentration is $10^{-9}M$.
- (b) How many (% of the total) receptor sites are occupied at a neurotransmitter concentration of $10^{-9}M$?
- (c) If the neurotransmitter concentration rose to $5 \times 10^{-8}M$, how many (% of the total) receptor sites are now occupied?
- (d) Graph 1 was obtained by a student studying the binding of a neurotransmitter to a receptor (Bound = concentration of neurotransmitter bound to receptors, Free = concentration of unbound neurotransmitter). Explain why this plot can not yield a correct K_D value?

- (e) Graph 2 shows the scatchard plots for two different neurotransmitter (A and B). Which neurotransmitter has the higher affinity for its receptor? Explain your answer.



Have a Merry Christmas and a Prosperous New Year

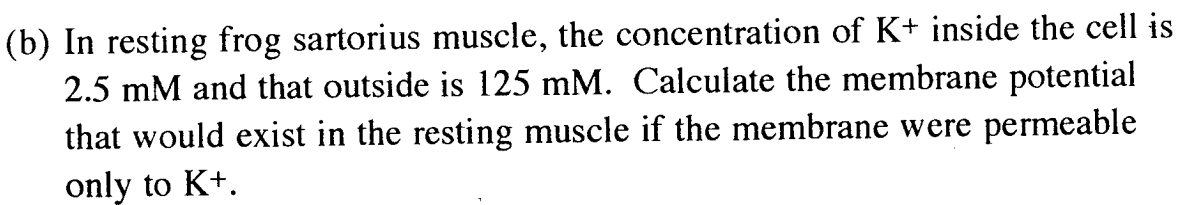
THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - DECEMBER 1994
C410 PAPER II

TIME : THREE HOURS

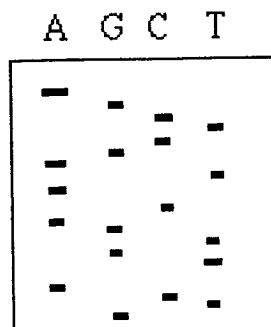
ANSWER : FOUR QUESTIONS

ALL QUESTIONS HAVE EQUAL MARKS

1.
 - (a) With reference to the *lac* operon, briefly describe gene regulation in prokaryotes.
 - (b) When lactose is used as an inducer, there is a lag before enzymes of the lactose operon are synthesized. With IPTG as the inducer, there is no lag. Explain this observation.
 - (c) Since a permease required for entry of lactose into *E. Coli* is itself a product of the operon, how can the first lactose molecule enter uninduced cells? Explain.
2.
 - (a) Outline the similarities and differences between enzymes and antibodies.
 - (b) What role is played by the complement in the fight against infection?
3. What forces are responsible for the interaction between a drug and a component of the body (or invading organism) resulting in the observed pharmacological effects.
4.
 - (a) In experiments to investigate the mechanism of transport of two substances, X and Y, across cell membranes, cells were incubated in media containing various concentrations of X and Y and the initial rate of transport of each of the substances into the cell was determined. The



5. (a) Describe the underlying principle in the new gel sequencing methods for polynucleotides.
- (b) An autoradiogram of a gel containing four lanes of DNA fragments produced by chemical cleavage is shown in the figure below. The DNA is labelled at its 5' end. What is its sequence?



(c) You have just isolated a DNA fragment from your pet bacterium. You suspect the fragment contains a promoter region. How can you prove that the sequence functions as a promoter?

5. Glutamine synthetase in bacteria is regulated at two levels; enzyme level and transcription level. Describe in detail how glutamine synthetase is regulated EITHER at enzyme level OR at transcription level. (Your answer should only deal with one aspect and not both).

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER, 1994

C420

PAPER I

TIME: THREE HOURS

ANSWER ANY FOUR QUESTIONS

1. (a) Outline the determination of Mn^{2+} as an activator by an enzymatic method.
- (b) In the Kjeldahl method for the determination of nitrogen in serum the sample is treated with concentrated H_2SO_4 in the presence of a catalyst to convert nitrogen to NH_4^+ (digestion). The solution is made strongly alkaline, where upon the NH_4^+ ion is converted to NH_3 which is then distilled into a known excess of a standard acid solution. The excess of unreacted acid is titrated with a standard base solution. From the following data, calculate the percent nitrogen in the serum ($\frac{W}{V}$).
10.00ml serum sample, 50ml of 0.1000M HCL, 22.36ml of 0.1064M NaOH.
- (c) Due to a large number of samples in hospitals and the need to furnish results as quickly as possible for such samples, Skeggs in conjunction with a company called Technicon developed the Auto-analyser in 1957. This instrument uses air segmentation. Show with aid of a sketch how it works.
2. (a) Show how limit of detection may be defined.
- (b) State the advantages of using instrumental methods of analysis over classical methods.
- (c) Why are calibrations used to evaluate the results of instrumental methods?
3. (a) Describe the Griess Iosovay method for the determination of NO_2 in the atmosphere. What modifications did Sallizamann make to the procedure?

- (b) The determination of SO_2 in the air of the UNZA library was performed as follows: The air was bubbled at a rate of 20l/min through a trap containing H_2O_2 . The H_2SO_4 produced in 30 min ($\text{SO}_2 + \text{H}_2\text{O}_2 \rightarrow 2\text{H}^+ + \text{SO}_4^{2-}$) was titrated with 5.62ml of 0.01000M NaOH solution. Calculate the concentration of SO_2 in the air in ppm given that the density of SO_2 is 2.86mg/ml.

4. (a) Routine analysis of water for domestic purposes is very important to avoid unnecessary diseases that arise due to supply of dirty water. Define the following and what is the significance of each in water analysis?

- (i) Biochemical Oxygen Demand (BOD)
- (ii) Chemical Oxygen Demand (COD)

- (b) Sulphate in a water sample was determined by a turbidimetric method as follows:

Standards were treated with 5ml of conditioning reagent (a mixture of 75g NaCl in 300ml water, 30ml of concentrated HCl , 100ml of 95% propan-2-ol and 50ml of glycerol). 0.5g of barium chloride crystals were added and made up to 100ml with water.

The following turbidity values on an NTU turbidimetric were obtained.

Conc of Sulphate mg/ml	Turbidity
Blank	02
5×10^{-3}	20
1×10^{-2}	40
2×10^{-2}	79
3×10^{-2}	105

A 5ml water sample from Kafue water works was treated like the standards and made up to 100ml. This gave a turbidity value of 75. Calculate the percent (W/V) of sulphate in the water sample.

5. (a) In flame spectrophotometry, what is the difference between emission and absorption spectrometry?
- (b) In food analysis, two methods are used for preparing sample for metallic contaminants estimation, briefly describe them. What precautions need to be taken during the sample preparation.
- (c) Three types of substances are allowed in Zambia Regulations to be used as preservatives in fatty foods. Name them and describe how you would determine them in such foods.
- (d) The width of certain peak (measured in time units) is 50 sec. and retention time is 50 min. How many theoretical plates does the column contain under these conditions?
6. (a) What are pesticides and can you name 3 of such compounds.
- (b) Name the 3 stages one takes in analysing the pesticides in samples.
- (c) Certain types of pesticides are such a problem in dairy products, what are they and how would you determine them using gas chromatography?
- (d) What is the main difference between flame ionization detector (FID) and flame photometric detector (FPD)? How would you use this difference to differentiate pesticides?
- (e) Some pesticides cannot be easily be determined by use of gas chromatography, but can easily be done by using high performance liquid chromatography why is this so? Can you give one example to illustrate this.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER, 1994

C420

ANALYTICAL CHEMISTRY

PAPER 2

TIME: THREE HOURS

INSTRUCTIONS: THIS EXAMINATION CONTAINS FIVE QUESTIONS
ANSWER FOUR QUESTIONS. EACH QUESTION
CARRIES TWENTY MARKS.

1. (a) Potassium chromate in basic solution exhibits an absorption maxima at 372nm. A basic solution containing $3.00 \times 10^{-5} \text{M}$ potassium chromate transmits 71.6% of the incident radiation at 372nm when placed in a 1cm cell.
 - (i) What is the absorbance of this solution?
 - (ii) What is the molar absorptivity of potassium chromate at 372nm?
 - (iii) Compound X exhibits molar absorptivity of 2.45×10^3 liter/mole-cm at 450nm. What concentration of X in a solution which will cause a 25% decrease in radiant power for 450nm radiation when the solution is placed in a 1cm cell?
- (b) The retention times of several compounds, measured from sample injection, are air, 45sec; propane, 1.5 min; pentane, 2.35 min; acetone, 2.45 min; xylene, 15.0 min. What are the relative retention times of the organic compounds using pentane as the standard?
- (c) What is the Bronsted-Lowry acid-base theory and what is conjugate acid or base?
- (d) What are Dole and Daviddow procedures for screening drugs and how do they differ?

- (e) Define the following terms used in chromatography by giving an equation, labelled diagram or description:
- (i) Resolution
 - (ii) Retention time
 - (iii) Stationary Phase
 - (iv) Theoretical Plate and
 - (v) Kovats Index
2. (a) Describe briefly how you carry out a non-aqueous titration highlighting the differences in dealing with basic and acidic compounds? Why is it necessary to carry out titrations in this environment?
- (b) Write ionisation reaction of aniline, $C_6H_5NH_2$ in glacial acetic acid and identify the conjugate acid on aniline. Write the ionization reaction of phenol, C_6H_5OH in ethylenediamine, $NH_2CH_2CH_2NH_2$ and identify conjugate base for phenol.
- (c) Explain why phenol can be titrated successfully in ethylenediamine than in water and pyridine can be titrated in dioxane but not in water.
- (d) Name any three classes of drugs of abuse and their effects to users. Mention 3 methods used to identify such drugs.
- (e) Relative retentions of codeine heroin, methadone, morphine, and propoxyphene are 1.00, 1.89, 0.55, 1.16 and 5.9 respectively and t_R is 6.00 min for codeine on a 2% SE-30 column at 215°C. Calculate retention times for the other compounds.
3. (a) Briefly describe 3 detectors used in HPLC their principles of operation.
- (b) What are the basic differences between detergents and soap. Outline how the quality of these products can be evaluated.

(c) The phosphorus content was determined by the gravimetric quinolinium phosphomolybdate method. If 3.114g of quinolinium phosphomolybdate, $(C_9H_7)_3PMo_{12}O_{40}$, were obtained from a 1.00g sample. Find the % P_2O_5 in the sample. Use: P=30.97, O=16.00, N=14.01 Mo=95.94.

(d) WET DEGESTION (or wet ashing) is an important means of decomposing organic matter. Name 3 common reagents used in wet digestion.

(e) Name 2 water-soluble vitamins found in food and describe briefly how they can be determined in fruits or vegetables.

4. (a) A series of methyl esters of fatty acids were chromatographed Time (in min) at peak maximum for known saturated esters were $C_{12}=2.65$, $C_{14}=4.6$ $C_{20}=27.0$, On a sample, run under identical conditions, peaks were observed at 2.55, 8.3, 15.2 26.9, and 48 min. Which esters were present in the sample.

(b) Calculate the iron content in a diethyldithiocarbamate extract using the following data:

Absorbance Units

Blank	Sample	iron added Mg/200ml
0.0020	0.0090	None
0.0214	0.0284	2.00
0.0414	0.0484	4.00
0.0607	0.0677	6.00

(c) A sample of mineral ash gave a meter reading of 37. Solutions B and C containing the same quantity of unknown solution plus 40 and 80 Mg/ml of added potassium, respectively, gave net meter readings of 65 and 93. Calculate the quantity of unknown potassium in the original sample.

- (d) The determination of chromate in an ore sample gave the following results: 26.53%, 28.47%, 28.72%, 28.39% and 28.64%. Calculate
- (i) The mean
 - (ii) The average deviation, and
 - (iii) The standard deviation.
5. (a) How would you identify nitrogen, sulfur and halogens in organic compounds?
- (b) Calculate the saponification number of fat. The weight of sample was 3.55g, 50.0 ml of 5 mol/l ethanolic solution of potassium hydroxide was added to the sample. The sample was boiled under reflux, cooled and the excess of potassium hydroxide determined. Using 0.5 mol/l HCL. using phenolphthalein as indicator. For the color change 33.2 ml of 0.5 mol/l HCl was required.
- (c) How would you determine fat-soluble vitamins in foods?
- (d) Name three methods of determining "crude fat" in foods.
- (e) Name 3 procedures used to prepare sample of rocks for analysis giving determination of copper as an example.
6. (a) A 16.42mg sample of a nitrogen-containing organic compound was subjected to a traditional analysis. Before ammonia was steam-distilled. 20.0ml of 0.20N HCl was placed in the receiver. After distillation, 8.4ml of 0.020N NaOH was required to back-titrate the excess acid. Calculate % nitrogen in the sample.
- (b) How would you identify a non-soap detergent?
- (c) What are the major steps in the atomization of an analyte using electrothermal furnace. Explain the physical and chemical processes that occur in each step.

- (d) Discuss one classical method for the determination of sulfur dioxide (SO_2) in food.
 - (e) What substances are determined in alcoholic drinks and outline how you would determine methanol in wine.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS- NOV/DEC. 1994

C440

INORGANIC CHEMISTRY

PAPER II

TIME: THREE HOURS

INSTRUCTION:

- (i) ATTEMPT ANY FOUR (4) QUESTIONS
 - (ii) USE DIFFERENT ANSWER BOOKLETS FOR EACH QUESTION
-

1. Consider cyclic C_4H_4 molecule. The molecule has two possible configurations - the square and the rectangular one. Using group theory considerations determine whether it is possible to distinguish the two isomers by IR or RAMAN spectra

2. (a). A unit (C_3H_3M) of a complex contains a bound cyclic C_3H_3 organic group. If all the C atoms are equivalent and bound to M in a 'half-sandwich' fashion, determine the number of IR peaks expected to be observed for entire unit.

(b) Deduce the number of C-H vibrational modes of the unit expected to be Raman active.

C440

3. (a). Classify the following solid oxides as insulator, semi-conductor or conductor:

MoO_3 , CuO , TiO , Cu_2O , TiO_2 , MgO

(b). How is polyacetylene, an "organic metal", ~~is~~ polymerised by the Ziegler - Natta method. Suggest the structure and type of semi-conductor it takes when doped with:

(i) H_2SO_4

(ii) Lithium metal

(c) VO and NiO both have the rock salt structure whereas VO is metallic pure NiO is an electric insulator. Explain.

4. (a). Zeolites have found a major role in petroleum industry as catalysts.

(i) What structures do they possess?

(ii) Discuss with examples the selective nature of these catalysts.

(b). In the mass spectra of $\text{Zr}(\text{acac})_4$ a peak is observed at $m/e = 305$. What is the peak due to? Show a mechanism for the reaction involved. (use mass of Zr isotope = 90)

(c). Distinguish between the mass spectra of $\text{Ga}(\text{PhCOCHCOCF}_3)_3$

(use mass Eu = 153, Ga = 71amu)

and of $\text{Eu}(\text{PhCOCHCOCF}_3)_3$.

(a). What name is given to a polyhedron with $n=4$ vertex if it is :

- (i) CLOSO (ii) NIDO (iii) ARACHNO

(b). Suggest an alkyl radical isolobal to $\text{Co}(\text{CO})\text{Rh}$ and determine its product of dimerisation given that its i.r. $\nu(\text{CO})$ occurs as a single peak at 1680cm^{-1} .

($\text{Rh}=45$)

(c). By employing Wade's rules draw the structures of:

- (i) $(\text{Os}_6(\text{CO})_{18})^{2-}$ (ii) $(\text{Os}_6(\text{CO})_{18})$
(iii) $(\text{Os}_6(\text{CO})_{18})^{2+}$

(a). Write briefly about

(i) Why Na^+ ions mostly are extracellular and K^+ ions intracellular when ionic radius of sodium is smaller than that of potassium?

(ii) How does sickle cell anemia arise? What antidote is employed?

(b). What are the main functions of calcium in the body?

What dangers are posed in trying to remove Lead(Pb) poisoning with Na_4EDTA ? How is the lead removed?

XX

END OF EXAMINATION

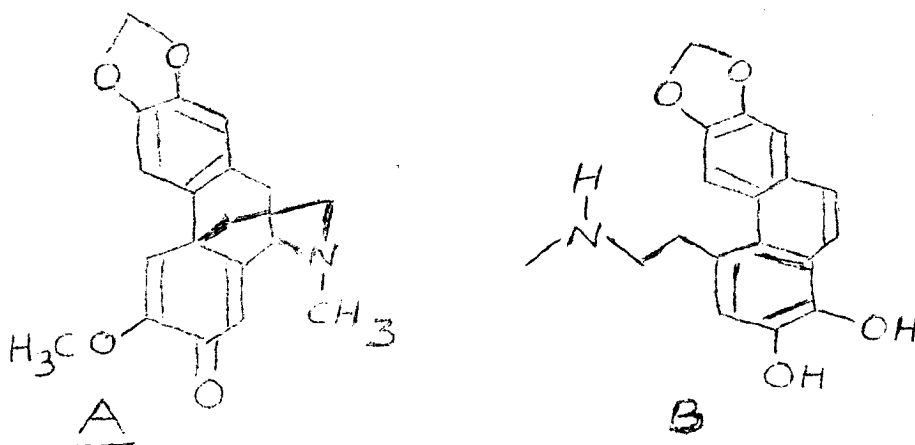
THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

C 450
ORGANIC CHEMISTRY
PAPER I

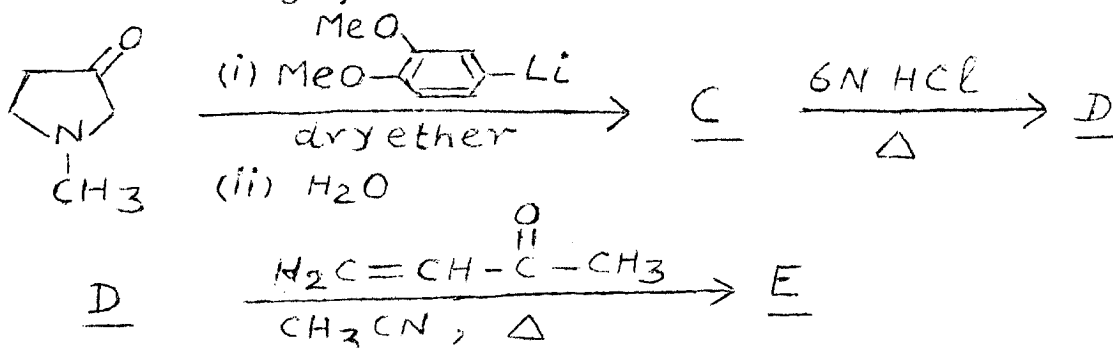
TIME: THREE HOURS

ANSWER: ANY FOUR QUESTIONS

1. (a) Treatment of an alkaloid A with 5% aqueous hydrochloric acid yielded a compound B. Propose a plausible mechanism for this transformation.

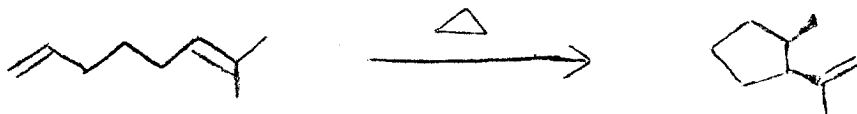


- (b) (i) Deduce the structure of alkaloid E from the following synthesis.

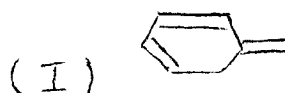


- (ii) Give mechanisms of the reactions involved in the formation of E from D.

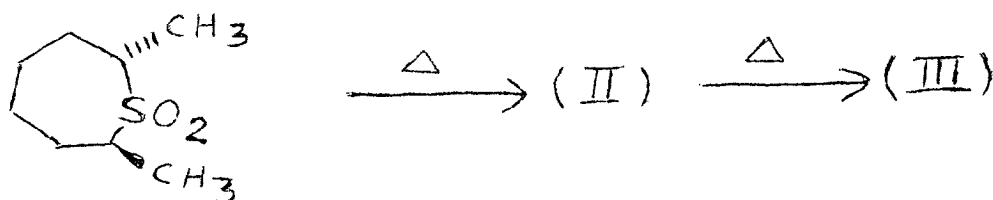
2. (a) Suggest a reaction mechanism to account for the observed stereochemistry of the product of the following reaction:



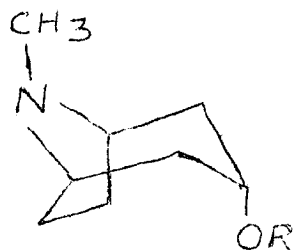
- (b) Compound (I) is considerably less stable than its aromatic isomer, toluene. Using Woodward-Hofmann rules explain why (I) does not readily isomerise to toluene.



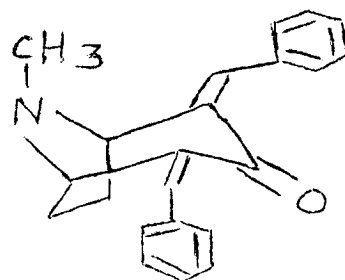
- (c) Predict the product(s), including pertinent stereochemistry, of the following pericyclic reaction sequence.



3. (a) Attempted preparation of G from F using excess benzoyl chloride and 20% aqueous sodium hydroxide unexpectedly gave a compound H.



COMPOUND F : $R = H$



H

COMPOUND G : $R = -\text{C}(=\text{O})-\text{C}_6\text{H}_5$

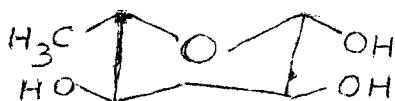
3. (a) The experiment was repeated but the reaction was quenched before completion. Analysis of the reaction mixture revealed the presence of benzaldehyde and other products including H. Suggest a mechanistic explanation for the formation of unexpected product H consistent with the experimental results.

(b) Labelling experiments have shown that the compound F, in question 3(a) above, is derived from the amino-acid ornithine, $\text{H}_2\text{NCH}_2\text{CH}_2\text{CH}_2\text{CH}(\text{NH}_2)\text{COOH}$, and acetoacetyl-

- coenzyme A.

On this basis propose a reasonable biogenetic pathway for F.

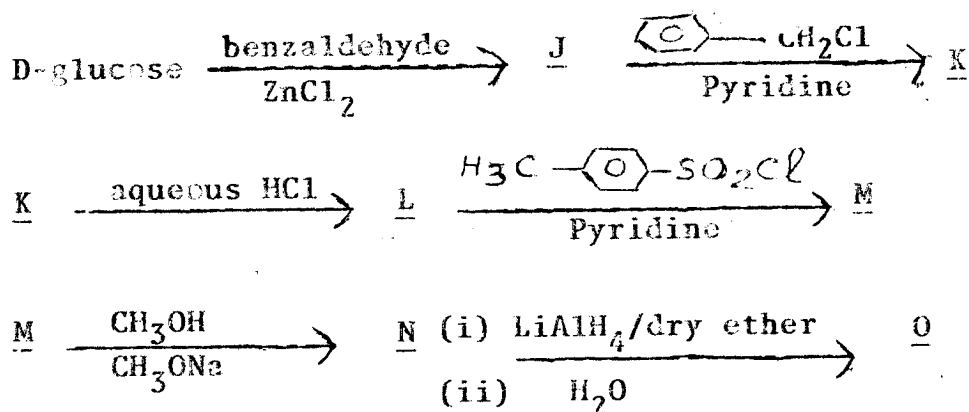
4. (a) Devise an efficient synthetic plan for compound I from D-glucose and any other readily available reagents.



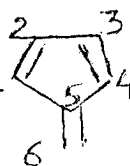
I

(b) Acid hydrolysis of a bio-active polysaccharide, X, isolated from a micro-organism, Type III pneumococcus, yields equimolar amounts of D-galactose and D-galacturonic acid. Exhaustive methylation of X, followed by acid hydrolysis, gives equimolar amounts of 2,3,6-tri-O-methyl-D-galactose and 2,4-di-O-methyl-D-galacturonic acid. Suggest a likely structure of polysaccharide X.

(c) Deduce the structure of a naturally occurring compound O from the following synthesis. Show the structures of intermediates J to N.



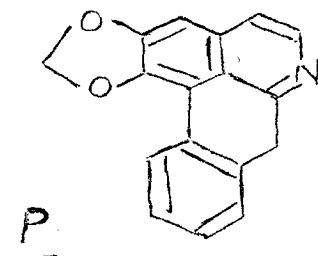
5. (a) The coefficients of first four orbitals of fulvene, 1, are given below



ORBITAL	COEFFICIENTS					
	C-1	C-2	C-3	C-4	C-5	C-6
ψ_1	0.43	0.39	0.39	0.43	0.52	0.25
ψ_2	0	0.50	0.50	0	-0.50	-0.50
ψ_3	0.69	0.37	-0.37	-0.60	0	0
ψ_4	-0.35	0.28	0.28	-0.35	-0.19	0.75

- (i) Identify the HOMO and the LUMO of fulvene.
(ii) Stating your reasoning, predict the products, including pertinent stereochemistry of the reaction of fulvene with
(A) Butadiene (B) $\text{EtOOC}-\text{C}\equiv\text{C}-\text{COOEt}$

- (b) Using the disconnection approach, devise a synthesis of the alkaloid P from readily available non-heterocyclic starting materials and any other needed reagents. Show your analysis.



6. (i) Interpret the following data on a natural product Z, $C_{13}H_{18}O_7$, and hence deduce its structure. Show your reasoning.

Z is hydrolysed by emulsin to D-glucose and a compound Q, $C_7H_8O_2$. Z does not react with ammoniacal silver (I) — nitrate solution. Oxidation of Z by dilute nitric acid yields a compound R that can be hydrolysed to D-glucose and a compound S, $C_7H_6O_2$, by dilute hydrochloric acid. Exhaustive methylation of Z gives a pentamethyl derivative of Z, which on acidic hydrolysis gives 2,3,4,6-tetra-O-methyl-D-glucose and a compound T, $C_8H_{10}O_2$.

COMPOUND S

I.R. (Nujol): $\bar{\nu}$ (cm^{-1}): 3200 (broad); 2850 (W); 2750 (W); 1680 (S); 1600 (M); 1580 (M); 1475 (M); 1250; 1000; 760

NOTE: S = strong; W = weak; M = medium

1H NMR ($CDCl_3$) of COMPOUND S

δ (ppm): 11.1 (s, 1H); 9.8 (s, 1H); 7.4-7.1 (complex m, 4H).

NOTE: (i) s = singlet, d = doublet; t = triplet; m = multiplet.

: 6 :

- (ii) The NMR signal at δ : 11.1 disappeared after deuteration.

COMPOUND Z

^1H NMR (D_2O)

δ (ppm): 7.4-7.1 (complex m, 4H);
5.48 (d, 1H, $J = 8.5$ Hz); plus other
signals in the δ range of 4.8 - 3.6
integrating for 8 protons.

- (ii) Outline a stepwise synthesis of Z from
D-glucose and other readily available materials.

END OF EXAMINATION

2 COPIES

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UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER, 1994

C 450

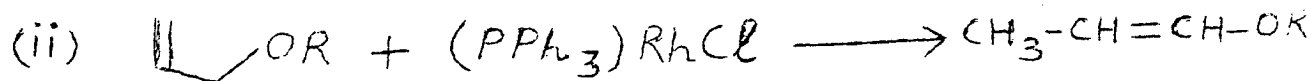
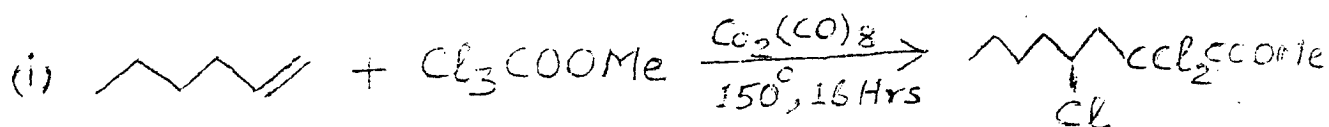
ORGANIC CHEMISTRY

PAPER II

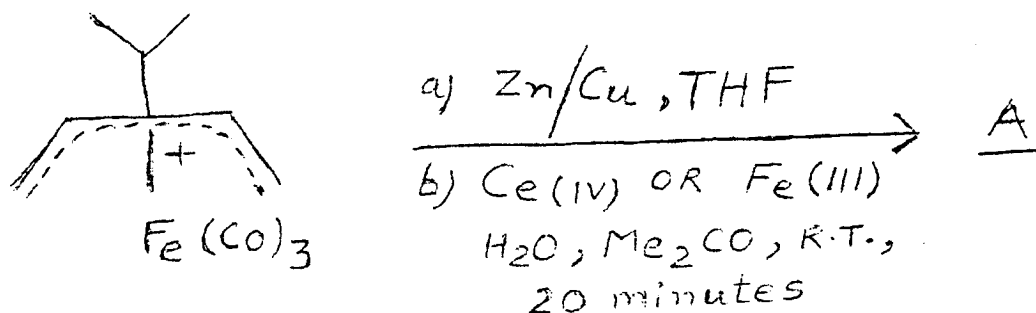
TIME: THREE HOURS

ANSWER: ANY ~~THREE~~ FOUR QUESTIONS

1. Provide plausible mechanisms for the following reactions.



2. (a) Give the products and mechanism of the following reaction.



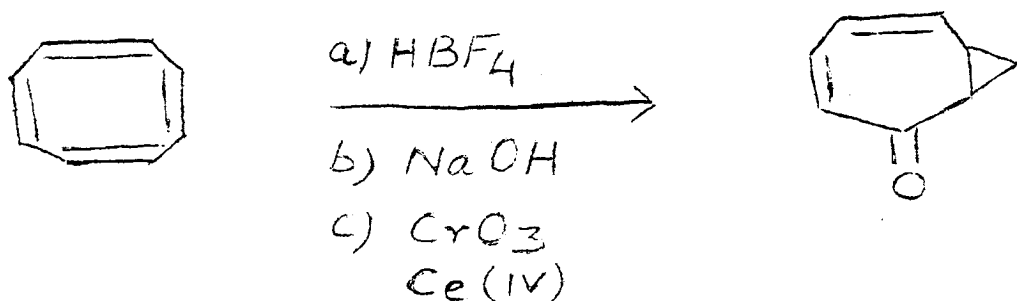
(b) Apply the 18 electron rule to the following combination of metals and ligands to predict possible complex metal-ligand stoichiometries.

(i) Fe, Co, NO

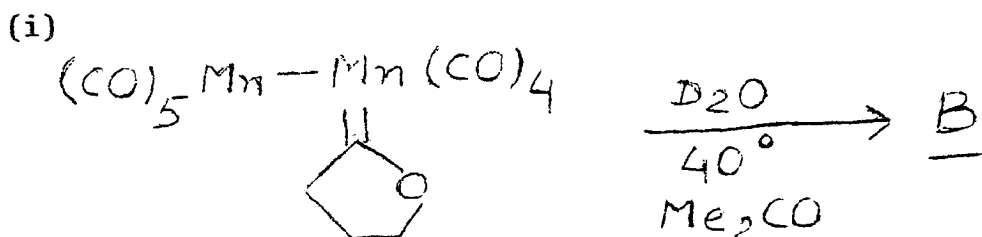
(ii) CO, Fe,



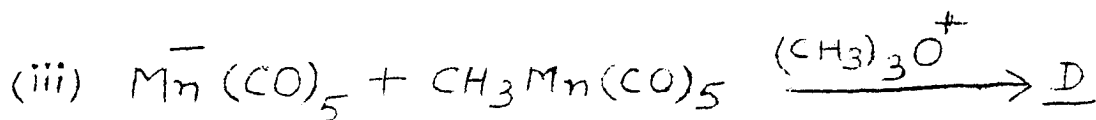
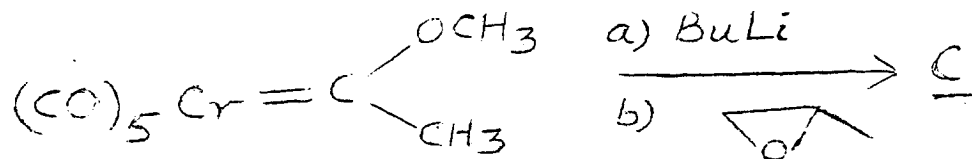
(c) Suggest a reasonable mechanism for the following reaction:



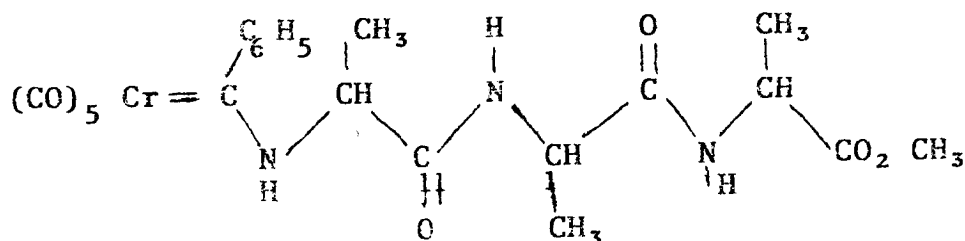
3. (a) Propose a mechanism and identify the products of the following reactions.



(ii)

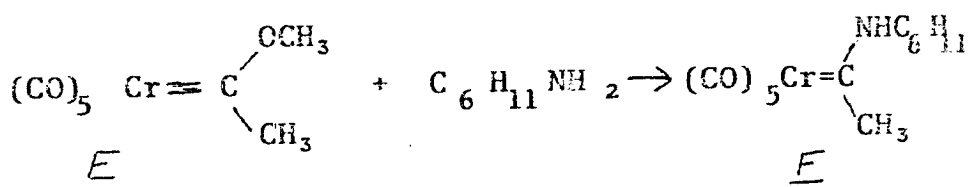


4. (a) Suggest a method of preparing the following compound using known organometallic and other reagents.



- (b) The reaction between the chromium carbene complex E below and cyclohexylamine to afford the amine carbene complex F,

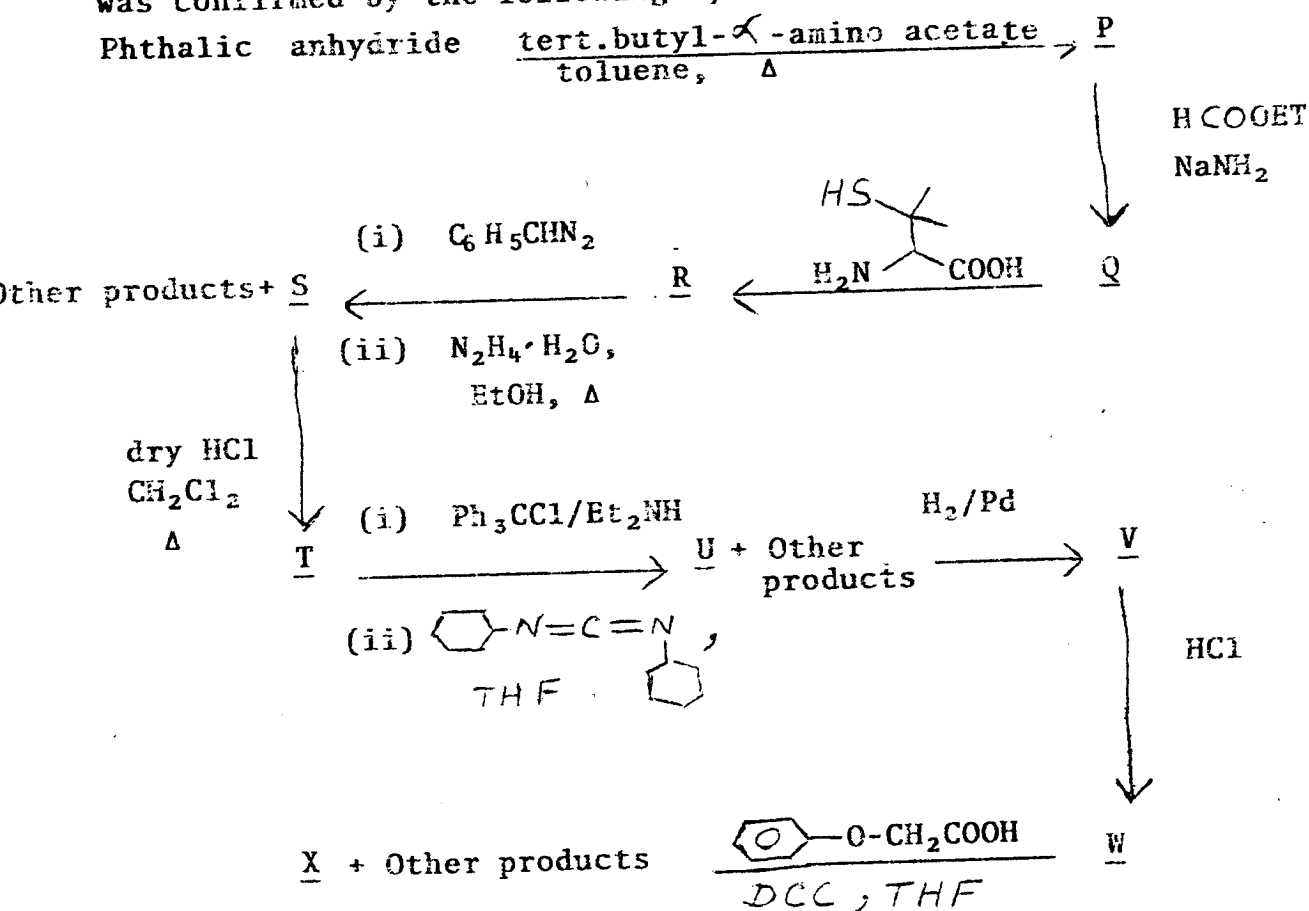
- (i) In hexane exhibits first order kinetics in the carbene complex and third order kinetics in the amine.
- (ii) In dioxane, is first order in the carbene complex and second order in the amine.



Suggest a mechanistic explanation for the above experimental results.

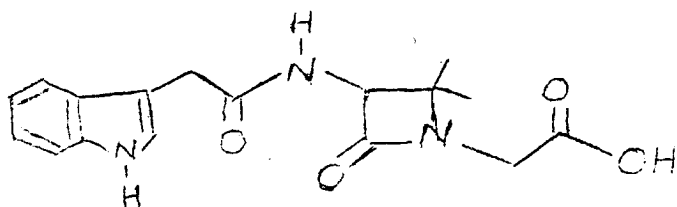
5. (a) Briefly state how soil samples can be tested for the presence of antibiotic producing microorganisms.

- (b) The structure of an antibiotic X, isolated from a soil sample was confirmed by the following synthesis:

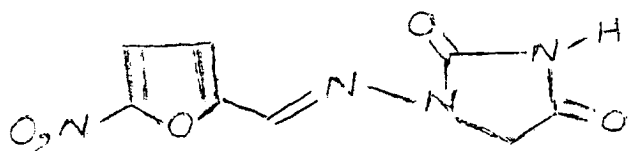


- (i) Identify compounds P to W and hence deduce the structure of X in the above synthesis.
- (ii) Give mechanisms of the reactions involved in the formation of:
 - (A) R from Q
 - (B) U from T
- (iii) Briefly explain the mode of anti-microbial action of X

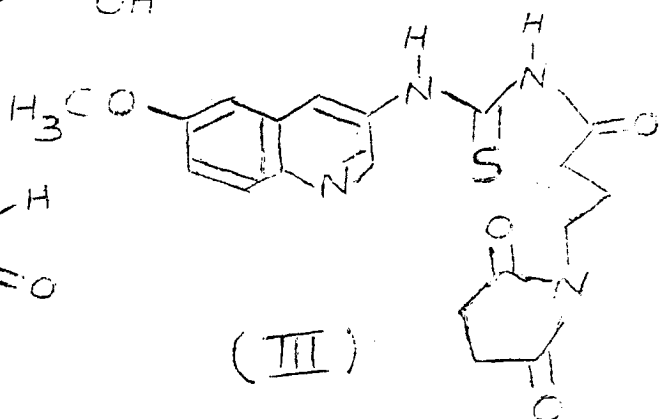
6. (i) Propose a stepwise synthesis of TWO of the following anti-bacterial agents from readily available starting materials and reagents. Show your analysis.



(I)



(II)



(III)

- (ii) How would you determine minimum inhibitory concentration, MIC, of (I) ?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - DECEMBER, 1994

C 460 PAPER I

PHYSICAL CHEMISTRY

TIME: THREE HOURS

ANSWER: ANY FOUR QUESTIONS

Useful informations:

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

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

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

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

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

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

$$= 23,060 \text{ cal mol}^{-1} \text{ eV}^{-1}$$

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

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

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

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

- (a) When is an operator linear? Which operator is related to the Kinetic energy? What is its value in Cartesian coordinates and polar coordinates?
- (b) If two operators A and B commute, show that they have the same set of eigenfunctions.
- (c) What is a Hamiltonian function? Express it as a function of the coordinates and the momenta. For a conservative system show that this function is equivalent to the total energy of the system.
- (d) What is a Hermitian operator? Prove that eigenvalues of a Hermitian operator are real.
- (e) Give the Hamiltonian operator for the Helium atom in atomic units.
- (f) Prove that the kinetic energy of a system containing two particles of masses m_1 and m_2 moving in only two dimensions

is given by

$$T = \frac{1}{2} (m_1 + m_2) (\dot{X}^2 + \dot{Y}^2) + \frac{1}{2} \frac{m_1 m_2}{m_1 + m_2} (\dot{x}^2 + \dot{y}^2)$$

- (a) Describe and explain at least two phenomenon which account for the failure of classical mechanics.
- (b) Describe the first postulate of Quantum mechanics and give the physical interpretation of the wave function.
- (c) How can an operator be set up for different observables?
Construct the quantum mechanical operator for Kinetic energy.
- (d) Derive Schrodinger's Wave equation for a single particle from Postulate III of quantum mechanics.
- (e) Show that the wave functions of an electron for two different states in a one dimensional box are orthogonal.
- (a) Calculate the allowed wave functions and energies for a particle constrained to move in a three dimensional box.
- (b) Find the lowest Kinetic energy of an electron in a rectangular box of dimensions 1×10^{-13} cm.; 1.5×10^{-13} cm.; and 2.0×10^{-13} cm.
- (c) What are the atomic units of Mass, Charge, Length, Angular momentum and Energy? Express Schrodinger equation and Hamiltonian in these units.
- (a) For systems having more than one electron, which methods have to be used for obtaining solutions to the wave equation?
Explain one of these.
- (b) Write the expression for the Hamiltonian for the rigid rotor.
Determine the allowed rotational energy levels.
- (c) Obtain the first three rotational energy levels of HBr molecule treating it as a rigid rotor. The bond distance is 1.42 Å in HBr. ($H = 1.008$; $Br = 79.904$)

5. (a) In Hydrogen atom write the expression for the Radial function $R(r)$ when normalised.
- (b) Discuss the significance of the radial wave functions in the case of Hydrogen atom.
- (c) Obtain the value of the energy of the electron in a Hydrogen atom or Hydrogen like ion.
- (d) Write the Hamiltonian operator for the Helium atom in ordinary units and atomic units.

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UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

C 480

PAPER I

E: THREE HOURS

WER: ANY FIVE QUESTIONS

Discuss the plots: (i) yield of $\text{SO}_3 = f(t)$,
where t - temperature of the SO_2 oxidation process;
(ii) SO_3 absorption = $f(C)$,
where C - concentration of sulphuric acid.

Describe the industrial methods of production of sulphur.

Describe the flow-sheet diagram for manufacturing Tower sulphuric acid (attached).

State the industrial methods manufacturing raw materials for ammonia synthesis.

Discuss the flow-sheet diagram for purification of a gas mixture from CO_2 with hot potash solution (attached).

Describe the flow-sheet diagram for manufacturing synthetic ammonia (attached).

Discuss the flow-sheet diagram for manufacturing not concentrated nitric acid (attached).

Describe the methods of production of ammonium nitrate and sulphate.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS-NOVEMBER/DECEMBER-1994

CA 210

ANALYTICAL CHEMISTRY

ONE HOUR

QUESTION ONE AND ANY OTHER TWO

QUESTION 1.

Calculate K_c for the reaction



at 200°C if 1.20 moles PCl_5 originally put in a 3.00l container were reduced to 1.00 mole at equilibrium?

Calculate the pH of the solution after mixing 50ml 0.010M

$\text{Ba}(\text{OH})_2$ and 150ml of 0.010M HNO_3

Calculate the pH of 0.10M barium acetate (BaA_2)

($\text{A} = \text{CH}_3\text{COO}^-$, K of $\text{CH}_3\text{COOH} = 1.75 \times 10^{-5}$)

Calculate the pH of the solution obtained by mixing 0.10 moles of

NaOH , 0.20 moles of acetic acid and 1.0 litre of water. K of

$\text{CH}_3\text{COOH} = 1.75 \times 10^{-5}$

Calculate the solubility of silver sulphate, Ag_2SO_4 in moles per

litre given that $K_{sp} = 1.2 \times 10^{-5}$.

Analysis of sodium on a sample gave the following readings (mg)

139.2 , 139.6 , 140.1 , 139.4

what is the range within which the true value lies at 95 %

confidence level?

ION 2.

Tartaric acid, H_2T is a weak diprotic acid

$$K_1 = 9.20 \times 10^{-4} ; K_2 = 4.31 \times 10^{-5}$$

derive the expression of fractional equilibrium species

in terms of K_1 , K_2 , and (H^+) .

Hence calculate , at pH = 3 and its corresponding equilibrium

concentration of the species for a 0.050M H_2T solution.

ION 3.

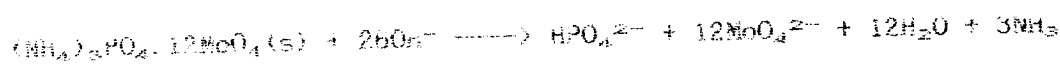
Calculate the pH after addition of 0.0 , 15.0 , 50.0ml of

0.100M HCl in the titration of 50.0ml of 0.100M NH_3

$$K_b \text{ of } NH_3 = 1.75 \times 10^{-5}$$

ION 4.

A 0.14g sample containing Phosphorous was digested in strong acids to give Phosphoric acid (H_3PO_4) as the only Phosphorous containing product. The Phosphoric acid was completely precipitated out of solution as $(NH_4)_3PO_4 \cdot 12 MoO_4$. The precipitate, after filtering, washing and drying was dissolved in excess NaOH (50.0ml, 0.200M).



The excess NaOH was back-titrated with HCl (14.17ml, 0.2000M).

With this data, determine the percentage Phosphorous in the sample.

$$A = 14.17 ; V = 14.17 ; Q = 14.17 ; m_0 = 0.14$$

QUESTION 5.

National Council for Scientific Research is currently involved in Uranium extraction from the local ores. The results (ppm) for the Uranium content of two sample ores :

Sample 1 : 10.32 , 10.39 , 10.19 , 10.21

Sample 2 : 10.45 , 10.41 , 10.51 , 10.36 , 10.34 , 10.39

By applying statistical analysis, deduce whether or not the two samples are significantly different at the 95% confidence level?

QUESTION 6.

A solution that is 0.010M Ca^{2+} and 1.0M EDTA is prepared. What will be the equilibrium concentration of Ca^{2+} ?

$$K_{\text{Ca}} = 5.0 \times 10^{10}$$

10.0ml of 0.100M AgNO_3 were added to 50.0ml of 0.0500M NaCl

during titration. Calculate the chloride and silver ion

concentration in the resulting solution. $K_{\text{sp}}(\text{AgCl}) = 1.75 \times 10^{-10}$

A mixture of 0.500g of KClO_4 and KCl was dissolved in water and

the ClO_4^- converted into Cl^- . If the total Cl^- required 32.0ml

of 0.138M AgNO_3 , determine the percentage of KClO_4 and KCl in

the sample. K = 39.1 , Cl = 35.5 , O = 16.0

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UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER, 1994

G 140

INTRODUCTION TO HUMAN GEOGRAPHY

PRACTICAL

PAPER II

TIME: THREE (3) HOURS

ANSWER: ALL QUESTIONS FROM SECTION A PLUS ANY TWO QUESTIONS FROM SECTION B.

MATERIALS PROVIDED:

1. ONE SHEET OF A4 METRIC GRAPH PAPER
2. TWO SHEETS OF A4 PLAIN PAPER

THE USE OF AN APPROVED ATLAS AND CALCULATOR IS ALLOWED.

SECTION A

INTRODUCTION TO MAPS AND AIR PHOTOGRAPHS

1. (a) List four ways in which Air Photographs can be used.
- (b) Outline and explain five (5) photo elements that would assist in the Aerial Photo Interpretation.
- (c) List three advantages and two disadvantages of Aerial Photographs over Maps.
- (d) Why is it difficult to make a map from an oblique Air Photograph?
- (e) List four major types of land cover (Land use)
2. (a) Explain briefly what you understand by the term "Map".
- (b) Mention five (5) characteristics that are associated with maps and explain the importance of each.
- (c) A map is 30 cm by 40 cm. Its Scale is 1:50,000. How large is the area shown on the map in square kilometres (Show your work).

- (d) Explain the importance of using symbols on maps.
 - (e) Construct a line scale in metric units for a map on a scale of 1:50,000, given that the available maximum space is 20 cm. (Show your work).
3. Examine Figure 1 given and answer the following:-
- (a) How best would you describe the relief on the map?
 - (b) In which general direction would the drainage flow? Give reasons for your answer.
4. Examine Figure 2 given and then divide it into its physiographic regions. Name and describe each region you have identified.

SECTION B

SPATIAL INDICES IN HUMAN GEOGRAPHY

5. Given the data below (Table 1) estimate net migration in the 9 provinces of Zambia between 1969 and 1980 and briefly comment on your findings.

Table 1: Population distribution by Province, Zambia, 1969 and 1980

Province	1969 Pop.	1980 Pop.
Central	358,655	513,835
Copperbelt	509,515	1,248,888
Luapula	335,584	412,798
Lusaka	353,975	693,878
Northern	545,096	677,894
N/Western	231,733	301,677
Southern	496,041	686,469
Western	410,087	487,988

Source: CSO(1974) and (1985), 1969 and 1980 Census of Final Reports, Lusaka.

6. Based on the data set in Table 2, determine the type of settlement pattern pertaining in the Copperbelt Province of Zambia covering 31,328 square kilometers.

Table 2: The Nearest Neighbour Distance in the Copperbelt Province

TOWN	NEAREST TOWN	NEAREST DISTANCE
1. Ndola	Luanshya	33,
2. Luanshya	Ndola	33
3. Kitwe	Kalulushi	14
4. Kalulushi	Kitwe	14
5. Chingola	Chililabombwe	18
6. Chililabombwe	Chingola	18
7. Mufulira	Kitwe	30

7. Table 3 shows the Urban Population distribution of Large Urban centres in Zambia, Show that the concept of primacy is slowly being applicable in Zambia.

Table 3: Urban Population Distribution of Large Towns in Zambia, 1990

Town	Pop. in 1990
Chingola	167,954
Chililabombwe	76,848
Kabwe	166,619
Kitwe	338,207
Livingstone	82,218
Luanshya	146,275
Lusaka	982,362
Mufulira	152,944
Ndola	376,311

Source: CSO, (199) 1990 Census of Population and Housing: Preliminary Report, Lusaka.

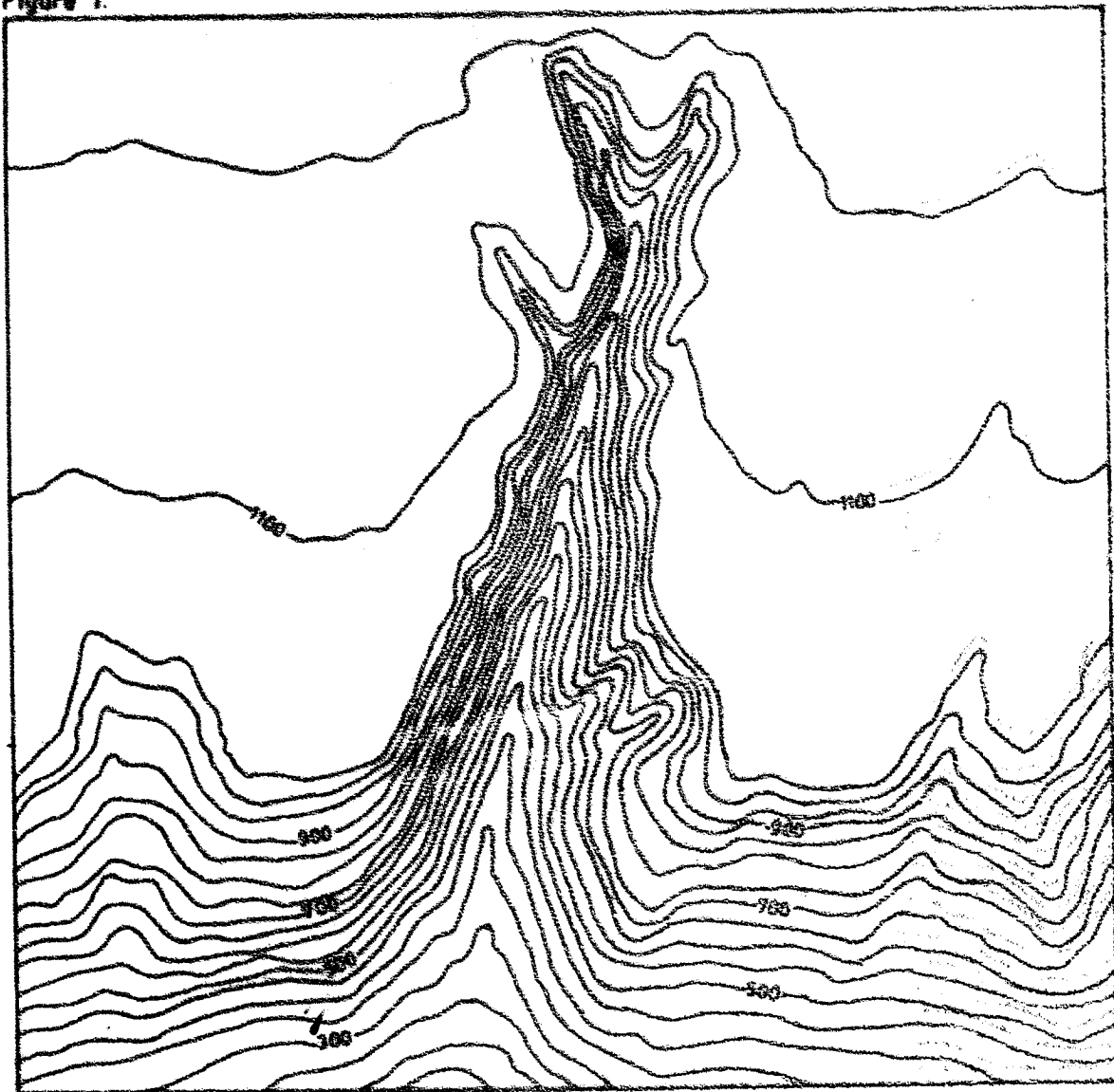
8. Assume you are given the data in Table 4. Which regions contributed significantly to the Wealth of the country and which economic activities needed further diversification?

Table 4: Gross Domestic Product by Kind of Economic Activity in Constant (1977) prices for the year 1988.

Economic Activity	Regions					
	A	B	C	D	E	F
1. Manufacturing	200	50	78	786	400	127
2. Mining	568	965	230	100	36	765
3. Fishing	389	56	389	110	186	102
4. Real Estate	55	256	10	15	190	368
5. Agriculture	990	289	788	321	543	378

END OF EXAMINATION

Figure 1.



SCALE 1:24,000
CONTOUR INTERVAL 50 METRES

Figure 2.



THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER 1994

G 220 PAPER I: CLIMATOLOGY

INTRODUCTION TO PHYSICAL GEOGRAPHY

TIME: THREE HOURS

ANSWER: ANY FOUR QUESTIONS

NOTE: ILLUSTRATIONS AND EXAMPLE
SHOULD BE USED WHEREVER APPROPRIATE
USE OF A CALCULATOR IS ALLOWED

1. Describe Zambia's three climatological seasons, paying particular attention to their causes and characteristics.

2. Describe in detail two effects of the tilt of the earth on its axis.

3. You have been allocated a project area in Chongwe for G 220. There is no meteorological station in that area and consequently you have decided to establish your own station. However, due to the limitations of resources, you have only managed to buy thermometers for measuring minimum and maximum temperatures.

In order to measure evaporation and rainfall, you have to make and calibrate your own instruments.

- (a) Describe how you would make and calibrate the instruments for measuring evaporation and rainfall.
- (b) How would you use the resulting data to calculate potential and actual evaporation?

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

- (a) minimax,
- (b) advection fog,
- (c) BWk climate,
- (d) warm front and
- (e) doldrums.

Describe global illumination, length of day and night and the apparent movement of the overhead sun at June solstice with reference to the equator, tropics of Cancer and Capricorn, Arctic and Antarctic Circles and the poles.

- (a) What is temperature inversion?
- (b) Explain how a ground inversion occurs.
- (c) What can be done to avoid crop damage as a result of night frost?

END OF EXAMINATION

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G 220 - II

GEOMORPHOLOGY

TIME: THREE HOURS

ANSWERS: 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) Isostasy
 - (b) Spheroidal weathering
 - (c) $Q = Av$
 - (d) Pediplain
 - (e) Fining upward sequence
 - (f) Karren
 - (g) Colluvium
 - (h) Saltation
 - (i) Barchan
 - (j) Helical flow
 2. Discuss mass wasting under the following headings:
 - (a) the angle of repose;
 - (b) the role of water;
 - (c) avalanches and landslides;
 - (d) mudflow;
 - (e) soil creep and solifluction.
 3. What are the possibilities and limitations of tourism on karst in Lusaka area.
 4. Discuss the formation of sedimentary rock from a loose sediment.
 5. Discuss the rock cycle in relation to plate tectonics.
 6. What would be the geomorphic effects of an increase in vegetation cover of a formerly arid region.

END OF EXAMINATION

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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) Sigmoid growth curve
 - (b) Law of limiting factors
 - (c) Adaptations
 - (d) Biological control
 - (e) Competitive exclusion principle
2. List the biotic and abiotic components of an ecosystem. Describe how these components interact to govern the flow of energy through a food web.
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.
 - (a) Briefly describe the nitrogen cycle as found in nature.
 - (b) Discuss the various effects and influences that man has had on the nitrogen cycle.

SECTION B: SOILS

Describe the various characteristics of soil water and their importance to plants.

- (a) List the soil textural classes in a decreasing diameter order (according to the USDA classification) and indicate the diameter range in SI units.
- (b) What is the importance of soil texture?

In what ways may the composition of parent material influence soil type in

- (a) in a semi-arid area
- (b) in a humid area

Write a brief account of each of the following

- (a) Layer silicates
- (b) Isomorphous substitution
- (c) Spodosol
- (d) Soil reaction
- (e) Soil micronutrients

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS NOVEMBER/DECEMBER, 1994

G 230

CARTOGRAPHIC AND QUANTITATIVE TECHNIQUES IN GEOGRAPHY

PAPER III

QUANTITATIVE METHODS IN GEOGRAPHY

TIME:

THREE HOURS

ANSWER:

FOUR QUESTIONS -- QUESTION ONE (COMPULSORY) AND ONE OTHER FROM SECTION B AND THE REMAINING TWO FROM EACH OF SECTION C.

ALL QUESTIONS CARRY EQUAL MARKS.

THE USE OF AN APPROPRIATE ATLAS AND CALCULATOR IS ALLOWED.

THE FOLLOWING TABLES FOR CRITICAL VALUES ARE

- (a) Chi Square,
- (b) Product moment correlation coefficient,
- (c) 'F' values and
- (d) Area under the normal curve.
- (e) Student 't' test
- (f) U test
- (g) Spearman's

A SHEET OF FORMULAE IS ALSO PROVIDED.

SECTION A

Q 1. What is meant by

- (a) negative skewness
- (b) a non-parametric test
- (c) mean deviation
- (d) $z = 2.34$ under the normal curve
- (e) Chebyshev's rule and
- (f) rejection region under the 't' distribution.

SECTION B

Q 2. Table 1 shows scores for a test in statistics:

Table 1: Scores for a test in statistics											
87	76	96	77	94	92	88	85	66	89	79	95
50	91	83	88	82	58	18	69	92	77.		

Use the data in Table 1 to:

- compute the three measures of central tendency.
- decide which one of your three measures of central tendency best represents the achievement of the class. Justify your answer.
- calculate the mean deviation.
- calculate the standard deviation (comment on the meaning of your standard deviation in relation to this data set).

Q 3. The mean number of trees counted by a biogeography student for a period of one week was 825. His standard deviation was 205.

What is the probability of this student

- counting 550 trees?
- counting 1,500 or more trees
- counting between 750 and 500 trees and
- counting between 700 and 956 trees.

SECTION C

Q 4. Table 2 shows the ages of husbands and their wives at the time of marriage. The data are normally distributed and on an interval scale.

Table 2: Ages of husbands and wives at the time of marriage

Husband's age	23	27	28	28	29	30	31	33	35	36
Wife's age	18	20	22	27	21	29	27	29	28	2

- Use of these data to prove whether or not the choice of a wife among husbands is significantly a function of age. Use the 0.01 level of significance.
- Predict the age of a woman that a 40 year old man would marry if he followed the pattern illustrated in Table 2

- Q 5. Data presented in Table 3 illustrate yields of beans in relation to sizes of plots. Show whether the yields are proportionally distributed in relation to sizes of plots. Use the 0.05 significance level.

Table 3: Yields of beans (25kg bags) from respective plots.

PLOT	SIZE OF PLOT IN (in ha.)	YIELD (in no. of 25kg bags)
A	15	6
B	10	15
C	25	10
D	16	12
E	30	25
F	18	19
G	35	26
H	27	16
I	40	20
J	24	11

- Q 6. A Psychologist wishes to investigate the difference in maze test scores for a strain of laboratory mice trained under different laboratory conditions. The experiment is conducted using eighteen randomly selected mice of this strain, with six receiving no training at all (control group), with six trained under condition 1, and six trained under condition 2. Then each of the mice is given a test score between zero and 100 depending on its performance in a test maze. The test produced the following results:

Table 4: Maze test scores for a strain of laboratory mice trained under different laboratory conditions.

CONTROL	CONDITION 1	CONDITION 2
58	73	53
32	70	74
59	68	72
64	71	62
55	60	58
49	62	61

Is there sufficient evidence to indicate a difference among mean maze test scores for mice trained under the three different laboratory conditions at the 0.05 level of significance?

G 230 FORMULAE SHEET

1.
$$t = \frac{\bar{x} - \bar{y}}{\sqrt{\frac{(\sum x^2 / nx) - \bar{x}^2}{nx - 1} + \frac{(\sum y^2 / ny) - \bar{y}^2}{ny - 1}}}$$

Use a one tailed test at the 0.05 significance level

2.
$$r = \frac{n \sum xy - \sum x \sum y}{\sqrt{[n \sum x^2 - (\sum x)^2][n \sum y^2 - (\sum y)^2]}}$$

or is it

$$r = \frac{n \sum xy - \sum x \sum y}{\sqrt{[n \sum x^2 - (\sum x)^2][n \sum y^2 - (\sum y)^2]}}$$

Use a two tailed test at the 0.01 significance level

3.
$$U_x = n_x n_y + \frac{n_x (n_x + 1)}{2} - \sum r_x$$

$$U_y = n_x n_y + \frac{n_y (n_y + 1)}{2} - \sum r_y$$

Use a one tailed test at the 0.025 significance level

4. $a = \bar{y} - b\bar{x}$ or is it $a = \sum y - b \sum x$

$$b = \frac{\sum xy - n \bar{x} \bar{y}}{\sum x^2 - n \bar{x}^2} \quad \text{or is it} \quad b = \frac{\sum x \bar{y} - n \bar{x} \bar{y}}{\sum x^2 - n \bar{x}^2}$$

$$5. \quad X^2 = \sum (O - E)^2 \quad \text{or is it} \quad X^2 = \sum \frac{(O - E)^2}{E}$$

Use the 0.05 significance level.

$$6. \quad \sigma = \sqrt{\frac{\sum x^2}{n} - \bar{x}^2} \quad \text{or} \quad \sigma = \sqrt{\frac{\sum x}{n} - \bar{x}^2}$$

$$7. \quad \hat{\sigma}_W^2 = \frac{\sum_k \sum_n (x - \bar{x})^2}{N - K} \quad \text{or is it?} \quad \hat{\sigma}_B^2 = \frac{\sum_k n (\bar{x} - \bar{x}_G)^2}{K}$$

$$F = \frac{\hat{\sigma}_B^2}{\hat{\sigma}_W^2}$$

$$F = \frac{\hat{\sigma}_W^2}{\hat{\sigma}_B^2}$$

Use the 0.05 level of significance.

$$8. \quad rs = 1 - \frac{6 \sum d^2}{n^3 - n}$$

$$rs = \frac{6 \sum d^2}{n^3 - n}$$

Use a one tailed test at the 0.01 significance.

$$9. \quad r_s = \frac{(A - B) + (A - C) - \sum d^2}{2\sqrt{(A - B)(A - C)}}$$

Use a two tailed test at the 0.05 significance level.

$$0. \quad Z = \frac{x - \bar{x}}{\sigma}$$

or is it

$$Z = \frac{\bar{x} - x}{\sigma}$$

8 Critical Values of Pearson's Product-Moment Correlation Coefficient r

Degrees of freedom	Significance level (one-tailed)			
	0.05	0.025	0.01	0.005
Degrees of freedom	Significance level (two-tailed)			
	0.1	0.05	0.02	0.01
1	0.9877	0.9969	0.9995	0.9999
2	0.900	0.959	0.980	0.990
3	0.805	0.878	0.934	0.959
4	0.729	0.811	0.882	0.917
5	0.669	0.755	0.833	0.875
6	0.622	0.707	0.789	0.834
7	0.582	0.666	0.750	0.798
8	0.549	0.632	0.716	0.765
9	0.521	0.602	0.685	0.735
10	0.497	0.576	0.658	0.708
11	0.476	0.553	0.634	0.684
12	0.458	0.532	0.612	0.661
13	0.441	0.514	0.592	0.641
14	0.426	0.497	0.574	0.623
15	0.412	0.482	0.558	0.606
16	0.400	0.468	0.543	0.590
17	0.389	0.456	0.529	0.575
18	0.378	0.444	0.516	0.561
19	0.369	0.433	0.503	0.549
20	0.360	0.423	0.492	0.537
25	0.323	0.381	0.445	0.487
30	0.296	0.349	0.409	0.449
35	0.275	0.325	0.381	0.418
40	0.257	0.304	0.358	0.393
45	0.243	0.288	0.338	0.372
50	0.231	0.273	0.322	0.354
60	0.211	0.250	0.295	0.325
70	0.195	0.232	0.274	0.302
80	0.183	0.217	0.257	0.283
90	0.173	0.205	0.242	0.267
100	0.164	0.195	0.230	0.254

Reject H_0 if calculated value of r is **greater than** critical value at chosen significance level (in absolute terms).

C7b: Critical Values of F at the 0.05 Significance Level

Degrees of freedom for larger variance estimate

		1	2	3	4	5	6	7	8	9
Degrees of freedom for smaller variance estimate	1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5
	2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38
	3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81
	4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00
	5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77
	6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10
	7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68
	8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39
	9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18
	10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02
	11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90
	12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80
	13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71
	14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65
	15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59
	16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54
	17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49
	18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46
	19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42
	20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39
	21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37
	22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34
	23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32
	24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30
	25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28
	26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27
	27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25
	28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24
	29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22
	30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21
	40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12
	60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04
	120	3.92	3.07	2.68	2.45	2.29	2.17	2.09	2.02	1.96
	∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88

continued

35 Critical Values of chi Square

Degrees of freedom	Significance level				
	0.1	0.05	0.01	0.005	0.001
1	2.71	3.84	6.64	7.88	10.83
2	4.60	5.99	9.21	10.60	13.82
3	6.25	7.82	11.34	12.34	16.27
4	7.78	9.49	13.28	14.86	18.46
5	9.24	11.07	15.09	16.75	20.52
6	10.64	12.59	16.81	18.55	22.46
7	12.02	14.07	18.48	20.28	24.32
8	13.36	15.51	20.09	21.96	26.12
9	14.68	16.92	21.67	23.59	27.88
10	15.99	18.31	23.21	25.19	29.59
11	17.28	19.68	24.72	26.76	31.26
12	18.55	21.03	26.22	28.30	32.91
13	19.81	22.36	27.69	30.82	34.53
14	21.06	23.68	29.14	31.32	36.12
15	22.31	25.00	30.58	32.80	37.70
16	23.54	26.30	32.00	34.27	39.29
17	24.77	27.59	33.41	35.72	40.75
18	25.99	28.87	34.80	37.16	42.31
19	27.20	30.14	36.19	38.58	43.82
20	28.41	31.41	37.57	40.00	45.32
21	29.62	32.67	38.93	41.40	46.80
22	30.81	33.92	40.29	42.80	48.27
23	32.01	35.17	41.64	44.18	49.73
24	33.20	36.42	42.98	45.56	51.18
25	34.38	37.65	44.31	46.93	52.62
26	35.56	38.88	45.64	48.29	54.05
27	36.74	40.11	46.96	49.65	55.48
28	37.92	41.34	48.28	50.99	56.89
29	39.09	42.56	49.59	52.34	58.30
30	40.26	43.77	50.89	53.67	59.70
40	51.81	55.76	63.69	66.77	73.40
50	63.17	67.51	76.15	79.49	86.66
60	74.40	79.08	88.38	91.95	99.61
70	85.53	90.53	100.43	104.21	112.32
80	96.58	101.88	112.33	116.32	124.84
90	107.57	113.15	124.12	128.30	137.21
100	118.50	124.34	135.81	140.17	149.45
Reject H_0 if calculated value of chi square is greater than the critical value at the chosen significance level.					

C. Critical Values of Student's t

Degrees of freedom	Significance level (one-tailed)				
	0.05	0.025	0.01	0.005	0.0005
	Significance level (two-tailed)				
	0.1	0.05	0.02	0.01	0.001
1	6.31	12.71	31.82	63.66	636.62
2	2.92	4.30	6.97	9.93	31.60
3	2.35	3.18	4.54	5.84	12.92
4	2.13	2.78	3.75	4.60	8.61
5	2.01	2.57	3.37	4.03	6.86
6	1.94	2.45	3.14	3.71	5.96
7	1.89	2.37	3.00	3.50	5.41
8	1.86	2.31	2.90	3.35	5.04
9	1.83	2.26	2.82	3.25	4.78
10	1.81	2.23	2.76	3.17	4.59
11	1.80	2.20	2.72	3.11	4.44
12	1.78	2.18	2.68	3.05	4.32
13	1.77	2.16	2.65	3.01	4.22
14	1.76	2.15	2.62	2.98	4.14
15	1.75	2.13	2.60	2.95	4.07
16	1.75	2.12	2.58	2.92	4.01
17	1.74	2.11	2.57	2.90	3.97
18	1.73	2.10	2.55	2.88	3.92
19	1.73	2.09	2.54	2.86	3.88
20	1.73	2.09	2.53	2.85	3.85
21	1.72	2.08	2.52	2.83	3.82
22	1.72	2.07	2.51	2.82	3.79
23	1.71	2.07	2.50	2.81	3.77
24	1.71	2.06	2.49	2.80	3.75
25	1.71	2.06	2.49	2.79	3.73
26	1.71	2.06	2.48	2.78	3.71
27	1.70	2.05	2.47	2.77	3.69
28	1.70	2.05	2.47	2.76	3.67
29	1.70	2.05	2.46	2.76	3.66
30	1.70	2.04	2.46	2.75	3.65
40	1.68	2.02	2.42	2.70	3.55
60	1.67	2.00	2.39	2.66	3.46
120	1.66	1.98	2.36	2.62	3.37
∞	1.65	1.96	2.33	2.58	3.29
Reject H_0 if calculated value of t is greater than critical value at chosen significance level.					

C3b Critical Values of U for a One-Tailed Test at the 0.025 Significance Level or a Two-Tailed Test at the 0.05 Level

$n_x \backslash n_y$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2								0	0	0	0	1	1	1	1	1	2	2	2	2
3					0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8
4				0	1	2	3	4	4	5	6	7	8	9	10	11	11	12	13	13
5			0	1	2	3	5	6	7	8	9	11	12	13	14	15	17	18	19	20
6			1	2	3	5	6	8	10	11	13	14	16	17	19	21	22	24	25	27
7			1	3	5	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34
8		0	2	4	6	8	10	13	15	17	19	22	24	26	29	31	34	36	38	41
9		0	2	4	7	10	12	15	17	20	23	26	28	31	34	37	39	42	45	48
10		0	3	5	8	11	14	17	20	23	26	29	33	36	39	42	45	48	52	55
11		0	3	6	9	13	16	19	23	26	30	33	37	40	44	47	51	55	58	62
12		1	4	7	11	14	18	22	26	29	33	37	41	45	49	53	57	61	65	69
13		1	4	8	12	16	20	24	28	33	37	41	45	50	54	59	63	67	72	76
14		1	5	9	13	17	22	26	31	36	40	45	50	55	59	64	76	74	78	83
15		1	5	10	14	19	24	29	34	39	44	49	54	59	64	70	75	80	85	90
16		1	6	11	15	21	26	31	37	42	47	53	59	64	70	75	81	86	92	98
17		2	6	11	17	22	28	34	39	45	51	57	63	67	75	81	87	93	99	105
18		2	7	12	18	24	30	36	42	48	55	61	67	74	80	86	93	99	106	112
19		2	7	13	19	25	32	38	45	52	58	65	72	78	85	92	99	106	113	119
20		2	8	13	20	27	34	41	48	55	62	69	76	83	90	98	105	112	119	127

Reject H_0 if calculated value of U is less than or equal to critical value at chosen significance level.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER, 1994

G340

GEOGRAPHY OF AFRICA WITH SPECIAL REFERENCE TO ZAMBIA

THREE HOURS

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

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

SECTION A:

Write brief explanatory notes on all of the following?

- (a) The effect of altitude on temperature in East Africa.
- (b) The distribution of winds and pressure belts on the African continent in July.
- (c) Factors influencing industrial development in Kenya.
- (d) The advantages of tourism as an aid to industrial, development in East Africa.
- (e) The vegetation and soils of the tropical rain forest.

Using specific examples. Outline and explain the various ways in which water transport is limited by physical factors on the African Continent and suggest possible solutions.

Either

- (a) Discuss the main factors, both natural and human, which tend to induce soil erosion in Africa.

or

- (b) To what extent is the crisis in the sahel man made rather than a result of 'Acts of God'?

SECTION B:

4. Compare and contrast the strategies of economic development followed by Ghana and the Ivory Coast after independence.
5. Assess the contention by Griffiths and Binns' (1988) that the Socio-economic crisis in African is largely due to lack of political will.
6. Explain why South Africa has the highest concentration of Industrial growth in Africa and show the distribution of industries within the country.

SECTION C:

7. In what ways is the changing geo-political situation in Southern Africa an advantage rather than a disadvantage to Zambia?
 8. Discuss the potential impact of market liberalization on farming in Zambia.
 9. Discuss the extent to which population distribution in Zambia conforms to the principle of environmental determinism.
 10. With the use of examples, discuss the view that human migration patterns in Zambia since 1969 reflect the effect of unequal distribution of socio-economic resources.
 11. Discuss Regional diversification of industrialization in Zambia with respect to the strategy of Import - substitution.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - AUGUST 1994

G 922

CLIMATOLOGY

TIME: Three hours

ANSWER: FOUR questions; question one and three others.

NOTE: Question one carried 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.

(a) According to McDonald's theory (1957), a gap in station A's records can be filled if the neighbouring stations B, C and D have complete records. The mean annual precipitation at station A, B, C and D are 695, 715, 735 and 750 mm. For calendar year 1992 the annual precipitation at stations B, C and D were 690, 710 and 725 mm respectively. Calculate the annual precipitation in 1992 at station A.

(b) Comment on the usefulness of this method, comparing it with the results of another method.

The figures for the climatological parameters for Lusaka come from a meteorological station at Lusaka International Airport (Lat. 15 degr. 19 min. S, Long. 28 degr. 27 min. E, Alt. 1154 m. ams). The temperature figures for the months June, July and August are as follows:

	max. T	min. T (°C)
June	24.2	08.3
July	24.2	07.7
August	26.2	10.6

At the beginning of July this year however, Lusaka was experiencing a cold fresh to strong breeze with daily maximum temperatures around 16 °C and minimum temperatures around 1 to 2 °C, which is very unusual for Lusaka. Describe and explain this weather situation.

4. In the months of December, January and February, South-West Tanzania and in some rainy seasons North-East Zambia get their rainfall from the south moving ITCZ, but also from another source.

Describe and explain this other source and discuss why this extra rainfall is so important for the region.

5. Describe giving full details the two isohyetal methods in the processing of precipitation data for a catchment area.

6. Discuss the recent climatic change and its likely effects on the environment.

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

- (a) an automatic rainfall recorder,
- (b) a lysimeter,
- (c) a meteorological map,
- (d) the waterbalance method of determining the recharge of groundwater and
- (e) a barometer used as an altimeter.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - AUGUST 1994

G 925

GEOGRAPHICAL HYDROLOGY

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 short explanatory notes on all of the following:
 - a) Chemical and latent heat characteristics of water.
 - b) Three pathways of runoff.
 - c) Criteria for the selection of weirs and why the v-notch is varied in sharp-crested weirs.
 - d) Floods and why the recurrence interval is not a forecast.
 - e) Three methods of baseflow separation.
 - f) Infiltrometer and its use.
 - g) Pumping test.
 - h) Calibration of a self made rain gauge.
 - i) Thiessen polygons.
 - j) Fault dam spring.
2. 'Drought is a chronic phenomenon in Zambia'. Discuss.
3. Discuss in retrospect Africa's experience and Zambia's future prospects for river basin development.

4. At a meteorological station, both precipitation and temperature were measured. The total mean precipitation per year was 800 mm and the annual average temperature was 20° C.
- a) Calculate the average evaporation (E_a) using the formulas by:
- =) Turc and Langbein
 - =) Coutagne
- b) Calculate and discuss the difference between the two results.
5. Explain, using examples, the difference between Coefficient of permeability and Coefficient of transmissibility.
6. What information can a hydrologist gather from the pattern of "Isohypsen" on a hydrological map and how can this information be used. Give an example.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER, 1994

G 941

POPULATION GEOGRAPHY

PRACTICAL PAPER II

TIME: THREE (3) HOURS

ANSWER: TWO QUESTIONS FROM EACH SECTION.
ALL QUESTIONS CARRY EQUAL MARKS.

SECTION A

1. Table 1: population of Copperbelt, Eastern, Lusaka and Western provinces, 1969 and 1980.

PROVINCE	1980	1969	ANNUAL RATE OF GROWTH 1969 - 1980 r ?
Copperbelt	1,248,888	816,309	r ?
Eastern	650,902	P ?	2.3%
Lusaka	P ?	352,584	6.3 %
Western	486,455	440,087	r ?

- (a) Calculate the following:
- (i) The rates (r) of growth between 1969 and 1980 for the Copperbelt and Western provinces
 - (ii) 1969 and 1980 population of Eastern and Lusaka provinces respectively.
- (b) Discuss briefly major factors responsible for the population dynamics in the Copperbelt province.

2. Assuming you are a Chief Land Use Planner at the Ministry of Agriculture Food and Fisheries in Lusaka and the Permanent Secretary requests you to find provinces where there is land shortage due to population increase. Which cartographic technique can you use in order to make the Permanent Secretary appreciate the Spatial Distribution of the population in the country at a glance?

Table 2: Area and Population Distribution by province. Zambia, 1990

PROVINCE	1990 POPULATION	AREA (SQ. KM (000))
Central	725,611	94
Copperbelt	1,579,542	31
Eastern	973,818	69
Luapula	526,705	51
Lusaka	1,207,980	22
Northern	867,795	148
North-Western	383,146	126
Southern	946,353	185
Western	607,497	126

Source: CSO, (1990), 1990 Census of Population, Housing and Agriculture: Preliminary Report, Lusaka.

NB. Use the Map of Zambia provided.

3. Based on the data given in Table 3 below, estimate the lifetime inter district migration in Luapula province in 1980 and comment on your results.

Table 3: Inter-District Lifetime Migration in Luapula Province, 1980.

District of Birth	District of Enumeration.				
	1	2	3	4	5
1. Kawambwa	50,634	938	1,686	1,464	523
2. Mansa	2,194	82,445	2,285	766	466
3. Mwense	2,867	1,839	52,434	868	518
4. Nchelenge	4,331	960	2,722	62,256	406
5. Samfya	448	2,019	344	256	87,591

SECTION B

4. Estimate the contribution of internal migration to the growth of urban population in Zambia between 1980 and 1990 if the total urban population in 1980 was 2,258,500 while the total population for Zambia was 5,661,801 and the urban population for 1990 was 3,285,766 as compared to the country's total population of 7,818,447. Show all necessary calculations and briefly comment on your results.
5. Presented in Table 4 is the distribution of population for country 'A'

Table 4: Population distribution for country 'A'.

AGE	MALES	FEMALES
0-4	2312	2194
5-9	2395	4669
10-14	2166	2047
15-19	1961	1872
20-24	2132	2105
25-29	1822	1788
30-34	1652	1607
35-39	1598	1572
40-44	1659	1572
45-49	1750	1794
50-54	1591	1683
55-59	1614	1746
60-64	1497	1709
65-69	1196	1511
70-74	779	1226
75-79	461	870
80+	367	892

Use data presented in Table 4 to:

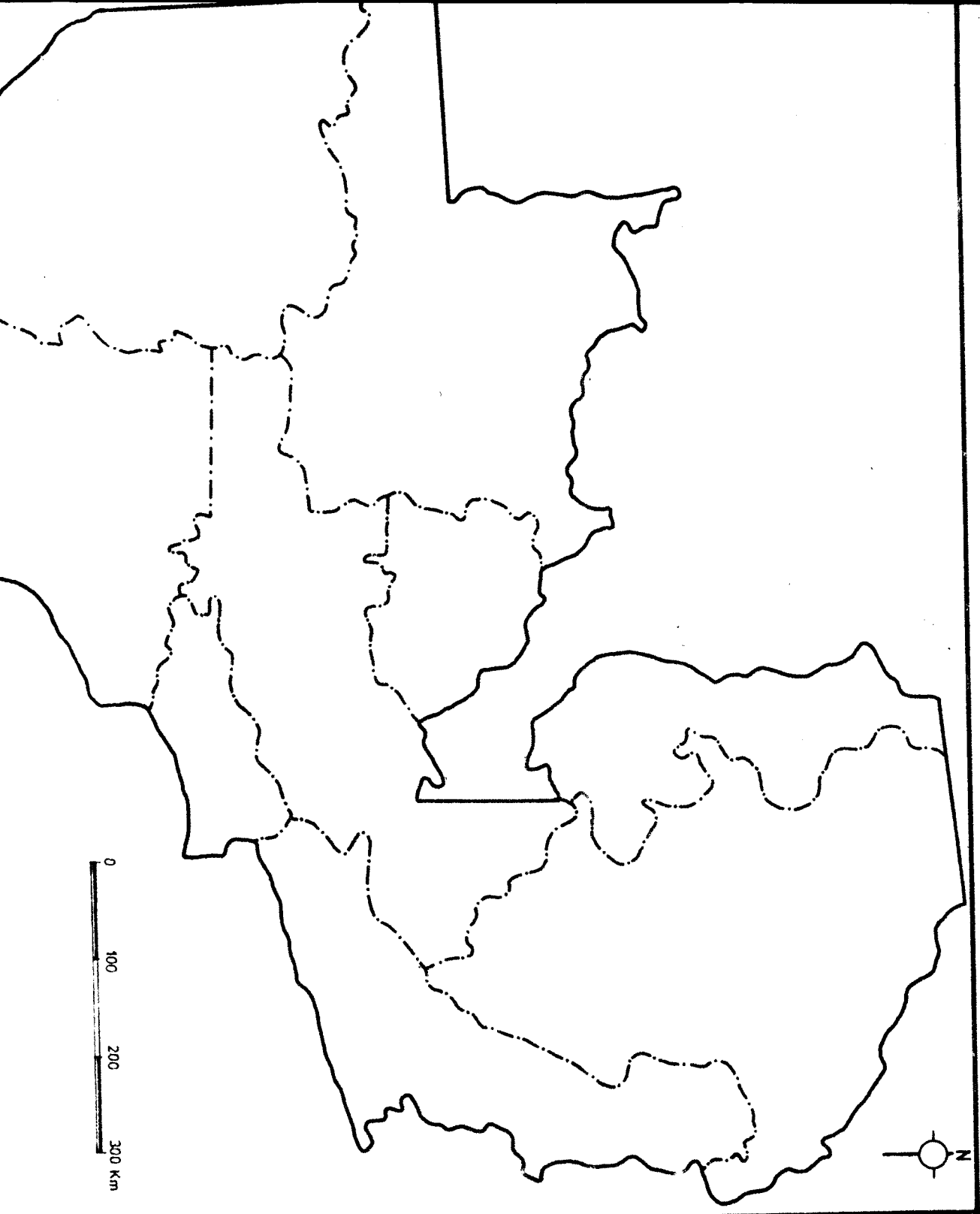
- (a) compute the child dependency ratio for the population in country 'A' and briefly explain what the socio economic implications of such a dependence ratio are,
- (b) compute the Aged dependency ratio and explain what it means and
- (c) compute the total dependence ration and suggest measures measures that the government of a country 'A' should take in

6. (a) Assuming that data presented in Table 5 were randomly selected, use an appropriate parametric statistical test to assess whether or not there is any association between GNP percapita and Total Fertility Rate (TFR).
- (b) Explain why your value is either weak, moderate or strong.

Table 5: GNP PER CAPITA AND TOTAL FERTILITY RATES FOR SELECTED COUNTRIES.

PER CAPITA	GNP (US \$)	TOTAL FERTILITY RATE
1.	310	3.6
2.	380	2.0
3.	290	6.5
4.	26,780	2.0
5.	3,010	1.7
6.	1,840	2.2
7.	110	6.3
8.	320	6.5
9.	28,220	4.4
10.	1,170	6.9

END OF EXAMINATION



MAP FOR CHAI II

G 941 FORMULAR SHEET

$$r = \frac{n \sum xy - \sum x \sum y}{\sqrt{[n \sum x^2 - (\sum x)^2][n \sum y^2 - (\sum y)^2]}}$$

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

G 960

ECONOMIC GEOGRAPHY AND DEVELOPMENT

TIME: THREE HOURS

ANSWER: FOUR QUESTIONS. ANSWER QUESTION 1 (COMPULSORY)
AND ONE OTHER FROM SECTION A AND ANY TWO FROM
SECTION B.

NOTE: ILLUSTRATIONS AND EXAMPLES SHOULD BE USED WHEREVER
APPROPRIATE.

SECTION A

1. Write brief explanatory notes on each of the following:
 - (a) the relationship between plant size and plant closure.
 - (b) external economies of scale as a locational factor.
 - (c) Smith's Variable Cost Model.
 - (d) Von Thunen's conception of Economic Rent.
2. Trace the origin of modern Economic Geography and discuss the major shifts in emphasis that have occurred to date.
3. "All decision making activities including locational decisions are behavioural processes" (Dicken, 1971). Discuss this statement with reference to Weber's Theory of Industrial Location.
4.
 - (a) In what ways does distance affect international commodity trade?
 - (b) Suggest ways by which Zambia can protect her collapsing manufacturing sector from foreign competition.

SECTION B

5. Comment on the view of G. Yoseph (1994) that Structural Adjustment is desirable and necessary if growth in African economies is to be restored.

. Compare and contrast Modernisation and Dependence Theories and show how each theory proposes to deal with the economic crisis in the Third World.

. To what extent and in what ways does 'Radical Geography' still have a role to play in understanding and resolving the economic crisis in the 1990s in the Third World.

. Show the relevance of the comparative models of development in mapping out development strategies for the Third World in the post 'cold war' period.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY MID-YEAR EXAMINATIONS - AUGUST 1994

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. (a) Define Rural Geography
(b) Discuss the significance of the Environmental perceptual approach to Rural Geography.
 2. In what ways are water and land rights interconnected, and to what extent do both rights constrain Rural development in Africa?
 3. To what extent is the material development of Rural Africa dependent on the role of transport and communications?
 4. Either
(a) What factors account for the location of settlements in Rural Zambia?

OR
(b) Discuss ways of fostering Rural Industrialization in Zambia.
 5. Evaluate Goran Hyden's view that the African peasantry is not 'captured' by other social classes.
 6. Evaluate why it is necessary to effectively integrate women into commercial agricultural production in Rural Africa.
 7. To what extent can modernization of indigenous methods of cultivation be a basis for sustainable agricultural development in Zambia?
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER 1994

G 965

URBAN GEOGRAPHY

TIME: THREE (3) HOURS

ANSWER: FOUR QUESTIONS - TWO FROM EACH SECTION.

ALL QUESTIONS CARRY EQUAL MARKS.

USE OF A CALCULATOR ALLOWED

SECTION A

1. Explain how the three different Approaches in Contemporary Urban Geography are associated by referring to the Physical Planning Problems of most Cities in Developing Countries.
2. Outline and critically evaluate the Operational definitions of an "Urban Place" as given by the Central Statistical Office during the 1980 and 1990 Censuses of Population of Zambia.
3. Show the quantitative differences between the Tempo of Urbanisation and the Rate of Urbanisation and comment on the type of Urbanisation trends in Zambia by use of the following data:-

Table 1: Urban Population of Zambia, 1963, 1969, 1980 and 1990

Census Year	Total Urban Population	Total Population in Zambia
1963	715,256	3,490,170
1969	1,192,116	4,056,995
1980	2,258,500	5,661,801
1990	3,285,766	7,818,447

Source: CSO (1970, 1974, 1985, 1991), Census of Population and Housing Reports. Lusaka.

4. Discuss and Explain the Socio-economic problems affecting Town Planning efforts in most African Towns today. In what ways can some of these problems be solved particularly in the so-called "Parasitic Cities."

SECTION B

5. 'The Key concepts of the Central place Theory remain informative for the urban Geographer.' Discuss.
 6. "The Geography of the City reflects the level of technology and the organisation of its economic activity". Discuss with reference to any city in Zambia.
 7. With reference to social status segregation assess the extent to which the residential structure of a city may be viewed as the outcome of several decisions by individual households about where to live.
 8. How are market forces manifested in the form and structure of urban areas in Zambia?
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

G 971

BIOGEOGRAPHY

ME: THREE HOURS

SWER: ANY FOUR QUESTIONS

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

The theory of Island Biogeography has been criticised as an oversimplified abstraction. What variables other than those discussed by McArthur and Wilson affect species diversity on islands?

Why should man today be concerned about the rapid destruction of the tropical rainforests?

The Linnean system of classification of living organisms is described as being generic, hierarchical, comprehensive and binomial. Discuss.

With specific reference to Zambia, outline and explain the practical value of vegetation burning.

'The theory of continental drift is nothing more than a scientist's dream, based on imagination rather than evidence.'

Evaluate this statement and suggest alternative explanations for the distribution of plants and animals.

Using specific examples, distinguish between evolutionary and climatic relict populations of plants and animals, and briefly discuss how such relicts might be characterised as biogeographical islands.

Outline the significance of vegetation surveys to nature conservation. And briefly describe how you would collect the necessary data for the conservation of any given area.

END OF EXAMINATION

4 Cops

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS -AUGUST, 1994

G 972

THE GEOGRAPHY OF NATURAL RESOURCES

TIME: THREE HOURS

ANSWER: FOUR QUESTIONS

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

-
- Q1. 'All is interdependent in today's world, it is impossible to reform any one thing without altering the whole.' Discuss this statement with respect to whether United Nations Conference on Environment and Development (UNCED) was an epitaph or advent.
- Q2. 'All resource problems are related to human population increase' Discuss this statement, with reference to the use of Zambia's natural resources by Man.
- Q3. Answer either (a) or (b)
- (a) "Historically soil erosion was a local problem. Individual civilizations whose food systems were undermined in earlier times declined in isolation (Brown, L. A. and Wolf, E. C. (1984))." Discuss this statement with respect to the effect of soil erosion on the global socio-economic relations.
 - (b) Evaluate the view that 'the globalisation of the United Nations Conference on Environment and Development (UNCED) agenda was merely a rush to superficially correct the injustice perpetrated by the rich on the poor and preservation of whatever natural resources still remain.'
- Q4. With reference to specific examples drawn from Zambia, outline giving reasons Man's intervention in the hydrological cycle at the river stage and briefly discuss the problems arising from that intervention.
- Q5. (a) Briefly outline some of the human strategies that traditional societies used to cope with environmental stress.
- (b) Discuss the likely constraints were these strategies incorporated in today's environmental management designs.

Q6. Answer either (a) or (b)

- (a) Discuss the role of the multiplier effect of deforestation on human populations.
- (b) With reference to forestry, explain what is meant by the term 'Tragedy of the Commons' and briefly discuss how this problem is being managed in the Zambian context.

END OF THE EXAMINATION

4 copies

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS -AUGUST, 1994

G 972

THE GEOGRAPHY OF NATURAL RESOURCES

TIME: THREE HOURS

ANSWER: FOUR QUESTIONS

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

-
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END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

G 975

SOIL GEOGRAPHY

TIME: THREE HOURS

ANSWER: QUESTIONS 1 AND 2 AND ANY OTHER TWO. 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. Write a brief account on each of the following:
 - (a) hydrolysis
 - (b) hydrous mica
 - (c) management type
 - (d) moisture control section
 - (e) orthents
 2. "We do not want soil maps. Just give us land capability." With reference to the above statement, justify the developmental significance of land capability maps.
 3. Define and explain the criteria used for the identification of an umbric, spodic, histic, and albic horizons.
 4. Explain in terms of soil forming processes, genesis of the following horizons and soils: Podzol, Spodosol, Laterite and Alfisol.
 5. (a) Name five types of soil survey used in Zambia and indicate the scale range, purpose and mapping units used in each type of survey.

(b) Describe with examples how your knowledge of airphoto interpretation and factors of soil formation help in soil surveys.
 6. Outline the socio-economic factors critical to the success of soil conservation, and indicate with justification, which two factors are critical to the Zambian situation.
-

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - NOVEMBER/DECEMBER 1994

G 981

CARTOGRAPHY

TIME: THREE (3) HOURS

ANSWER: FOUR QUESTIONS
(ALL QUESTIONS CARRY EQUAL WEIGHT)

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

Write brief explanatory notes on the following:

- (a) Map projections
- (b) Choropleth mapping
- (c) Dasymetric mapping
- (d) Isarithmic mapping
- (e) Cartographic generalization

Illustrate with an example, the need for and importance of maps in Zambia.

'The use of symbols on maps, is a convenient way of representing geographic information'. Discuss.

To what extent is colour in Cartography worth all the effort and expense involved?

Explain at least four (4) methods of representing relief on topographic maps and discuss the problems associated with each method.

Discuss the view that computer techniques have brought only speed and standardisation to modern map-making.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY MID-YEAR EXAMINATIONS - AUGUST, 1994

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)

Write brief explanatory notes on all of the following:

- (a) False colour film and panchromatic film.
 - (b) The assumptions upon which the validity of the inferences that can be drawn from a satellite image is based.
 - (c) Time-critical and time-stable observations.
 - (d) The difference between supervised and unsupervised classification.
-
- (a) Explain why a minus-blue filter is normally used with false colour film.
 - (b) Explain why it is not possible to see the ground surface in 3 - dimensions looking out of the window of a high-flying aircraft whereas two overlapping photos of the same area taken from the same aircraft can be seen as a 3-D model under a stereoscope.
 - (c) A set of 1:25 000 air photographs is required of an area with an average altitude of 1180 m above sea level. A super wide angle lens of 83mm is to be used. What should the flying height of the aircraft be?

3. (a) What is image parallax on vertical aerial photographs?
- (b) Two overlapping vertical aerial photographs have been aligned in the flight direction and fastened after obtaining a stereomodel. The photos cover Lusaka's Central Business District (CBD) and it is required to estimate the height of the tallest building in the CBD. Using a parallax bar, the parallax of the base of the building is found to be 45.5mm and that of the top of the same building is 43.5mm.

Calculate the height of the building if the scale of the square 230mm photos, which were taken with a 150mm focal length camera, is 1:10,000. The distances between the principal points and the transferred principal points of the two photos are 90.5mm and 93.5mm respectively.

- (c) Aerial photographs of a plantation consisting of two classes of trees at different growth stages, are undertaken at a scale of 1:20 000 using a narrow angle (300mm) camera.

-the height difference between the two classes is found to be about 1.5m. When the photos are examined under a stereoscope, would you be able to make a distinction between these classes? Explain your answer.

SECTION B (40)

4. Assume that you are an employee of the National Environmental Council (NEC) of Zambia, and have been given the task of conducting a deforestation study in Chongwe area.

What type of aerial photographs would you require and how would you utilize them to detect and monitor the spatial extent of the problem, between 1960 and 1990?

5. Define ground truthing and outline its significance in satellite remote sensing.
 6. 'The degree of detail and the accuracy by which thematic information can be extracted from satellite imagery and the economic cost does not depend solely on the characteristics of the remote sensing system used.'
Discuss.
 7. Outline the approaches used in the Box classifier method of image classification and state the inherent constraints.
 8. Draw a diagram showing a typical reflectance curve of a normal healthy plant leaf and discuss the factors responsible for the pattern of the curve.
-

END OF EXAMINATIONS

b) Evaluate Two of the following integrals:

i) $\int \frac{dx}{\sqrt{x^2 + 3x + 5}}$

ii) $\int \ln(1 + x^2) dx$

iii) $\int \frac{\cos \theta}{1 + \cos \theta} d\theta.$

6.

a) The Laplace's equation in \mathbb{R}^2 , is given by

$$\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} = 0.$$

Verify that $f(x,y) = \ln(x^2 + y^2)$ satisfies Laplace's equation.

b) i) Find the distance from the point $A(1,1,7)$ to the line through points $B(2,-1,4)$ and $C(3,1,6)$.

ii) Calculate a unit normal vector to the curve

$$f(t) = \left(\frac{t^3}{3} - t \right) \hat{i} + t^2 \hat{j};$$

at $t = 3$.

7.

Find the general solution of the differential equation

i) $\frac{d^2 y}{dx^2} + 2 \frac{dy}{dx} - 3y = x^2$ *Handwritten: $\frac{d^2 y}{dx^2} + 2 \frac{dy}{dx} - 3y = x^2$*

and solve any two of the following:

ii) $\frac{dy}{dx} + \frac{1 + y^3}{xy^2(1+x^2)} = 0$

iii) $\frac{dy}{dx} + \frac{2}{x} y = 6x^3$

iv) $(x^2 - 2y^2)dy + 2xydx = 0.$

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATION 1994
MATHEMATICS M220

TIME ALLOWED: Three(3) hours

INSTRUCTIONS: Full marks may be obtained for
complete answers to any six (6) questions

1. a) Given a 2×2 matrix $A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$ with $ad - bc \neq 0$, what are the entries in the matrix B that satisfy $BA = I$? Show that this same B satisfies $AB = I$

- b) For what values of t will the matrix $T = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 1 & 1 & t-1 \end{bmatrix}$

be noninvertible? For all other values of t what is the inverse?

- c) Reduce the matrix $Y = \begin{bmatrix} 1 & 0 & 2 \\ 2 & -2 & 3 \\ 4 & 3 & 8 \end{bmatrix}$ to

- i) Echelon form
ii) Row reduced echelon form

2. a) Given the system of linear equations $AX = B$, where

$A = (a_{ij})$, $X = (X_i)$, $B = (b_j)$, give the meaning of each of the following terms

- i) the rank of the matrix A
ii) a consistent system of equations
b) i) Determine the rank of each of the following matrices:

$$A_1 = \begin{bmatrix} 2 & 1 & -2 \\ 3 & 2 & 2 \\ 5 & 4 & 4 \end{bmatrix}; \quad A_2 = \begin{bmatrix} 2 & 1 & -2 & 10 \\ 3 & 2 & 2 & 1 \\ 5 & 3 & 4 & 4 \end{bmatrix}$$

Hence deduce that the system of equations

$$2x + y - 2z = 10$$

$$3x + 2y + 2z = 1$$

$$5x + 4y + 4z = 4$$

is consistent.

- c) Find a solution set for the system $A_1 X = \begin{bmatrix} 10 \\ 1 \\ 4 \end{bmatrix}$ where A_1 is the matrix in question 2(a).

3. a) Give the definition of each of the following terms as applied to vector spaces

i) an \mathbb{K} -basis of a vector space V

b) Given that U and W are subspaces of a vector space V , then prove that $U \cup W$ is also a subspace of V

c) Verify that the subset W of $V_3(\mathbb{F})$ given by

$$W = \{(a, b, c) \in V_3(\mathbb{F}) \mid k_1 a + k_2 b + k_3 c = 0\}$$

where k_i ($i = 1, 2, 3$) is a scalar,

is a subspace of $V_3(\mathbb{F})$.

Hence determine an \mathbb{K} -basis for W .

4. Give the definition of each of the following terms

i) a linear transformation

ii) the kernel, $\ker T$ of a linear transformation

a) Let $T: V \rightarrow W$ be a linear transformation between K -spaces V and W . Verify that $\ker T$ is a subspace of V

b) Let $T: V_2(\mathbb{F}) \rightarrow V_3(\mathbb{F})$ be a mapping given by

$$T(\alpha, \beta) = (\alpha + 3\beta, 2\alpha - 5\beta, 3\alpha + \beta).$$

Show that T is a linear transformation.

5. Let $T: V \rightarrow W$ be a linear transformation between K -spaces V and W . Then give the meaning of each of the following terms

- i) The matrix of a linear transformation T
- ii) The image, $\text{im}T$ of the linear transformation T .

- a) Show that if $T: V \rightarrow W$ is a linear transformation, then $\text{im}T$ is a subspace of W

- b) Let $T: V_2(\mathbb{F}) \rightarrow V_3(\mathbb{F})$ be the linear transformation given by

$$T(u_1) = v_1 + 2v_2 - v_3$$

$$T(u_2) = v_1 - v_2$$

where $\{u_1, u_2\}$ and $\{v_1, v_2, v_3\}$ are \mathbb{F} -bases for $V_2(\mathbb{F})$ and

$V_3(\mathbb{F})$ respectively. Then

determine the matrix of T relative to

- i) The usual (natural) bases for $V_2(\mathbb{F})$ and $V_3(\mathbb{F})$

- ii) The bases $\{-u_1 + u_2, 2u_1 - u_2\}$

$$\text{and } \{v_1, v_1 + v_2, v_1 + v_2 + v_3\}.$$

6. Define each of the following terms as applied to linear transformations

- i) a non-singular linear transformation.
- ii) The nullity of a linear transformation.

- a) Let I be the linear transformation on V such that $I(v) = v$ for all $v \in V$. Prove that if $T: V \rightarrow V$ is a linear transformation such that $T^2(v) = 0$ for all $v \in V$, then $I - T$ is nonsingular

- b) Determine the nullity of the linear transformation

$T : V_3(\mathbb{R}) \rightarrow V_3(\mathbb{R})$ given by

$$T(\alpha_1, \alpha_2, \alpha_3) = (3\alpha_1 - \alpha_2, \alpha_1 - \alpha_2 + \alpha_3, -\alpha_1 + 2\alpha_2 - \alpha_3)$$

Hence deduce that T is nonsingular. Give a rule for T^{-1} , the inverse of T .

7. Let $T : V \rightarrow V$ be a linear transformation of V onto V .

- Define an eigenvalue λ of T
- If V_λ denotes the set of all eigenvectors of T belonging to the eigenvalue λ (the eigenspace of λ) prove that V_λ plus the zero vector is a subspace of V .
- for the linear transformation whose matrix is

$$A = \begin{bmatrix} 2 & 1 & 1 \\ 1 & 2 & 1 \\ 0 & 0 & 1 \end{bmatrix} \quad \text{find all the eigenvalues and}$$

corresponding eigenvectors of A . Hence or otherwise find a matrix U such that $U^{-1}AU$ is a diagonal matrix D . Give the diagonal matrix D .

8. Let V be an inner product space over a field K .

- Define
 - An orthogonal set of nonzero vectors $\{u_i\} \in V$
 - An orthonormal set $\{v_i\} \in V$
- Prove that an orthogonal set of nonzero vectors $\{v_1, v_2, \dots, v_n\}$ in V is linearly independent
- Let V be the subspace of $C[0,1]$ containing real polynomials of degree at most 3. Apply the Gram-Schmidt orthogonalization procedure to the R-basis $\{1, X, X^2, X^3\}$

9. Given an R-basis $\{v_1, v_2, \dots, v_n\}$ for V .

a) Define

i) a real quadratic form on V

ii) a diagonal quadratic form on V

b) Given the form $x^2 + xy + y^2 = 1$

i) write down its matrix

ii) By an appropriate orthogonal transformation reduce this equation to diagonal form and hence describe its graph (shape, size and location).

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SESSIONAL EXAMINATIONS - NOV/DEC 1993/94

MATHEMATICS M260 AND M261

TIME ALLOWED: M261: 1 HOUR 40 MINUTES
M260: 3 HOURS

INSTRUCTIONS: M261: Answer question 1 and any THREE(3) questions.

M260: Answer question 1 and any FIVE (5) questions

Mathematical tables and calculators are allowed.

- Q1. A sports fisherman angling in the Kafue River near Kafue National Park recently caught twenty-three bream in a single day. The weight of each bream in grammes, is given below.

475	211	146	807	612	119
368	312	1209	390	403	271
601	334	247	382	341	374
159	840	627	493	559	

a) i) Define the sampling unit.

ii) Define the population.

iii) What is the variable used?

b) Present the distribution using stem-and-leaf plot, frequency histograms and Box-and-Whisker plots. Use standard measures to describe the essential characteristic of the distribution. Identify any value which may be considered outliers. Summarize the results of your analysis verbally.

- Q2. MMD party officials are concerned about the possibility of low voter turnout for the upcoming by-election. One official has suggested that the party should conduct membership drive. The election committee decides to conduct a survey to determine whether party membership affects voting pattern. A random sample of voters registered for the upcoming election is selected. A questionnaire requesting information about their voting behaviour in the last election is sent to each voter in the sample. Responses are collected anonymously to preserve confidentiality and improve reliability of response. Each respondent is asked to record membership status and vote at the time of the last election. The survey results are tabulated below.

M260/M261

PARTY	MEMBERSHIP		STATUS
	MEMBER	FORMER-MEMBER	NON-MEMBER
CS	63	58	29
	17	25	31
D VOTE	9	22	44

Define the variables and method of data collection.

What conclusions can you draw from the survey data?
Use statistical methods to support and clarify your analysis.

If X and Y are discrete random variables, show that

$$\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y}) =$$

$$= \sum_{i=1}^n x_i y_i - \frac{1}{n} \left(\sum_{i=1}^n x_i \right) \left(\sum_{i=1}^n y_i \right)$$

Two instructors gave the same test to their classes. Both classes had a mean score of 72 but the score of class A showed standard deviation of 4.5 while class B showed a standard deviation of 9. Discuss the difference in the two cases.

Prove that if $A_1, A_2, A_3, \dots, A_k$ constitute a partition of the sample space S , and B is an arbitrary event on S , then for $r = 1, 2, 3, \dots, k$

$$P(A_r | B) = \frac{P(A_r) \cdot P(B | A_r)}{\sum_{r=1}^k P(A_r) \cdot P(B | A_r)}$$

Miss Mbewe and Mr. Lilanda have established reputations for missing statistics classes. Miss Mbewe is absent from class 20% of the time. Mr. Lilanda misses 50% of the classes. And at least one is absent 60% of the time.

- i) What is the conditional probability that Miss Mbewe will be absent from class given that Mr. Lilanda is absent?
- ii) Are the absences of Miss Mbewe and Mr. Lilanda independent? Explain.

A company produces carpet material. The number of orders follows poisson distribution with mean 0.8 per day.

- a) What is the probability that in a particular day there are
- no orders
 - at least one order?
- b) the length of material (in metres) required to meet each order is a discrete random variable, X , with the following probability distribution:

X	$P(X)$
50	0.50
60	0.08
70	0.04
80	0.05
90	0.08
100	0.25

- Find the mean and the standard deviation
 - What is the probability that in a day during which exactly two orders are placed the total length of material ordered is 120m?
 - What is the mean of the total length of material ordered in any day?
 - What is the probability that in a particular day 100m of material will be sufficient to meet the orders (if any) received?
8. Dorothy is a regular customer of LK007 taxis. She rings from home the time, X , a taxi takes to arrive is normally distributed with mean 19 minutes, standard deviation 3 minutes.
- What is the probability of her having to wait less than 15 minutes for a taxi?
 - What waiting time will be exceeded with a probability of 0.1?
 - Dorothy decides to try LK616 taxis. The standard deviation of her waiting time, Y , is 7 minutes and the probability of Y exceeding 8 minutes is 0.97725

- i) Find the mean of Y , assuming a normal distribution.
- ii) What is the distribution of T where $T = Y - X$?
(X and Y may be assumed independent).

iii) If both LK007 and LK616 taxis were rung at the same time. What is the probability that LK007 taxi would arrive first?

- iv) In order to catch a train Dorothy needs a taxi within 10 minutes. Which taxi would you advise her to ring. Explain your answer.

7. A postgraduate student in the school of Education is studying the effect of alcohol consumption on intellectual activity. The student devises two equivalent tests which entail a series of arithmetic operations. Eight undergraduate statistics students are selected to take the first test. The following day the same eight students are each given three medium sized glasses of Moser which they promptly consume. Immediately after consuming the beer, the students take the second test. Although there were great many volunteers to take the second test, only eight students were also willing to take the first test. The results are listed below:

STUDENT ID	FIRST TEST	SECOND TEST
A	72	61
B	84	52
C	67	74
D	73	68
E	78	60
F	53	66
G	69	64
H	64	59

- a) Does alcohol affect mental performance? Support your conclusion statistically.
- b) Construct a 95% confidence interval for the difference in test results.

8. The manager of administrative support services is faced with the problem of training the secretarial staff in the use of word processors. The manager wishes to select for training those typists who will be most effective as word processing. The manager is considering selecting candidates on the basis of typing skill. However, except for the keyboard skill, the skills required for effective use of word processing equipment are different from those required for a typist. Before making the selections the manager decides to conduct a test to determine whether skillful typists will also be effective word processing

users.

Ten typists are selected at random from the typing pool.

The typing speed in words per minute is recorded from each typists personnel file. All typists are given a short introductory word processing course at the conclusion of which each typists prepares a standard document. The time required to satisfactorily complete the document is recorded for each typist.

The record for each typist is listed below:

TYPES	TYPING SPEED (Word/Min)	WORD PROCESSING EXERCISE (minutes to complete)
A	62	78
B	85	43
C	70	85
D	102	48
E	96	37
F	54	83
G	67	90
H	61	72
I	75	58
J	78	56

- Is there a relationship between typing speed and word processing ability? If so, what is the nature of this relationship?
- Using methods of statistical analysis what prediction of time required to complete the standard word processing document would you make for a typist whose typing speed is 80 words per minute? Calculate a 95% confidence interval for your prediction.
- Is typing speed an effective criterion for selecting candidates for word processing training? Explain.

END OF EXAM

THE UNIVERSITY OF ZAMBIA

SESSIONAL EXAMINATIONS NOVEMBER-DECEMBER 1993/94

MATHEMATICAL METHODS (III) AND ENGINEERING MATHEMATICS II

M310/EM310

TIME ALLOWED: Three (3) hours.

- INSTRUCTIONS:
- i) There are eight(8) questions in this final paper and candidates are advised to attempt any six (6) questions of their choice.
 - ii) Indicate on your answer booklet whether you belong to M310 or EM310 class.
 - iii) Write down the number of questions you have answered on your answer book.
-

1. a) Solve the following differential equation using Laplace transforms:

$$\frac{d^2 y}{dx^2} + 9y = 0$$

given that $y(0) ; y'(0) = 2$

- b) Briefly explain the Superposition Principle and give a detailed example to illustrate this.
2. a) Find the work done in moving a particle once around an ellipse C in the xy -plane if the ellipse has centre at the origin with semi major and semi minor axes 4 and 3 respectively given the force field as
- $$F = (3x-4y+2z)i + (4x+2y-3z^2)j + (2xz-4y^2+z^3)k$$
- b) Show that the complex form of the Fourier Series of the function

$f(x) = x(-\pi < x < \pi)$ is given by

$$f(x) = i \sum_{\substack{n=-\infty \\ n \neq 0}}^{\infty} \frac{(-1)^n}{n} \cdot e^{inx}$$

3. a) Briefly outline the steps that an Engineer ought to take in order to solve a problem for maxima and minima values by the method of Lagrange Multipliers given a function $f(x,y) = 0$ which is subjected to some constraint condition $\phi(x,y) = 0$

Hence use your outlined steps to find points on the unit circle centred at the origin where the product xy is a minimum.

- b) Find the relative maxima or minima of $f(x) = \ln(x)^x$ and sketch its graph.

4. a) By sketching the 3-dimensional region R bounded by $x + y + z = a$ ($a > 0$), $x = 0$, $y = 0$, $z = 0$ or otherwise, evaluate and give a physical interpretation to the following triple integral;

$$\iiint_R (x^2 + y^2 + z^2) dx dy dz$$

- b) If $r = a \cos wt + b \sin wt$ where a and b are any constant non collinear vectors and w is a constant scalar, prove that

$$r \times \frac{dr}{dt} = w(a \times b)$$

5. a) Use the series method to solve the differential equation

$$x^2 y'' + xy' - 3y = x^2 e^x$$

Upto and including the term in x^5 .

- b) State (without proof) Stoke's theorem and hence verify the theorem for $A = 3yi - xzj + yz^2k$, where s is the surface of the paraboloid $2z = x^2 + y^2$ bounded by $z = 2$ and C is its boundary.

6. a) Evaluate the following:

i) $\frac{1}{(D-4)(D+3)(D+1)} (e^{-2x} \cos 2x)$

ii) $\mathcal{L} \left[3\sqrt[3]{t} + 4e^{2t} \right]$

iii) $x^{-1} \left[\frac{1}{s^2 + 2s} \right]$

- b) If $f(x,y) = x^2 \tan^{-1}(y/x)$, show that

$$x \frac{\partial f}{\partial x} + y \frac{\partial f}{\partial y} = 2f(x,y)$$

c) Estimate by series method;

$$\int_0^1 \frac{(1-\cos x)}{x} dx$$

7. Find the fourier expansion of the periodic function whose definition in one period is

$$f(x) = 1 + x \quad (-1 < x < 1)$$

Use your series above to find the sum of the series

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

Hence or otherwise evaluate

$$\tan \left[\sum_{n=0}^{\infty} \frac{(-1)^n}{2n+1} \right]$$

Hence deduce that

$$\int_1^e \tan \left[\sum_{n=0}^{\infty} \frac{(-1)^n}{2n+1} \right] dx = (e-1)$$

8. a) Let $w = f(u,v)$ be a function of two independent variables u and v and suppose that u and v are related with other variables x and y by the equations

$x = x(u,v)$ and $y = y(u,v)$; derive the Jacobian determinant $J(u,v)$ of u and v with respect to x and y .

b) If $u = \frac{x+y}{z}$ and $v = \frac{z+y}{x}$

$$\text{evaluate } J(x,y) = \frac{\partial(u,v)}{\partial(x,y)}$$

Hence express y in terms of u,v and w given that

$$w = \frac{x+y+z}{xz}$$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SESSIONAL EXAMINATION NOV/DEC 1993/94

MATHEMATICS M320

TIME ALLOWED: Three(3) Hours

INSTRUCTIONS: Attempt ANY three(3) questions from section A
and ANY two(2) questions from Section B

SECTION A

(Attempt any three questions from this section)

1. Define the terms
- i) a Normal subgroup of a group G
 - ii) a Factor(Quotient) group of a group G with respect to a normal subgroup N .
- (a) i) Prove that a subgroup N of a group G is normal in G if and only if it is a union of complete conjugacy classes of G .
- ii) Prove that if θ is a homomorphism of a group G into a group H , then $G/\ker\theta \cong \text{im}\theta$
- (b) i) Given that the symmetric group S_5 of degrees 5 has seven conjugacy classes of orders 1, 10, 20, 15, 30, 20 and 24 respectively; and that the alternating group A_5 of degree 5 has five conjugacy classes of orders 1, 20, 15, 12, and 12 respectively, show that A_5 is the only non-trivial normal subgroup of S_5 . Further show that A_5 is simple.
- ii) Let G be a group such that for some fixed integer $n > 1$, $(gh)^n = g^n h^n$ for all $g, h \in G$. Show that the subset G_n of G given by $G_n = \{g \in G \mid g^n = e\}$, where e denotes the identity in G , is a normal subgroup of G .

Let G^n be the subset of G given by

$$G^n = \{g^n \mid g \in G\}$$

and let the mapping $\phi: G \rightarrow G^n$ be defined by

$$\phi(g) = g^n$$

Show that ϕ is a homomorphism; and hence deduce that

$$G/G_{\phi} \cong G^{\phi}.$$

2. Define the terms i) the centre $Z(G)$ of a group G

ii) an abelian group G .

(a) i) Show that $Z(G)$ is a normal subgroup of G

ii) Show that if N is a subgroup of the centre $Z(G)$ of a group G such that G/N is generated by a single left coset gN of N in G , then G is abelian.

(b) i) Show that if a group G has only one element of order $n > 1$ then it has a non-trivial centre.

ii) Show that if G is a group which has no non-trivial element of order 2, and is such that

$$x^2 y = y x^2 \quad \text{for all } x, y \in G,$$

then G is an abelian group.

3. Let R be a commutative ring with 1. Define the following terms

i) a maximal ideal M in R

ii) an irreducible polynomial in $R[x]$.

(a) i) Prove that a field \mathbb{F} contains no proper ideals. Hence show that if R is a commutative ring with 1 and M is an ideal in R such that R/M is a field then M is maximal in R .

ii) Show that if \mathbb{F} is a field and $f(x)$ is an irreducible polynomial over \mathbb{F} , then $\langle f(x) \rangle$ is a maximal ideal in $\mathbb{F}[x]$.

(b) Determine whether the given ideal $\langle f(x) \rangle$ is maximal in the given ring $R[x]$. Hence indicate, with full justification, when $R[x]/\langle f(x) \rangle$ is a field:

i) $\langle x^2 + x + 1 \rangle$ in $\mathbb{Z}_5[x]$

ii) $\langle x^2 + x + 1 \rangle$ in $\mathbb{Z}_6[x]$

iii) $\langle 2x^2 + 3x + 6 \rangle$ in $\mathbb{Z}_7[x]$.

4. Let R be an Integral Domain. Define each of the following terms (i) a prime element in R

(ii) an irreducible element in R .

a) i) Prove that in R every prime element is irreducible

ii) Prove that in a unique Factorisation domain, every irreducible element is prime.

b) Let R be a ring defined by

$$R = \{\alpha + \beta\sqrt{-5} \mid \alpha, \beta \in \mathbb{Z}\}$$

where \mathbb{Z} denotes the set of integers.
Then show that:

i) R is an Integral Domain

ii) 3 and $2 + \sqrt{-5}$ are irreducible elements in R .

By considering the factorisation $(2 + \sqrt{-5})(2 - \sqrt{-5})$ of 9 in R or otherwise, confirm that R is not a Unique Factorisation Domain.

SECTION B

(Attempt any two questions from this section)

5. Give the definition of each of the following terms

i) a metric space ii) an open set in a metric space

a) i) Given that each point x of X is an ordered pair of the form $x = (x_1, x_2)$, where x_1 and x_2 are reals, then show that the function $d: X \times X \rightarrow \mathbb{R}$ from X to the set of reals \mathbb{R} given by

$$d(x, y) = \left\{ \sum_{i=1}^2 (x_i - y_i)^2 \right\}^{1/2}$$

is a metric on X .

ii) Show that in any metric space an open ball is an open set

- b) i) Prove that in any metric space (X, d) a set G is open if and only if it is a union of open balls in X .
- ii) Let X be defined as in question 5(a) part (i); and let d_2 be a second metric on X defined by

$$d_2(x, y) = \max\{|x_1 - y_1|, |x_2 - y_2|\}.$$

Then show that the subset G of (X, d_2) defined by

$$G = \{x = (x_1, x_2) \in X \mid x_1 > 0\}$$

is an open set in X .

6. Define the terms i) a Basis ii) a continuous mapping (iii) an open mapping as applied to topological spaces.

- a) i) Given that (X_1, τ_{X_1}) and (X_2, τ_{X_2}) are topological spaces, and that

$X = X_1 \times X_2$ is a cartesian product of the sets X_1 and X_2 ; let $P_i : X \rightarrow X_i$ denote the i^{th} projection defined by $P_i(x) = x_i$. Then determine the basis \mathcal{B} of the product topology τ_X on X induced by the $\{P_i\}_{i=1,2}$.

Show that if Y is a set and τ_X is the product topology on the cartesian product X of two topological spaces (X_1, τ_{X_1}) , (X_2, τ_{X_2}) , then

the mapping $\psi: Y \rightarrow X$ is continuous if and only if the composite mapping $P_i \circ \psi$ is continuous for each $i = 1, 2$.

- a) ii) Given a topological space (X, τ_X) and set Y , let \mathcal{S} be a mapping $\mathcal{S}: X \rightarrow Y$. Then define the quotient topology $\tau_{\mathcal{S}}$ on Y coinduced by the mapping \mathcal{S} , verifying that you have indeed obtained a topology on Y .

If $\sigma : X \rightarrow Y$ is a continuous open surjective mapping between the topological spaces (X, τ_X) and (Y, τ_Y) , then prove that τ_Y is the quotient topology on Y coinduced by σ .

- b) Let $I = [0,1]$, the closed unit interval in \mathbb{R} ; and let $f: I \rightarrow X = \{a,b\}$ be a map defined by

$$f(x) = \begin{cases} a & 0 \leq x < \frac{1}{2} \\ b & \frac{1}{2} \leq x \leq 1 \end{cases}$$

where the topology on X is given by $\tau_X = \{\emptyset, \{a\}, X\}$.

Then show that f as defined is a quotient map.

7. Define the terms (i) Hausdorff (ii) Regular and (iii) compactness, when applied to topological spaces.

- a) i) Prove that a closed subspace of compact space is compact
- ii) By using the fact that in a Hausdorff space, a compact set and a point not in it can be separated by open sets or otherwise, show that in a Hausdorff space compact sets are closed. Hence deduce that a compact Hausdorff space is regular.

- b) i) Let (X, τ_X) be a topological space, where

$$X = \{a, b, c, d, e\}$$

$$\text{and } \tau_X = \{\emptyset, \{a\}, \{b, c, d, e\}, X\}.$$

Then determine whether (X, τ_X) is Hausdorff? Regular?

- ii) Given that D is a subset of the set \mathbb{R} of reals defined by

$$D = \{x \in \mathbb{R} : x = -3 + \frac{2}{n}, n = 1, 2, 3, \dots\}$$

determine whether D is a compact subset of \mathbb{R} .

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATIONS NOVEMBER-DECEMBER 1994
M330 - REAL ANALYSIS I

TIME ALLOWED: (3) Three hours

INSTRUCTIONS: Answer any five(5) questions.
State major result(s) used where necessary.

1. a) Define the following:

- i) limit point of a set.
- ii) interior point of a set.
- iii) open set.

b) Prove the following:

- i) The set \mathbb{Q} of rational numbers has no interior point.
- ii) If A is a subset of \mathbb{R} which has the greatest lower bound that is not in A , then the greatest lower bound is a limit point.
- iii) If B_1, B_2, \dots, B_n are open sets then

$$B = \bigcap_{j=1}^n B_j.$$

is open.

c) Discuss divergence or convergence of the following

- i) $\sum_{n=0}^{\infty} \frac{(-1)^n x^{2n}}{(2n)!}$
- ii) $\sum_{n=1}^{\infty} \frac{(-1)^{n+1} x^n}{n}$

2. a) Define the following:

- i) Composition of two functions.
- ii) limit of a function at a point.
- iii) continuity of a function at a point.

b) Prove the following:

- i) If $f: A \rightarrow B$ is continuous at P and suppose that $g: B \rightarrow D$ is continuous at $f(P)$, then $g \circ f$ is continuous at P .
- ii) A function $f: E \rightarrow D$ is continuous if and only if $f^{-1}(V)$ is open whenever V is open.
- iii) If $f: A \rightarrow V$ is a one-one and onto continuous function on a compact set A then the inverse function is continuous.

c) Let $f: A \rightarrow \mathbb{R}$, where $A = [-2, 2]$

and $f(x) = 2x - 1$, find

- i) the range of f
- ii) the image of $(-1, 2)$ under f .
- iii) the inverse image of $(-1, 2)$ under f .

a) Define the following:

- i) convergence of a sequence.
- ii) convergence of an infinite series.
- iii) uniform convergence of a sequence $\{f_n\}$ of functions.

b) Prove the following

- i) If $\{f_n\}$ is a sequence of functions defined on E then then $\{f_n\}$ converges uniformly on E if and only if $\forall \epsilon > 0 \exists N \quad \forall m, n$ with $m \geq n \geq N$ and $\forall x \in E$,

$$|f_n(x) - f_m(x)| < \epsilon.$$

- ii) A power series $\sum a_n x^n$ converges absolutely for $|x| < r$,

$$\text{where } \frac{1}{r} = \lim_{n \rightarrow \infty} \left| \frac{a_{n+1}}{a_n} \right| \text{ if } \left| \frac{a_{n+1}}{a_n} \right| \text{ converges}$$

$$\text{or } \frac{1}{r} = \lim_{n \rightarrow \infty} \sqrt[n]{|a_n|} \text{ if } \sqrt[n]{|a_n|} \text{ converges.}$$

- iii) If $\{a_n\}$ is a sequence which converges to a and $\{b_n\}$ is a sequence which converges to b , then $\{c_n\} = \{a_n \cdot b_n\}$ converges to ab .

c) Let $f_n(x) = x^n$ and $E = [0,1]$.

$$\text{If } f(x) = \begin{cases} 0, & 0 \leq x < 1 \\ 1, & x = 1 \end{cases}$$

Show that f_n converges pointwise to f on E but not uniformly.

a) Define the following:

- i) open covering of a set.
- ii) compact set.
- iii) a function has a derivative at a point.

b) Prove the following

- i) If f is continuous on a compact set A , then f is bounded on A and there exists points x_1 and x_2 in A such that $f(x_1) \leq f(x) \forall x \in A$ and $f(x_2) \geq f(x) \forall x \in A$.
- ii) If f is a continuous function on $[a,b]$ and differentiable on (a,b) with $f(a) = f(b)$ then there is a number $P \in (a,b) \ni f'(P) = 0$.

- iii) If $\{f_n\}$ is a sequence of functions defined on E with $|f_n(x)| \leq M_n$ for $n = 0,1,2,\dots$ and the series

$$\sum_{n=0}^{\infty} M_n \text{ converges, then } \sum_{n=0}^{\infty} f_n(x) \text{ converges uniformly on } E.$$

c) State the mean value theorem and use it to approximate

$$(79)^{1/4}.$$

a) Define the following:

- i) Upper and lower Darboux sum of a function
- ii) upper and lower Riemann integral of a function
- iii) Conditional convergence of an infinite series.

b) Prove the following

- i) If f is monotone increasing on $[a, b]$, then f is Riemann integrable on $[a, b]$.
- ii) If f is integrable on $[a, b]$ and if $f = F'$ for some function F on $[a, b]$ then $\int_a^b f(x) dx = F(b) - F(a)$.
- iii) If f is continuous on a compact set B , then $f(B)$ is compact.

c) Using the definition show that $\frac{3 - 2n}{4n + 2}$ converges to $-\frac{1}{2}$ and find the smallest N if $\epsilon = 0.01$ and 0.005

a) Define the following:

- i) f is one to one function.
- ii) Absolute convergence of an infinite series
- iii) f is uniformly continuous on a set.

b) Prove the following

- i) If f is continuous for each x on a compact set B , then f is uniformly continuous on B .
- ii) If a sequence $\{a_n\}$ converges to a , then the sequence $\{a_n^2\}$ converges to a^2 .
- iii) If f is non-negative and monotone decreasing, integrable function on $[1, \infty)$, then the series $\sum_{n=1}^{\infty} f(n)$ and $\int_1^{\infty} f(x)dx$ converge or diverge together.

c) State Taylor's theorem and use it to approximate $(67)^{1/3}$ using the first four terms.

END OF EXAM

THE UNIVERSITY OF ZAMBIA

SESSIONAL EXAMINATIONS NOV/DEC. 1993/94

M410 - Theory of functions of a complex variable

TIME ALLOWED: THREE (3) hours.

INSTRUCTIONS: Attempt any FIVE (5) questions

1. a) Prove that $\sqrt{2}|z| \geq |Re\ z| + |Im\ z|$.
b) Let γ^* be the triangle with vertices at $z = 0, z = i$ and $z = 2$.
Give the parametric representation of γ , oriented in the counter-clockwise direction.
c) The hyperbolic cosine and sine are defined by

$$\cosh z = \frac{1}{2}(e^z + e^{-z}), \quad \sinh z = \frac{1}{2}(e^z - e^{-z}),$$

express them through $\cos iz$ and $\sin iz$.

2. a) Assuming that $f'(z)$ exists, find the differentiation formula for

$$\frac{d}{dz}(C^{f(z)}), \text{ where } C \text{ is a constant.}$$

- b) Show that the function

$$u = e^x(x \cos y - y \sin y)$$

is harmonic and find a corresponding analytic function

$$f(z) = u(x, y) + iv(x, y)$$

3. a) By writing $w - a^2 + r^2 = \rho \exp(i\phi)$, where a and r are real numbers and $r > 0$, show that the mapping $w = z^2$ transforms the circle $z = r \exp(i\theta)$ into the limaçon $\rho = 2r(a + r \cos \phi)$
- b) Evaluate the cross ratios $(z, 2, 1, 0)$ and $(w, 1, 0, i)$. Hence or otherwise, find a mobius transformation that maps the points 2, 1 and 0 into the points 1, 0 and i , respectively.
4. a) Let γ be a closed rectifiable path in \mathbb{C} . Prove that for each $w \in \mathbb{C} - \gamma^*$, there is an integer

$$n(\gamma; w) = \frac{1}{2\pi i} \int_{\gamma} \frac{dz}{z - w}.$$

Hence or otherwise, show that if G is a region, $f : G \rightarrow \mathbb{C}$ is analytic and γ is a closed rectifiable path with $\gamma^* \subset G$, then for all $w \in \mathbb{C} - \gamma^*$

$$n(\gamma; w) f(w) = \frac{1}{2\pi i} \int_{\gamma} \frac{f(z)}{z - w} dz.$$

- b) Let $1 < \rho < 3$ and $\gamma(t) = \rho \exp(it)$, $t \in [0, 2\pi]$. Evaluate

$$\int_{\gamma} \frac{4z + 3}{z(z + 2)(z - 3)} dz.$$

5. a) Represent the function

$$f(z) = \frac{z^2 + 1}{z(z - 1)(z - 2)}$$

in a Laurent series in the region $1 < |z| < 2$.

- b) Let

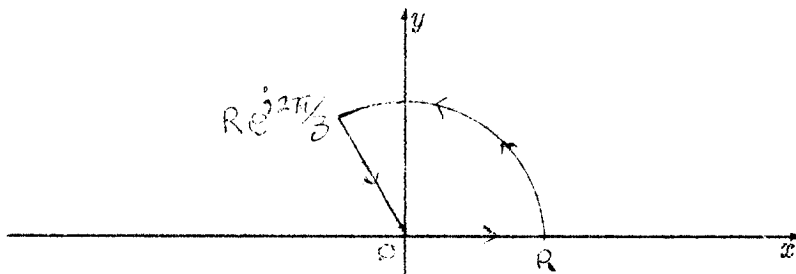
$$f(z) = \frac{1}{z^3(z + 4)}.$$

Find the residue of f at $z = -4$, i.e. find $\text{Res}(f; -4)$.

- c) Let γ be the circle $|z + 2| = 3$. Evaluate

$$\int_{\gamma} \frac{dz}{z^3(z + 4)}.$$

6. a) Using the contour shown here,



apply the calculus of residues to prove that

$$\int_0^{\infty} \frac{dx}{x^3 + 1} = \frac{2\pi}{3\sqrt{3}}.$$

- b) Establish the integration formula

$$\int_0^{2\pi} \frac{d\theta}{5 + 4 \sin \theta} = \frac{2\pi}{3}.$$

7. a) Define a meromorphic function on an open set $G \subset \mathbb{C}$.

- b) The argument principle states:

Let G be an open subset of \mathbb{C} and $f : G \rightarrow \mathbb{C}_{\infty}$ be meromorphic.

Let $a \in G$ and $r > 0$ such that

$\{z : |z - a| < r\} \subset G$. Let γ be a rectifiable closed path,

$\gamma^* \subset \{z : |z - a| < r\}$. Let p_1, p_2, \dots, p_m be poles of f and

z_1, z_2, \dots, z_k be zeros of f in $\{z : |z - a| < r\}$, listed according to multiplicity. Then

$$\frac{1}{2\pi i} \int_{\gamma} \frac{f'(z)}{f(z)} dz = \sum_{j=1}^k n(\gamma, z_j) - \sum_{l=1}^m n(\gamma, p_l).$$

Prove the argument principle.

c) Rouché's theorem states:

Suppose f and g are meromorphic in a neighbourhood of $\{z : |z-a| \leq R\}$ with no zeros or poles on the circle $\gamma(t) = a + Re^{it}$, $t \in [0, 2\pi]$. If Z_f and Z_g are the numbers of zeros and P_f and P_g are the numbers of poles of f and g respectively inside γ , counted according to their multiplicities, and if

$$|f(z) + g(z)| < |g(z)| \quad \text{on } \gamma^*,$$

then

$$Z_f - P_f = Z_g - P_g.$$

Prove Rouché's theorem.

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA

SESSIONAL EXAMINATION NOV/DEC 1993/94

M420 - ALGEBRA(II)

TIME ALLOWED: Three (3) hours.

INSTRUCTIONS: There are two(2) sections in this paper, section A and section B. Candidates are advised to answer any three(3) questions from section A and any two(2) questions from section B. All questions carry equal marks.

SECTION A

(Answer any three(3) questions from this section)

1. Briefly explain the following terms as applied to a finite group G :

- i) G is a solvable group
- ii) G is a nilpotent group.

a) Prove (by induction) that for a group G , if $G = G_0 > G_1 > G_2 > \dots > G_n = \{e\}$ is its solvable series then $G^{(i)} \leq G_{i+1}$, where

$G^{(i)}$ denotes the i^{th} derived group of G .

Hence deduce that G is solvable if

$G^{(n)} = \{e\}$ for some non-negative n .

- b) i) Given that H is a subgroup of a group G and if G is solvable prove that H is also solvable.
- ii) Show that the order of the center of a nilpotent group G is atleast two.

2. What do you understand by the following terms as applied to a group G ?

- i) a syLOW p subgroup of G
- ii) a permutation representation of G

Prove that

- a) If G is a group of order n where p is a prime and p^α is the highest power of p that divides n , then G contains a Sylow p -subgroup of order p^α .
- b) there is no simple group of order 500.

3. Define the terms

- i) a semi-direct product of the subgroups K and Q
- ii) an inner automorphism φ
- a) Prove that if G is a semi-direct product of K by Q , then there exists some $\varphi: Q \rightarrow \text{Aut}(K)$ such that

$$G \cong K \rtimes_{\varphi} Q$$

- b) i) Show that $\text{Inn}(G)$ is normal in $\text{Aut}(G)$ and that

$$G/Z(G) \cong \text{Inn}(G)$$

- ii) Show that if H is a subgroup of a group G then the centralizer of H in G is a normal subgroup of the normalizer of H in G and that

$$\frac{N_G(H)}{C_G(H)} \cong \text{Aut}(H)$$

4. Define the following terms

- i) a left R -module M
- ii) an irreducible matrix representation of G .
- a) Prove that if S and T are representations of G with representation spaces U and V respectively, then if U is isomorphic to V as KG -modules S is equivalent to T
- b) i) Let $G = \langle x, y/x^4 = 1; yxy^{-1} = x^{-1} \rangle$ be the dihedral group of order 8. Show that the map $T: G \rightarrow GL_2(\mathbb{C})$ given by

$$T(x) = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix} \text{ and } T(y) = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$$

defines a representation of G of degree 2.

- ii) Determine the left regular representation of the dihedral group of order 6.
-

SECTION B

(Answer any two (2) questions from this section)

5. Briefly explain the following terms:

- i) a minimum polynomial m of α over a field K
- ii) a splitting field for a polynomial $f \in K[x]$
- a) Prove that
 - i) If α is algebraic over a field K which has m as its minimum polynomial, then m is irreducible.
 - ii) If α is algebraic over K with minimum polynomial m , then each element in $K[x]$ has a unique expression of the form $r(\alpha)$ where r is a polynomial over K .
- b) Show that for any given polynomial $f \in K[x]$ there exists a splitting field for f over K . obtain the splitting field for a polynomial

$$f(x) = x^5 - 3x^3 + x^2 - 3 \in \mathbb{Q}[x]$$

6. Define the following terms:

- i) an exponent $e(G)$ of a finite group G .
- ii) a prime subfield of a field F .
- a) Use the fact that any finite abelian group G contains an element of order $e(G)$ to prove that when G is a finite abelian group with $e(G) = |G|$ then G is a cyclic group.
- b) Prove that for any prime p and any positive integer n , \mathbb{F} has p^n elements if and only if \mathbb{F} is a splitting field for $x(x^{q-1} - 1)$ over \mathbb{Z}_p where $q = p^n$

7. What do you understand by the following terms?

- i) a radical field extension $L:K$
- ii) the galois group $\overline{[L:K]}$ of a field extension $L:K$.

Prove that

- a) If $L:K$ is a radical extension with normal closure M , then $M:K$ is radical.
- b) If K is a field such that $\text{char } K = 0$ and L is the splitting field for the polynomial $x^p - 1$ over the field K , where p is a prime number, then $\overline{L:K}$ is abelian.

Show that $f(x) = x^5 - 4x + 2$ is not solvable by radicals.

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA

SESSIONAL EXAMINATIONS NOV/DEC 1994

M430 REAL ANALYSIS II

TIME ALLOWED: Three (3) hours

INSTRUCTIONS: Attempt any FIVE(5) Questions

- a) Define (i) a denumerable set,
(ii) a countable set.
- b) Let A and B be denumerable sets.
Prove that $A \cup B$ is also denumerable.
- c) Prove that the set $\{x: 0 < x < 1, x \neq \frac{1}{n}\}$ is uncountable.
- a) Define (i) a partial order relation in a non-empty set,
(ii) a totally ordered set.
- b) Let Ω be the power set of the set \mathbb{N} of the natural numbers.
For $A, B \in \Omega$ say that $A < B$ if $B - A$ is finite and $A \subseteq B$. Show that $<$ is a partial order on Ω .
- 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 , for $1 \leq p < \infty$.
ii) State Baire's Category Theorem (without proof).
Hence, assuming that ℓ_p is a metric space whose induced metric is defined by $d(x, y) = \|x - y\|_p$, prove that the space ℓ_p is of second category.

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.

Compute $\bigcap_{i=1}^{\infty} A_n$ and $\bigcap_{i=1}^{\infty} B_n$ 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.

Let A be a subset of a metric space (X, d) .

Prove that $d(x, A) = 0 \iff x \in \bar{A}$ (the closure of 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.

(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.

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 $\|F_y\| = \|y\|_q$.

Prove that $\forall x, y$ in an inner product space X ,

$$i) \quad \|x+y\|^2 + \|x-y\|^2 = 2(\|x\|^2 + \|y\|^2)$$

ii) State the polar identity for inner product norms (without proof).

Prove that the normed linear space \mathbb{C} of complex numbers is an inner product space and show that for each $z \in \mathbb{C}$,

$$\langle z, z \rangle = |z|^2.$$

i) Let $\phi_1, \phi_2, \dots, \phi_n$ 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 orthogonal 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 NOV/DEC 1993/94
M 440 - COMPUTER SCIENCE II

ALLOWED: 3 Hours

INSTRUCTIONS: Answer ANY FIVE(5) Questions

DO NOT ATTEMPT MORE THAN FIVE QUESTIONS.

INDICATE THE QUESTION NUMBERS ATTEMPTED ON YOUR
ANSWER SCRIPTS

a) Define the following

- i) Virtual Machine
- ii) Translator
- iii) Assembly language
- iv) Computer Architecture

b) Give atleast two reasons why you would write a Program in Assembly Language than in Pascal assuming the same level of your Programming Competence in both Languages

c) A certain University wishes to acquire a translator program to be used with teaching a Programming Language like Pascal to first year students in a Micro computer environment. They expect the translator program together with its entire software environment to support interactive program debugging, traceable program execution and ease of control of programs during execution.

- i) List four reasons in your choice of advice whether a compiler or an interpreter is suitable.
- ii) Name the method(s) of execution associated with both High and Low level languages.

THE UNIVERSITY OF ZAMBIA
SESSIONAL EXAMINATIONS NOV/DEC 1993/94
M 440 - COMPUTER SCIENCE II

TIME ALLOWED: 3 Hours

INSTRUCTIONS: Answer ANY FIVE(5) Questions

DO NOT ATTEMPT MORE THAN FIVE QUESTIONS.

INDICATE THE QUESTION NUMBERS ATTEMPTED ON YOUR
ANSWER SCRIPTS

- (a) Define the following
- i) Virtual Machine
 - ii) Translator
 - iii) Assembly language
 - iv) Computer Architecture
- (b) Give atleast two reasons why you would write a Program in Assembly Language than in Pascal assuming the same level of your Programming Competence in both Languages
- (c) A certain University wishes to acquire a translator program to be used with teaching a Programming Language like Pascal to first year students in a Micro computer environment. They expect the translator program together with its entire software environment to support interactive program debugging, traceable program execution and ease of control of programs during execution.
- i) List four reasons in your choice of advice whether a compiler or an interpreter is suitable.
 - ii) Name the method(s) of execution associated with both High and Low level languages.

- (a) Define the following terms as applied to computer storage
- i) TAG BIT
 - ii) RAM
 - iii) ROM
 - iv) SECONDARY MEMORY
- (b) Explain in chronological order, the operation of a typical processor of a computer in its fetch-execute cycle pointing out the registers concerned. [No Diagram(s)]
- (c) A computer memory consists of cells each of which can store information and be referred to by a number called its address. If a memory has n cells, it will have 0 to $n-1$ addresses. If a cell consists of r bits, then it can hold 2^r different bit combinations.
Using this idea give three different organisations of a 96-bit memory.
- (d) A student speculated on building a computer to be equipped with 262,144 bytes of memory but this surprised his class mates who wondered why he thought of such a peculiar number instead of an easy-to-remember number such as 250,000.

Justify his choice of 262,144.

- a) Define the following
- (i) A Time-sharing System
 - (ii) Deadlock
 - (iii) A Process
 - (iv) Utility Software

List five desirable functions of an operating system and which of these function(s) would be least prominent in a Micro-Computer Environment.

Briefly explain your choices

- b) Define the following terms as applied to Disk Storage and access.

- (i) Seek time
- (ii) Latency
- (iii) Recording Density

- c) (i) Distinguish between Main Memory and Auxiliary Memory.
- (ii) How long does it take to read an entire disk with 800 cylinders, each containing five(5) tracks of 32 sectors? First, all the sector of track 0 are to be read starting at sector 0, then all the sectors of track 1 starting at track 1 and so on. The rotation time is 20ms and a seek takes 10ms between adjacent cylinders and 50ms for the worst case. [Calculate both the best and worst cases of the read time]

- a) Define the following terms:
- (i) DBMS
 - (ii) Data Independence
 - (iii) Data Manipulation Language
 - (iv) Normalisation

~~the rotation time is 20 ms and a seek takes 10ms between adjacent~~

~~cylinders and 50 ms for the worst case~~

~~Calculate both the best and worst cases of the read time!~~

- (b) Below is an employee file that contains information about the warehouses where employees work for use by the Engineering and Payroll department of a company. The file name is WAREHOUSE-EMPLOYEE and it contains the fields as shown.

WNUMBER	CITY	FLOORS	EMPNUMBER	SALARY	YEAR
WH2	NEW YORK	5	E1	22,000	1983
WH1	DALLAS	3	E3	21,000	1990
WH2	NEW YORK	5	E4	25,000	1987
WH3	CHICAGO	3	E6	23,000	1989
WH1	DALLAS	3	E7	25,000	1988
WH4	NEW YORK	3	E8	23,000	1987
WH1	DALLAS	3	E9	24,000	1990
WH4	NEW YORK	3	E10	26,000	1986

- i) There is massive data redundancy in the above file. Name the fields that have these redundancies.
- ii) What is the major disadvantage of holding data as shown in the above file.
- (a) Define the following as applied to computer networking
- iii) Using the database concept, show how the above file could be stored without the massive data redundancy shown above.
- (i) A local Area Network
- (ii) A file server
- (iii) Host
- (iv) Subnet

For a local Area Network to work, it must possess some useful properties for its operation. List down these properties.

- (b) Discuss briefly the two types of Network Topologies used in the Implementation of a Local Area Network, namely the Broadcast and the point to point networks. Using one of the two topologies discussed, state in which category Ethernet network falls and Explain briefly how Ethernet works.

- (a) List down and describe the stages involved in the design and

Implementation of a System. Draw a diagram for your description

- b) System Maintenance is a vital organ of the life-cycle of a system. Distinguish the types of system maintenance that are involved when a system has been delivered.
- c) (i) Distinguish between User Documentation and System Documentation. Briefly describe Problems with Documentation.
- (ii) Describe two Commonly-used program design methodologies.

END OF EXAM

THE UNIVERSITY OF ZAMBIA

SESSIONAL EXAMINATION NOV/DEC 1993/94

MATHEMATICS M460

TIME ALLOWED: 3 THREE HOURS

INSTRUCTIONS: Answer any five(5) questions.

Statistical Tables will be provided

- (a) Suppose that X_1, X_2, X_3 are independent random variables each with unit variance.

Let $Y_1 = X_1 + X_2 + X_3$, $Y_2 = X_1 - X_2$ and

$Y_3 = X_1 - X_3$. Find the covariance and correlation matrices

of Y where $Y^T = [Y_1, Y_2, Y_3]$.

- (b) If $X \sim N_3(\mu, \Sigma)$ and $C^T = \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \end{bmatrix}$, what would be the implication if

$$E(C^T X) = 0?$$

- (c) If the moment generating function of the random vector X of part (b) is

$$M_X(t) = \exp\left[t_1 - t_2 + 2t_3 + t_1^2 + \frac{1}{2}t_2^2 + 2t_3^2 - \frac{1}{2}t_1t_2 - t_1t_3\right].$$

find a constant c such that $p[2x_1 - 3x_2 + x_3 > c] = .95$

- (a) Could the matrix given below be a product matrix $X'X$, where X is any $p \times 2$ matrix? Explain.

$$X'X = \begin{bmatrix} 2172 & 802 \\ 802 & 284 \end{bmatrix}$$

- (b) If each of Y_1, \dots, Y_k is a vector of dimension p , what is the maximum rank of H . Where

$$H = Y_1 Y_1' + Y_2 Y_2' + \dots + Y_k Y_k'$$

- (c) When a variable or factor is added to a linear regression model, can the sum of squared residuals (SSE) increase? Can total sum of squares (SST) increase? Explain.
- (d) A student working on a summer internship in the economic research office of a large corporation studies the relation between sales of a product (Y , in millions of kwacha) and population (X in millions of persons) in the firm's 50 marketing districts. He wanted to employ the model

$$Y_i = \beta_0 + \beta_1 X_i + \epsilon_i$$

where β_0 and β_1 are parameters and ϵ_i are independent

$N(0, \sigma^2)$. The student first wished to test whether or not a relation between Y and X existed. Using a time-sharing computer service available to the firm, the student accessed an interactive simple linear regression program and obtained the following information on the regression coefficients:

parameter	Estimated value	95% confidence limits
Intercept	7.43119	-1.18518, 16.0476
Slope	.755048	.452886, 1.05721

- (i) The student concluded from these results that there is a relation between Y and X . Is the conclusion warranted? Explain. What is the implied level of significance?
- (ii) Someone questioned the negative lower confidence limit for the intercept, pointing out that kwacha sales can not be negative even if population in a district were zero. Discuss.

Q3. An experiment is conducted in which values of a criterion variable Y are recorded at six selected values of an explanatory variable X . Four observations of Y are taken at the first value of X ; two observations of Y at the second value of X ; three observations at the third value of X ; five at the fourth value; six at the fifth and two at the sixth. A regression line is fitted to these data points and the following sums of squares calculated.

Total uncorrected 570

Regression 190

Lack of it 220

Pure error 160

Find the correct degrees of freedom for each sum of squares and perform a test of lack of fit.

(b) An experiment was conducted in the school of veterinary medicine of UNZA on the effect of the ticks on cows. The weights of offsprings of two groups of cows, one group consisting of resistant mothers and the other group consisting of susceptible mothers, were recorded in the first year of their births. A plot of weight versus age of one group in the sample exhibited a linear relation. The results of the linear regression using MINITAB are shown below with some values missing.

The regression equation is

$$C_2 = \boxed{(i)} + 67.9C_1$$

PREDICTOR	COEF	STDEV	T-RATIO
CONSTANT	(i)	1.253	12.79
C_1	67.917	$\boxed{(ii)}$	33.23

S = 2.036

R-SQ = 99.1%

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS
REGRESSION	1	4580.7	$\boxed{(v)}$
ERROR	$\boxed{(iii)}$	41.5	4.1
Total	11	\boxed{iv}	

C_2 = weight in kg

C_1 = Age in years

Obtain the missing values in (i), (ii), (iii), (iv), (v)

(c) In a regression model with n observations, let ϵ_i and e_i be the i th error term and residual respectively.

(i) Define the following:

residual and standardized residual

(ii) Distinguish between

$$E(\epsilon_i) = 0 \quad \text{and} \quad \bar{e} = 0 \quad \text{where}$$

$$\bar{e} = \frac{\sum_i e_i}{n}$$

Q4. (a) Consider the model $Y = X\beta + \epsilon$, where X has full column rank and the variance - covariance matrix of ϵ is $I\sigma^2$.

Let $\hat{\beta}$ and \hat{Y} be the least squares estimates of the regression coefficients and predicted values of Y respectively. Let

$e = Y - \hat{Y}$ be the residual errors of prediction. Prove the following statements:

(i) $e' \hat{Y} = 0$

(ii) $e' Y = \text{SSE}$ where SSE is the sum of squared errors.

(iii) $V(\hat{\beta}) = (X'X)^{-1}\sigma^2$

(b) For each of the following models, indicate whether it is a linear regression model, an intrinsically linear regression model or neither of these. In each case of an intrinsically linear model, state how it can be expressed as a linear model by a suitable transformation.

(i) $Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i1}^2 + \epsilon_i$

(ii) $Y_i = \epsilon_i \text{Exp}(\beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2}^2)$

(iii) $Y_i = \beta_0 + \log(\beta_1 X_{i1}) + \beta_2 X_{i2} + \epsilon_i$

(c) Let X_1 and X_2 be two predictors of a response variable Y . Consider the following models

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \epsilon \quad (\text{Full model})$$

$$Y = b_0 + b_1 X_1 + \epsilon \quad (\text{Reduced model})$$

If X_1 and X_2 are uncorrected, what can you say about b_1 and β_1 . Hence briefly comment on multicollinearity among the independent variables.

(d) In a full rank linear regression model with n observations and k independent variables, state how many degrees of freedom are associated with the following sums of squares:

- (i) Total sum of squares
- (ii) Total sum of squares corrected for mean
- (iii) Sum of squares for regression
- (iv) Sum of squares for errors
- (v) Regression sum of squares corrected for the mean.

5. A group of 21 psychiatric patients were randomly assigned to one of three drug treatments as shown below. The data elements are the changes in behaviour over a six week interval.

Drug	Treatment	
A	B	C
3	1	0
5	2	0
3	1	0
3	2	1
2	2	2
4	2	2
4	0	1

Assuming that the changes in behaviour of a patient are described by the linear model

$$y_{ij} = \beta_0 + \beta_i + \epsilon_{ij} \quad \begin{array}{l} i = 1, 2, 3 \\ j = 1, 2, \dots, 7 \end{array}$$

where y_{ij} is the observation on the j^{th} patient receiving drug i . Using the above data, express the model equations in matrix form

$Y = X\beta + \epsilon$ where β is the vector of parameters with β_i the $(i + 1)$ th element describing the effect on changed behaviour due to i th drug treatment. Also state the assumptions you would like to impose on ϵ .

- (c) Is X a full column rank matrix? Explain
- (d) Find a solution to the normal equations $X'X\beta = X'Y$ of the fitted linear model.

- (e) Given that the function $k'\beta$ of elements of β for some row

k' of constants is estimable if \exists a vector t such that $t'E(Y) = k'\beta$, determine if the following functions of the parameters are estimable? If yes, give their point estimates:

- (i) $\beta_1 - \beta_2$
- (ii) β_3
- (iii) $\beta_1 - \frac{(\beta_1 + \beta_2 + \beta_3)}{3}$

- (f) Test the hypothesis at .01 level of significance that the effects of the three drugs are equal and write the conclusion. You may use that $SSE = 14.29$

- a) The Ministry of labour wishes to test the effect on absenteeism of a bonus scheme proposed by building trade union officials for unionized workers in the building trades. A pilot study of the scheme is undertaken. Four trades are selected for the study: mechanics; carpenters; plumbers; and electricians. Six workers who have comparable job performance records are selected from each trade. Three workers from each trade are randomly assigned to work under the bonus scheme for the next year. The remaining three will work under normal conditions. At the end of one year, the total days absent from work for any reasons are recorded for each of the twenty four workers in the study. The results are listed below:

Traders

	Mechanics	Carpenters	Plumbers	Electricians
Bonus	60,49,50	43,26,36	48,38,46	37,42,29
No Bonus	88,67,82	63,65,61	58,71,51	80,96,82

(i) State the model you will use to analyse the effect on absenteeism of the bonus scheme and of the trade type.

(ii) Complete the following ANOVA table:

Source	SS	DF	MS
Bonus	5400	*	*
Trade	116	*	*
Interaction	*	*	*
Residuals	962	*	*
<hr/>			
Total	8402	*	

(iii) Test whether the bonus scheme is effective.

(iv) Test whether the trade type has any effect on absenteeism.

(v) Test whether the factors trade type and bonus scheme interact. Confirm your findings by a graphical representation of the data.

(b) For a single factor study involving three levels, demonstrate how the residual plots would appear if the error variance increased over time. Develop another set of residual plots which show the effect of error terms negatively correlated over time. Do the residuals sum to zero for each level? If yes show how?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SESSIONAL EXAMINATION NOV/DEC 1993/94

MATHEMATICS M910
NUMERICAL ANALYSIS

Time: 3Hours

INSTRUCTIONS: ANSWER ANY FIVE (5) QUESTIONS.

- (a) Write an algorithm for the bisection method of finding a solution to $f(x) = 0$, where f is a continuous function defined on the interval $[a,b]$, and $f(a)$ and $f(b)$ have opposite signs.
- (b) Determine the minimum number of iterations necessary to approximate $\sqrt[3]{25}$ in the interval $[2,3]$ to an accuracy of 10^{-4} using the Bisection method and find the approximation using the Bisection method.

- a) Let X_0, X_1, \dots, X_n be distinct numbers and

$$P_n(X) = a_0 + a_1 (X - X_0) + a_2 (X - X_0)(X - X_1) + \dots \\ + a_n (X - X_0)(X - X_1)(X - X_2) \dots (X - X_{n-1}).$$

Suppose a function f is such that for

$k = 0, 1, \dots, n$, $f(X_k) = P(X_k)$. Determine the constants a_0 , a_1 and a_2 as divided differences and write down the divided difference representation for general

$$a_k, k = 0, 1, \dots, n$$

b) Consider the following table of divided differences

X	f(X)	1 st DD	2 nd DD	3 rd DD	4 th DD
1.0	0.7651977	?			
1.3	0.6200860	-0.5489460	-0.1087339	0.0658784	?
1.6	0.4554022	?	-0.0494433	0.0680685	
1.9	0.2818186	-0.5715210	?		
2.2	0.1103623				

i) Find the missing values of divided differences

ii) Approximate $P_4(2.0)$

a) Let f be a function defined on the interval $[a, b]$. Derive the Trapezoidal rule for approximating $\int_a^b f(x)dx$, assuming that f is twice continuously differentiable.

b) Use the Trapezoidal rule to approximate the value of $\int_{1.8}^{2.6} f(x)dx$ using the

following values

X	1.8	2.0	2.2	2.4	2.6
f(x)	0.21146	0.10989	0.05219	0.02269	0.00904

a) Find the inverse for the matrix $\begin{bmatrix} -1 & 1 & 2 \\ 3 & -1 & 1 \\ -1 & 3 & 4 \end{bmatrix}$

using the Gauss-Jordan method.

Hence solve the system of linear equations:

$$-x + y + 2z = 3$$

$$3x - y + z = 2$$

$$-x + 3y + 4z = -1$$

b) Given the system of linear equations:

$$2x_1 - x_2 + 10x_3 = -11$$

$$3x_2 - x_3 + 8x_4 = -11$$

$$10x_1 - x_2 + 2x_3 = 6$$

$$-x_1 + 11x_2 - x_3 + 3x_4 = 25;$$

find the first three(3) iterations of the Gauss-Seidel method using $\bar{X}^{(0)} = (0,0,0,0)^t$.

a) Use euler's method to approximate the solution to the initial value problem

$$y' = \frac{1}{t} (y^2 + y), \quad 0 \leq t \leq 3, \quad y(1) = -2, \quad h = 0.5$$

b) Calculate two (2) steps for the solution of the initial value problem

$$y' = f(x,y) = xy^{1/3}, \quad 1 \leq x \leq 2, \quad y(1) = 1$$

with step size $h = 0.2$, using the fourth order Runge-Kutta method.

a) The following data has been experimentally collected.

X	1.00	1.01	1.02
f(x)	1.27	1.32	1.38

i) Approximate $\frac{df}{dx}$ at the values $X = 1.005$

and $X = 1.015$

ii) Approximate $\frac{d^2f}{dx^2}$ at the value $X = 1.01$

b) Apply the Taylor method of order four to the initial value problem

$$y' = -y + t + 1, \quad 0 \leq t \leq 1, \quad y(0) = 1$$

$h = 0.1, \quad N = 10$. Do iterations up to $t = 0.3$ with values accurate to 7 decimal places.

END OF EXAM

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - AUGUST 1994

NR 435

NATURAL RESOURCE ECONOMICS

THREE HOURS

INSTRUCTIONS: ANSWER QUESTION ONE AND THREE OTHER QUESTIONS.

The following questions relate to a forest from which timber is to be obtained:-

- (a) with a discount rate of 25%, what is the present value of K100 000 obtained for each unit volume of timber sales
 - (i) 5 years from now
 - (ii) 10 years from now
 - (iii) 20 years from now
 - (iv) if the K100 000 is earned indefinitely starting from year 5?
- (b) with a discount rate of 75%, repeat the calculations in a(i) to a(iv).
- (c) given that the source of discount rates is the social rate of time preference (S RTP), state and briefly explain the implication of a high discount rate for the future generations in terms of availability of the forest.

With reference both to the modern economist's view and to that of old-time economists like Malthus, discuss whether or not there are "limits to economic growth" imposed by natural resource availability.

Describe and analyse how marketable pollution permits can simulate a commodity market to arrive at an optimal level of pollution for a waterway like the Kafue river.

Outline Hotelling's model for the optimal depletion of a non-renewable natural resource and explain the effect of a decrease in each of the model's influencing parameters on this optimal depletion path.

Outline the negative externality situation that can occur in an open access fishery in a developing country and discuss the options for intervention which a regulatory authority can use to solve these externalities.

Using four detailed examples, discuss the role of substitution in solving energy resource scarcity problems.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS - 1993/94

P250
(CLASSICAL MECHANICS)

TIME: THREE (3) HOURS

MAXIMUM MARKS: 100

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

WHERE NECESSARY, YOU MAY USE THE FOLLOWING:

$$\vec{r} = r\hat{r} + r\theta\hat{\theta} \quad \vec{a} = (r - r\ddot{\theta})\hat{r} + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\hat{\theta}$$

$$y = A \cos \omega t + B \sin \omega t$$

$$r_o = \frac{1+e}{1+e \cos \theta} \quad r_o = \frac{mh^2}{k(1+e)} \quad a = \frac{mh^2}{k(1-e^2)}$$

$$\vec{r}_{ext} = m \frac{d\vec{v}}{dt} + \vec{v} \frac{dm}{dt} - \vec{u} \frac{dm}{dt} \quad \vec{L} = \vec{r}_{cm} \times m\vec{v}_{cm} + \sum \vec{r}_i \times m_i \vec{v}_i$$

$$\frac{d}{dt} \frac{\partial L}{\partial \dot{q}} = \frac{\partial L}{\partial q} \quad \frac{\partial H}{\partial p} = \dot{q} \quad \frac{\partial H}{\partial q} = -\dot{p}$$

$$x' = \frac{x - vt}{\sqrt{1 - v^2/c^2}} \quad t' = \frac{t - (v/c^2)x}{\sqrt{1 - v^2/c^2}} \quad \Delta x' = \frac{\Delta x - v\Delta t}{\sqrt{1 - v^2/c^2}} \quad \Delta t' = \frac{\Delta t - (v/c^2)\Delta x}{\sqrt{1 - v^2/c^2}}$$

- Q1. (a). Can the direction of the velocity of a body change when its acceleration is constant? Explain. (2 marks)
- (b). A small ball is fastened to a long rubber band and twirled around in such a way that the ball moves in an elliptical path given by the equation

$$\vec{r}(t) = b\cos\omega t \hat{i} + 2b\sin\omega t \hat{j}$$

where b and ω are constants.

- (i) At what times is the ball at its minimum distance and maximum distance from the origin. (3 marks)
- (ii) Find the speed of the ball as a function of t . In particular, find v at its minimum and maximum distance, respectively. (5 marks)
- (c). A bee goes out from its hive in a spiral path given in plane polar coordinates by

$$r = be^{kt} \quad \theta = ct$$

where b , k , and c are positive constants. Show that the angle between the velocity vector and the acceleration vector remains constant as the bee moves outward.

(10 marks)

- Q2. (a). Why do raindrops fall with constant speed during the later stages of their descent? (2 marks)
- (b). A gun is fired straight up. Assuming that the air drag on the bullet varies quadratically with speed,
- (i) show that the speed varies with height according to the equations

$$v^2 = Ae^{-2ky} - g/k \quad (\text{upward motion})$$

$$v^2 = g/k - Be^{2ky} \quad (\text{downward motion})$$

in which A and B are constants of integration, g is the acceleration of gravity, and $k = c_2/m$ where c_2 is the drag constant and m is the mass of the bullet.

(Note: y is measured positive upward)

(10 marks)

- (ii) Show that when the bullet hits the ground on its return, the speed will be equal to

$$\frac{v_o v_t}{(v_o^2 + v_t^2)^{1/2}}$$

where v_o is the initial upward speed and $v_t = (mg/c_2)^{1/2} = \text{terminal speed} = (g/k)^{1/2}$.

(8 marks)

- (a). Suppose you are given a block of unknown mass and a spring of unknown force constant. Show how you would predict the period of oscillation of this block-spring system. (5 marks)
- (b). A spring of stiffness k supports a box of mass M in which is placed a block of mass m . If the system is pulled downward a distance d from the equilibrium position and then released,
- find the force of reaction between the block and the bottom of the box as a function of time. (9 marks)
 - For what value of d will the block just begin to leave the bottom of the box at the top of the vertical oscillations? Neglect any air resistance. (6 marks)
- (a). Can there be motion in two dimensions with acceleration in only one dimension? Explain and if so, give an example. (3 marks)
- (b). Show that the variation of gravity with height can be accounted for approximately by the following potential energy function:

$$V = mgy \left(1 - \frac{y}{r_e} \right) \quad (6 \text{ marks})$$

in which r_e is the radius of the earth and y is the vertical distance from the earth's surface.

- Find the force given by the above potential function. (3 marks)
 - From this, find the component differential equations of motion of a projectile under such a force. (3 marks)
 - If the vertical component of the initial velocity is v_{oy} , how high does the projectile go? (5 marks)
- (a). An artificial satellite is in a circular orbit about the earth. How will its orbit change if one of its rockets is momentarily fired
- toward the earth,
 - in the forward direction,
 - at right angles to the plane of the orbit?
- (3 marks)
- (b). A particle of mass m is subject to an attractive central force of magnitude k/r^2 , k being a constant. If at the instant when the particle is at an extreme position in its closed orbit, at a distance a from the center of force, its speed is $\sqrt{\frac{k}{2ma}}$, find
- the other extreme position, and (6 marks)
 - the speed of the particle at this position. (4 marks)

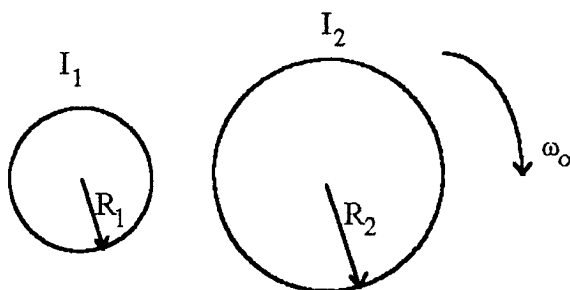
- (c). Prove that the time average of the potential energy of a particle describing an elliptic orbit, in the inverse-square force field $f(r) = -k/r^2$, is $-k/a$ where a is the semimajor axis of the ellipse. (Time average of any function f , is $\bar{f} = \frac{\int f dt}{T}$, where integration is over a complete planetary year, T and $\int (1 + e \cos \theta)^{-1} d\theta = 2\pi(1 - e^2)^{-1/2}$) (7 marks)

5. (a). Explain why we cannot use the equation $\vec{F}_{\text{ext}} = d(m\vec{v})/dt$ for a system of variable mass. (2 marks)
- (b). Show that the angular momentum of a two-particle system is

$$\vec{r}_{\text{cm}} \times m\vec{v}_{\text{cm}} + \vec{R} \times \mu\vec{v}$$

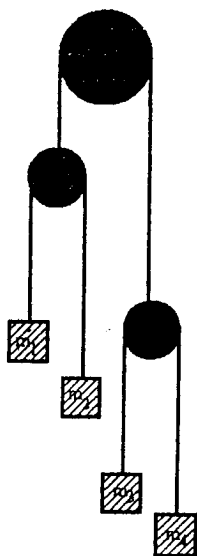
where $m = m_1 + m_2$, μ is the reduced mass, \vec{R} is the relative position vector, and \vec{v} is the relative velocity of the two particles. (10 marks)

- (c). A block of wood rests on a smooth horizontal table. A gun is fired horizontally at the block and the bullet passes through the block emerging with half its initial speed just before it entered the block. Show that the fraction of the kinetic energy of the bullet that is lost as frictional heat is given by $\frac{3}{4} - \frac{1}{4}\gamma$, where γ is the ratio of the mass of the bullet to the mass of the block ($\gamma < 1$). (8 marks)
- (a). If two circular disks of the same weight and thickness are made from metals having different densities, which disk, if either, will have the larger moment of inertia? (4 marks)
- (b). A solid uniform sphere of radius a has a spherical cavity of radius $a/2$ centered at a point $a/2$ from the center of the sphere. Find the center of mass. (8 marks)
- (c). Two cylinders of radii R_1 and R_2 and moment of inertias I_1 and I_2 , respectively, are supported by fixed axes perpendicular to the plane of the figure below. The large



cylinder is initially rotating with angular velocity ω_0 . The small cylinder is moved until it touches the large cylinder and is rotated by the frictional force between the two cylinders. Eventually, slipping ceases and they finally rotate in opposite directions. Find the angular velocity ω_1 of the small cylinder. (8 marks)

8. (a). How many degrees of freedom does the system shown below has and what are its generalized coordinates? (4 marks)
- (b). (i) By using Lagrange's method, set up the equations of motion of the "double-double" Atwood machine shown below. Neglect masses of the pulleys. (10 marks)
- (ii) Find the actual accelerations for the case $m_1 = m$, $m_2 = 4m$, $m_3 = 2m$, and $m_4 = m$. (6 marks)



- (a). Two events are simultaneous but separated in space in one inertial reference frame. Will they be simultaneous in any other frame? Will their spatial separation be the same in any other frame? (4 marks)
- (b). An observer in the S' frame notes that an event occurs along the common $x-x'$ axis and records its space-time coordinates as $x = 2.0$ m and $t = 5.0$ ns. The S' frame is moving with a speed v with respect to the S frame along their common axis.
- (i). If $v = 0.50c$, what space-time coordinates would the S' observer record for this event. Take $c = \text{speed of light} = 3.0 \times 10^8$ m/s. (6 marks)
- (ii) What would be the result if the Galilean transformation equations held? (2 marks)
- (c). An observer S sees a flash of red light 1200 m from his position and a flash of blue light 720 m closer to him and on the same straight line. He measures the time interval between the occurrence of the flashes to be $5.0 \mu\text{s}$, the red flash occurring first.
- (i) What is the relative velocity \vec{v} (magnitude and direction) of a second observer S' who would record these flashes as occurring at the same place? (5 marks)
- (ii) From the point of view of S' , which flash occurs first? (1 mark)
- (iii) What time interval between them would S' measure? (2 marks)

***** THE END *****

T H E U N I V E R S I T Y O F Z A M B I A
PHYSICS DEPARTMENT

UNIVERSITY EXAMINATIONS 1993/94 ACADEMIC YEAR

COURSE CODE: P260

ELECTRICITY AND MAGNETISM, ATOMIC PHYSICS

MAXIMUM TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS ONLY, AT LEAST TWO (2) FROM EACH SECTION. ALL QUESTIONS ARE OF EQUAL MARKS.

Maximum Marks : 100

Where-ever necessary, the following data and formulas can be used:

$$\text{speed of light} = 3.0 \times 10^8 \text{ m/s}$$

$$1 \text{ Angstrom unit (} \text{\AA} \text{)} = 10^{-10} \text{ m; } 1 \text{ micron (} \mu \text{)} = 10^{-6} \text{ m}$$

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

$$\text{electronic charge } e = 1.60 \times 10^{-19} \text{ C}$$

$$\text{electronic mass } m_e = 9.1 \times 10^{-31} \text{ Kg}$$

$$\text{Planck's constant } h = 6.626 \times 10^{-34} \text{ J-s}$$

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

$$\Delta\lambda = h/m_e c [1 - \cos(\theta)]$$

$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 i$$

$$\mathbf{E} = - N \frac{d\phi}{dt}$$

$$\phi = \mathbf{B} \cdot \mathbf{A}$$

$$L = L_1 + L_2 \pm 2M$$

$$M = k \sqrt{L_1 L_2}$$

$$\oint_{cs} \mathbf{E} \cdot d\mathbf{S} = \frac{\sum q_i}{\epsilon_0}$$

$$\int_0^{\infty} x e^{-ax} dx = 1/a$$

S E C T I O N A: Electricity and Magnetism.

The electric field (E) around a charged object can also be described by a scalar quantity, the electric potential, V .

What do you understand by the terms electric field (E) and electric potential and how are they related ? [3]

Why is it usually advantageous to describe the field in terms of the electric potential ? [3]

A thin conducting spherical shell of outer radius R carries a positive charge $+Q$. Sketch

- i) the magnitude of the electric field E and [2]
- ii) the potential V , versus the distance r from the center of the shell. [2]

Figure 1 shows a section through two long concentric cylinders of radii a and b respectively. The cylinders carry equal and opposite charges , λ , per unit length. Prove , using Gauss's law

i) that $E = 0$ for $r > b$ and for $r < a$; [5]

ii) that between the cylinders E is given by [5]

$$E = \frac{1}{2\pi\epsilon_0} \frac{\lambda}{r} \text{ N/C}$$

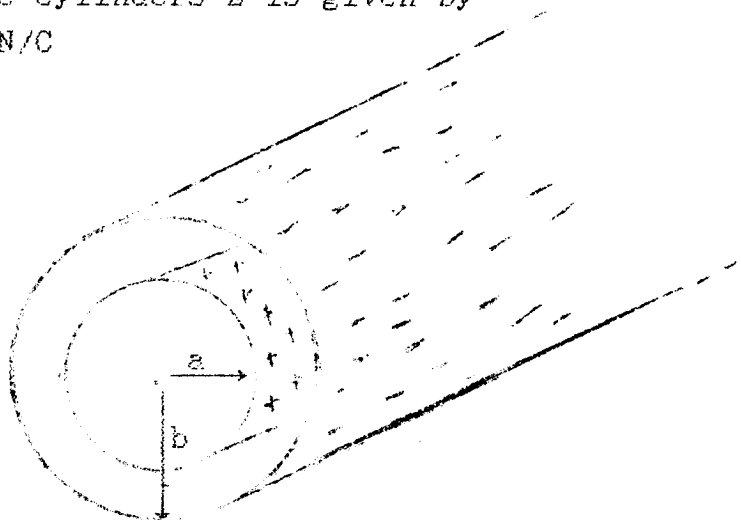


figure 1

Explain the physical meaning of the equation

$$\oint_C \mathbf{B} \cdot d\mathbf{S} = 0$$

where \mathbf{B} is the magnetic induction over a closed surface S . [2]

Suppose we set up a path of integration around a cable that contains twelve wires with different currents (some in opposite directions) in each wire. How do we calculate i (the current) in Amperes' law in such a case ? [3]

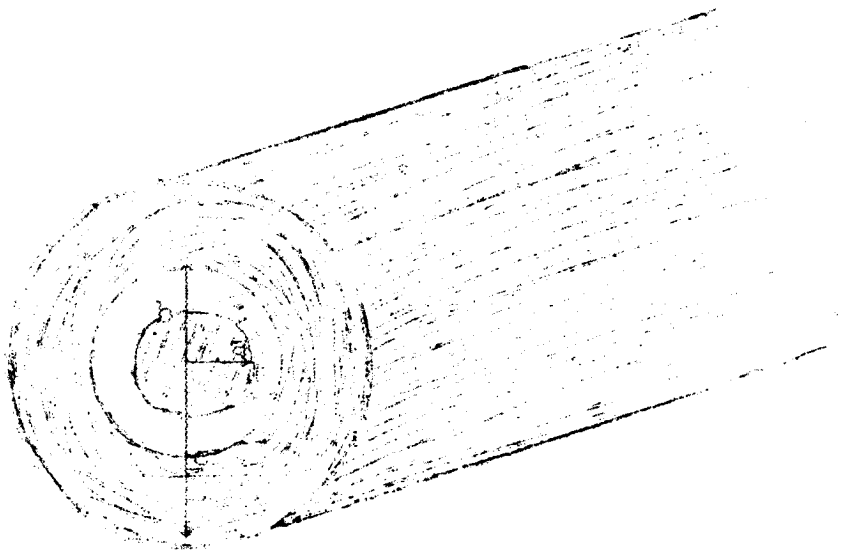
A long co-axial cable consists of two concentric conductors with dimensions shown in figure 2. There are equal and opposite currents i in the conductors. Find the magnetic field B

- (i) at distances r within the inner conductor (i.e. $r < a$)
- (ii) between the two conductors i.e. $a < r < b$
- (iii) within the outer conductor i.e. $b < r < c$
- (iv) outside the cable i.e. $r > c$

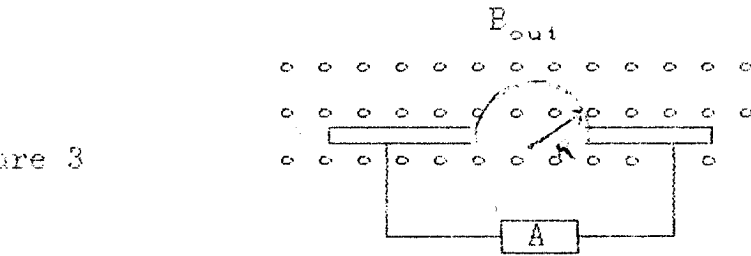
[9]

Make a rough sketch of the variation of the field from the center of the conductor to infinity. [6]

Figure 2



A stiff wire bent into a semi-circle of radius R is rotated at frequency f in a uniform magnetic field B as shown in figure 3



Show that the magnitude of the induced emf is given by $\pi R^2 \omega B \sin(\omega t)/2$ where ω is the loop's angular velocity. [9]

What will be the magnitude and amplitude of the induced current if the internal resistance of the meter is 1000Ω and the remainder of the circuit has negligible resistance? [5]

Two identical coils are connected in series in such a way that one half the flux from one coil threads the second coil. If the self inductance of one coil is L henrys, find the inductance of the pair of coils connected in series, assuming that the coils are connected in such a way that the fluxes add rather than subtract. [6]

(i) What do you understand by the term "root-mean-square" of a current or voltage? [1]

(ii) The average value of a sinusoidal alternating current over a complete cycle is zero. However, the average value of the same quantity taken during the positive half-cycle is not zero. Show that this value is given by $2I_0/\pi$, where I_0 is the current amplitude. [4]

(iii) A tightly wound circular coil of area A has N turns of wire and rotates about its diameter, which is perpendicular to a uniform magnetic field B . It has a (Question Continued on page 4)

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THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS

P270

INTERMEDIATE PHYSICS C

: Three Hours

er: Attempt Three questions from section A and Two questions from section B.

Questions Carry Equal marks

Maximum Marks: 100

SECTION A

- i. State Hooke's Law and show how it may be written quantitatively in terms of Young's modulus.
- ii. A long thin rod of diameter 0.4cm and length one meter is bent strongly into a semi - circular form by a string tied to its ends. Find the Young's modulus of the material of the rod, if the tension in the string is 50N.

(4 + 6 marks)

A horizontally cantilevered diving board has a length $L = 3 \text{ m}$, a width $W = 35\text{cm}$ and a thickness $h = 4\text{cm}$. A student whose mass is $M = 65\text{kg}$ stands at the free end of the board and causes small - amplitude bending oscillations. Assume that Young's modulus for the board is $Y = 1.4 \times 10^{10}\text{Pa}$. Neglect the mass of the

board and show that the period of oscillation obeys the following formula and evaluate T .

$$T = 2\pi \sqrt{\frac{ML^3}{3YI_A}}$$

(6 + 4) marks

(a) A ball floats on the surface of water in a container exposed to the atmosphere. Explain what happens to the ball if;

- i) the container is covered and the air is removed?
- ii) the container is covered and the air is compressed? (2 + 2) marks

(b) Given the speed of efflux of a liquid from an opening in a tank as V_0 , and taking into account the velocity V of the top surface of the liquid,

- i) Show from Bernoulli's equation that

$$V_0^2 = V^2 + 2gh$$

where V is the speed of the top surface.

- * ii) Then by considering the flow as one big tube flow and by obtaining V/V_0 from the equation of continuity show that;

$$V_0 = \sqrt{2 \frac{gh}{1 - \left(\frac{A_0}{A}\right)^2}}$$

where A is the tube cross sectional area at the top and A_0 is the tube cross sectional area at the opening.

(5 + 5)marks

(c) A horizontal tube 0.8mm in diameter and 16 cm long is connected at one end to a constant - level water tank whose height is 200cm. If 600 cm³ of water flows through the tube in 8 minutes, find the coefficient of viscosity of water.

(6 marks)

(a) Explain what is meant by linear coefficient of expansion, and derive a relationship between the coefficients of linear and cubical expansion.

(3 + 5 marks)

(b) A tank of water has been outdoors in cold weather until a 5.0cm thick slab of ice has formed on its surface (fig 3.1). The air above the ice is at - 0°C. Calculate the rate of formation of ice (in m/s) on the bottom surface of the ice slab. Take the thermal conductivity (k) of ice as $17 \times 10^{-1} \text{ J/s.m.K}$, density of ice as $0.92 \times 10^3 \text{ kg/m}^3$ and heat of fusion of ice as 335kJ/kg. Assume that no heat enters or leaves the water through the walls.

(6 marks)

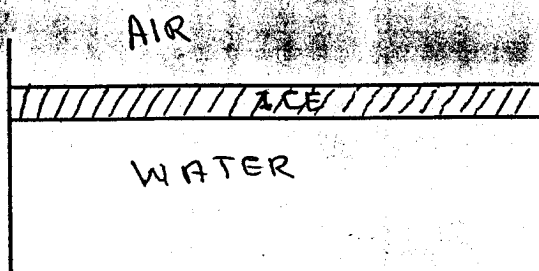


fig 3.1

- i. Show from first principles that for a quasi - static adiabatic expansion of an ideal gas

$$PT^{\frac{\gamma}{1-\gamma}} = \text{constant}$$

where $\gamma = C_p/C_v$ is the ratio of the specific heat capacities of the gas at constant pressure to that at constant volume.

(5 marks)

- ii Helium ($\gamma = 5/3$) at 300K and at a pressure of 1 atm is compressed quasi - statically and adiabatically to a pressure of 5 atmosphere. Assuming that helium behaves like an ideal gas, what is the final temperature?

(5 marks)

- b) If a Carnot cycle is run backward, we have an ideal refrigerator. A quantity of heat Q_2 is taken in at the lower temperature T_2 and a quantity of heat Q_1 is given out at higher temperature T_1 . The difference is the work W that must be supplied to run the refrigerator;

(i) show that;

$$W = Q_2 \frac{T_1 - T_2}{T_2}$$

- (ii) Find the work that must be done to extract 1.0J of heat from a reservoir at 7°C and transfer it to one at 27°C.

(6 + 4)marks

- a) Two samples of a gas initially at the same temperature and pressure are compressed from a volume V to a volume $(V/2)$, one isothermally, the other adiabatically. In which sample is the final pressure greater? Does the entropy of the gas change in either process? Explain your answers.

(4 marks)

- b) A gas obeys the equation $P(V - b) = RT$ where b is constant and has a constant C_v . show that

- i) U is a function of T only
- ii) that a relation that holds during an adiabatic process is $P(V - b)^\gamma = \text{Constant}$. Where $\gamma = C_p/C_v$

(4+4 marks)

- c) Consider an isolated system that consists initially of 0.5 Kg of water in a beaker at a temperature of 3°C and a 10 gram ice cube at 0°C (not in contact with water). The ice cube is now placed in the water and eventually the system reaches equilibrium with all of the ice melted. Calculate the change in entropy of the system. (Neglect the heat capacity of the beaker) Take Latent heat of fusion of water as $L_f = 333 \text{ KJ/Kg}$ and Specific heat Capacity of water $C_w = 4200 \text{ J/Kg}^\circ\text{C}$.

(8 marks)

SECTION B

- a) Does the focal length of a lens depend on the medium in which the lens is immersed? Is it possible for a given lens to act as a converging lens in one medium and a diverging lens in another medium?

(4 marks)

- b) Figure below shows a glass rod whose ends are spherical in shape. The refractive index of glass is n . The radius of curvature of surface B is half the radius of curvature of side A. An object O is at a distance of $2R$ from the surface of the larger radius of curvature. The distance between the apexes of the ends is $3R$. Show that the image point of O is formed at a distance of

$$\frac{9R - 4nR}{10n^2 - 29n + 18}$$

from the right hand vertex.



(8 marks)

c) A thin converging lens of focal length 20 cm forms an image 4 mm high of a distant object. Determine the nature and focal length of the second lens which, when placed 5 cm behind the first lens produces an image 1 cm high of the same object on a screen in the focal plane of the combination.

(4 + 4) marks

a) A person in a dark room, looking through a small window, can see a second person standing outside in bright sunlight. The second person cannot see the first person. Is this a failure of the principle of optical reversibility? Assume no absorption of light.

(4 marks)

b) Explain with derivation of formula the formation of Newton's rings by monochromatic light reflected normally. Account for perfect blackness of the central spot. What is the difference between these fringes and those formed by a biprism.

(8 marks)

c) Fringes of equal inclination are observed in a Michelson interferometer. As one of the mirrors is moved back 1 mm, 3663 fringes move out from the center of the pattern. Calculate the wavelength of light. What will be observed if one then changes to white light?

(8 marks)

a) i. Distinguish between the Fresnel and the Fraunhofer classes of diffraction.

ii. Sodium light is incident normally on a plane transmission grating having 3000 lines per centimeter. Find the direction of the first order for the D lines and the width of the grating necessary to resolve them. (wavelength of D lines are 5890 Å and 5896 Å)

(4 + 6) marks

b) i. Explain what you understand by resolving power of an optical instrument. State Rayleigh's criterion for resolution and apply it to distinguish between the resolving power and dispersive power of a diffraction grating.

ii. A spy satellite circles the earth at an altitude of 150 Km and carries out surveillance with a special high resolution telescopic camera having lens diameter of 35 cm, if the angular resolution of this camera is limited by diffraction, estimate the separation of two objects on the earth's surface that are resolved in yellow - green light of wavelength 5500 Å.

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UNIVERSITY OF ZAMBIA
PHYSICS DEPARTEMENT
UNIVERSITY EXAMINATIONS-1993/94
P-302
(Computational physics-I)

Time: Three Hours.

Max. Marks: 100

Answer: (i) Question One 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: Wherever necessary, use the information given in Appendix

2.1.(A) Identify errors if any in each of the following Basic statements.
It is assumed that the unknowns are given.

[6]

- (i) FOR J=1 TO 10 STEP -1
- (ii) Z\$ = 4.5 + B
- (iii) DIM A(4;5), B(1,-2)
- (iv) A = (-2.5)[↑]1.5
- (v) NAME= "PHYSICS"
- (vi) PRINT X, Y, X+Y

(B) Translate the following expressions into BASIC statements.

[4]

- (i) $ab^{\frac{1}{2}}e^{-x}$
- (ii) $x^a + y^b / z^{\frac{1}{2}} / \sin(p) e^{-x}$

(C) Write the value of C% when the following program is executed.

[5]

```
DIM A(5)
FOR J% = 1 TO 5
  READ A(J%)
  C% = A(J%) + 0.6
NEXT J%
DATA 0.2, 1.6, 0.9, 1.4, 2.8
```

(D) You are given the following data on an input file EX1.DAT for variables (x_i, y_i)

[10]

2.1	3.4
4.5	6.8
5.6	7.8
7.3	4.5

Write a program in Basic to

(i) read the data from the file and put it on an output file EX1.OUT in a tabular form with title XI and YI,

(ii) find the sums $\sum x_i^2$, $\sum y_i^2$, $\sum x_i y_i$, and $\sum x_i$, $\sum y_i$,
Write these sums on the output file each on separate lines on the output file.

Q.2. A rocket is launched from the ground. Its acceleration a is registered at times given in the table below.

[25]

t, (s) :	10	20	25	28	30
a, (ms ⁻²) :	32.1	34.5	36.2	37.8	40.5

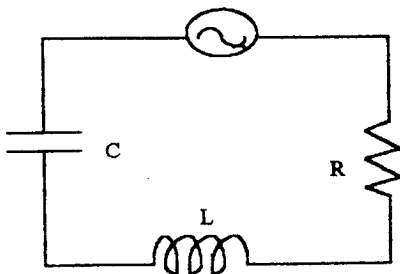
Assuming that the speed at any time is given by

$$v = v_0 + a t$$

write an algorithm in pseudo code to calculate the velocity at any given time.
Use least square fit method for the data.

Q.3. A resonant electric circuit is shown below.

[25]



Natural frequency of the circuit is given by

$$f_0 = 1 / 2\pi \sqrt{LC} \quad \text{with } L = 5.0 \mu \text{ H} \quad \text{and} \quad f_0 = 550 \text{ kHz}$$

and the half width or selectivity of the circuit is given by

$$\Delta f = L / 4\pi R$$

Write a program to compute

- (i) capacitance C for a given input frequency from the default device,
- (ii) compute the resistance necessary for half widths

$$\Delta f = f_0 / 5 \quad , \quad f_0 / 20 \quad , \quad f_0 / 80$$

- (iii) print all the above with appropriate labels.

Q.4. Joule-Thompson effect is the change of temperature which occurs in the expansion of a gas through a throttle from high pressure P_1 to low pressure P_2 . For temperatures $T > T_i$ a Joule-Thompson expansion necessarily warms up the gas and T_i is called the inversion temperature. The inversion temperature is found from the equation describing the inversion curve [25]

$$P = -\frac{3RT}{2b} + \frac{2}{b} \left(\frac{2RTa}{b} \right)^{\frac{1}{2}} - \frac{a}{b^2}$$

The above equation is derived from van-der-Waals equation for a real gas. Write a program for a given a , b to

- (i) determine T_i which is the solution of the above equation for $P=0$,
- (ii) determine P as a function of T between the limits of temperature $(0, T_i)$ in steps of $\Delta T = 5^\circ \text{ K}$.

The gas constants a , b and R are to be input from the default device. The output should contain the name of the gas as the title of the output.

Q.5. Suppose that the projectile is fired from the origin at time $t=0$ with the speed v_0 at an angle of elevation θ_0 . Assuming, for ballistic velocities, the projectile faces the resistance to air and is varying as the square of velocity, we get [25]

$$\frac{1}{v^2} = \cos^2 [A - C \arctan(\sin \theta)] - C \sin \theta$$

where A and C are constants which are given.

Now the trajectory is determined by the co-ordinates x , y , and t given by

$$x = -\frac{1}{g} \int_{\theta_0}^{\theta} v^2 d\theta$$

$$y = -\frac{1}{g} \int_{\theta_0}^{\theta} v^2 \tan \theta d\theta$$

$$t = -\frac{1}{g} \int_{\theta_0}^{\theta} v \sec \theta d\theta$$

and $r(t) = \sqrt{x^2 + y^2}$.

Write an algorithm in pseudo-code to determine x, y, t as a function of θ and $r(t)$ as a function of t . Assume that A, C, g and θ_0 as given. Include in your algorithm a criterion for the convergence of the integrals.

Q.6. Simple pendulums do not swing forever. They lose energy as a result of friction at the pivot and in the medium in which they move. Assuming that the damping is due to friction in the medium only, the acceleration of the vibrating mass at any time is given by [25]

$$\frac{dv}{dt} = -\frac{g}{L} x - c v \quad \text{where} \quad \text{velocity} = v = \frac{dx}{dt}$$

Here c = damping constant, L = length of the pendulum and g = acceleration due to gravity.

Given the initial conditions at $t = 0, x = 0, v = v_0$, write down an algorithm in pseudo-code to determine the velocity v as a function of time in the interval 0 to 60 sec with an increment of time 0.1 sec .

Hint: At any time $t_0 + h$, the distance x is given by

$$x(t_0 + h) = x(t_0) + h v(t_0)$$

Use this to solve the differential equation given above for v at time $t_0 + h$. Use RK-method for solving the differential equation.

.....END OF EXAMINATION.....

APPENDIX

Least square fit to a straight line:

$$y_i = a + b x_i \quad \text{with } i = 1, 2, \dots, n$$

$$a = \frac{\sum x_i (\sum x_i y_i) - (\sum x_i^2)(\sum y_i)}{n(\sum x_i^2) - (\sum x_i)^2}$$

$$b = \frac{n(\sum x_i y_i) - (\sum x_i)(\sum y_i)}{n(\sum x_i^2) - (\sum x_i)^2}$$

Let α be the standard error in b and
 β be the standard error in a , then

$$\frac{\alpha^2}{n} = \frac{\beta^2}{\sum x_i^2} = \frac{\sum d_i^2}{(n-2)[n \sum x_i^2 - (\sum x_i)^2]}$$

$$\text{where } d_i = y_i - a - b x_i$$

2. Integration:

Trapezoidal Rule:

$$\int_a^b f(x) dx = 0.5 h [f(a) + f(b) + 2 \sum_{j=1}^{m-1} f(x_j)]$$

$$\text{and } x_j = a + j h \quad \text{with } j = 1, 2, \dots, m$$

Simpson Rule:

$$\int_a^b f(x) dx = \frac{h}{3} [f(a) + f(b) + 4(f_1 + f_3 + f_5 + \dots + f_{2n-1}) + 2(f_2 + f_4 + f_6 + \dots + f_{2n})]$$

Non - Linear Equations:

Newton- Raphson Method:

$$x_n = x_{n-1} - \frac{f(x_{n-1})}{f'(x_{n-1})}$$

Solution of Differential Equation:

$$\frac{dy}{dx} = f(x, y)$$

with initial conditions.

Fourth Order RK- Method:

$$y_{i+1} = y_i + (k_1 + 2k_2 + 2k_3 + k_4)/6$$

where

$$k_1 = hf(x_i, y_i)$$

$$k_2 = hf(x_i + \frac{h}{2}, y_i + \frac{k_1}{2})$$

$$k_3 = hf(x_i + \frac{h}{2}, y_i + \frac{k_2}{2})$$

$$k_4 = hf(x_i + h, y_i + k_3)$$

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - DECEMBER 1994

P 332

STATISTICAL PHYSICS AND THERMODYNAMICS

TIME : THREE (3) HOURS

ANSWER ANY FOUR (4) QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

Whereever necessary , you may use the following

$$\Gamma \left(\frac{1}{2} \right) = \sqrt{\pi}$$

$$\Gamma(1) = 1$$

$$\Gamma(z+1) = z \Gamma(z)$$

$$\int_0^{\infty} e^{-\alpha x^2} x^n dx = \frac{1}{2} \Gamma\left(\frac{n+1}{2}\right) \alpha^{-\left(\frac{n+1}{2}\right)}$$

$$\int_0^{\infty} \frac{x^3 dx}{e^x - 1} = \frac{\pi^4}{15}$$

1. A man is walking randomly in steps of equal length up and down a slope. (Assume the motion is one dimensional). The probabilities of his taking a step down or up the slope are $2/3$ and $1/3$, respectively.

(a) What is the probability that his first five steps are all down the slope and the next five are all up the slope ? [7]

(b) What is the probability that he is found at the starting point after a total of 10 steps ? [5]

(c) Calculate the probability that after 10 steps he is found (i) two steps below (ii) two step up , from the point where he started. [5]

(d) What is the expected position of the man after a total of 10 steps ? [5]

(e) Why would it be unrealistic to use the Gaussian distribution in the above problem ? [3]

2. (a) The single particle partition function for an atom in a gas of volume V is

(3)

$$Z_1 = \frac{V}{h^3} (2 \pi m k_B T)^{\frac{3}{2}}$$

What is the meaning of Z_1 ?

(b) How is Z related to the total partition function for N particles under the low density limit (perfect classical gas). [5]

(c) Find an expression for the Gibb's free energy , F , of the gas . [10]

(d) Entropy is defined as $S = - \frac{dF}{dT}$, use this to show that

for a perfect monatomic gas under adiabatic conditions

$$P V^{\frac{5}{3}} = \text{constant}. \quad [10]$$

3. (a) Write down the Fermi - Dirac distribution function

$f_{FD}(\epsilon)$ in the form that is appropriate when temperature T is much smaller than the Fermi temperature T_F .

Sketch a diagram to show $f_{FD}(\epsilon)$ plotted against n (occupation number) for both $T = 0$ and $T > 0$. [6]

(4)

- (b) If $D(\epsilon)$ is the density of states, what information is given by the product $f_{FD}(\epsilon) D(\epsilon) d\epsilon$? Sketch diagram to show $f_{FD}(\epsilon) D(\epsilon)$ plotted against T for $T = 0$ and $T > 0$. [6]

- (c) An ideal gas of N neutrons is contained in a box of volume V . Show that the Fermi temperature of this gas is given by

$$T_F = \frac{h^2}{2m_n k_B} \left(\frac{3\pi^2 N}{V} \right)^{\frac{2}{3}}$$

where m_n is the mass of one neutron. [8]

- (d) Calculate the mass of a neutron star, taken to be a sphere of radius 10 km. Assume a model in which the star consists of an ideal neutron gas of uniform density with $T_F = 7.9 \times 10^8$ K, and the temperature the gas is much smaller than T_F .

$$\text{Mass of the sun} = 2.0 \times 10^{30} \text{ kg}$$

$$\text{Mass of a neutron, } m_n = 1.67 \times 10^{-27} \text{ kg}$$

Density of states for particle of mass m_n in a

$$\text{box of volume } V, D(\epsilon) = \frac{V}{4\pi^2} \left(\frac{2m_n}{h^2} \right)^{\frac{3}{2}} \epsilon^{\frac{1}{2}}$$

[5]

4. (a) Derive an approximate expression relating the diffusion coefficient in a gas to the mean free path. [10]

- (b) Water at 20 °C almost fills a test-tube 3cm in length which is open to the air . Assuming that the density gradient of water vapour falls linearly from the water surface to the top of the tube , show that the level of the water falls , due to evaporation , at $(\text{time})^{\frac{1}{2}}$. Calculate how long it takes for water to evaporate completely. [15]

5. Assuming that photons obey Bose - Einstein statistics and that the number of photon states in volume V in the frequency range w to $w + dw$ is

$$g_w dw = \frac{8 \pi V}{(2 \pi c)^3} w^2 dw$$

- (a) Find a formula for the average energy of a photon gas , and hence find an expression for the constant 'a' in the formula aT^4 for the energy density of black body radiation . [12]

- (b) Sketch a diagram of spectral density (energy per unit volume per unit frequency range) against frequency and discuss its importance in the development of the quantum theory. [5]

- (c) Show that the spectral density is at a maximum at a frequency given by

$$w = A \frac{kT}{h}$$

and find an approximate value for A . Estimate the surface temperature of a blue star (very hot star assumed to radiate as a black body). [8]

6. (a) The speed of molecules in a classical ideal gas follows the maxwell distribution , such that the number of particles with speeds between v and $v + dv$ is given by

$$dN_v = A v^2 \exp (- M v^2 / 2 k_B T) dv$$

where M is the mass of the particle , T is the temperature of the gas and A is a constant.

Find A .

**THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATION - 1993/94**

**P340
(ELECTRONICS I)**

TIME 3 HOURS

MAXIMUM MARKS 100

ANSWER 5 QUESTIONS

ANSWER AT LEAST ONE QUESTION FROM EACH SECTION

SECTION ONE

- Q.1 a) What is meant by the term "Impedance Matching"? Derive the load impedance and power output when such a condition is attained. Assume a non-complex impedance. (5 marks)
- b) i) For the circuit in figure 1. find the value of the resistance X that gives the maximum power dissipation in X . (10 marks)
- ii) Calculate the value of this maximum power. (5 marks)

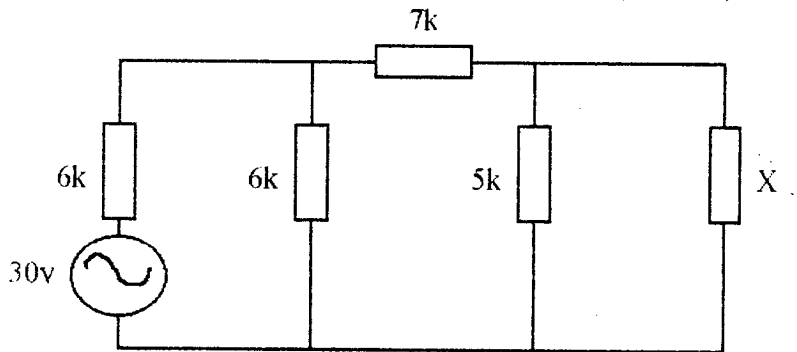


figure 1.

- Q.2. a) In the circuit in figure 2. derive the impedance and its magnitude between a and b . (10 marks)

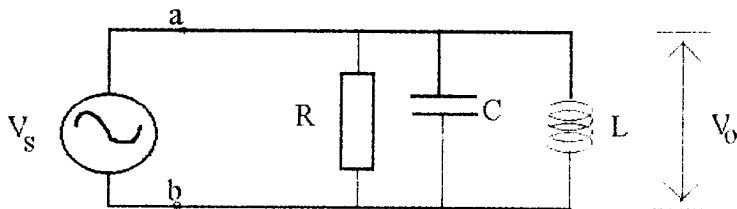


figure 2.

- b) Find the expression for the resonance frequency ω_r and quality factor Q for this circuit. (7 marks)
- c) Draw an approximate bode plot that gives V_o/V_s as a function of the frequency ω . Indicate the position of ω_r . (3 marks)

- Q.3. a) Draw a circuit that transforms a sinusoidal a.c. signal to a d.c. signal using

- Q.3. a) Draw a circuit that transforms a sinusoidal a.c. signal to a d.c. signal using
- a center tapped transformer (2 marks)
 - a bridge of diodes (2 marks)
- b) Briefly explain how the two circuits work with the aid of signal diagrams (voltage vs time graphs) (5 marks)
- c) What is meant by the term "RIPPLE FACTOR" and what is its significance? What affects the value of the RIPPLE FACTOR? (5 marks)
- d) For the circuit below show the output waveform if the input is a sinusoidal wave. (5 marks)

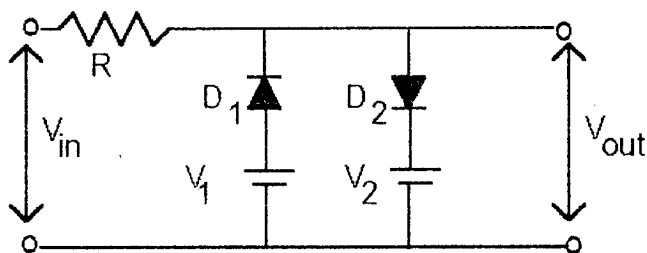


figure 3.

SECTION TWO

- Q4. a) Briefly explain the meaning of the following terms with regards to transistors:
- saturated region (2 marks)
 - cutoff region (2 marks)
 - large signal current gain (2 marks)
- b) The silicon transistor connected in figure 4. has a value of $\beta = 55$, find the currents I_B , I_C , I_E and V_{CE} . (12 marks)

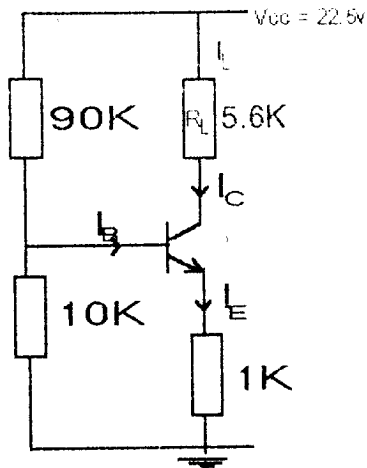


Figure 4.

c) Is the transistor operating in the active or saturated region? Give reason.

(2 marks)

5. The transistor amplifier circuit used in figure 5. has the following hybrid parameters:
 $h_{ie} = 1K$; $h_{re} = 0$; $h_{fe} = 50$; $h_{oe} = 0$.

a) Draw the equivalent circuit of the amplifier using the simplified hybrid model.
 (3 marks)

b) Calculate i) the voltage gain A_v .
 (7 marks)

ii) the input resistance R_i .
 (7 marks)

c) Why is the common-emitter amplifier with emitter resistance more stable than one without an emitter resistance?
 (3marks)

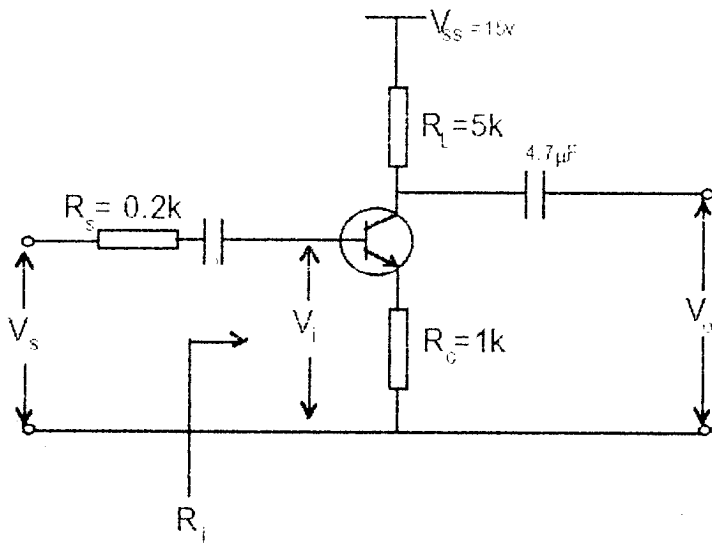


Figure 5.

SECTION THREE

- 6 a) Give the characteristics of an ideal operation amplifier. (2 marks)
- b) Draw the inverting and non-inverting amplifier using an ideal op-amp and derive the expression for the respective voltage gains. (10 marks)
- c) Draw an integrator circuit using an ideal op-amp and derive the output. (8 marks)
- 7 a) State one form of De Morgan's theorem. (3 marks)
- b) Prove the following identities;
 $A + AB = A$
 $A + \overline{A}B = A + B$ (6 marks)
- c) For the digital circuit in figure 6, write the Boolean equation relating the output to the input. Make the corresponding truth table for the circuit. (6 marks)

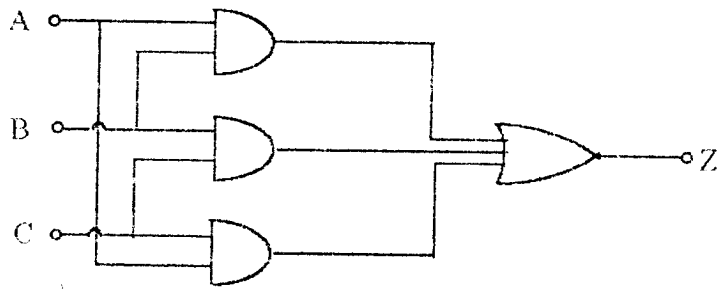


figure 6.

d) i) Convert the decimal number 21 to a binary number (1 mark)

ii) Use the twos complement method to perform the binary subtraction $1101 - 0110$. (4 marks)

Q.8. a) Construct the gates NOT, NOR and AND using NAND gates. (4 marks)

b) Using NAND gates draw the circuit diagram of a J-K master-slave flip-flop and briefly describe its operation. (6 marks)

c) What is the advantage of the master-slave flip flop over a single stage flip-flop? (2 marks)

d) Draw the circuit for a four stage binary ripple counter using J-K flip flops. (4 marks)

e) Draw the circuit for a binary full adder. (4 marks)

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

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS - 1993/1994
P351 - QUANTUM MECHANICS

3 HOURS

MAX MARKS: 100

ATTEMPT ANY **FOUR** QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

You may use the following information:

Electron rest mass m_0	$= 9.1 \times 10^{-31} \text{ Kg}$
Boltzmann constant k	$= 1.38 \times 10^{-23} \text{ J/K}$
Proton rest mass M_p	$= 1.67 \times 10^{-27} \text{ Kg}$
Planck's constant h	$= 6.6 \times 10^{-34} \text{ J.s}$
Speed of light c	$= 3 \times 10^8 \text{ m/s}$
$\hbar = h/2\pi$	$= 1.05 \times 10^{-34} \text{ Js}$
1 e.V.	$= 1.6 \times 10^{-19} \text{ J}$
Stefan's constant σ	$= 5.67 \times 10^{-8} \text{ W/m}^2.\text{K}^4$

$$\int_{-\infty}^{\infty} e^{-ax^2} dx = \left(\frac{\pi}{a} \right)^{\frac{1}{2}}$$

$$\int_{-\infty}^{\infty} x^2 e^{-ax^2} dx = \frac{\sqrt{\pi}}{2} a^{-\frac{3}{2}}$$

$$\int_0^{\infty} \frac{x^3 dx}{e^x - 1} = \frac{\pi^4}{15}$$

$$\int_0^{\infty} \frac{x^2 du}{e^x - 1} = 2.4$$

The energy density $\rho(\lambda,T)$ in black-body radiation is given by the Planck's law

$$\rho(\lambda,T) = \frac{8\pi hc}{\lambda^5 [\exp(hc/\lambda kT) - 1]}$$

Show that in the long wave-length limit, the law reduces to the Rayleigh Jeans law

$$\rho(\lambda,T) = \frac{8\pi kT}{\lambda^4}$$

(5 marks)

Prove that the total energy ρ_{tot} is proportional to T^4 .

(8 marks)

Show that the number of photons per unit volume is $N = 2.03 \times 10^7 T^3$.

(8 marks)

Calculate the average energy per photon as a function of temperature.

(4 marks)

What is meant by a quantum mechanical expectation value?

(2 marks)

The wave-function for a one-dimensional simple harmonic oscillator is given by

$$U_0(x) = C \exp\left(\frac{-kx^2}{2\hbar\omega}\right)$$

where C is a constant.

Show that the normalised wave-function is given by

$$U_0(x) = \left(\frac{k}{\pi\hbar\omega}\right)^{1/4} \exp\left(-\frac{kx^2}{2\hbar\omega}\right)$$

(5 marks)

Find the expectation value of x. What is the physical significance of your result?

(5 marks)

Calculate the expectation value of x^2 . Can it be negative for any wave-function?

(5 marks)

Calculate the expectation value of the momentum squared, i.e. p^2 .

(8 marks)

THE UNIVERSITY OF ZAMBIA

PHYSICS DEPARTMENT

EXAMINATIONS - 1993/1994

P361

ELECTROMAGNETIC THEORY

TIME THREE (3) HOURS

ANSWER ANY FOUR (4) QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

MAX MARKS 100

ever necessary, you may use the following information.

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ H m}^{-1}$$

$$\mu_0 = 4 \times 10^{-7} \text{ H m}^{-1}$$

$$1 \text{ nm} = 10^{-9} \text{ m}$$

$$c = 3 \times 10^8 \text{ m/s} = 1/\sqrt{\epsilon_0 \mu_0}$$

$$\mathbf{a} \times (\mathbf{b} \times \mathbf{c}) = \mathbf{b} (\mathbf{a} \cdot \mathbf{c}) - (\mathbf{a} \cdot \mathbf{b}) \mathbf{c}$$

$$\nabla \cdot \mathbf{D} = \rho_f ; \quad \mathbf{D} = \epsilon_r \epsilon_0 \mathbf{E} ; \quad \mathbf{B} = \mu_0 (\mathbf{H} + \mathbf{M})$$

$$= -\nabla \cdot \mathbf{P} ; \quad \mathbf{J}_m = \nabla \times \mathbf{M} ; \quad \mathbf{S} = \mathbf{E} \times \mathbf{H}$$

$$= \frac{\mu_0 I a^2}{2 (a^2 + r^2)^{3/2}} ; \quad u = (\mathbf{E} \cdot \mathbf{D} + \mathbf{H} \cdot \mathbf{B})/2$$

$$= \frac{\mu_0 I}{4\pi} \oint \frac{\mathbf{dl} \times \mathbf{r}}{r^3} ; \quad e = \frac{d}{dt} \int_s \mathbf{B} \cdot \mathbf{da}$$

$$\nabla \cdot (\mathbf{a} \times \mathbf{b}) = \mathbf{b} \cdot (\nabla \times \mathbf{a}) - \mathbf{a} \cdot (\nabla \times \mathbf{b})$$

$$= \frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial u}{\partial r} \right) + \frac{1}{r^2 \sin \theta} \frac{\partial}{\partial \theta} \left(\sin \theta \frac{\partial u}{\partial \theta} \right) + \frac{1}{r^2 \sin^2 \theta} \frac{\partial^2 u}{\partial \phi^2}$$

QUESTION 1.

A spherical charge distribution of uniform charge density has radius R . Use Poisson's equation to find the potential and electric field outside and inside the charge distribution. Draw a sketch of the field as a function of distance r from the center. (5+5+2 MARKS)

Show that the electric field intensity E at a distance r from the axis of a long straight, thin wire carrying a uniformly distributed line charge of density λ is given by

$$E = (2 \lambda) / (4 \pi \epsilon_0 r) \hat{r} \quad (6 \text{ MARKS})$$

Show that the potential at a point a distance r_1 and r_2 respectively from the centers of long parallel pair of wires of negligible cross-section and having equal and opposite linear charge density λ coulomb-meter is given by

$$V = (\lambda / 2 \pi \epsilon_0) \ln (r_2/r_1) \quad (7 \text{ MARKS})$$

QUESTIONS 2.

Consider a linear and isotropic dielectric with permittivity ϵ and electric susceptibility χ_e .

Show that the polarization P is related to the electric displacement D by

$$D = P (1 + \chi_e) / \chi_e \quad (7 \text{ MARKS})$$

Obtain an equation for the displacement current density and explain the meaning of the terms contained in the equation. (2+1+1 MARKS)

For a continuous charge distribution of density ρ , the potential energy can be given by

$$W = \frac{1}{2} \int_{\tau} V \rho_f d\tau$$

where V is the potential due to all the charges contained in an arbitrary volume τ .

Using Poisson's equation, show that the energy of the charge distribution can be given by

$$W = \frac{\epsilon_0}{2} \int_{\tau} E^2 d\tau$$

where E is the electric field intensity. (7 MARKS)

If a dielectric is present in the vicinity of the charge distribution, show that the electric potential energy W is

$$W = \frac{1}{2} \int_{\tau} (\mathbf{D} \cdot \mathbf{E}) d\tau \quad (7 \text{ MARKS})$$

QUESTION 3.

Define an electric image. (2 MARKS)

A hollow grounded sphere of radius R contains a charge q at a distance D from the center of the sphere. The potential V is uniform over the surface of the sphere.

Show that the field inside the sphere is the same as if there was no sphere, instead a charge $q' = -aq/D$ at $b = R^2/D$. (8 MARKS)

Calculate the potential and electric field intensity at an arbitrary point P outside the sphere at distance r from the center. (6 MARKS)

. Calculate the induced charge density on the inner surface of the sphere. (3 MARKS)

Calculate the force of attraction between the charge q and the image charge. (3 MARKS)

Show that the total induced charge is equal to the image charge. (3 MARKS)

QUESTION 4.

Show that Faraday's law of induction in differential form can be expressed as

$$\nabla \times \mathbf{E} = - \partial \mathbf{B} / \partial t \quad (7 \text{ MARKS})$$

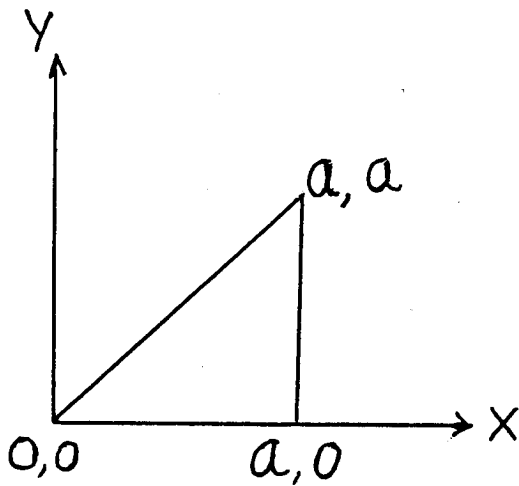
Obtain an expression for the induced electric field intensity \mathbf{E} in terms of the vector potential \mathbf{A} and show that \mathbf{E} can arise from accumulation of charges or from changing magnetic fields or from both. (6 MARKS)

A rectangular toroidal solenoid of thickness h , external and internal radii r_2 and r_1 respectively for a circular path concentric with the toroid, has N turns uniformly

distributed over its circumference. I is the current flowing in the windings and B is the magnetic flux induced in every part of the circular path of radius r . Starting from Ampere's law, show that the self inductance of the solenoid is

$$L = \frac{\mu_0 N^2 h}{2\pi} \ln(r_2/r_1) \text{ henries} \quad (6 \text{ MARKS})$$

Evaluate $\oint \mathbf{A} \cdot d\mathbf{l}$ along the path shown if $\mathbf{A} = 2xy\mathbf{i} + x^2\mathbf{j}$.
What do you conclude from your result? (6 MARKS)



QUESTION 5.
Define the term magnetization \mathbf{M} . If \mathbf{J}_m is the magnetization current density then show that the curl of magnetic field strength \mathbf{H} is equal to the free charge current density \mathbf{J}_f . Show that this equation can give Ampere's circuital law. (2+8+2 MARKS)

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
 UNIVERSITY EXAMINATIONS - 1993/94
P - 401
(Computational Physics-II)

Time: Three Hours.

Max. Marks: 100

Answer: (i) Question One 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: Wherever necessary, use the information given in Appendix.

1.(A) Make necessary corrections if any in the following:

[10]

- (i) $X=Y+EXP(2P)$
- (ii) $T=LOG(5/6)$
- (iii) DIMENSION A(12.5), B(-2,5)
- (iv) CHARACTER*8 P,QR),TS**10
- (v) REAL (I, J , LET (6,8)
- (vi) DO 10 , J = 1, 5
- (vii) IF (A.GT.B.OR.C) STOP
- (viii) OPEN (-3, FILE = ' EXAM.DATA ')
- (ix) 10 IF (L.EQ. 0) GO TO 10
- (x) 50 FORMAT (2X, ' UNIT = ' E 14.10 , A 6.2)

(B) Which of the following computations would be fast and why ?

[2]

- (i) $A = 2 * EXP(X)$
- (ii) $A = EXP(X) + EXP(X)$
- (iii) $A = EXP(X)$
 $A = A + A$

(C) Given a matrix

[5]

$$\begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix}$$

write a set of statements so as to replace all except diagonal elements by zeros.

- (D) Given (x_i, y_i) for $i = 1, 2, \dots, 10$, [8]
using Do-loops write a program to calculate

$$\sum x_i, \sum x_i^2, \sum y_i, \sum y_i^2, \sum x_i y_i$$

- Q.2: (A) Describe how an integral can be calculated using Monte-Carlo Method. [5]
What are the advantages and disadvantages of this method.

- (B) Integral of the type [20]

$$I = \int_0^z \frac{dz}{A - Bz}$$

are of interest in many physical problems. Note that it has a singularity at $A = Bz$.

Write a subroutine program to calculate the integral using Monte-Carlo Method up to 0.001 precision.

Use this subroutine in the main program to tabulate values of integral as a function of z up to z_m .

Given : A, B and z_m .

- Q.3. You are given the following data corresponding to variables (x_i, y_i) [25]
tabulated as follows on a file named EX1.DAT

0.1 , 0.52
0.2 , 0.83
0.45 , 1.01
0.32 , 1.36
0.55 , 1.61

Write a program to

- (i) read the data from the file and put it on an output file of your choice. The name is to be given from the default device.
- (ii) calculate in double precision the deviation

$$\sum y_i^2 - (\sum y_i)^2$$

and write the output on the output file with the description "Deviation".

4. Define

[25]

$$S = \frac{\sum (y_i - \bar{y}_i)^2}{n - m}$$

where y_i = an experimental value,

\bar{y}_i = a value computed from a least square fit,

n = the number of x-y pairs,

m = the number of parameters in the relation.

The Gauss criterion of goodness fit states that the best fit is the one that minimizes S . Write a program to verify for a given N points of data, whether a linear or a quadratic relation gives a better fit.

Given: For a linear fit $y_i = A + B x_i$, the subroutine

LINEAR(N,X,Y,A,B)

and quadratic fit $y_i = A + B x_i + C x_i^2$, the subroutine

QUAD(N,X,Y,A,B,C)

5. The Lorentzian line shape function is given by

[25]

$$I(\lambda) = \frac{I_0}{1 + 4(\lambda - \lambda_0)^2 / \Gamma^2}$$

Measured data is available for $I(\lambda)$ as a function of λ . Assuming I_0 and Γ are given, determine λ_0 by minimizing the error

$$S = \sum_j [I_j - I(\lambda_j)]^2$$

Here λ = wavelength of light emitted,

λ_0 = resonant wavelength,

Γ = full width at half maximum,

I_0 = intensity at λ_0 .

Assuming a starting value of λ_0 , evaluate S at λ_0 , evaluate S at $\lambda_0 + h$, λ_0 and $\lambda_0 - h$ where h is properly selected increment.

Write an algorithm in pseudo-code to find the value of λ_0 which minimizes

S . Determine the value of λ_0 with a precision of 10^{-6} .

6. The degree to which solar energy is attenuated is determined to a great extent by the density profile (density as a function of height) $\rho(z)$ where z - altitude coordinate. Assuming that tropospheric air which extends approximately 0-12 km, is well mixed and behaves as an ideal gas, the density profile is given by [25]

$$\rho(z) = \rho_0 \frac{T_0}{T(z)} \exp \left[-\frac{\bar{M}g}{R} \int_0^z \frac{dz}{T(z)} \right]$$

where $T(z) = T_0 - \Gamma z$

T_0 = ground temperature, Γ = thermal lapse rate= 6×10^{-3} K/m

$\bar{M} = 29$ a.m.u. , $R = 8317$ J/ kg mole - K ,

$\rho_0 = 1.29$ kg/m³ .

Write an algorithm in pseudo-code to calculate the density profile as a function of z in steps of 1×10^3 m using Monte-Carlo Method. Include in your algorithm a criterion for convergence of the integral.

..... END OF EXAMINATON.....

APPENDIX

Least square fit to a straight line:

$$y_i = a + b x_i \quad \text{with } i = 1, 2, \dots, n$$

$$a = \frac{\sum x_i (\sum x_i y_i) - (\sum x_i^2) (\sum y_i)}{n (\sum x_i^2) - (\sum x_i)^2}$$

$$b = \frac{n (\sum x_i y_i) - (\sum x_i) (\sum y_i)}{n (\sum x_i^2) - (\sum x_i)^2}$$

Let α be the standard error in b and
 β be the standard error in a , then

$$\frac{\alpha^2}{n} = \frac{\beta^2}{\sum x_i^2} = \frac{\sum d_i^2}{(n-2) [n \sum x_i^2 - (\sum x_i)^2]}$$

where $d_i = y_i - a - b x_i$

Integration:

Trapezoidal Rule:

$$\int_a^b f(x) dx = 0.5 h [f(a) + f(b) + 2 \sum_{j=1}^{m-1} f(x_j)]$$

and $x_j = a + j h$ with $j = 1, 2, \dots, m$

Simpson Rule:

$$\int_a^b f(x) dx = \frac{h}{3} [f(a) + f(b) + 4(f_1 + f_3 + f_5 + \dots + f_{2n-1}) + 2(f_2 + f_4 + f_6 + \dots + f_{2n})]$$

Non - Linear Equations:

Newton- Raphson Method:

$$x_n = x_{n-1} - \frac{f(x_{n-1})}{f'(x_{n-1})}$$

Solution of Differential Equation:

$$\frac{dy}{dx} = f(x, y)$$

with initial conditions.

Fourth Order RK- Method:

$$y_{i+1} = y_i + (k_1 + 2k_2 + 2k_3 + k_4)/6$$

where

$$k_1 = hf(x_i, y_i)$$

$$k_2 = hf(x_i + \frac{h}{2}, y_i + \frac{k_1}{2})$$

$$k_3 = hf(x_i + \frac{h}{2}, y_i + \frac{k_2}{2})$$

$$k_4 = hf(x_i + h, y_i + k_3)$$

(2)

- (a) Discuss the variation of the output pulse amplitude with increase in the applied voltage between the plates of a gas-filled detector and identify the regions of operation of various types of gas-filled detectors. Draw the figure and explain in short its main features. [10 marks]
- (b) An alpha particle of energy 9 MeV loses all its energy in a proportional counter. One electron-ion pair is produced for each 30-eV of energy loss. The proportional counter has a multiplication factor $M = 600$, and the total capacitance between the anode and ground is 35 pF. What is the voltage of the output pulse ? [7]
- (c) Draw the differential pulse-height spectrum and the corresponding counting curve for a mixed alpha-beta source of typical energies for a proportional counter and explain them. [8]
- (a) Write short notes on the following three processes :
- (i) fluorescence,
 - (ii) phosphorescence, and
 - (iii) delayed fluorescence.
- Which process is desirable for a material to be a good scintillator, and explain why ? [7]
- (b) How does the scintillation mechanism proceed in an inorganic scintillator doped with an activator ? [8]
- (c) A Cs-137 source emitting 0.662 MeV gamma rays is placed in front of a NaI(Tl) detector of size 5 cm \times 5 cm. The source-to-detector distance is 25cm. If the number of counts in the photo-peak for a 5-minute counting period is 15000, calculate the intrinsic photo-peak efficiency of the detector.
- Calculate also the absolute efficiency of the detector if the number of counts outside the photo-peak for the same period of counting is 25000.
- Given, the activity of the source is 1 micro-curie; Cs-137 emits a 662 KeV gamma ray in 92% of its emissions. [10]

3. (a) A given radionuclide has a decay constant λ_1 and at time $t = 0$ there are N_1^0 parent nuclei and $N_2^0 = 0$ daughter nuclei. The daughter nucleus is radioactive with decay constant λ_2 . The number of daughter nuclei N_2 at time $t > 0$ is

$$N_2 = N_1^0 \frac{\lambda_1}{\lambda_2 - \lambda_1} \left[e^{-\lambda_1 t} - e^{-\lambda_2 t} \right]$$

The value of N_2 becomes zero at $t = 0$ and at $t = \infty$. Hence it passes through a maximum at some time t_m . Show that t_m is given by

$$t_m = \tau_2 \frac{T_1}{T_1 - T_2} \ln \left[\frac{T_1}{T_2} \right]$$

where T_1 and T_2 are the half-lives of the parent and the daughter respectively, and τ_2 is the mean life of the daughter. [9]

- (b) Show that if $R_p(T)$ is the range of a proton of kinetic energy T , the range $R_M(T_M)$ of a charged particle of mass M , kinetic energy T_M , and charge ze is given by

$$R_M(T_M) = \frac{M}{z^2 m_p} R_p \left[\frac{m_p T_M}{M} \right] \quad [8 \text{ marks}]$$

- (c) In natural radioactive decay, ^{238}U may be said to decay to ^{206}Pb with a mean life of 6.48×10^9 years, while ^{235}U decays to ^{207}Pb with a mean life of 1.03×10^9 years.

In a certain sample of uranium-bearing rock the proportions of atoms of ^{238}U , ^{235}U , ^{206}Pb , ^{207}Pb were measured to be 1000 : 7.19 : 79.7 : 4.85. The rock contained a negligible amount of ^{208}Pb , usually the most common isotope of lead, indicating that all the lead in the rock came from uranium decay.

Estimate the age of the rock.

[8]

- (a) Mention three types of neutron sources and briefly describe how neutrons are produced in each case.

Neutrons do not interact with matter in the same way as charged particles do; explain why this is so, and describe briefly the type of interactions that neutrons may undergo. [9]

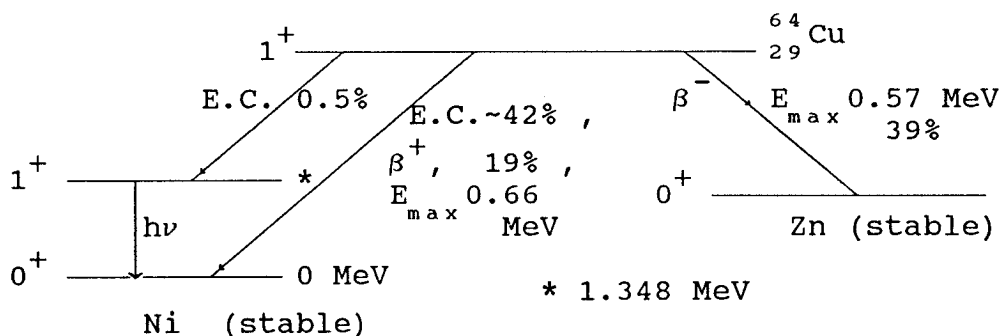
- (b) The cross section for the reaction $^{10}\text{B} + n \longrightarrow ^7\text{Li} + ^4\text{He}$ is $4 \times 10^3 \text{ b}$ at a certain energy and it is the only reaction that takes place.

Calculate the fraction of ^{10}B layer that disappears in a year in a flux of neutrons of $10^{15} \text{ n.m}^{-2}.\text{sec}^{-1}$? [8]

- (c) The decay scheme given here is for $^{64}_{29}\text{Cu}$ decaying to ^{64}Ni and/or ^{64}Zn :

(i) explain the meaning of the symbols and describe fully the particle and photon emissions that occur.

(ii) sketch, not to scale, separately the form of the electron/positron and photon energy spectra. [8]



- 5.(a) Distinguish between the radiative and collision losses in the interaction of fast electrons with matter indicating their relative importance as a function of electron energy and the nature of the absorber. [8]

- (b) Counters A and B are non-paralysable with dead-times of 50 and 120 micro-seconds respectively. At what true event rate will the dead-time losses in counter B be twice as those for counter A ? [9]

- 5.(c) An aluminium cylinder 5cm long is used in an experiment to measure the total neutron cross section with a well-collimated neutron beam. If the neutron detector registers 2500 counts/sec with the cylinder removed from the neutron beam, and 300 counts/sec with the cylinder inserted in the beam, calculate the total cross section of aluminium for these neutrons. [8]
- 6.(a) Write short notes on (i) relative efficiency, and (ii) energy resolution of a detector. [3 + 3]
- (b) Sketch the output response that one would expect from an "intermediate" size gamma ray detector in which all the three major interaction processes take place. Label the peaks and explain the features in the spectrum. [9]
- (c) The total time available to a certain counting experiment is 45 minutes. This time is to be sub-divided optimally between counting, (i) the source plus background, and (ii) the background alone. Find the optimal allocation of time that minimises the expected standard deviation in the net source counting rate. By what factor has the expected error been reduced in the optimal situation ?
- Given, a 20-minute count of source + background results in 1500 counts, and the background alone counted for 20 minutes gives a total of 150 counts. [10 marks]

-- End of examination --