UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2004 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMS

962	-	BIOGEOGRAPHY
BS 112	-	SYSTEMS BIOLOGY
BS 212	-	PLANT AND ANIMAL PHYSIOLOGY (PAPER I THEORY)
S 322	-	ECOLOGY PAPER II (PRACTICAL)
BS 332	-	ANIMAL PHYSIOLOGY PAPER II
BS 342	-	MYCOLOGY - PRACTICAL PAPER
BS 352		PARASITOLOGY- THEORY PAPER
BS 362		GENETICS - PAPER I
BS 375	-	INVERTEBRATE ZOOLOGY- THEORY PAPER
BS 435	-	MEDICAL MICROBIOLOGY PAPER II PRACTICAL
BS 442	-	ADVANCED MOLECULAR BIOLOGY II (DEC 2004)
BS 442	-	ADVANCED MOLECULAR BIOLOGY II (JAN 2005)
BS 455	-	WILDLIFE ECOLOGY (PAPER I THEORY)
BS 455	-	WILDLIFE ECOLOGY PAPER 2 PRACTICAL)
BS 925	-	TERRESTRIAL VERTEBRATE BIOLOGY PAPER 2 (PRACTICAL)
BS 925	-	TERRESTRIAL VERTEBRATE BIOLOGY PAPER 2 PRACTICAL)
C 102	-	INTRODUCTORY CHEMISTRY II
C 212	-	INTRODUCTORY BIOCHEMISTRY
C 252	-	ORGANIC CHEMISTRY II
C 265	-	PHYSICAL CHEMISTRY
C 312	-	DEFERRED EXAMS- JANUARY 2005
C 312	-	--
C 322	-	ANALYTICAL CHEMISTRY III
C 342	-	INORGANIC CHEMISTRY II
C 352	-	ORGANIC CHEMISTRY IV
CST 2012	-	PROGRAMMING II
CST 2032	-	FUNDAMENTALS OF COMPUTER ARCHITECTURE
CST 3022	-	PROGRAMMING LANGUAGE PARADIGMS
CST 3032	-	INTRODUCTION TO ARTIFICIAL INTELLIGENCE
CST 3062	-	ADVANCED DATABASES AND INFORMATION SYSTEMS
CST 3142	-	SOFTWARE ENGINEERING II
CST 3252	-	ELECTRONICS FOR COMPUTING II
CST 4252	-	ELECTRONICS FOR COMPUTING IV
GEO 111	-	INTRODUCTION TO HUMAN GEOGRAPHY I
GEO 155	-	INTRODUCTION TO PHYSICAL GEOGRAPHY
GEO 175	-	INTRODUCTION TO MAPPING TECHNIQUES PAPER II: THEORY
GEO 211	-	THE GEOGRAPHY OF AFRICA

GEO 271 - QUANTITATIVE TECHNIQUES IN GEOGRAPHY I
GEO 272 - QUANTITATIVE TECHNIQUES IN GEOGRAPHY II
GEO 272 - QUANTITATIVE TECHNIQUES IN GEOGRAPHY II FORMULARS
GEO 415 - SETTLEMENT GEOGRAPHY
GEO 472 - APPLIED GEOCHEMISTRY PAPER II- PRACTICAL
GEO 495 - ENVIRONMENTAL HAZARDS AND DISASTERS
GEO 912 - GEOGRAPHY OF MIGRATION AND REFUGEES
GEO 922 - GEOGRAPHY OF REGIONAL PLANNING AND DEVELOPMENT
GEO 932 - URBAN GEOGRAPHY
GEO 952 - GEOGRAPHICAL HYDROLOGY
GEO 972 - AIR PHOTOGRAPHY PRACTICAL
GEO 971 - AIR PHOTOGRAPHY
GEO 972 - SATELLITE REMOTE SENSING AND GIS
M 111 - MATHEMATICAL METHODS I
M 112 - MATHEMATICAL METHODS II A
M 112 - MATHEMATICAL METHODS II A
M 112 - MATHEMATICAL METHODS II A
M 114 - MATHEMATICAL METHODS II
M 162 - INTRODUCTION TO MATHEMATICS AND STATISTICS
M 211 - MATHEMATICAL METHODS III
M 212 - MATHEMATICAL METHODS IV
M 232 - REAL ANALYSIS II
M 292 - INTRODUCTION TO PROBABILITY
M 332 - REAL ANALYSIS IV
M 362 - LINEAL MODELS AND DESIGN ON EXPERIMENTS
M 412 - THEORY OF FUNCTIONS OF A COMPLEX VARIABLE
M 432 - ANALYSIS VI
M 462 - BAYESIAN INFERENCE AND DISCRETE ANALYSIS
M 465 - NON - PARAMETRIC METHODS
M 912 - MATHEMATICAL METHODS VI
P 192 - INTRODUCTORY PHYSICS II (OPTION A)
P 198 - INTRODUCTORY PHYSICS II (OPTION B)
P 212 - ATOMIC PHYSICS
P 272 - OPTICS
P 332 - STATISTICAL PHYSICS AND THERMODYNAMICS
P 342 - INTRODUCTORY DIGITAL ELECTRONICS
P 412 - NUCLEAR PHYSICS
P 422 - SOLID STATE PHYSICS II
P 442 - DIGITAL ELECTRONICS II
P 455 - QUANTUM MECHANICS II
P 485 - PHYSICS OF RENEWABLE ENERGY AND

Coll 4

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2004 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATION

962
BIOGEOGRAPHY

TIME : 3 hours

INSTRUCTIONS : Answer any four (4) questions
All questions carry equal marks

---

1. Write short explanatory notes on all of the following:

    a. Fire momentum
    b. Endemism
    c. Modes of dispersal
    d. Isolation
    e. Biomes

2. Analyse the statement by Cox and Moore (2000:70) that "the spatial and temporal separation of organisms, as well as the specialisation of groups within populations, can lead to the formation of new species and an increase in biodiversity".

3. Outline the biogeographical consequences of human activities in the world.

4. Discuss the impacts of past shifting of continents and climatic changes on the distribution of mammals and flowering plants on the continent today.

5. Describe the ways in which limiting factors influence the abundance and distribution of the plants and animals in the terrestrial ecosystems.

6. Imagine you are employed as a planning officer in the Ministry of Tourism, Environment and Natural Resources. You have been assigned the task of establishing a Natural Resources Conservation Area.

a. Explain how you can apply the principles of Island Biogeography Theory when designing the Natural Resources Conservation Area.
b. What are the limitations of the application of principles of Island Biogeography Theory to a Natural Resources Conservation Area?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

THE UNIVERSITY SECOND SEMESTER EXAMINATIONS JANUARY 2004

BS 222 FUNCTION, FORM AND DIVERSITY OF ANIMALS

THEORY PAPER

TIME: Three (3) Hours

Special Instructions

Answer a total **of six (6)** Questions. **Three** from Section A and **three** from Section B. All questions carry the equal marks

Answers for each Section should be in a **separate** Answer Book

SECTION A

Q1 a) What are the similarities and differences between Piries and the Dumbbell models on the origin of life?
b) How do theories on the origin of life link up with the theories on the origin of metazoa?

Q2 Describe the modes of reproduction observed in the phylum Protozoa.

Q3 Write brief notes on each of the following:
a) Food capture and digestion in the phylum Porifera.
b) Internal transport in Coelenterates.
c) Sensory reception in Platyhelminthes.
d) Excretion and osmo-regulation in Nematodes.
e) Locomotion in Annelides.

Q4 a) Briefly describe the characteristics of the sub-phyla of the phylum arthropoda.
b) Discuss the significance of the cuticle in the form and function of arthropods.

SECTION B

Q5 Define the following words and phrases as commonly used in the study of Chordates and vertebrates:

i) Hemicordata
ii) Placodermi
iii) Chelonia
iv) Ornithischia
v) Chiroptera
vi) Metametrical segmentation
vii) Amniotic egg
viii) Acrania
ix) Ratite
x) Stenophagous.

Q6 Using appropriate diagrams, describe functions of the following organs and structures in taxonomic groups indicated below:

i) Pharynx in Urochordates
ii) Gill slits in Chondrichthyes
iii) Swim-bladder in Osteichthyes
iv) Lungs in Amphibia; and
v) Rumen in Ungulates.

Q7 The Class Amphibia provides an important link in the evolution of vertebrates. Explain how the class Amphibia demonstrates relationships between the two groups of the Gnathostomata.

Q8 Discuss adaptation strategies to the environment demonstrated in the class Mammalia.

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FINAL EXAMINATIONS
JANUARY 2004.

BS 319 : BIOSTATISTICS.

TIME: THREE HOURS.

ANSWER: FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

---

1. **a. What are the essential features of a significance test?**

b. What is the central limit theorem, and why is it important?

c. What does the normal distribution look like, and why is it important?

d. What are the parameters of a t-distribution, and when must it be used Instead of a normal distribution?

2. The following 10 measurements of the length (cm) of the petiole of the second Youngest leaf on the Kafue weed (*Eichhornia crassipes* Solms-Laubach) were taken from 10 separate plants on two separate occasions (November 2000 and January 2001) at the Kafue Marina on the Kafue River. Test the N.H. that there was no significant growth in the length of the leaf petiole between the two dates:

November 2000: 33.20 30.10 23.45 23.50 22.20 30.70 32.70 27.50 32.10 27.00

January 2001 : 29.20 34.25 28.40 26.30 24.80 24.80 32.30 25.50 30.70 23.90

3. Mean soil temperature and germination interval (time in days between sowing and he appearance of the shoot/coleoptile above ground) for winter wheat during the 1981 –92 growing seasons are recorded below:

Mean soil temperature :	57	42	38	42	45	42	44	40	46	44	43	40
No. of days:	10	26	41	29	27	27	19	18	19	31	29	33

Obtain the regression equation of germination on mean soil temperature.

---

4. The following shows mean numbers of egg pods of the Armoured Ground Cricket that were collected from soils with different concentrations of Phosphorus element (mg/Kg).

Mean Egg Pod Number:	4.80	9.40	4.20	4.80	5.00	0	1.60	0.60
	4.60	6.80	1.80	2.20	1.80	1.60	1.80	0.60
Phosphorus:	5.81	30.94	8.26	14.11	2.42	3.50	2.14	12.53
(mg/Kg)	0	6.76	17.54	4.34	9.70	9.42	3.50	2.77

Calculate the correlation between mean number of egg pods and soil Phosphorus content and test the N.H. that rho equals zero.

5. Provide a summary of the (i). Location, (ii). Scatter, and (iii). Standard error of the mean of each of the following samples and then (iv). Test the equality of their scatters.

Sample A:

5, 3, 7, 5, 7, 5, I, 4, 2, 5,
8, 3, 6, 5, 7, 5, 8, 3, 6, 5,
9, 5, 5, 4, 2

Sample B:

3, 3, 7, 3, 3, 7, 7, 7, 3, 7,
3, 7, 3, 7, 7, 5, 3, 3, 7, 3,
7, 3, 3, 7, 7

6. An experiment to investigate the effect of winter-feeding on milk production uses a Latin Square Design. Four diets (A-D), in order of increasing starch equivalent, were each fed for four weeks to each cow. The yield of milk (in litres) of the cows in the study period are presented in the table below: Test the Null hypothesis that there are no significance differences in the diets given.

PERIOD	COW 1	COW 2	COW 3	COW 4
1	A = 192	B = 195	C = 292	D = 249
2	B = 190	D = 203	A = 218	C = 210
3	C = 214	A = 139	D = 245	B = 163
4	D = 221	C = 152	B = 204	A = 134

7. **Conduct an ANOVA on the following results of an experiment involving a completely randomized design**

REPLICATES	TREATMENTS			
	A	**B**	**C**	**D**
1	53	61	42	169
2	49	112	97	137
3	42	30	81	169
4	21	89	95	85
5	52	63	92	154

8. **Four different plant densities, A-D, are included in an experiment on the growth of lettuce. The experiment is laid out as a randomized block, and the same number of plants is harvested from each plot, giving the weights (Kg) recorded below. Examine whether density appears to affect yield. (It may be assumed that planting density increases in the order A, B, C, D).**

DENSITY	BLOCKS					
	I	**II**	**III**	**IV**	**V**	**VI**
A	2.7	2.6	3.1	3.0	2.5	3.0
B	3.0	2.8	3.1	3.2	2.8	3.1
C	3.3	3.3	3.5	3.4	3.0	3.2
D	3.2	3.0	3.3	3.2	3.0	3.1

END OF EXAMNINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – JANUARY 2004

BS322

ECOLOGY

(THEORY PAPER I)

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER QUESTION ONE AND FOUR OTHER QUESTIONS AND USE ILLUSTRATIONS WHEREVER POSSIBLE.

---

1. An *Isoberlinia angolensis* tree had 60 pods, each with 5 seeds with a mass of 10g per seed. Eighty percent of the seeds were destroyed by bruchid larvae at an infestation rate of 4 larvae per seed with each larva weighing 1.0g. Describe this trophic structure with the use of ecological pyramids and indicate their weaknesses.

2. Discuss the species concept from biodiversity and ecological perspectives

3. Communities A and B have 10 and 25 species, respectively, and 5 species are present in both communities. Using Sorensen's indix, discuss the similarity between the two communities

4. How have human activities affected the nitrogen cycle and what are their consequences on the environment.

5. How do deciduous savanna plants growing in oligotrophic soils reduce the loss of N and P to the ecosystem.

6. Determine and discuss the population growth of a flour beetle population grown in a bottle from the following data:

Day	0	7	14	21	28	35	42
Number of beetles	4	8	18	30	72	120	262

7. Discuss the Lotka-Volterra model in relation to inter-specific population interactions.

8. To what extent are the theories of facilitation and initial floristic composition similar in explaining secondary successions.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – JANUARY 2003
BS322

ECOLOGY

(PRACTICAL PAPER II)

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS AND USE ILLUSTRATIONS WHEREVER POSSIBLE.

---

1. Specimen A represents a plant that lives in a special habitat. Name the habitat and describe the adaptive features that the plant has. (20 marks)

2. Photographs B, C, D and E represent habitat types. Name the habitat represented by each photograph and indicate its distinguishing characteristics. (20 marks)

3. Illustrations F, G, H, I and J represent different life-forms. For each illustration, name the life-form that it represents and its distinguishing feature. (20 marks)

4. Illustrations K, L, M, N and O represent organisms that are adapted to specific habitat factors. For each illustration, name the habitat factor to which the organism(s) is/are adapted to. (20 marks)

5. Illustrations P, Q, R, S and T represent interactions between organisms and/or species. For each illustration, name the type of interaction that it represents and the effect of the interaction on the interacting organisms and/or species. (20 marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

JANUARY 2004

BS 332

ANIMAL PHYSIOLOGY

THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: Answer **FIVE** Questions.

---

1. (a) Define the term "Symbiosis". (4 marks)
   (b) Discuss the digestion of cellulose in a herbivore. (16 marks)

2. (a) What is a nephron? (4 marks)
   (b) Explain the role of the loop of Henle in the formation of urine in the mammalian kidney. (16 marks)

3. List the enzymes that are found in the small intestine of a mammal, their functions and place of origin. (20 marks)

4. Write briefly on each of the following:

   (a) Essential amino acid. (4 marks)
   (b) Uricotelic. (4 marks)
   (c) Glucostatic theory. (4 marks)
   (d) Relationship between body mass and oxygen consumption (O_2 liters Kg^{-1} hour $^{-1}$). (4 marks)
   (e) Acclimation to hypoxia. (4 marks)

5. State the functions of the following:

   (a) Growth hormone.
   (b) Insulin.
   (c) Thyroid hormone.

   (20 marks)

6. Explain why the hypothalamus is an endocrine organ. (20 marks)

7. (a) Describe the sequences of the cardiac cycle.
   (b) What is ECG? How is ECG recorded?

(20 marks)

8. (a) Define Osmoregulation.
   (b) Compare and contrast the mechanisms of osmoregulation in terrestrial and marine animals.

(20 marks)

End of Examination

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS
DECEMBER 2003

BS 342: MYCOLOGY
Theory Paper

ANSWER FIVE QUESTIONS
ALL QUESTIONS CARRY EQUAL MARKS

1. Give an overview of the classification of fungi. State one example for each class named and the ecological significance of it.

2. Describe in detail the structure of a fungal hypha. Explain how the hypha is structurally adapted for survival in its environment.

3. The growth rate of Saccharomyces cereviciae is monitored in a batch culture. Discuss by graphic illustration (hypothetical) the pattern of growth demonstrated by the fungus. State the advantages of using a batch culture in industry.

4. Give a brief account with examples of any three of the following topics:
   (i) appresoria formation
   (ii) sclerotia
   (iii) rhizomorphs
   (iv) mycelial strands

5. What is differentiation? Discuss the process of differentiation leading to the formation of sporangiospores, using the example of Saprolegnia spp.

6. What is a vesicle? Explain the various functions of vesicles in a fungal hypha. Discuss the various hypotheses that explain the movement of vesicles to the apex of a hypha.

7. What are the nutritional needs of a typical fungus? Discuss the metabolism of nitrogen and explain the significance of the element in the health of a fungus as illustrated by the knowledge gained in the laboratory.

8. Compare and contrast the nutrition of fungi and that of mammals. Why would you consider the fungi to be more primitive?

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATION

JANUARY 2004

BS 352 (I) PARASITOLOGY

TIME ALLOCATION: THREE (3) HOURS

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS

---

1. Discuss Host-Parasite relations, highlighting the various ways in which parasites depend on their hosts, and the different types of parasites and hosts.

2. Give an account of the life cycle of the malaria parasite. Why is it difficult to develop an effective vaccine for this parasite.

3. Compare and contrast
   a) Gambian sleeping sickness and Rhodesian sleeping sickness.
   b) Serological diagnosis and parasitological diagnosis of trypanosomiasis.
   c) Stable and Unstable malaria.

4. Describe the life cycle and transmission of *Strongiloides stecoralis.*

5. a)Differentiate between auto-infection and retro-infection as seen in helminths, giving examples.
   b) How is the endemicity of hookworm infections affected by environmental factors?
6. Give an account of the following:
   a) Life history of *Wuchereria bancrofti.*
   b) Patogenesis of *Trichinela spiralis.*

7. Discuss the Bionomics and ecology of *Glossina* tsetse flies in relation to trypanosomiasis in terms of vector behaviour, transmission and human exposure to infections.

8. Write short notes on each of the following:
   a) Structure of strobila in tapeworms.
   b)Why *Balantidium coli* infections thrive in malnourished individuals.
   c) Pathogenesis attributable to tick infestations.
   d) List the different modes of transmission of parasites to humans, giving examples.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGICAL SCIENCES

UNIVERSITY EXAMINATIONS – JANUARY 2004

BS 362 GENETICS

TIME: THREE HOURS

ANSWER: **FIVE** questions only. **Three should be from section A and two from section B**

All questions carry equal marks **MARKS**

SECTION A: ANSWER ANY THREE QUESTIONS

20

1.0 a) What are protoperithecia and trichogynes in fungal genetics?

b) A geneticist obtained the following ordered tetrad data from a cross with *Neurospora.*

Top of ascus				Number of tetrad
(1,2)	(3,4)	(5,6)	(7,8)	
A	A	a	a	61
a	a	A	A	55
a	A	a	A	40
A	a	A	a	44
				Total = 200

What is the distance between A and its centromere?

20

2.0 a) What are transposons?

b) What do you understand by transposon tagging?

c) Which of the following pairs of DNA sequences could qualify as target site duplications at the point of an IS50 insertion? (a) 5^1-AATTCGCGT-3^1 and 5^1-AATTCGCGT-3^1, (b) 5^1-AATTCGCGT-3^1 and 5^1-TGCGCTTAA-3^1, (c) 5^1-AATTCGCGT-3^1 and 5^1-TTAAGCGCA-3^1, (d) 5^1-AATTCGCGT-3^1 and 5^1-ACGCGAATT-3^1. explain.

20

3.0 A three-point transformation mapping experiment was done in *Bacillus* bacteria and the following results were obtained:

Donor: $a^+ b^+ c^+$

Recipient: $a^- b^- c^-$

	1	2	3	4	5	6	7
a:	-	-	+	-	+	+	+
b:	-	+	-	+	-	+	+
c:	+	-	-	+	+	-	+
Number	700	400	2600	3600	100	1200	12000
							Total = 20600

What is the gene order and the linkage distance between each pair of genes?

20

4.0 A karyotype analysis of root tip chromosomes of onion showed that in a population of onion plants some plants had chromosome **Number 3** showing the following sequences:

(a) 1 2 5 6 7 8
(b) 1 2 3 4 4 5 6 7 8
(c) 1 2 3 4 5 8 7 6

(i) What kind of chromosome change is present in each?
(ii) Illustrate diagramatically how these chromosomes would pair with a homologous chromosome No. 3 whose sequence is 1 2 3 4 5 6 7 8

20

5.0 a) Discuss how you would artificially produce auto and allopolyploids in higher plants.

b) Plant Cytotaxonomists have established that modern bread wheat resulted from crosses among primitive cereal plant species in the Middle East in its evolutionary development. This is explained by the fact that bread wheat comprises of three genomes, namely AA BB DD.

The three wild cereal species were:

Species 1: **AA** genome with haploid number of (n = 7) chromosomes

Species 2: **BB** genome with haploid number of (n = 7) chromosomes

Species 3: **DD** genome with haploid number of (n = 7) chromosomes

If you were asked to confirm this evolutionary path of bread wheat by artificial hybridization of the three species claimed by cytotaxonomists as being the wild relatives of wheat, illustrate how you would do that.

20

6.0 Shrunken endosperm of maize is governed by a recessive gene ***sh*** and waxy endosperm by another recessive ***wx***. Both of these loci are linked on chrosome 9. A plant which is heterozygous for a translocation involving chromosome 8 and 9 and which developed from a plump, starchy kernel is pollinated by a plant from a shrunken waxy kernel with normal chromosomes. The progeny is:

171 shrunken, starchy, normal ear
205 plump, waxy, semi-sterile ear
82 plump, starchy, normal ear
49 shrunken, waxy, semi-sterile ear
17 shrunken, starchy, semi-sterile ear
40 plump, waxy, normal ear
6 plump, starchy, semi-sterile ear
3 shrunken, waxy, normal ear

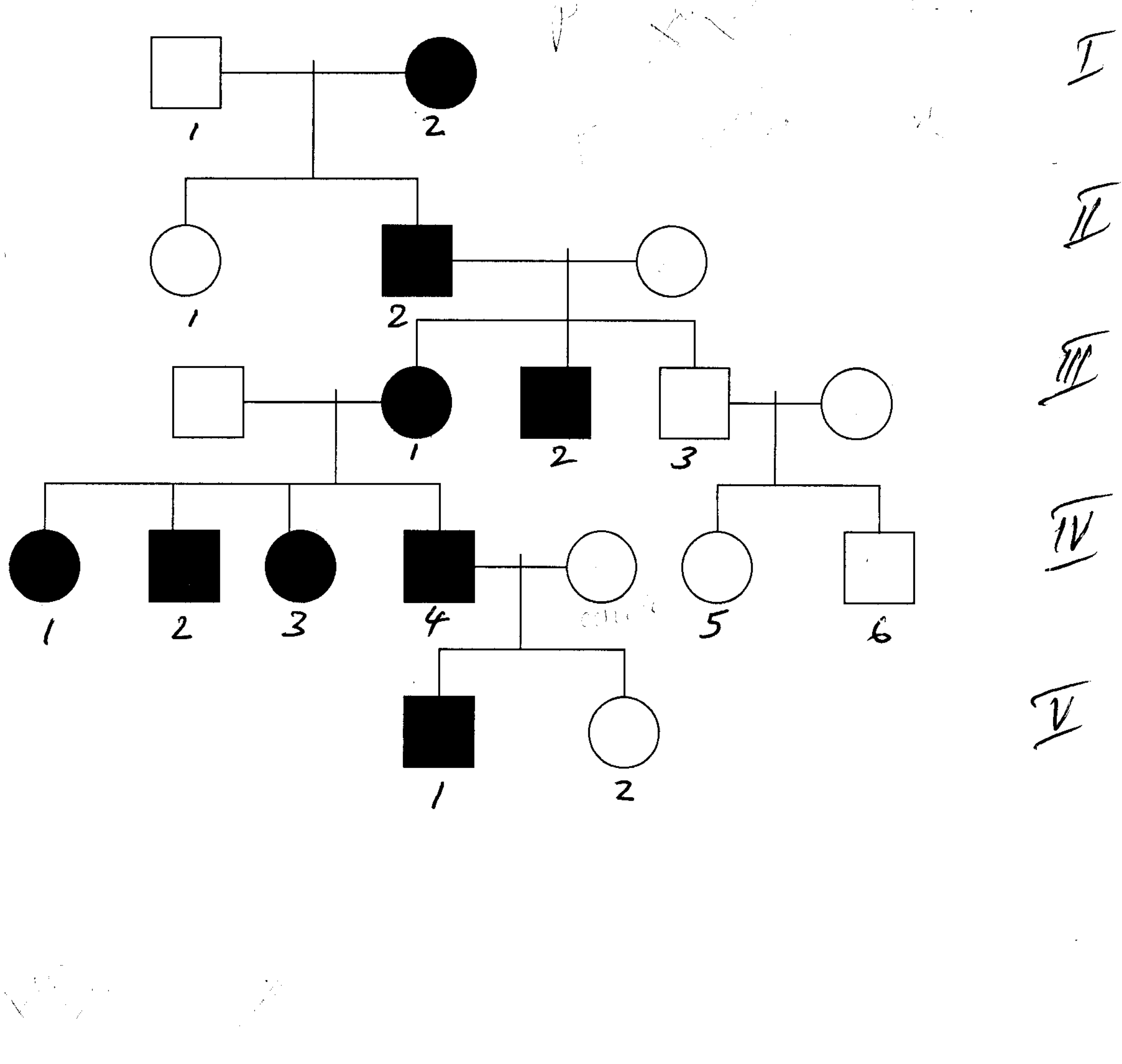
What is the distance between :
(i) *sh* and *wx* loci
(iii) wx and T
(iv) *sh* and T

NOTE: the point of translocation may be considered as agene because it produces a phenotypic effect of semi-sterility. The translocation would be designated by **T** while the wild type with no translocation can be designated by **t**

SECTION B: ANSWER ANY TWO QUESTIONS

20

7.0 In the accompanying pedigree of a rare human trait, determine which modes of inheritance are most probable, possible and impossible.



20

8.0 Robertson, A. in 1957, calculated the components of variance of two characters of *Drosophilla melanogaster* shown in the table below. The data was published in an article entitled "Optimum group size in progeny testing", in Biometrics Journal number 13, pages 442-50. Using this same data, estimate the dominance and epistatic components and calculate heritability estimates in the narrow and broad sense.

Variance Components	Thorax Length	Eggs laid in four days
V_{Ph}	100	100
V_A	43	18
V_E	51	38
$V_D + V_I$	?	?

20

9.0 a) The frequency of children homozygous for the recessive allele for cystic fibrosis is about one in twenty - five - hundred. What is the percentage of heterozygotes in this population? (8 Marks)

b) A particular recessive disorder is present in one in ten thousand individuals. If the population is in Hardy-Weinberg Equilibrium, what are the frequencies of the two alleles? (8 Marks)

c) What allelic frequencies will generate twice as many recessive homozygotes as heterozygotes? (4 Marks)

20

10.0 The following electropheretic data are from a sample of filed mice for their salivary amylase - 1 genotypes. The two alleles are *F* and *S*, for fast and slow migration in an electric field: *FF*, 43; *FS*, 54; and *SS*, 3. Is selection acting? What would you look for in data to determine among frequency - dependent selection, heterozygote advantage and transient polymorphism?

-------------------------END OF EXAMONATION GOOD LUCK----------------------------

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

JANUARY 2004

BS 432

ADVANCED PARASITOLOGY II

THEORY PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS: Answer **<u>FIVE</u>** **(5)** Questions only. One question from Section A, Two questions from Section B and Two questions from Section C. Answers for each section should be in a separate answer book.

All questions carry equal marks. Illustrations (diagrams, graphs and tables) may enhance the quality of your answer.

<u>SECTION A</u>

Q1. (a) Draw a parasitic cell structure and label its components.

(b) Explain why the nucleus is called the "Control Centre" of the cell.

(c) Describe the sites of the following:

(i) Protein synthesis.
(ii) Energy synthesis.

Q2. (a) State the functions of microvilli, cilia and flagella of parasitic cell.

(b) Discuss the functional changes in the tegument (the parasitic surface) during transformation of the Schistosome from Cercaria to Schistosomulum and eventually to adult worm.

SECTION B

Q3. How do parasites invade the host tissues? Indicate ways by which human malaria parasite invades red blood cells. Draw a diagram showing the process of invasion to support your answer.

Q4. Once a parasite has invaded the host's body, it migrates to the chosen target. Migration of parasites shows a high degree of site specificity within the host. Describe various types of migration and support your answer by drawing the process of migration.

Q5. How does a mediated diffusion contribute to nutrient up take by endoparasites from their hosts? Draw a schematic model which represent glucose transport across the biological membrane of such a parasite.

SECTION C

Q6. Differences in Folate metabolism in man and protozoa have led to the development of anti-malarial drugs. Discuss the mechanisms of action, therapeutic uses and adverse effects. Support your answer by drawing the tree diagram of folate inhibitors.

Q7. (a) Explain how parasite paralysis is achieved by neuromuscular blockers (NMP). Give examples of specific parasites in your answer.

(b) What is the drug of choice for tapeworm infections? State its side effect and its mode of action.

Q8. (a) Mention the three (3) available drugs that could be used in the treatment of sleeping sickness (Trypanosomiasis). State the mode of action of any of them and its relative toxicity.

(b) African sleeping sickness (Trypanosomiasis) is one of the major parasitic diseases. Explain the circumstances under which trypanosome parasite can avoid the immune responses of their hosts.

End of Examination.

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

JANUARY 2004

BS 435
MEDICAL MICROBIOLOGY
PAPER I- THEORY

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ANY SIX (6)** QUESTIONS.
WELL LABELLED DIAGRAMS AND TABLES MAY BE USED.
ALL QUESTIONS CARRY EQUAL MARKS.

Q1 The spread of drug resistant pathogens is one of the most serious threats to the successful treatment of microbial diseases. Discuss five ways by which bacteria become resistant to chemotherapeutic agents.

Q2 What is the mechanism of action of the following virulence factors (microbial products) that are involved in pathogen dissemination throughout the body?

(i) **Coagulase**: produced by *Staphylococcus aureus.*
(ii) **Hyaluronidase**: a product of groups A, B, C and G streptococci, staphylococci and clostridia.
(iii) **Haemolysins**: produced by Staphylococci, Streptococci, *Escherichia coli* and *Clostridium perfringens*?
(iv) **Exotoxin B**: produced by A streptococci and *Streptococcus pyogenes.*
(v) **Collagenase**: produced by clostridium species

Q3 What are the three categories of exotoxins? For each of the following exotoxins:

(i) Cholera toxin
(ii) Diphtheria toxin
(iii) Heat labile enterotoxins
(iv) Botulinum toxin
(v) Shiga toxin

State (a) the organism that secretes the toxin
(b) the genetic control of toxin production
(c) the biologic effect(s) of the toxin
(d) Category of the exotoxin

Q4 (i) Discuss the five ways (mechanisms) in which chemotherapeutic agents damage or kill bacterial pathogens. Give two examples of chemotherapeutic agents for each mechanism.
(ii) What are antimetabolites? Give two examples of antimicrobial drugs that use this mechanism.

Q5 (i) How does the indigenous microbiota establish defense of the host against infections? Consider the microbiota of the skin, the mouth, the intestines and the vagina. How do they become pathogenic?
(ii) Describe nosocomial infections. What two general sources are responsible for nosocomial infections? Give examples.

Q6 (a) Group and discuss the following mycoses:

(i) Cryptococcosis
(ii) Pneumocystis pneumonia
(iii) Tinea corporis
(iv) Tinea pedis
(v) Maduromycosis

(b) What characteristics aid in the identification of fungi? Explain.

Q7 (i) Name four techniques used in the diagnosis of viral infections and what do they detect? Give example of a viral disease detected by the methods listed.
(ii) Describe five pathological changes that result from infections by viruses?

Q8 (i) List and discuss five **bacterial** diseases of the lower digestive system. Indicate the causative agent, mode of transmission and treatment.
(ii) What is meant by the term O119:K14:H6 used for certain pathogenic strains of *Escherichia coli*?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

JANUARY 2004

BS 455
WILDLIFE ECOLOGY

PAPER ONE (THEORY)

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE (5)** QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY.

---

1. Discuss the meaning of the following terms as used in wildlife studies:

   (i) $1 - e^{-H}$
   (ii) Jolly – Seber method
   (iii) *Panthera pardus*
   (iv) *Numida meleagris*
   (v) Aldo Leopold

2. The energy available to, and utilize by, an animal can serve many different functions. Suppose a herd of Impala *(Aepyceros melampus)* consists of a juvenile, adult female and a male in a game sanctuary within a Mopane woodland habitat, how would their energy demand be partitioned over the course of the year. Detail the patterns of energy flow from the environment to these animals, showing those resulting in either positive or negative energy balance.

3. Describe the main characteristics of a wildlife habitat and relate these to the significance of the *Wetland* and *Acacia – Combretum* habitats in the conservation of wildlife species in Zambia.

4. A census of Oribi *(Ourebia ourebi)* in the east part of the Busanga plain gave initial capture of 75 animals which were marked and released, and in the second capture 358 animals were caught and of this capture 21 were recaptures; (a) Using the Lincoln – Petersen Index, calculate the populations of Oribi in the area, and (b) Discuss limitations of this method in assessing wildlife populations.

5. What are the problems associated with life in the arid zones and how do animals cope with these problems?

6. Explain the concept of carrying capacity in wildlife species populations as applied to a single population model, and discuss the assumptions and limitations associated with this model.

7. Briefly describe the protected area system in Zambia, and give reasons why populations of most wildlife species are declining.

8. Discuss the management application of the following terms as used in wildlife ecology:

   (i) Kidney / Fat Ratio Index
   (ii) Habitat evaluation and improvement

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

JANUARY 2004

BS 455
WILDLIFE ECOLOGY

PAPER TWO (PRACTICAL)

TIME: THREE HOURS

INSTRUCTIONS: QUESTIONS **ONE (1)** AND **TWO (2)** ARE **COMPULSORY.** ANSWER QUESTIONS **ONE (1)** AND **TWO (2)** AND THREE (3) OTHERS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY.

---

1. Study the specimens provided and answer the following questions.

Specimen A, Indicate:

(i) Class

(ii) Order

(iii) Family

(iv) Species

Specimen B, Indicate:

(i) Species

(ii) Sex

(iii) Habitat preference

(iv) Food habits

Specimen C, Indicate:

(i) Species

(ii) Breeding habits

(iii) Distribution in Zambia

(iv) Economic importance

Specimen D, Indicate:

(i) Order

(ii) Breeding habits

(iii) Dental formula

(iv) Conservation status

2. You are required to use the map provided to answer this question. Study the map carefully.

It is assumed that you have just completed an ecological study of the area, and from this study answer the following questions:

(i) Which habitats are important for the following species and why?

(a) Sitatunga *(tragelaphis spokei)*
(b) Zebra *(Equus burchelli)*
(c) Tsessebe *(Damaliscus lunatus)*
(d) Porcupine *(Hystrix africaeaustralis)*

(i) Describe the process which you might recommend in establishing this area as a wildlife sanctuary or a Protected Area within the community.

3. Zambezi - Samaki Farms Ltd is considering establishing a game ranch in the Choma District along the Munyeki stream. Initial investigations show that the

INFORMATION FOR QUESTION TWO (2)

THE MAP AND THE DESCRIPTION OF THE AREA:

Vegetation types:

A: Termitaria grassland

B: Munga woodland

C: Chipya woodland

D: Miombo woodland

E: Hyparrhenia grassland

F: Swamp

The area is located in the western part of Mpika District in Chief Chiundaponde, Northern Province of Zambia. Average annual rainfall is approximately 1300 mm. Lake Bakabaka is a fresh water lake, and has fish. The river is perennial with riparian vegetation mainly *Diospyros sp* and *Zyzygium sp.* The Hot spring is salty. There is only one village of about seven household (or about 40 people). Its main activity is fishing. Farming is done at a low scale in vegetation type E. Hunting is important.

The area is being considered for protection because of its importance to biodiversity. You have been asked to carry out an ecological study of the area. And from your study information, answer question two (2).

MAP FOR QUESTION 2

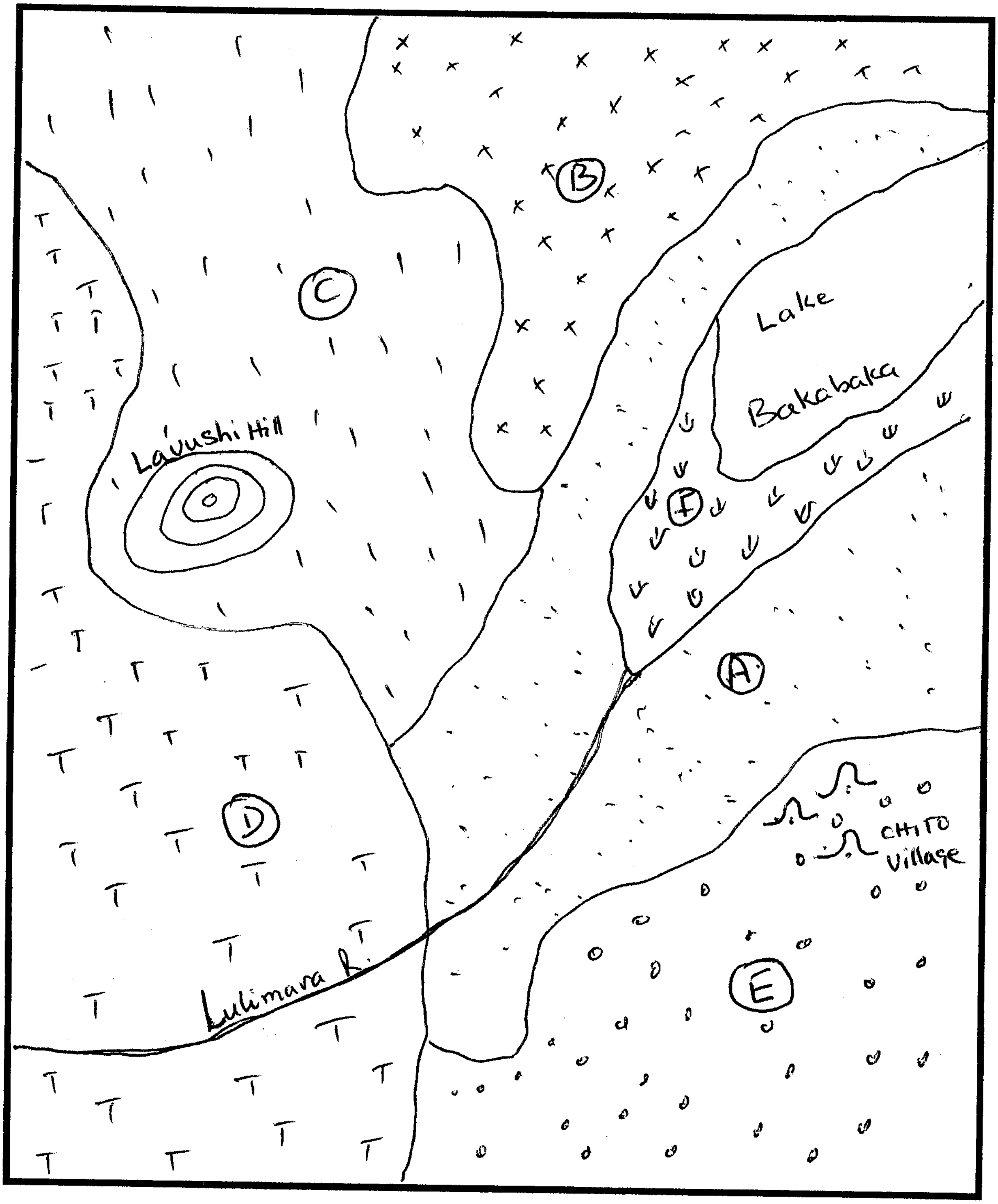
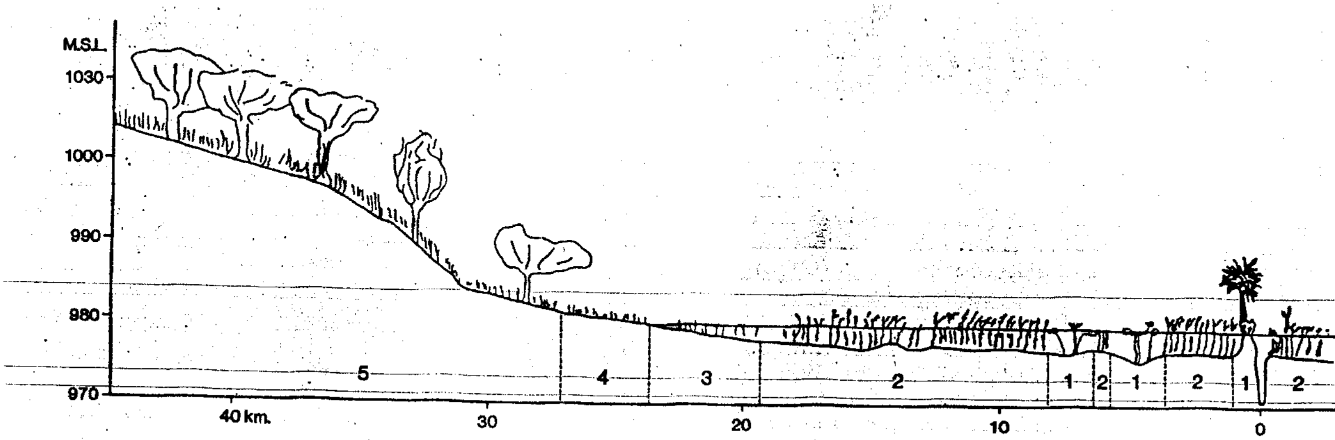


FIGURE FOR QUESTION 5



Schematic cross section of the Kafue river North Bank at Mutchabi, showing the major vegetation zones: 1. Levees and lagoons; 2. Tall grass floodplain grassland; 3. Water meadows; 4. Termitaria grasslands and 5. Woodland.

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

JANUARY 2004

BS 482
FOOD MICROBIOLOGY

TIME: THREE HOURS

INSTRUCTIONS: ANSWER QUESTIONS **1 TO 4** AND ONE OTHER.

Q1. Food Microbiology covers, food pathogens, food spoilage and food production. Discuss in detail each of these areas.

Q2. Classify the following foodborne diseases as either microbial intoxication or food infection. What foods are involved and how can the diseases be prevented?

1) Staphylococcus food poisoning.
2) Botulism.
3) Mushroom poisoning.
4) Cholera.
5) Salmonellosis – Typhoid fever.
6) Dysentery (Shigellosis)
7) *Clostridium perfringens* gastroenteritis.
8) *Bacillus cereus* gastroenteritis.
9) Enteropathogenic *E. coli* gastroenteritis.
10) Campylobacter gastroenteritis.

Q3. The major foodstuffs serve as good media for the growth of many different microorganisms.

(i) What are the effects of microbial growth on/in food? What factors influence microbial growth in/on food.

(ii) For the following foods give examples of the types of spoilage and microorganisms involved:

(a) Bread (b) Fresh meat (c) Concentrated orange juice
(d) Fresh fruit and vegetables (e) Milk

Q4. Compare the antimicrobial action of the following methods of food preservation: canning, low temperature, dehydration and increased osmotic pressure.

Q5. Discuss the following techniques of microbiological examination of foods. What is the purpose of each method?

(i) Conventional methods.
(ii) Enzyme linked immunosorbent assay (ELISA).
(iii) Membrane filtration.
(iv) Nucleic acid probes and polymerase chain reaction (PCR).

Q6. Identify and indicate function of microorganisms involved in:

1) Commercially manufactured buttermilk.
2) Starter culture in the curdling of milk during cheese manufacture.
3) Fermentation in the production of yoghurt.
4) Production of vinegar.
5) Production of wine, beer, ale, bread.

Q7. What physiological types of bacteria are most likely to be present when canned food spoils? State the type of spoilage, example of organisms: types of food products and signs of spoilage (can and contents of can).

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER EXAMINATION

JANUARY 2004

BS 492 – FISHERIES BIOLOGY – THEORY PAPER

TIME: THREE (3) HOURS

INSTRUCTION: Answer five questions and use illustrations wherever possible. All questions carry equal marks.

---

1. State the principles underlying the determination of individual age of fish in general, and, in particular, the problems encountered in doing so for fish in tropical regions.

2. Briefly describe the main phases of a fish cohort over its life span in an exploited population.

3. Explain the von Bertalanffy method for estimating the length-based von Bertalanffy growth parameters.

4. Explain the following terms as applied to fish stock assessment: (i) year-class; (ii) recruitment; (iii) absolute partial fecundity; (iv) fishery; (v) age-group.

5. Give and explain two methods that can be used to evaluate the food efficiency after ingestion of food by fish.

6. Give two indices that can be used to estimate the dietary similarity between two fish species.

7. In the fishery context, define a fish population and provide its main features.

8. Explain the principle, advantages and limitations of the Allen method to estimating the fish production. Then give the difference between fish production, ichtyomass and fish yield.

End of Examination. Good luck.

THE UNIVERSTY OF ZAMBIA

SECOND SEMESTER EXAMINATION

JANUARY 2004

BS 492: FISHERIES BIOLOGY – PRACTICAL PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS: answer two questions and use illustrations wherever possible. All questions carry equal marks.

---

1. The following table gives the frequency distribution of total length (cm) of a fish species.

TL (cm)	Number of fish
22	4
23	21
24	34
25	57
26	83
27	89
28	89
29	72
30	61
31	53
32	50
33	41
34	45
35	43
36	26
37	26
38	15
39	20
40	12
41	9
42	2
43	1
44	3
45	1
46	0
47	0
48	1

Plot the scatter diagrams and curves showing individuals of same age groups as obtained using the Battacharya method (Plotting curves by eye is not allowed; use appropriate statistical techniques, which are the basis of the Battacharya method).

2. The following table shows the age-at-length data of *Hydrocynus vittatus* of Lake Kariba, estimated by Kenmuir (1972).

Age (years)	Length (cm)
1	19.3
2	29.7
3	37.8
4	44.4
5	49.5
6	54.0
7	58.0
8	61.7
9	64.9

(i) Estimate the von Bertalanffy growth parameters using the Ford-Walford method.

(ii) Using the Pauly (1980)'s empirical equations, estimate the value of t_0 and of the growth performance Ø'.

(iii) Using the results of (i) and (ii) above, write the length-based von Bertalanffy growth equation for *H. vittatus* in Lake Kariba.

3. Sample the scales in the region around the pectoral fin of the fish species provided. To do this, use a pointed tweezers. Clean two or three scales with warm water and let them dry. Mount them "dry" and tightly bound them between two slides with scotch tape. Observe them under a dissecting microscope. Describe the scales and give the legend as appropriate.

End of examination. Good luck.

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

JANUARY 2004

BS 925
TERRESTRIAL VERTEBRATE BIOLOGY

PAPER TWO (PRACTICAL)

TIME: THREE HOURS

INSTRUCTIONS: ANSWER <u>ALL</u> QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY.

---

1. Complete each statement by answering the question for each specimen examined from A to T, and use the answer sheet provided.

SPECIMEN A:
a) Class
b) Family

SPECIMEN B:
Reproductive Habits:

SPECIMEN C:
a) Species
b) Habitat :

SPECIMEN D:
a) Genus
b) Species

SPECIMEN E:
a) Order
b) Family

SPECIMEN F:
a) Class
b) Species

SPECIMEN G:
Dental formula

SPECIMEN H:
Reproductive Habits:

SPECIMEN I:
Feeding Habits:

SPECIMEN J:

Species distribution in Zambia :

SPECIMEN K:

a) Suborder
b) Species

SPECIMEN L:

a) Class
b) Genus

SPECIMEN M:

Label structures indicated as (a) and (b)

SPECIMEN N:

Conservation status in Zambia:

SPECIMEN O:

a) Species
b) Economic importance

SPECIMEN P:

a) Family
b) Species

SPECIMEN Q:

a) Family
b)Genus

SPECIMEN R:

Field impression

SPECIMEN S:

a) Order
b) Family

SPECIMEN T;

Draw and label the main parts of this specimen

---

2. Describe a procedure used for the preservation of specimens of the following species:

(i) *Rousettus aegyptiacus*

(ii) *Mabuya varia*

(iii) *Anhinga rufa*

(iv) *Xenopus laevis*

3. Study the specimen provided and briefly construct a key which could be used for the identification of the species.

4. Define the following taxonomic characteristics as used in the identification of vertebrate species:

(i) Bill is spatulate
(ii) Toes are totipalmate
(iii) Carapace
(iv) Inguinal glands

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - SEMESTER II 2003

INTRODUCTORY CHEMISTRY II - C102

JANUARY 200

DURATION: Three (3) hours

INSTRUCTIONS TO THE CANDIDATES

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

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

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

Section **B** has five **(5)** long answer questions: **ATTEMPT ANY FOUR (4)**. (Total marks = **60**). Questions carry equal marks

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

DATA SHEET

PHYSICAL CONSTANTS

Avogadro's constant, N_A	$= 6.02 \times 10^{23}$ mol^{-1}
Speed of light, c	$= 2.998 \times 10^{8}$ m s^{-1}
Molar volume of gas at S.T.P	= 22.4 dm^3
Universal gas constant, R	= 8.314 J K^{-1} mol^{-1}
	= 0.0821 atm L K^{-1} mol^{-1}
	= 8.314 kPa L K^{-1} mol^{-1}

1 atm = 760 mmHg = 760 torr =101325 Pa = 101325 Nm^{-2}

1Å = 10^{-10} m

THE PERIODIC TABLE IS PRINTED AT THE BACK OF THIS PAGE

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number
X
Atomic mass
Name of the element X

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** .01 drogen																1 **H** 1.01 Hydrogen	2 **He** 4.00 Helium
3 **Li** .94 thium	4 **Be** 9.01 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
11 **Na** 3.00 dium	12 **Mg** 24.31 magnesium											13 **Al** 27.99 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
19 **K** 9.10 assium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.65 Copper	30 **Zn** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 71.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypto
37 **Rb** 5.47 bidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** 97.91 Technetium	44 **Ru** 101.07 Ruthenium	45 **Rh** 102.91 Rhodium	46 **Pd** 106.42 Palladium	47 **Ag** 107.87 Silver	48 **Cd** 112.41 Cadmium	49 **In** 114.82 Inidum	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 tellurium	53 **I** 126.90 Iodine	54 **Xe** 131.29 Xenon
55 **Cs** 32.91 aesium	56 **Ba** 137.33 Barium	57 – 71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.84 Tungsten	75 **Re** 186.21 Rhenium	76 **Os** 190.23 Osmium	77 **Ir** 192.22 Iridium	78 **Pt** 195.08 Platinum	79 **Au** 196.97 Gold	80 **Hg** 200.59 Mercury	81 **Tl** 204.38 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 208.98 Bismuth	84 **Po** 208.98 Polonium	85 **At** 209.99 Astatine	86 **Rn** 222.02 Radon
87 **Fr** 23.02) ancium	88 **Ra** 226.03 Radium	89 - 103	104 **Unq** 261.11	105 **Unp** 262.11	106 **unh** 263.12	107 **uns** 262.12	108 **Uno** 265.00	109 **Une** 265									

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

Department of Chemistry-UNZA

SECTION A: ANSWER ALL QUESTIONS

A1. (a) At 45°C, a plot of ln[N_2O_5] versus time for a certain reaction gives a slope of -6.18×10^{-4}. Calculate the half-life of N_2O_5 at 45°C.

(b) Consider a car fitted with a catalytic converter. The first few minutes after it started are the most polluting. Why?

A2. At 25°C, the pH of a 0.20 M solution of HF is 1.92. Determine the K_b for F^-.

A3. Calculate the number of grams of HI that are present at equilibrium with 1.25 mol of I and 63.5 g of iodine in a 5.00 L flask at 448°C.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad K_c = 50.2 \text{ at } 448°C$$

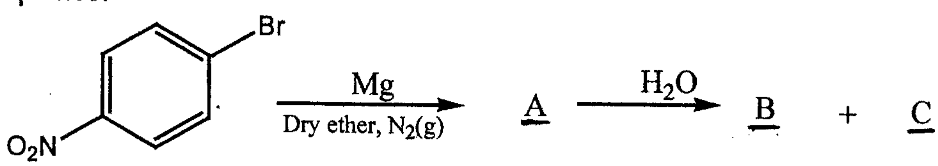
A4. (a) Explain why the ionization constant, K_a, for HI is larger than that for HF at the sam temperature.

(b) Which is a stronger base, $(CH_3)_3N$, $K_b = 7.4 \times 10^{-5}$ or H_3BO_3, $K_a = 5.8 \times 10^{-10}$? Explain.

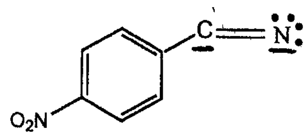
A5. If we shake a carbon dioxide fire extinguisher on a cool day (say 18°C), we can hear liqui CO_2 sloshing around inside the cylinder. However the same cylinder appears to contain no liquid on a hot summer day (say 35°C). Explain these observations.

A6. A sulfuric acid solution containing 200.1 g of H_2SO_4 in 0.3500 L of solution at 20°C has density of 1.3294 g/mL. Calculate the mole fraction of H_2SO_4 and the molality of th solution.

A7 Give molecular structures of the compounds **A**, **B**, and **C** in the following reactio sequence.



A8. Determine the formal charges on the underlined atoms in the molecular species shown below.



A9 Draw the **skeletal** structures for the carbonyl compounds represented by the molecular formula C_3H_6O and state the type of isomeric relationships existing in these compounds.

A10. (a) Draw the orbital pictures for ammonia, NH_3, and the molecular anion species, $\overset{-}{CH_3}$.

(b) State the similarities, if any, between the shapes of the two molecules.

SECTION B. ANSWER ANY FOUR (4) QUESTIONS

B1. (a) (i) Explain why third order reactions are uncommon?

(ii) The rate constants for the decomposition of acetaldehyde, CH_3CHO, to methane, CH_4, and carbon monoxide, CO, in the gas phase are 1.10×10^{-2} L $mol^{-1}s^{-1}$ at 703 K and 4.95 L $mol^{-1}s^{-1}$ at 865 K. Applying the concepts of the **graphical method**, Determine the activation energy for th decomposition. ***[NO GRAPH PAPER REQUIRED]***

(b) Calculate the concentrations of the solute species in 1.3×10^{-4} M (C_5H_5NH solution, K_b for $C_5H_5N = 1.7 \times 10^{-9}$.

B2. (a) For the reaction $Q \longrightarrow W + X$, the following data were obtained at 30°C.

[Q]	0.170	0.212	0.357
Rate	6.68×10^{-3}	1.04×10^{-2}	2.94×10^{-2}

Determine the rate constant of this reaction and state its units?

(b) Antimony pentachloride, $SbCl_5$, decomposes according to the following equation:

$$SbCl_5(g) \rightleftharpoons SbCl_3(g) + Cl_2(g)$$

An equilibrium mixture in a 5.00 L flask at 448°C contains $[SbCl_5] = 0.002575$ M, $[SbCl_3] = 0.008014$ M and $[Cl_2] = 0.008011$ M.

(i) State the type of equilibrium in the reaction.

(ii) Calculate the mass in grams of each species that will b found when the mixture is transferred into a 2.00 L flask at the sam temperature.

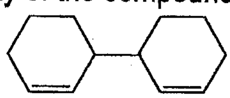
Tuque

B3. (a) An unknown metal is found to have a specific gravity of 10.200 at 25°C. It is foun to crystallize in a body-centered cubic lattice with a unit cell edge length of 3.147Å. Determine the atomic weight and identify the metal.

(b) Consider a solvent whose molar mass is 100.0 g/mol and whose vapour pressure at 25°C is 25 mmHg. 100.0 g of a solute whose molar mass is 50.00 g/mol is dissolved in 1.000 kg of that solvent. The solute is not an electrolyte. The vapour pressure of the pure solute is 0.01 mmHg at 25°C. What is the vapour pressure (in mmHg) of the solution at 25°C?

(c) Pepsin is an enzyme that catalyzes the metabolic cleavage of amino acid chains A solution of a 0.500 g sample of purified pepsin in 30.0 mL of benzene exhibits a osmotic pressure of 8.92 torr at 27.0°C. Estimate the molecular weight of pepsin.

B4 Cyclohexene reacted with bromine solution in the presence of a few drops of hydrogen peroxide, HOOH, in carbon tetrachloride as solvent to give a compound **E**, C_6H_9Br, traces of water and a small quantity of the compound **F**,



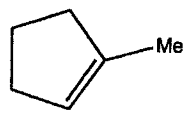
(a) Give the structure and the IUPAC name of the compound **E**.

(b) Using curved arrow notation, write the mechanisms of the reactions involved in the formation of the compound **E**.

(c) Show how your proposed reaction mechanisms can explain the formation of water and compound **F** in this reaction.

B5 (a) Write the synthesis for 2,4,6-trimethylheptane, using any monohalogen compoun containing six (6) carbon atoms or less as the only sources of carbon atoms. Stat clearly the reagents, including the solvents, and the reaction conditions needed fc each step of your synthesis.

(b) The polarity of iodine monochloride, I—Cl, is similar to the polarity of hydroge chloride, H—Cl. Basing on this fact, the reaction of 1-methylcyclopentene, structure shown below, with the polar reagent iodine monochloride at 25°C yielde two isomeric compounds **G,** and **H** of formula $C_6H_{10}ICl$.



1-methylcyclopentene

i) Give the structures and the IUPAC names for the compounds **G** and **H**.

ii) Using curved arrow notation, show all steps in the mechanism of this reaction.

THE END

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS SEMESTER II- JAN 2004

INTRODUCTORY BIOCHEMISTRY- C212

INSTRUCTIONS TO CANDIDATES:

WRITE YOUR COMPUTER NUMBER ON THE ANSWER BOOKLET

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

ANSWER ALL QUESTIONS IN SECTION **A** AND ANY FOUR **(4)** FROM SECTION **B.**

SECTION **A** CARRIES **40 MARKS** WHILE SECTION **B** CARRIES **60 MARKS.**

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

YOU ARE REQUIRED TO PRESENT YOUR WORK NEATLY AND ORDERLY.

SECTION A

ANSWER ALL QUESTIONS (10 MARKS EACH):

QUESTION A1

a) What is meant by the following terms?

i. Nucleotide (use adenine as an example)

ii. Quaternary structure of a protein

b) A sample of double stranded DNA was found to have guanylate as 29% of the nucleotid residues. What is the %AT of this DNA? [2, 8]

....

QUESTION A2

You isolated and purified a protein from the leg of a mouse. You found its molecular weight t be140.030 kilo Daltons.

a) Calculate the number of amino acid residues in the protein.

b) If 22% of the protein was alpha helical, calculate the length of this alpha helix in mm.

c) If the entire protein was an alpha helix, what will be its volume in cm^3 if its diameter was 15 Å? ($1Å=1x10^{-10}m$, mwt of an amino acid =110) [2, 5, 3

....

QUESTION A3

a) List the four layers of the digestive tract and describe their functions.

b) Draw a labeled diagram of a single villus from the small intestine showing clearly on the diagram where the brush border enzymes are secreted.

c) By using a simple diagram show how glucose is transported from the intestinal lumen int the body fluid.

[4, 3, 3

QUESTION A4

a) By which process does fluid leave the blood and enter the tissue fluid?

b) Which components of blood do not enter the tissue fluid?

c) Draw the structure of the porphin molecule

[2, 4, 4

SECTION B

ANSWER ANY FOUR QUESTONS (15 MARKS EACH):

QUESTION B1

a) What is the chemical explanation for the high heat of fusion of water (8.0 kcal mol^{-1}).Wha the biological significance of the large specific heat capacity of water (1.0 $calg^{-1}deg^{-1}$)?

b) Describe the preparation of 5 liters of a 0.3M acetate buffer, pH 4.47 starting from a 2.0M stock solution of acetic acid and a 2.5M stock solution of KOH.
(pKa of acetic acid = 4.77, mwt of KOH= 56.0g/mol, mwt of acetic acid =60.0g/mol and th of potassium acetate=98.0g/mol)

c) The buffer in part (b) was used as a solvent for the peptide of sequence: **Met-Arg-Cys-Lys-Gly.**

What would be the net charge on the peptide at the pH of the buffer (pH4.47)? If it was transferred to a buffer of pH 9.5 what would be its net charge?

d) Draw the predominant structure of the dipeptide **Met-Arg** at pH 9.5
(Met-pKa_2=9.2; Arg- pKa_1=2.2, pKa_R=12.5; Cys- pKa_R =8.2; Lys- pKa_R=10.5; Gly-pKa_1=2

[3, 3, 4,

QUESTION B2

The following data were recorded for the enzyme-catalyzed reaction S→P in the absence an presence of the inhibitor I.

[S] mM	V (without I) nmoles min^{-1}	V(with I) nmoles min^{-1}
0.200	16.67	6.25
0.250	20.00	7.69
0.333	24.98	10.00
0.500	33.33	14.29
2.000	66.67	40.00
2.500	71.40	45.45
3.333	76.92	52.63
4.000	80.00	57.14
5.000	83.33	62.50

a) Estimate V_{max} and K_m

b) What type of inhibitor is I?

[7.5, 7.5

QUESTION B3

The standard enthalpy of combustion of ethanol (C_2H_5OH) at 25°C and 1 atm pressure is -328,000 cal/mole and that of acetaldehyde (CH_3CHO) is -279,000 cal/mole.

$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ H= -328,000 cal/mole
$CH_3CHO + 2½O_2 \rightarrow 2CO_2 + 2H_2O$ H= -279,000 cal/mole

Given that $\Delta E_o'$ of the oxidation of ethanol to acetaldehyde is +1.02 V, F=23.063 kcal/V/mol a n=2, calculate

i. ΔH

ii. $\Delta G'$ and

iii. ΔS for the reaction: $C_2H_5OH + ½O_2 \rightarrow CH_3CHO + H_2O$

[5, 5, 5]

QUESTION B4

a) An unknown trisaccharide was isolated from the duodenum of a fresh water fish. The monomeric units were shown to be linked by α- glycosidic bonds. Exhaustive methylation the trisaccharide with DMS and acid hydrolysis at 100°C, yielded a **1:1:1**ratio of 2,3,4,6-tetra methyl galactose ,2,4,6-trimethyl glucose and 2,3,6-trimethylglucose . Using Hawort structures draw the probable structure of the trisaccharide showing clearly the linkage between the sugars.

b) On hydrolysis a compound **X** gave the following products: glycerol, palmitoleic acid, palm acid and an inorganic phosphate .The compound **X**, which was extractable into a hexane/methanol mixture, was also observed to be optically active. Draw the possible structure(s) of compound **X**.

[9, 6]

QUESTION B5

a) What is the difference between fibrin and fibrinogen?

b) Explain the entire blood clotting mechanism. Illustrate your answer with chemical reactio

c) Give reasons why blood clotting does not take place in hemophiliacs.

[3, 9, 3

QUESTION B6

a) The table below refers to some enzymes involved in the digestion of carbohydrates in the human digestive system.
Copy and complete the table by writing the correct word(s) for the site of secretion. For products of reaction, draw the respective chemical structures.

Name of enzyme	Site of secretion	Products of reaction
Lactase		
Sucrase		
Maltase		

b) Amylase is secreted into the lumen of the gut, but maltase is attached to the surface of th epithelial cells. Illustrate the importance of this difference.

c) Starch and cellulose are high molecular weight polysaccharides.

i. Which hexose sugar forms their basic unit?

ii. What is the essential structural difference between starch and cellulose?

iii. What happens to ingested cellulose in humans? Why?

[9, 3, 3]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY SEMESTER II 2003 EXAMINATIONS

ORGANIC CHEMISTRY II – C252

JANUARY 2004

TIME ALLOWED: THREE (3) HOURS.

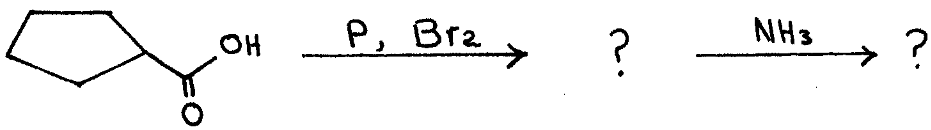
INSTRUCTIONS:

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

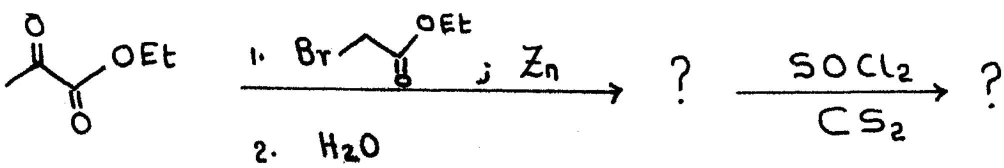
QUESTION ONE.

Predict the major organic product(s) and give the mechanisms for the following reactions:

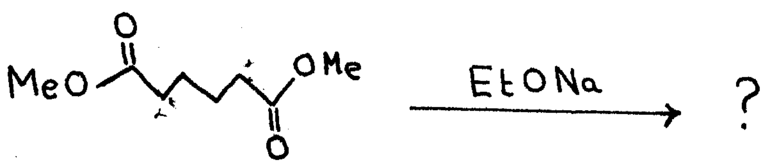
i)



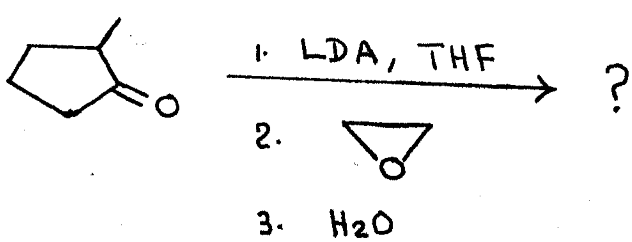
ii)



iii)



iv)



QUESTION TWO.

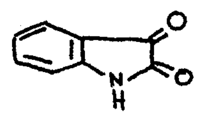
(a) Phenylglyoxal, C_6H_5COCHO, is converted by aqueous potassium hydroxide into potassium mandalate, $C_6H_5CHOHCOOK$. Suggest a likely mechanism for this conversion.

11 marks

(b) Esters can be condensed with aromatic aldehydes in the presence of alkoxides to give α,β-unsaturated esters. For example, benzaldehyde and ethylacetate, CH_3COOEt, in the presence of potassium tert-butoxide give ethyl-3-phenylpropenoate, $C_6H_5CH{=}CHCOOEt$. Show all the steps in the mostly likely mechanism for this reaction.

11 marks

(c) An anti-viral drug **A**, $C_9H_8N_4S$, was synthesized by refluxing a mixture of isatin, structure shown below, and thiosemicarbazide, $S{=}C(NH_2)\text{-}NHNH_2$, in ethanol in the presence of traces of concentrated sulfuric acid.



Isatin

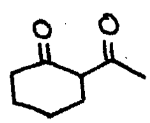
i) Deduce the structure for the antiviral drug **A**

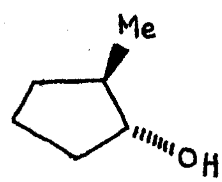
ii) Give the mechanism for this reaction.

8 marks

QUESTION THREE.

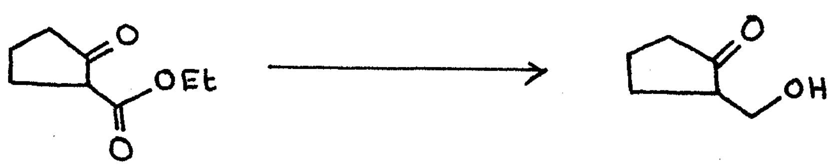
a) Propose a synthesis of the following compounds from alcohols of six carbon atoms or fewer, using any other needed laboratory reagents. State the reagents and the reaction conditions for each step of your synthesis. **(Reaction mechanisms are not required to be shown)**

i) 

ii) 

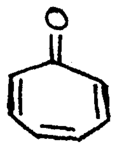
14marks

b) Show clearly how the following transformation may be achieved in three steps. State clearly the reagents that are needed, including the solvents, if any, and show the products of each step.

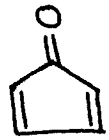


9 marks

c) Cycloheptatrienone, structure shown, is a very stable compound, but cyclopentadienone, structure shown, is so reactive that it exists only for few seconds as an intermediate during a reaction. Basing on this information, comment briefly on the different stabilities of the two molecules.



Cycloheptatrienone

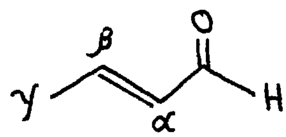


Cyclopentadienone

7 marks

QUESTION FOUR.

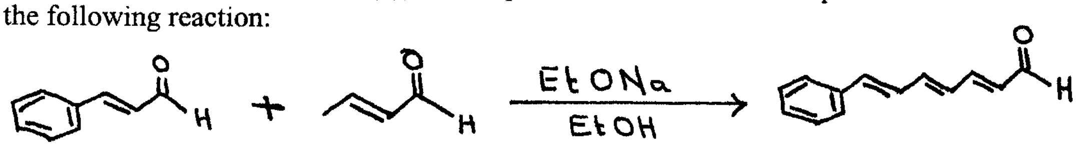
a) The hydrogen atoms of the γ-carbon of crotonaldehyde, structure shown below, are appreciably acidic, $K_a=10^{-20}$



Crotonaldehyde

i) Write the resonance structures that will explain this fact in an alkaline medium.

ii) Based on the information in 4(a)(i) above, provide the mechanistic explanation for the following reaction:



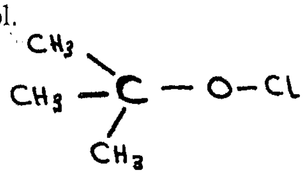
Cinnamaldehyde

12 marks

b) Suggest how would you prepare propene from 1-butanol in a laboratory, clearly showing the reagents that you would need and state the reaction conditions?

10 marks

c) Allylic chlorination is sometimes accomplished by the use of a chlorination reagent, **B**, structure shown below, which is prepared by passing chlorine gas into an alkaline solution of tert-butyl alcohol.



Reagent, **B**

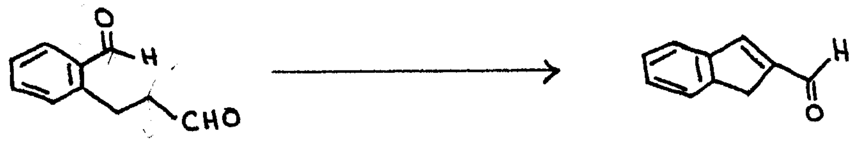
Write a reasonable mechanism for the chlorination of trans-4,4-dimethyl-2-pentene at -78^0C, using the chlorination reagent, **B**, and clearly show the configuration of the product(s). Give the major product and state your reasoning.

8 marks

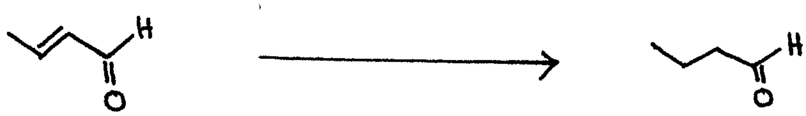
QUESTION FIVE.

State the reagents and the reaction conditions for the following reactions: **(Reaction mechanisms are not required to be shown)**

a) (i)

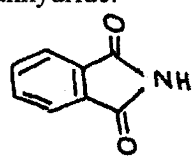


(ii)



8 marks

b) Phthalimide, structure shown, used in the Gabriel synthesis, is prepared by the reaction of ammonia with phthalic anhydride.



Phthalimide

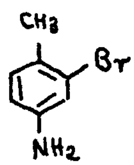
i) Propose a reaction mechanism for this synthesis.

ii) When phthalimide obtained in 5(b)(i) above is treated with isopropyl iodide in the presence of aqueous potassium hydroxide, what product would you expect to obtain? Suggest the mechanism for this reaction.

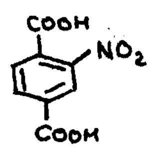
14marks

c) Outline the methods for the preparation of the following compounds in a reasonably pure state and good yield from benzene by electrophilic substitution.

i)



ii)



8 marks

END OF EXAM

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY
SEMESTER II, 2003
PHYSICAL CHEMISTRY C265

TIME: 3 Hour

Instructions:

This question paper is divided in two sections **A (55%)** & **B (45%)**. Answer **all questions** in section A and section B.
Answer Section A and B in **separate answer booklets.**

Constants:
R= 8.314 $Jmol^{-1} K^{-1}$, h= 6.63 x 10^{-34}Js, N = 6.02 x 10^{23} mol^{-1},
Boltzmann constant= 1.381 x $10^{-23}JK^{-1}$, 1 mass unit = 1.6605 x 10^{-27} kg.
[Caesium = 132.9, lead = 207, Iodine = 127, Oxygen = 16]

Standard electrode potentials:

$Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$ −0.13 E°/V

$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$ +0.34 E°/V

Section A

A1. (a) Consider a hypothetical mechanism for the reaction of A and B to give C & D.

$$A \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} D + M$$

$$B + M \xrightarrow{K_2} C$$

Where M is a reactive intermediate.

(i) Write an expression for the net rate of change in concentration of each species A, M, B, C and D.

(ii) Derive an expression for the concentration of M in terms of A, B and D.

(iii) If concentration of M is in steady state derive an expression for the rate of formation of C.

(b) The thermal isomerization of bicyclo [2, 1] pent-2-ene is a unimolecular reaction with

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Computer Studies

CST3021 **Introduction to Database and File Systems** **Academic year 2003 Semester II**

Prof. Jan Broeckx **Examination Questions** **Time allocated: 3 hours**

There are **2 groups of questions** and one compulsory question (question 2). You have to answer question 2 and **one question from each of the two groups**.

GROUP 1: DATABASE ENVIRONMENT AND THE RELATIONAL MODEL.

Answer either question 1A or 1B. Each of them has 30% weight in the final mark.

Question 1A: Relational Model.

1A-1 Define and explain each of the following terms: relation, attribute, domain, tuple, degree, cardinality, relational database, relation schema, relation instance, relational database schema.
1A-2 Define the two principal integrity rules for the relational model, and explain why they are needed.

Question 1B: Three-level ANSI-SPARC Architecture.

1B-1 Describe the 3-level ANSI-SPARC architecture, and explain the nature of each of the three levels (conceptual level, internal level, external level). Give a simple example.
1B-2 Discuss what is meant by logical data independence and by physical data independence, and how this is achieved in the 3-level ANSI-SPARC model. Why is this data independence desirable?

QUESTION 2: RELATIONAL ALGEBRA, TUPLE RELATIONAL CALCULUS, SQL QUERIES

Question 2 is compulsory. It has 40% weight in the final mark.

The question refers to the "Company" database used during the practicals (see attached sheet):

Question 2:

For each of the three following English language queries, produce
- a relational algebra expression
- a tuple relational calculus expression
- an SQL query

2-1 List department number and department name for all departments having a location at "Houston".
2-2 List the first name, last name and salary of all employees from the "Research" department.
2-3 List the SSN, first name and last name of <u>all</u> employees together with the first name and relationship of their dependents. The list should include all employees, whether they have dependents or not. If an employee has several dependents, the list should include one line for each of them.

2-4 Produce an SQL query for the following English language query: "Produce a list of the first names and last names of all employees with for each of them the number of dependents. If an employee has no dependents, the number of dependents should be 0 (not blank or null) The list should be ordered alphabetically according to the last names."

$\log k(s) = 14.21 - 112\theta^{-1}$ Where $\theta^{-1} = 2.303\ RT$ kJmol^{-1}.

What is the Arrhenius activation energy, E_a.

(c) A sample of caesium is heated to 500°C in an oven. In one wall there is a small hole. Some atoms emerge to form an atomic beam. Calculate their average velocity?

A2. (a) When an acid, HP, is dissolved in water following two equilibriums are set up.

$$HP_{(s)} \rightleftharpoons HP_{(solution)}$$

$$HP_{(solution)} + H_2O \rightleftharpoons H_3O^+ + P^-$$

Show that $pH = pK_a - \log[(S-S_o)/S_o]$

Where $S = [HP_{(solution)}] + [P^-]$ and $S_o = [HP_{(solution)}]$.

(b) The solubility of lead iodate $[Pb(IO_3)_2]$ in water at 25 ^{0}C is 4.00×10^{-5} mol dm^{-3} and the K_{sp} is 5.00×10^{-13} in aqueous KNO_3 solution.

Calculate

(i) The solubility product

(ii) Mean activity coefficient of the electrolyte

(iii) The solubility in KNO_3 solution.

A3. Following data have been given for the dissociation of water vapour in 1 dm^3 vessel, according to the reaction

$$H_2O_{(g)} \rightleftharpoons H_{2(g)} + \tfrac{1}{2} O_{2(g)}.$$

T /K	1300	1500	1705	2155	2257	2300
Dissociation %	0.0027	0.02	0.102	1.18	1.77	2.60

(a) Calculate the equilibrium constant at various temperature.

(b) Plot ln K verses 1/T. From the graph calculate enthalpy change of reaction in this temperature range.

SECTION B

B1. (a) A monatomic gas at 298 K and a pressure of 5 atm is expanded to a final pressure of 1 atm: (1) isothermally and reversibly; (2) isothermally against a constant pressure of 1 atm.

Calculate for each of these expansions

(i) final temperature of the gas;
(ii) q, heat absorbed for the gas;
(iii) w, the work done on the gas;
(iv) ΔU, the increase in the internal energy of the gas;
(v) ΔH, the enthalpy of the gas.

(b) From a thermodynamics point of view explain (briefly) why the denatured state of a protein is a more favoured state and how the native protein remains stable.

B2 (a) You decided to build a cell from lead and copper half-cells.

(i) Which is the negative half-cell?
(ii) Draw a diagram of the cell.
(iii) Write the overall cell reaction in two ways, the first showing the direction that the reaction takes, and the second as an equilibrium reaction.

(b) A student said that under standard conditions the reaction $\Delta G°(Cd^{2+}) = -77.6$ kJ mol^{-1} and $\Delta G°(Cr^{3+}) = -204.9$ kJ mol^{-1}.

$$2Cr^{3+}(aq) + 3Cd(s) \rightarrow 2Cr(s) + 3Cd^{2+}(aq)$$

would take place at 298 K.

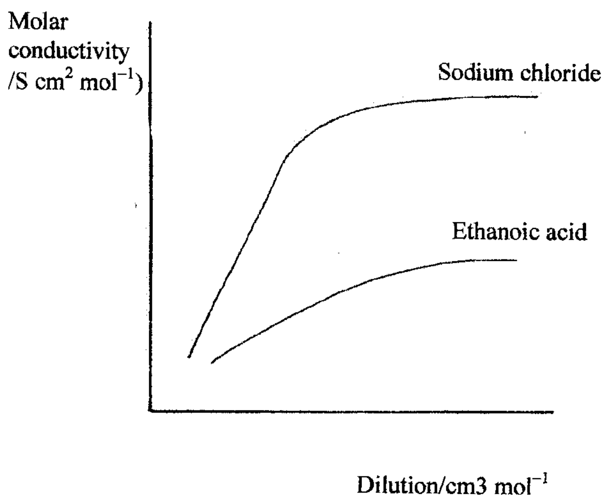
(i) Explain why the student was wrong.
(ii) Having realized the error, the student wrote down the reaction showing the correct direction

$$2Cr(s) + 3Cd^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 3Cd(s)$$

(iii) Calculate ΔG, the number of moles of electrons transferred in the reaction and E° for cell used in the reaction.

(iv) Calculate E° given $E°_{Cd^{2+}/Cd} = -0.40$ V and $E°_{Cr^{3+}/Cr} = -0.74$ V. How do the two results compare?

B3 (a) The diagram below shows a variation molar conductivity versus dilution for a strong electrolyte (NaCl) and weak electrolyte (ethanoic acid). Explain in brief the behaviour observed in the graph.



(b) The limiting molar conductivities (in Ω^{-1} m^2 mol^{-1}) of aqueous sodium propionate, sodium chloride and hydrochloric acid are 0.859×10^{-2}, 1.264×10^{-2} and 4.261×10^{-2}. Calculate the limiting molar conductivity of aqueous propionic acid at this temperature.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – January 2003

C312

TIME: THREE HOURS.

ANSWER QUESTIONS AS INDICATED IN BOTH SECTIONS A AND B. ALL QUESTIONS ARE OF EQUAL VALUE. SEPARATE YOUR ANSWERS FOR SECTION A QUESTIONS AND SECTION B QUESTIONS INTO DIFFERENT ANSWER BOOKLETS.

SECTION A. Enzymes, Catalysis, Purine-Pyrimidine Biosynthesis, DNA, RNA, Protein Synthesis. Answer **three questions** in this section.

1. A. How does an enzyme catalyze a reaction?

   B. Describe in detail the specific mechanism by which either lysozyme or chymotrypsin catalyzes a reaction. Include in your description the nature and function of important catalytic residues.

2. A. Show the specific reactions and enzymes that are responsible for the biosynthesis of either the purines (A & G) or the pyrimidines (C & U). You may use a black box as directed as long as you show the ring structure in the box and indicate the source of all ring atoms.

   B. Show the control points in the pathways you drew. Indicate on the pathway diagram which enzymes are affected by what molecules.

3. A. Our species, and all species, are critically dependent upon molecular mechanisms that ensure fidelity in the duplication and use of the information stored in our genome. Describe in detail the enzymes and processes that ensure fidelity.

   B. In which of the processes described in Part A would a mistake likely have the most significant consequences for the organism? Which process would potentially have the least significant consequences should a mistake occur? Defend your answers.

4. A. What is the Hanus number for a 0.45 g lipid sample that was analyzed using standard procedures resulting in the following values:

Blank titration:	13.5 ml $S_2O_3^{-2}$
Sample titration:	7.3 ml $S_2O_3^{-2}$
$S_2O_3^{-2}$ concentration:	0.097 M
I_2 molar mass:	253.8 g mole^{-1}

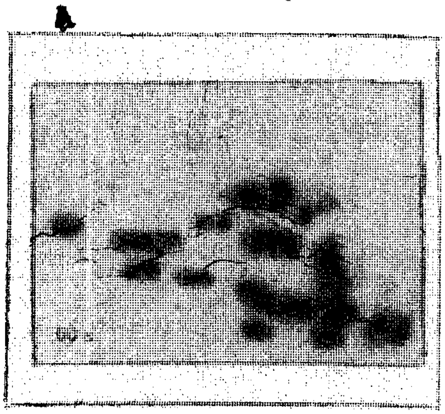
   B. If this sample was a simple mixture of oleic (16:1) and stearic (18:0) acids what would be the mole ratio of the two fatty acids in the sample?

SECTION B. Photosynthesis, Lipid Metabolism, Amino Acid Metabolism. Answer **three questions** in this section, and put your answers in a separate answer booklet from that used to answer the Section A questions above.

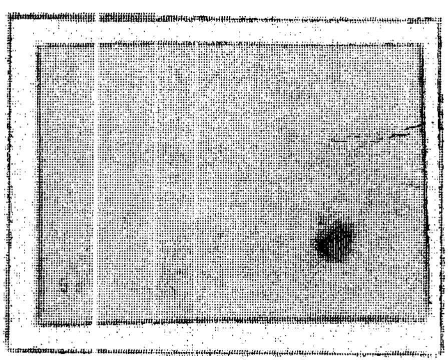
√ 1. A. Photosynthesis is the reverse of aerobic respiration. What are your comments on this statement?

B. Compare the two processes using the following:
   i. Raw materials
   ii. End products
   iii. Which cells have these processes
   iv. Organelles involved
   v. Pathways of energy

2. A. Calvin investigated the pathway by which carbon dioxide is converted to organic compounds during photosynthesis. He used *Chorella* alga and radioactive ^{14}C to trace the fate of CO_2. He homogenized the killed algal cells and carried out two-way paper chromatography to detect the earliest intermediate component produced during photosynthesis. The diagram below shows the chromatograms he obtained. The spots are those containing radioactive compounds.



After 60 seconds



After 5 seconds

i. Name the compound present in each spot on the chromatogram.
ii. Which enzyme catalyzed the reaction to form the first detectable radioactive compound?
iii. Name the stage of photosynthesis that produces oxygen.
iv. Why was it necessary for the algal cells to be killed very quickly?

B. Explain how ATP is produced in photosynthesis according to the chemiosmotic model.

3. A.

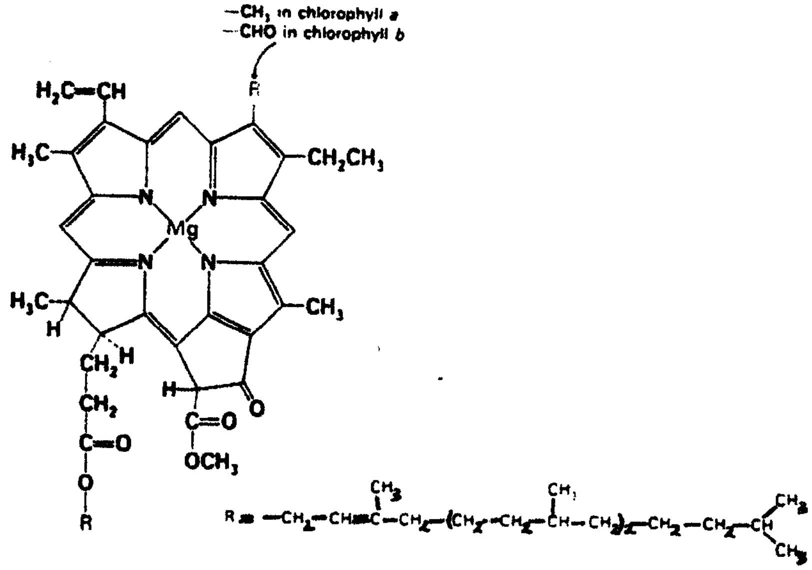


Figure 1. Chlorophyll a and b.

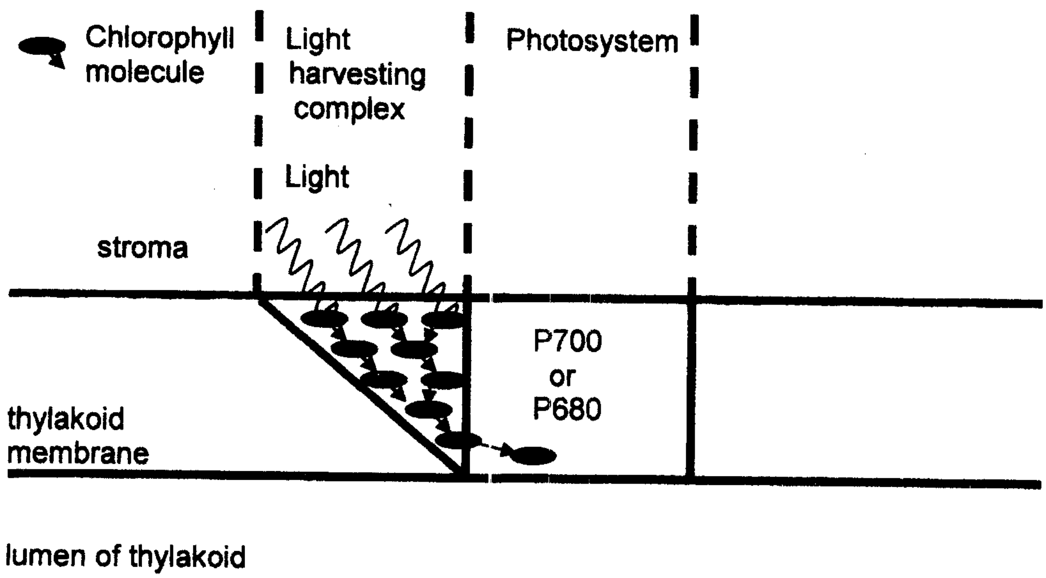


Figure 2. The light harvesting complex.

Chlorophyll a is found in all plants. The structure of chlorophyll a is shown in Figure 1. The structure of a light harvesting complex is shown in Figure 2. At the base of the funnel-like structure is a photosystem. The chlorophyll molecules in the light harvesting complex collect light energy and feed it to the chlorophyll molecules in the photosystem.

i. Look at the structure of chlorophyll a (Figure 1). What part of the chlorophyll molecule anchors the molecule in the membrane and why?

ii. Light energy is aborbed by the chlorophyll molecules. How do chlorophyll molecules give out the energy they have absorbed?

iii. What are the names of the two photosystems that are found at the base of the light harvesting complexes?

iv. Why do the many chlorophyll molecules found in a light harvesting complex all feed into a single photosystem?

B. Distinguish between non-cyclic and cyclic photo~~respiration~~. phosphorylation

4. Discuss how the C_4 pathway increases the effectiveness of the Calvin cycle in certain types of plants.

5. A. Show the specific reactions and enzymes that are responsible for amino acids degradation.

B. i. Classify lipids and explain how a triglyceride is formed.
ii. What is a phospholipid?
iii. List three specific uses of phospholipids.

END OF C312 EXAM

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER II EXAMINATION

JANUARY 2004

C322 - ELECTROCHEMICAL- CHROMATOGRAPHY

INSTRUCTIONS : Three(3) Hours

TIME ALLOWED: Answer any four questions

---

1. (a) Explain the principle of potentiometric titration method.

   (b) Explain the differences found in potentiometric, amperometric and coulometric titrations respectively.

   (c) Define back-emf-, overpotential, overvoltage, concentration polarization and IR drop.

   (d) Differentiate between an electrode of the first kind and the electrode of the second kind respectively.

   (e) Explain principle of the glass electrode.
   (i) Explain acid and alkaline error in glass electrode respectively.
   (ii) Explain asymmetry potential in glass electrode.

   (f) Nickel is to be deposited from a solution that is 0.20M in Ni^{2+} and buffered to pH 2.00. Oxygen is evolved at a partial pressure of 1.00 atm, at a platinum anode. The cell has a resistance of 3.15 Ω; the temperature is 25°C. Calculate:

   (i) the thermodynamic potential needed to initiate the deposition of nickel. [E^o = - 0.25V]
   (ii) the IR drop for a current of 1.10A.
   (iii) the initial applied potential, given tht the oxygen overvoltage is 0.85V.
   (iv) the applied potential needed when [Ni^{2+}] is 0.0020M assuming that all other variables remain unchanged.

(i) Suppose we wish to electrolyze I^- to I_3^- in a 0.10M KI solution containing 3.0×10^{-5}M I_3^- at pH 10.00 with P_{H_2} fixed to 1 at m.

$$3I^- + 2H_2O \rightarrow I_3^- + H_2(g) + 2OH^-$$

(ii) Find the cell potential if no current is flowing.

(iii) Then suppose that electrolysis increases $[I_3^-]_s$ to 3.0×10^{-4} M, but other concentrations are unaffected. Suppose that the cell resistance is 2.0Ω, the current is 63mA, the cathode overpotential is 0.382V and the anode overpotential is 0.025V. What voltage is needed to drive the reaction?

Reactions:

Cathode: $2H_2O + 2e^- \rightarrow H_2(g) + 2OH^-$ E^o -0.828V

Anode: $I_3^- + 2e^- + 2e^- \rightarrow 3I^-$ $E^o = 0.535V$

2. (a) Explain the principle of coulometric method.

(b) Compere coulometric titration and volumetric titrations respectively.

(c) Calculate the time needed for a constant current of 0.961A to deposit 0.500g of Co(11) as:

(i) elemental cobalt on the surface of a cathode

(iv) Co_3O_4 on the anode.

(d) A 650 mg sample of German silver was dissolved in acid, diluted with water and transferred to an electrolysis cell equipped with an electronic coulometer. The solution was electrolyzed at -0.3V versus S.C.E. to reduce Cu^{2+} to Cu^o, which required 98.30C of electricity. The potential of the working electrode was adjusted to -0.85V versus S. C. E., where 27.05C was required to reduce Ni^{2+} to Ni^o. Finally 43.45C was required to reduce Zn^{2+} to Zn^o at -1.40 V versus S.C.E. Calculate the % Cu, % Ni and % Zn in the sample respectively.

(e) Quinone can be reduced to hydroxtinone with an excess of electrolytically generated Sn(11).

$$C_6H_4O_2 + Sn^{2+} + 2H^+ \rightarrow C_6H_6O_2 + Sn^{4+}$$

The polarity of the working electrode is then reversed, and the excess

Sn(11) is oxidized with Br_2 generated in a coulometric titration:

$$Sn^{2+} + Br_2 \rightleftharpoons Sn^{4+} + 2Br^-$$

Appropriate quantities of $SnCl_4$ and KBr were added to a 50.0 ml sample. Calculate the weight of $C_6H_4O_2$ in the sample from the data

Working Electrode Functioning as	Generation Time with a constant current of 1.062 mA min
Cathode	8.34
Anode	0.691

3. (a) Explain the principle of polarographic method

(b) Distinguish between:

(i) Limiting current and diffusion current respectively.
(ii) Capacitance current and residual current respectively.

(c) Define:
(i) Half-wave potential

(ii) Kinetic current

(iii) Adsorption current

(d) Explain and draw the graph for determination of Z.
(i) for polarographic reversible system and
(ii) for polarographic irreversible system respectively.

(e) Calculate the diffusion coefficient of cadmium. The concentration of cadmiun in polarographic cell was 0.5×10^{-3}M of Cd^{2+}. Diffusion current was 4.5×10^{-3} mA. From capillary fallen down 100 drops after 4.0 min, which weight 0.360g.

f) Calculate the amount of zinc in the sample. Weight of the sample is 2.50g. Sample were dissolved and prepared stock solution of 250ml. To the polarographic cell is added 15.0 ml of unknown + supporting electrolyte, and register polarogram. After then add 2.0ml of standard of zinc which have concentration 0.5mg/ml, and register the second polarographic curve.

What is the concentration of zinc in the sample in mg.
[h_1 = 350 mm and h_2 = 54.0 mm].

g) What is the relative decrease of concentration of Pb^{2+} ion in % after electrolysis on the DME which the electrolysis is constant.
[100 drops fallen down in 6.0 min, weight 1.200g, D = 9.0 x 10^{-6}cm^2/s, C = 0.5 x 10^{-4}M, V = 10.0 ml].

4. a) Describe the principle of chromatographic method.

b) i) Define mobile phase, ii) stationary phase; iii) retention time
iv) partition ratio, v), capacity factor, vi), selectivity factor,
vii) plate height.

c) Draw the graph for contribution of various mass transfer coefficient to plate height H for the column. Explain each part of it.

d) Explain, what is the number of theoretical plate N and the plate height H.

e) Calculate H and N for a 25.0cm column if methylbenzyl alcohol has a retention time of 17.6 min and the half-place width of 0.59 min.

f) The following data apply to a column for liquid chromatography

length packing	25.4cm
flow rate	0.356 ml/min
V_m	1.48 ml
Vs	0.175 ml

A chromatogram of a mixture of species X, Y, Z, W^1 provided the following data.

	Retention time min	Width of Peak base (w) min
Non-retained	3.4	-
X	6.3	0.43
Y	13.8	1.09
Z	14.5	1.18
W^1	22.3	1.83

Calculate:

i) the number of plates from each peak
ii) the mean and the standard deviation for N
the plate height for the column.

From the data in problem 4f. Calculate for X,Y, Z and W^1
i) the capacity factor
ii) the partition coefficient

From data in problem 4f, for species X and Y calculate:
i) the resolution
ii) the selectivity factor
iii) the length of column to give a resolution of 1.5
iv) the time required to separate Y and Z with resolution of 1.5

From the data in problem 4f, for species Z and W^1 calculate
i) the resolution
ii) the length of column required to give resolution 1.5

5. a) Explain briefly gas chromatography method

b) Write equation for corrected retention volume V_R^o and V_M and for specific retention volume Vg.

c) Draw the graph for gas chromatography and explain each part of it.

d) Explain the type of detectors for gas-liquid chromatography.

e) A gas chromatogram of a mixture that contained benzene, anthracene, and air (not retarded on the column) was obtained. The retention time of each component was measured and recorded. Assuming the column is a cylindrical tube with a length of 50.0 cm and the internal diameter of 1.00cm, and a flow rate is $30cm^3/min$; calculate k' for benzone, Vm, Vs (assuming he total volume of the column is Vm + Vs), K for benzene, the relative retention of anthracene with respect to benzene, and the fraction of time an average molecule of benzene spends in the phase.

Compound	t, min
Benzene	3.24
Anthracene	5.73
Air	0.25

f) The following data were obtained by gas-liquid chromatography on a 40-cm packed column:

Compound	t_R, min	$w_{½}$, min
air	1.9	—
methylcyclohexane	10.0	0.76
methylcyclohexene	10.9	0.82
toluene	13.4	1.06

Calculate:

i) an average number of plates from the data
ii) the standard deviation for an average in I)
iii) an average plate height for the column

g) Referring to problem 5f, calculate the resolution for

i) methylcyclohexene and methylcyclohexane
ii) methylcyclohexene and toluene
iii) methylcyclohexane and toluene

END OF EXAMINATION.

DATA SHEET

PHYSICAL CONSTANTS

Avogadro's constant, N_A	$= 6.02 \times 10^{23}\ mol^{-1}$
Speed of light, c	$= 2.998 \times 10^{8}\ m\ s^{-1}$
Molar volume of gas at S.T.P	$= 22.4\ dm^3$
Universal gas constant, R	$= 8.314\ J\ K^{-1}\ mol^{-1}$
	$= 0.0821\ L\ atm\ K^{-1}\ mol^{-1}$
	$= 8.314\ kPa.\ L.\ K^{-1}\ mol^{-1}$.

1 atm = 760 mmHg = 760 torr =101325 Pa = 101325 Nm^{-2}

THE PERIODIC TABLE IS PRINTED AT THE BACK OF THIS PAGE

Important Derived Quantities and Relationships

Name	Calculation of Derived Quantities	Relationship to Other Quantities
Linear mobile-phase velocity	$u = L/t_M$	
Volume of mobile phase	$V_M = t_M F$	
Capacity factor	$k' = (t_R - t_M)/t_M$	$k' = \frac{KV_S}{V_M}$
Partition coefficient	$K = \frac{k'V_M}{V_S}$	$K = \frac{c_S}{c_M}$
Selectivity factor	$\alpha = \frac{(t_R)_B - t_M}{(t_R)_A - t_M}$	$\alpha = \frac{k'_B}{k'_A} = \frac{K_B}{K_A}$
Resolution	$R_S = \frac{2[(t_R)_B - (t_R)_A]}{W_A + W_B}$	$R_S = \frac{\sqrt{N}}{4}\left(\frac{\alpha - 1}{\alpha}\right)\left(\frac{k'_B}{1 + k'_B}\right)$
Number of plates	$N = 16\left(\frac{t_R}{W}\right)^2$	$N = 16R_S^2\left(\frac{\alpha}{\alpha - 1}\right)^2\left(\frac{1 + k'_B}{k'_B}\right)^2$
Plate height	$H = L/N$	
Retention time	$(t_R)_B = \frac{16R_S^2 H}{u}\left(\frac{\alpha}{\alpha - 1}\right)^2\frac{(1 + k'_B)^3}{(k'_B)^2}$	

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number
X
Atomic mass
Name of the element
X

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

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

Department of Chemistry-UNZA

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY SEMESTER II 2003 EXAMINATIONS

ORGANIC CHEMISTRY IV – C352

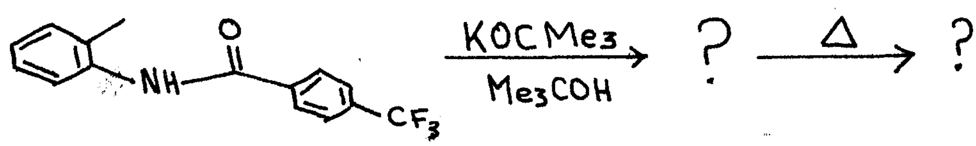
JANUARY 2004

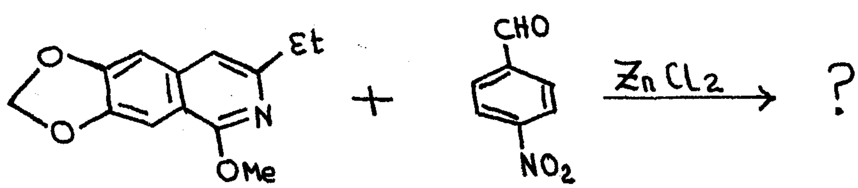
TIME ALLOWED: THREE (3) HOURS.

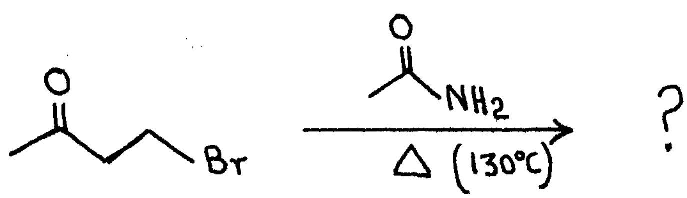
INSTRUCTIONS:
1. **This paper has five (5) questions. Answer any four (4) questions.**
2. **Each question carries thirty marks.**
3. **Marks for each part of the question are indicated.**

QUESTION ONE.

Predict the major organic product(s) and give the mechanisms for the following reactions:

i) 

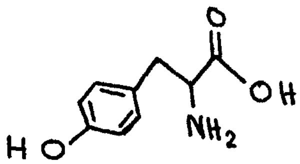
ii) 

iii) 

30 marks

QUESTION TWO.

(a) Devise a malonic ester synthesis of 2-amino-3-(p-hydroxyphenyl)propanoic acid, structure is shown below. State the reagents and the reaction conditions for each step of your proposed synthesis.



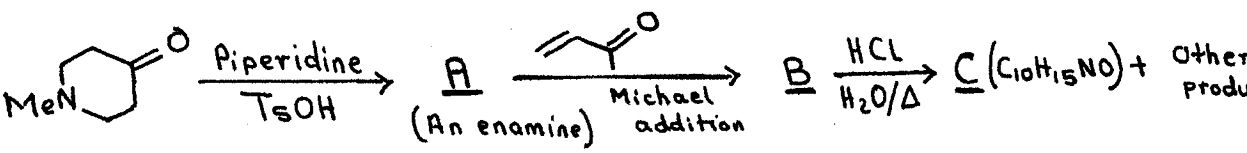
2-amino-3-(p-hydroxyphenyl)propanoic acid

12 marks

(b) A reaction of pyridine N-oxide with benzyl bromide gives N-benzyloxypyridinium bromide. If this salt were treated with a methanolic sodium hydroxide solution, what product(s) would you expect to obtain? Show the mechanism of this reaction and name the product(s).

6 marks

(c) i) Deduce the structures of the compounds **A** – **C** from the following synthesis.



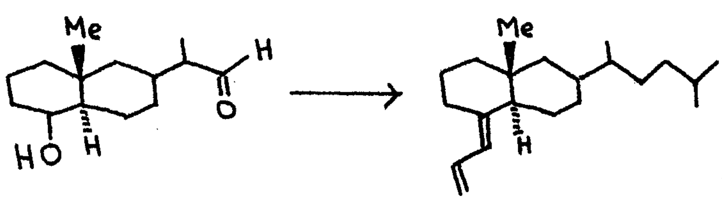
ii) Show the reaction mechanism for the formation of compound **A** in (c)(i) above.

iii) Give a reaction mechanism for the formation of compound **B** from compound **A** in (c)(i) above.

12 marks

QUESTION THREE.

a) Making use of the Wittig and any other needed reactions, show clearly how the following multi-step transformation can be achieved in good yield. State the reagents and the reaction conditions needed for each step of your proposal.

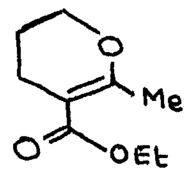


10marks

b) Monoximes are compounds of ammonia and are well known for their nucleophilic character. For example, the reaction of 2,4-pentadione with hydroxylamine gives a monoxime, which on warming yields a compound, **D**. On the basis of this information write a mechanism for this reaction, clearly showing all the steps involved in the formation of compound, **D**. Provide the name of compound, **D**.

12marks

c) Treatment of ethylacetoacetate with 1,3-dibromopropane in the presence of sodium ethoxide in ethanol gave an unexpected compound, **E**, structure shown below, in small yield. Propose a mechanism to account for the formation of compound, **E**, in this reaction.



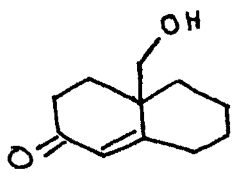
Compound **E**

8 marks

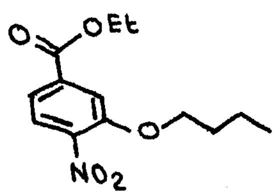
QUESTION FOUR.

a) Applying the disconnection approach, propose a synthesis for any **two (2)** of the following compounds from readily available starting materials. State the reagents and the reaction conditions needed for each step of your proposed synthesis. **(Your analysis must be shown)**

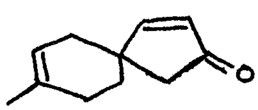
(i)



(ii)



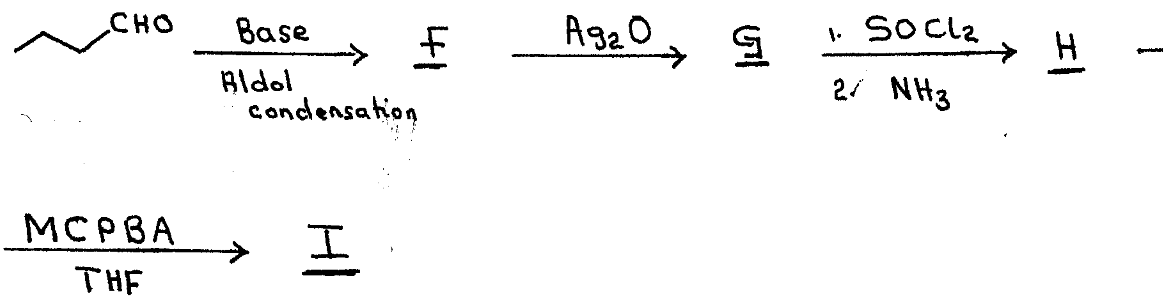
(iii)



30 marks

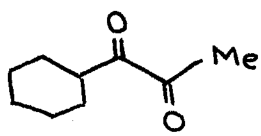
QUESTION FIVE.

a) Deduce the structure of the minor tranquilliser, **I**, from the following synthesis.



10 marks

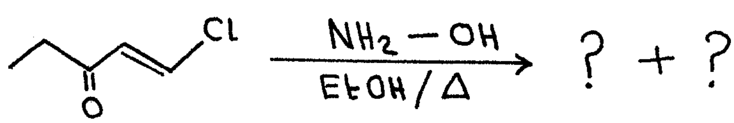
b) Using dithiane chemistry, provide a synthesis for the compound, **J**, from readily available starting materials. Show the reagents and the reaction conditions needed for each step of your synthesis.



Compound **J**

10 marks

c) The reaction of 1-chloro-3-pentenone with hydroxylamine in ethanol yields two isomeric products as indicated below.



i) Provide the structures of these two isomeric products.

ii) Suggest the most likely reaction mechanism that would explain the formation of the two isomeric products. Show clearly all the steps of the reaction mechanism.

10marks

END OF EXAM

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – January 2003

C412

TIME: THREE HOURS.

ANSWER QUESTIONS AS INDICATED IN SECTIONS A, B and C. ALL QUESTIONS ARE OF EQUAL VALUE.

SECTION A. Answer three questions in this section. Write like one trained in science; be specific, detailed, technical and accurate.

1. Choose any five of the following and for each write a short description that tells what this is and why it is important:

VJD	gp120
V3	Innate immunity
VHH	Library
scFv	Chimeric immunoconjugate
CDR	Immunomodulation
CD4	Direct neutralizing antibody

2. A. Why is HIV immunologically such a formidable human pathogen?
   B. In your opinion what is the best immunological research approach to pursue as we search for answers to the HIV/AIDS pandemic?

3. A. Describe in detail the methods used by Venter and Celera to determine the sequence of the human genome.
   B. Why were other researchers skeptical about the Venter approach?

4. What were the most important outcomes of the sequencing of the human genome.

5. A. Describe the two transgenes currently used in the most popular agricultural applications of modern biotechnology. For each tell what the gene is, what is the source of the gene, what the gene encodes, and what metabolic processes are involved.
   B. Are these genes safe to use? Defend your answer with specific details.

SECTION B. Answer two questions in this section.

1. It is possible to obtain only 500 to 750 bases of sequence from an individual sequencing experiment. Assume that the yield of terminated product is 100 at the first A in the sequence being determined, and that the lower limit of detection is a yield of 1. To obtain 500 bases of sequence from a DNA sample that contained 27% A, what would be the upper limit for termination at each A? You may round your answer to the nearest integer percent.

2. In our attempt to determine the EPSPS K_m for PEP, a 5 mM stock solution was used to prepare tubes containing 5, 10, 20, 50 and 100 µM PEP with a final volume in each tube of 200 µl. Describe a dilution scheme that could be used to prepare these tubes.

3. What is the value of $2^{30,000}$? How much larger than $2^{20,000}$ is it? What is the significance of these numbers?

SECTION C. Answer one question in this section.

1. Alice and her vacuum which nature abhors illustrate in a humorous way one of the truly fundamental principles of biology. What is the biochemical foundation for this principle?

2. If you have your choice of opportunities how would you like to use the biochemistry that you learned in this course to serve Zambia and Zambians? Be specific about what the biochemistry is and how it could be applied for what benefit.

END OF C412 EXAM

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – January 2003

C412

TIME: THREE HOURS.

ANSWER QUESTIONS AS INDICATED IN SECTIONS A, B and C. ALL QUESTIONS ARE OF EQUAL VALUE.

SECTION A. Answer three questions in this section. Write like one trained in science; be specific, detailed, technical and accurate.

1. Choose any five of the following and for each write a short description that tells what this is and why it is important:

VJD	gp120
V3	Innate immunity
VHH	Library
scFv	Chimeric immunoconjugate
CDR	Immunomodulation
CD4	Direct neutralizing antibody

2. A. Why is HIV immunologically such a formidable human pathogen?
   B. In your opinion what is the best immunological research approach to pursue as we search for answers to the HIV/AIDS pandemic?

3. A. Describe in detail the methods used by Venter and Celera to determine the sequence of the human genome.
   B. Why were other researchers skeptical about the Venter approach?

4. What were the most important outcomes of the sequencing of the human genome.

5. A. Describe the two transgenes currently used in the most popular agricultural applications of modern biotechnology. For each tell what the gene is, what is the source of the gene, what the gene encodes, and what metabolic processes are involved.
   B. Are these genes safe to use? Defend your answer with specific details.

SECTION B. Answer two questions in this section.

1. It is possible to obtain only 500 to 750 bases of sequence from an individual sequencing experiment. Assume that the yield of terminated product is 100 at the first A in the sequence being determined, and that the lower limit of detection is a yield of 1. To obtain 500 bases of sequence from a DNA sample that contained 27% A, what would be the upper limit for termination at each A? You may round your answer to the nearest integer percent.

2. In our attempt to determine the EPSPS K_m for PEP, a 5 mM stock solution was used to prepare tubes containing 5, 10, 20, 50 and 100 μM PEP with a final volume in each tube of 200 μl. Describe a dilution scheme that could be used to prepare these tubes.

3. What is the value of $2^{30,000}$? How much larger than $2^{20,000}$ is it? What is the significance of these numbers?

SECTION C. Answer one question in this section.

1. Alice and her vacuum which nature abhors illustrate in a humorous way one of the truly fundamental principles of biology. What is the biochemical foundation for this principle?

2. If you have your choice of opportunities how would you like to use the biochemistry that you learned in this course to serve Zambia and Zambians? Be specific about what the biochemistry is and how it could be applied for what benefit.

END OF C412 EXAM

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2003 ACADEMIC YEAR SECOND SEMESTER EXAMINATIONS - JANUARY-2004
C422 - APPLIED ANALYTICAL CHEMISTRY

TIME: 3 HOURS

ANSWER ANY 4 FROM THE 5 QUESTIONS IN THIS PAPER

QUESTION 1

(a) Retention times (corrected for air peak) are given for the following compounds on a particular column. What is the retention index of each of the compounds on this column? Ethane, 0.25min; 2-methylbutane, 1.20min; propane, 0.45 min; butane-1, 0.80; n-butane, 0.95 min; n-hexane, 3.50min; benzene,3.75 min; butanol, 8.4 min; heptane, 6.95min; water, 3.50 min and octane, 13.7 min(5).
(b) Explain the following terms used in mass spectrometry: field ionization and chemical ionization...(3)
(c) Describe the testing methods used in flavour analysis. (3)
(d) How would you determine 2 fat-soluble vitamins in food.(4)

QUESTION 2

(a) Using the data given in figure1 and the additional information given below. Identify the unknown compound.(6)

	P+1	P+2
$C_7H_{10}N_4$	9.25	0.38
$C_9H_{10}O_2$	9.96	0.84
$C_8H_8NO_2$	9.23	0.78
C_7H_7O	7.64	0.45
$C_8H_{12}N_3$	9.98	0.45

(b) Explain the terms, metastable ions, N rule and ring rule as used in mass spectrometry (3)
(c) Describe 2 methods you would use in crude protein analysis. (3)
(d) Describe the important components of Mazoe drink and describe the determination of one of the minor components of this famous drink. (3)

QUESTION 3

(a) H_2O_2 solution is analysed by adding excess standard $KMnO_4$ solution and back-titrating the unreacted KMnO4 with Fe^{2+}.A 0.587g sample of H_2O_2 solution is taken,25ml of 0.0125M $KMnO_4$ added and the back-titration required5.10 ml of 0.112 M Fe^{2+} solution. What % H_2O_2 is in the sample. What other method can be used to determine the concentration of H_2O_2?
. (4)

(b). Name two antioxidants allowed in Zambian foods and describe how to detect any 2 of them in such foods and include their uses in food (3)

(c) Describe 3 drugs abused in Zambia and how you would analyse for their ingredients. (4)

(d) How would you determine the levels of organochlorides in cabbages include some examples of such pesticides. (4)

QUESTION 4

(a) Decane and nonane give retention times of 65 and 60 seconds on a column that has 4900 theoretical plates. (1) What resolution will be obtained if both compounds are run on this column? (11) How many plates would be required to achieve a resolution of 1.8 if the retention times remain unchanged? (5).
(b) Discuss the methods used to extract flavour compounds in foods. (4)
(c) Describe how to make a detergent and discuss how its qualities are established. (3)
(d) What are the important components of cocoa and tea and describe the determination of 2 of these ingredients. (3)

QUESTION 5

(a) A concentration of soluble protein was determined as follows: A 0,5ml portion was diluted with 0.9ml of water. From the diluted solution,0.5ml aliquot wastreatedwith4.50ml Biuret reagent and colour allowed to develop. The absorbance of the solution was 0.18 at 450nm in 1cm cell. A 0.5ml portion of standard solution containing 4.0mg of protein per ml was treated in the same manner as the diluted sample solution and gave an absorbance of 0.12.Calculate the concentration of protein in the undiluted unknown extract(4)

(b)Explain operating principles of following detectors used in HPLC : evaporative light-scattering and fluorimeter detectors. (3)

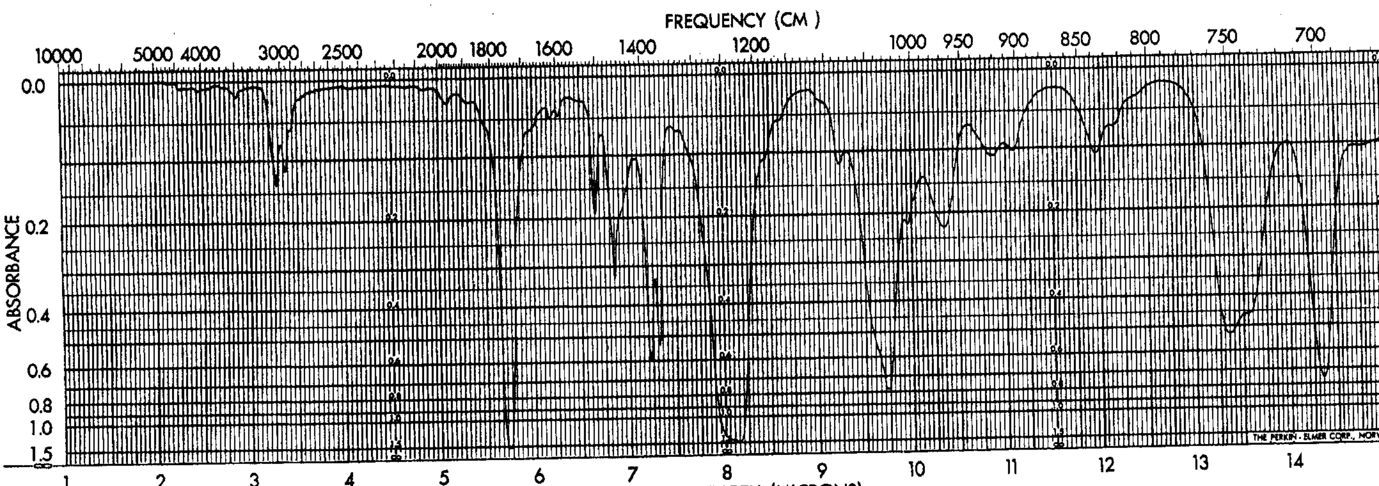
(c)Describe 3 reactions used in the identification of aldehydes in organic compounds.(3)

(d) Describe or explain the following terms : non-ionic gemini, detergent, antioxidant and agglutination. Include in your answer their uses if any. (4).

(K= 39.1; Fe= 55.8; Mn = 54.9; O= 16.0; C= 12.0)

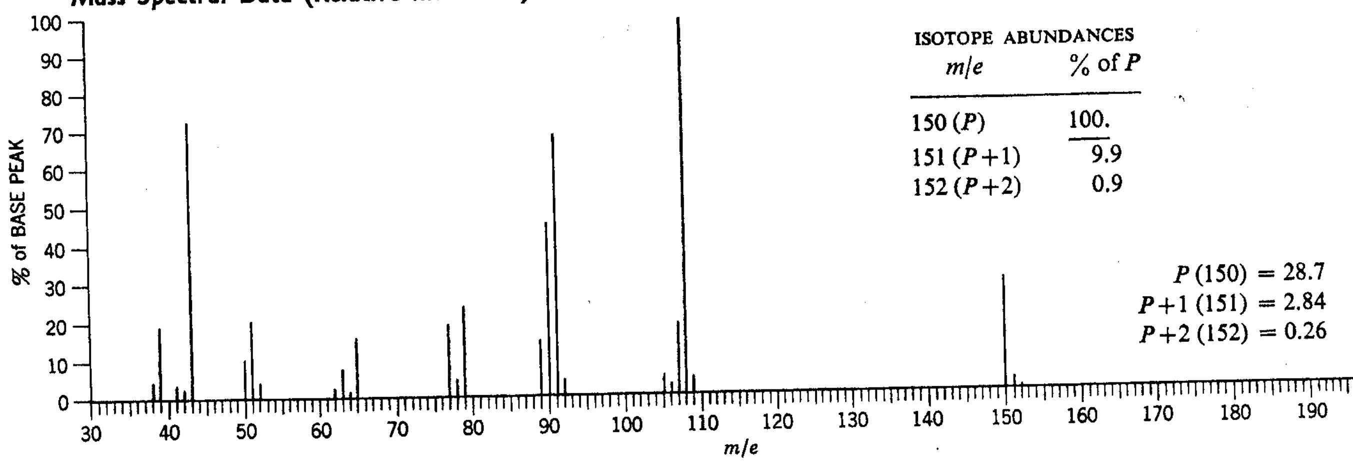
FIG. 1

Infrared Spectrum



Cell thickness 0.01 mm

Mass Spectral Data (Relative Intensities)



ISOTOPE ABUNDANCES

m/e	% of *P*
150 (*P*)	100.
151 (*P*+1)	9.9
152 (*P*+2)	0.9

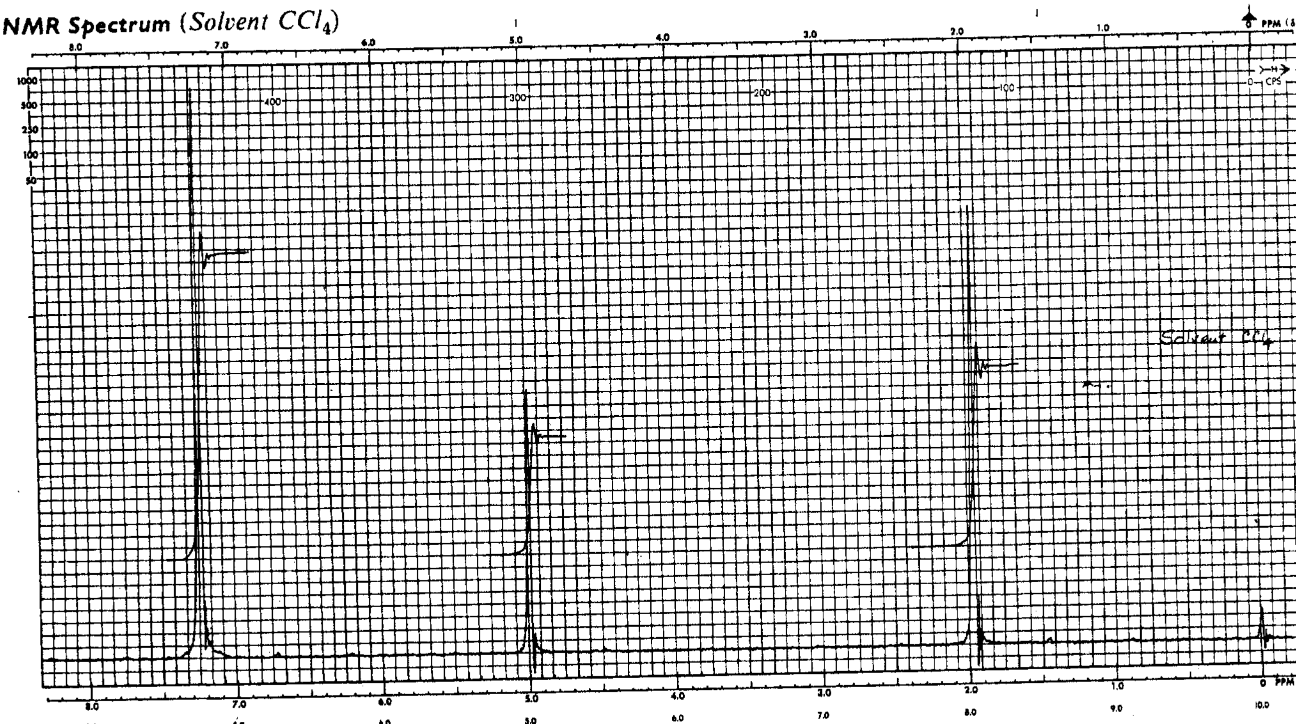
P (150) = 28.7
P+1 (151) = 2.84
P+2 (152) = 0.26

Ultraviolet Data

λ_{max}^{EtOH}	ϵ_{max}
268	101
264	158
262	147
257	194
252	153
248 (*s*)	109
243 (*s*)	78

(*s*) = shoulder

NMR Spectrum (Solvent CCl_4*)*



THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER II, 2003 EXAMINATIONS
C475: MEDICINAL CHEMISTRY

JANUARY 2004

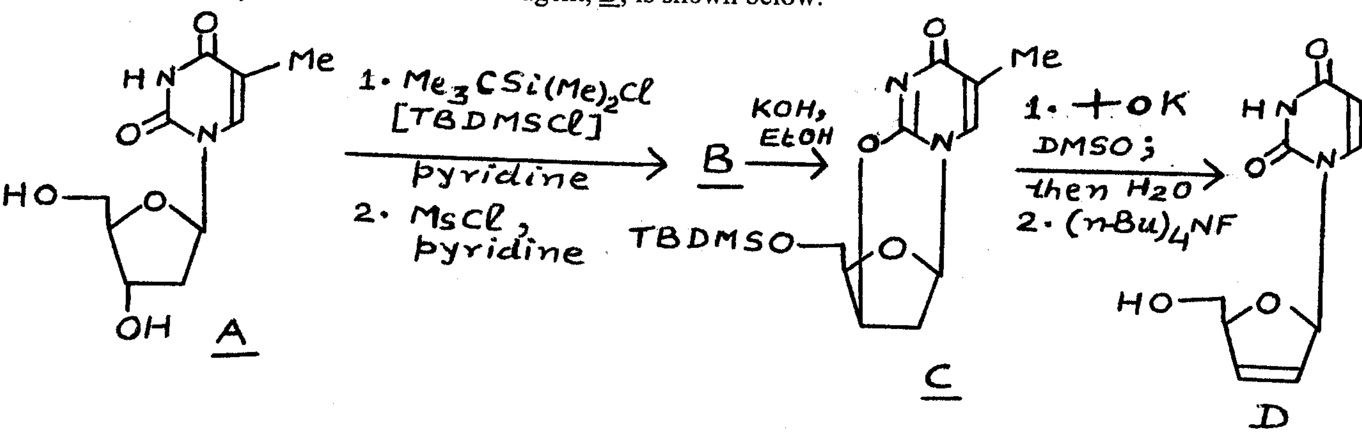
<u>TIME ALLOWED</u>: THREE (3) HOURS

<u>INSTRUCTIONS:</u>

1. **This paper has five (5) questions. Answer any four (4) questions.**
2. **Each question carries thirty (30) marks.**
3. **Marks for each part of the question are indicated.**

<u>QUESTION ONE</u>

(a) The synthesis of an anti-HIV agent, **D**, is shown below.



i) Identify the intermediate, **B**, in the above synthesis.

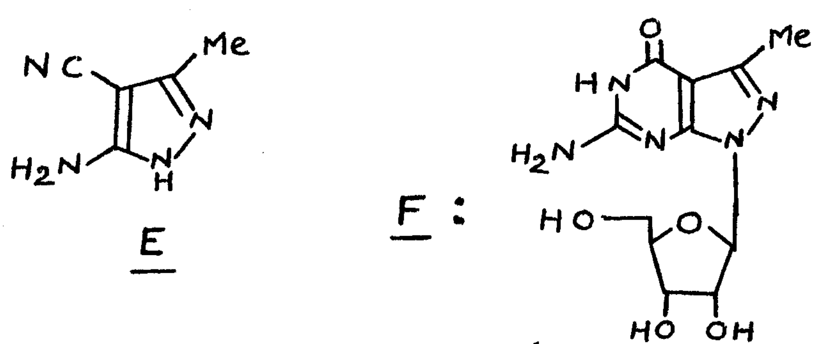
ii) Suggest the mechanisms of the reactions involved in the formation of compound, **D**, from compound, **B**. Clearly show the intermediate compound, **C**.

12 marks

(b) Briefly describe the processes underlying the passage of drug molecules across the cell membranes.

8 marks

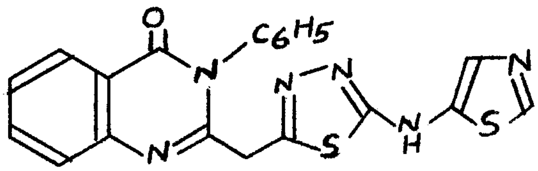
(c) Propose a synthesis of the immuno-stimulant, **F**, from the compound, **E**.



10 marks

QUESTION TWO

(a) Propose a synthesis of the anticonvulsant drug, <u>G</u>, structure shown below, from readily available non-heterocyclic starting materials.



Compound, <u>G</u>

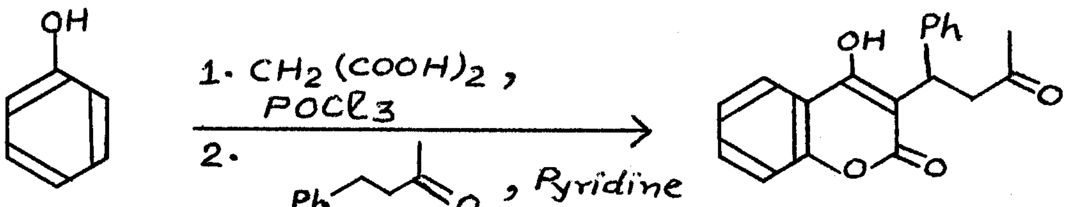
14 marks

(b) Briefly describe a procedure for the screening of the plant materials, traditionally used as medicine, for the presence of alkaloids. State the principle of your test and state the significance of the results obtained.

8 marks

(c) Suggest the mechanisms of the reactions involved in the following synthesis of a biologically active compound, <u>H</u>.

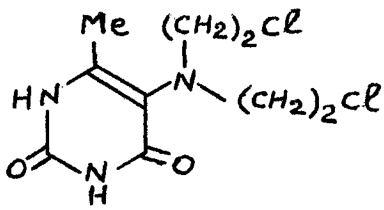
8 marks



<u>H</u>

QUESTION THREE

(a) Suggest a synthesis of the anti-cancer drug, <u>I</u>, structure shown below from readily available non-heterocyclic starting materials.



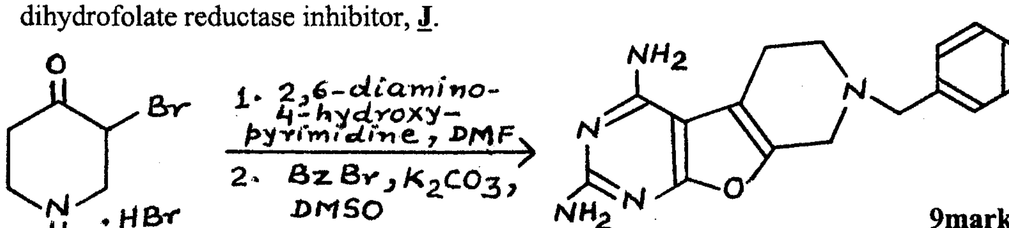
Compound, <u>I</u>

12 marks

(b) Explain the mode of anti-cancer action of the compound, <u>I</u>, shown in 3(a) above.

9 marks

(c) Give the mechanisms of the reactions involved in the following synthesis of the dihydrofolate reductase inhibitor, <u>J</u>.

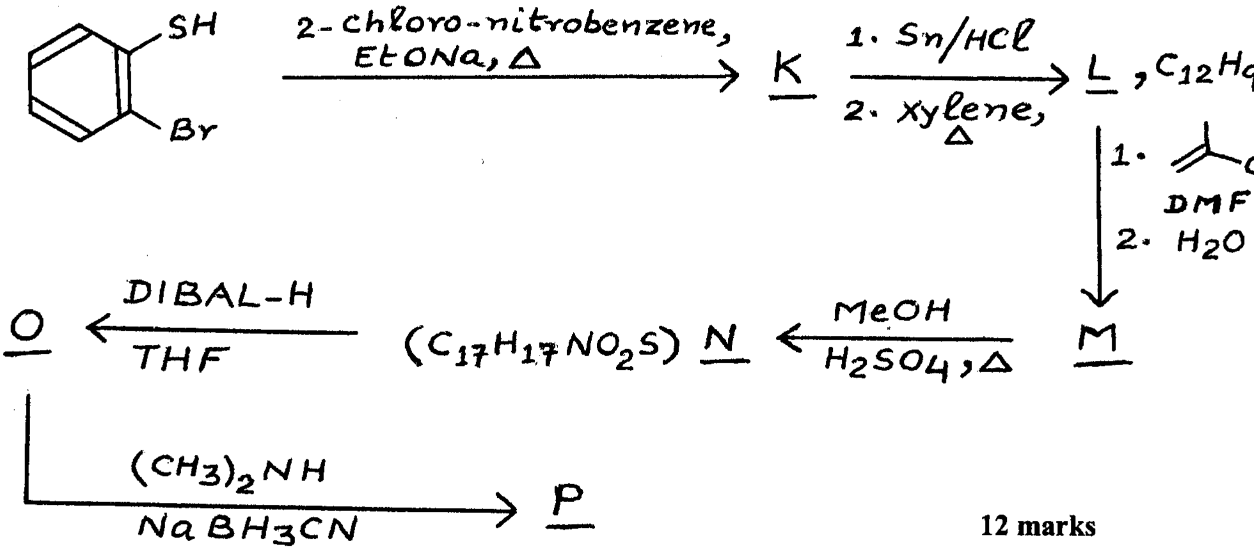


<u>J</u>

9marks

QUESTION FOUR

(a) Deduce the structure of the major tranquilizer, **P**, from the following synthesis. Show the structures of the intermediates **K** - **O**.

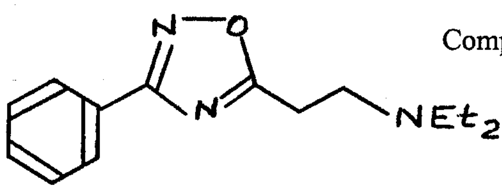


12 marks

(b) Discuss the structure activity relationships in the 4-aminoquinoline antimalarials.

8 marks

(c) Devise a synthesis of the anti-spasmodic compound, **Q**, structure shown below.

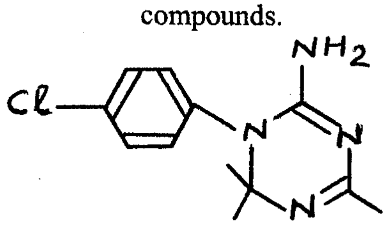


Compound, **Q**

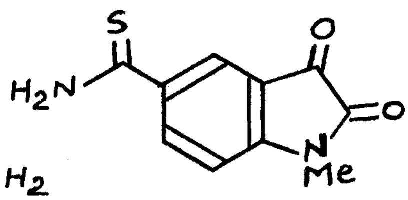
10 marks

QUESTION FIVE

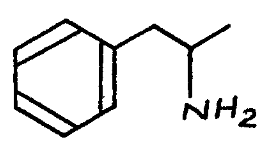
(a) (i) Give the principal pharmacological effect(s) and systematic names for the following compounds.



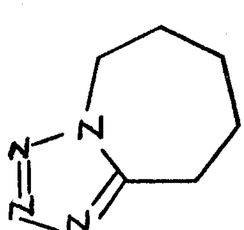
R



S



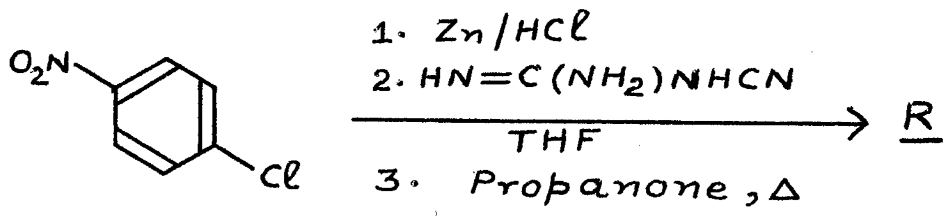
T



U

8 marks

(ii) Suggest the mechanisms of the reactions involved in the following synthesis of compound, **R**, structure shown in 5(a)(i) above.



6 marks

(iii) Briefly explain the mode of pharmacological action of compound, S, structure shown in 5(a)(i) above.

5 marks

(b) Propose a plausible metabolic pathway for compound, T, structure shown in 5(a)(i) above. Predict the structure(s) of the metabolite(s) that could be expected to be present in the urine of a patient who has been receiving the drug, T, orally. Justify your prediction.

7 marks

(c) Adrenaline prolongs the duration of action of the injectible local anaesthetics. Provide an explanation for this observation.

4 marks

END OF EXAM.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER II EXAMINATION

JANUARY 2004

C 482 - INORGANIC INDUSTRIAL CHEMISTRY

TIME: **THREE (3) HOURS**

INSTRUCTIONS: **ANSWER ANY FIVE (5) QUESTIONS**

---

1. The main raw materials for the production of Ammonium sulphate are Ammonia, Sulphuric acid and Gypsum. Briefly describe the production process of $(NH_4)_2SO_4$ from:

   (i) Gypsum,

   (ii) Ammonia and sulphuric acid;

   (iii) By-product Ammonia (from Coke-oven gas) with Sulphuric acid (the flow-sheet is attached).

2. In the production of dilute Nitric acid, Ammonia is mostly used. Outline:

   (i) The physicochemical foundation manufacturing dilute Nitric acid,

   (ii) The manufacturing process of concentrated Nitric acid by means of dehydrating agents.

   (iii) Suggest the methods to minimize impurities in the off gas (in the processes indicated in 2 (ii) above).

3. In the production of Sulphuric acid, Sulphur or Iron pyrite is mainly used.

   (i) What are the advantages and disadvantages associated with the use of these raw materials?

   (ii) By means of a reaction and diagrams explain how efficiency of the oxidation SO_2 to SO_3 can be increased.

   (iii) Why 98.3 % H_2SO_4 is used for absorption of SO_3 containing gas?

4. Write down the reactions and outline the major steps involved in the production of:

   (i) Ammonium nitrate,

   (ii) Urea,

   (iii) Superphosphate.

5. Given the following potassium salts;

   K_2SO_4, KOH, K_2CO_3, KNO_3, $KBrO_3$, KBr, KIO_3, $KMnO_4$ and $K_2Cr_2O_7$.

   (i) Describe the production reactions of each.

   (ii) What are their use(s)?

   (iii) Write down Four (4) physical properties of each.

6. What do you know about?

   (i) Mixed (Blended) fertilizers,

   (ii) Microfertilizers,

   (iii) Pesticides.

END OF EXAMINATIONS

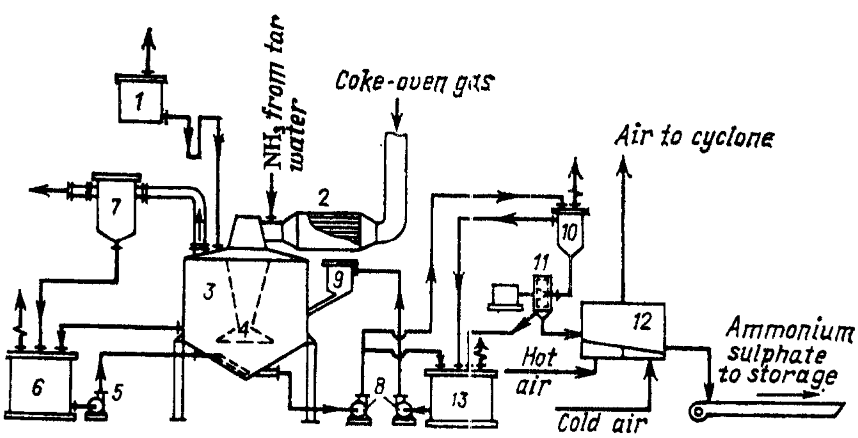


Fig. Flow diagram for the manufacture of ammonium sulphate from coke-oven by-product ammonia by the semidirect process:
(1) constant-head tank for sulphuric acid, (2) gas preheater, (3) saturator, (4) sparger, (5) pump, (6) circulating tank, (7) acid trap, (8) pump, (9) mother-liquor receiver, (10) crystal receiver, (11) centrifugal filter, (12) fluidized-bed drier, (13) mother-liquor receiver

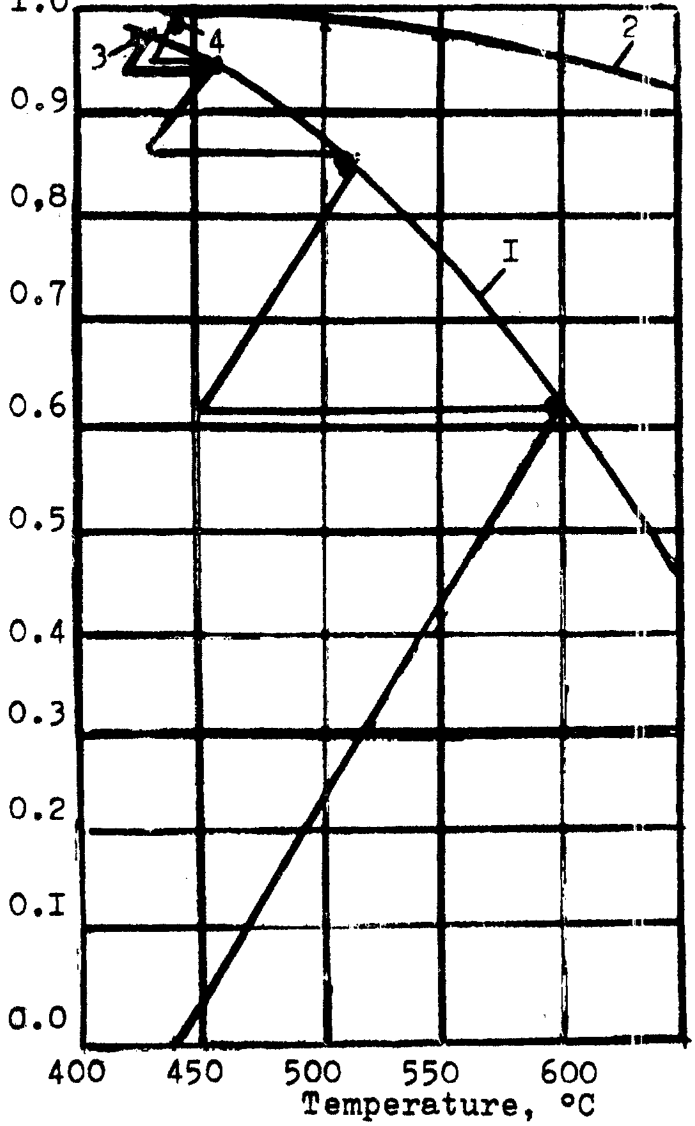


Fig. Course of catalytic oxi-
dation in a multihearth react-
I, equilibrium curve for the
gas (Ist stage in the double-
sorption contact process); 2,
uilibrium curve for the feed
after the intermediate SO_3 ab-
sorption; 3, last-bed adiabat-
curve for the single-absorpti-
contact process; 4, last-bed
batic curve for the double-ab-
tion contact process; X, SO_2
version.

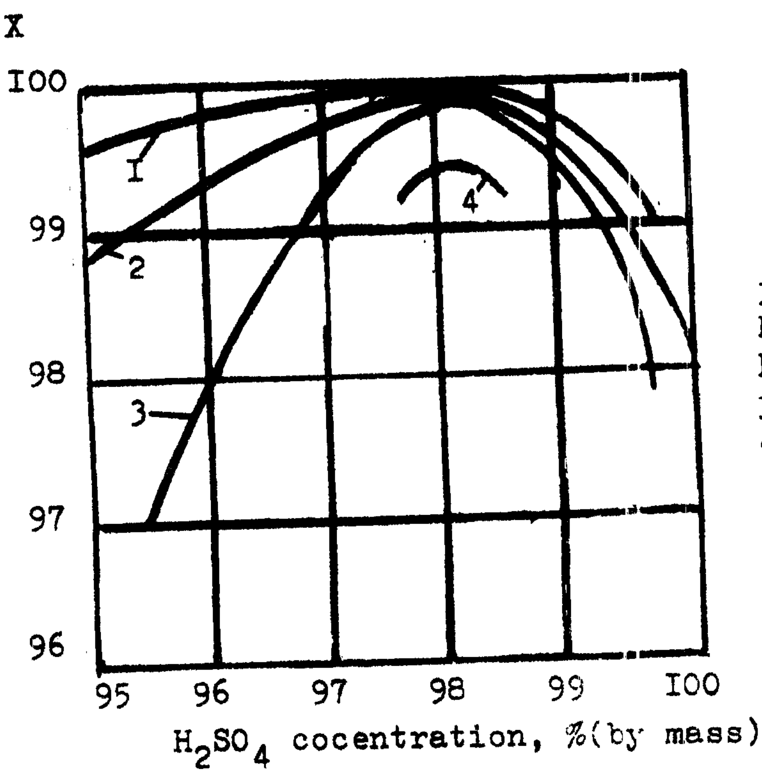


Fig. SO_3 absorption in a mo-
hydrate absorber at several
peratures:

I, 60°C; 2, 80°C; 3, I00°C;
4, I20°C; X, SO_3 absorption,

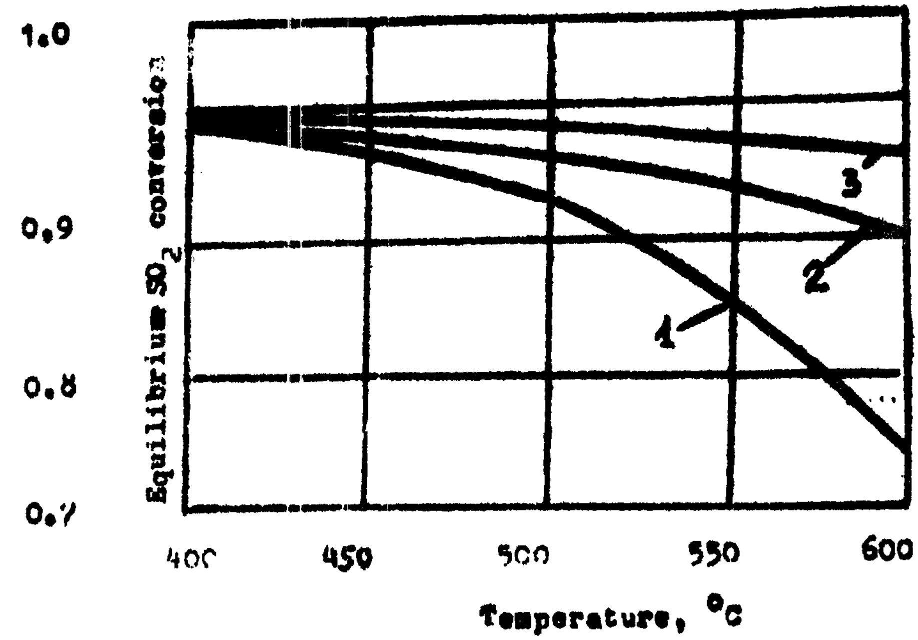


Fig. Equilibrium conversion of SO_2 as a functio
of temperature at various pressures:
I, 0,I MPa; 2, I,0 MPa; 3, I0,0 MPa; Feed composi
tion: 7 vol. % SO_2, II vol. % O_2, 82 vol. % N_2;

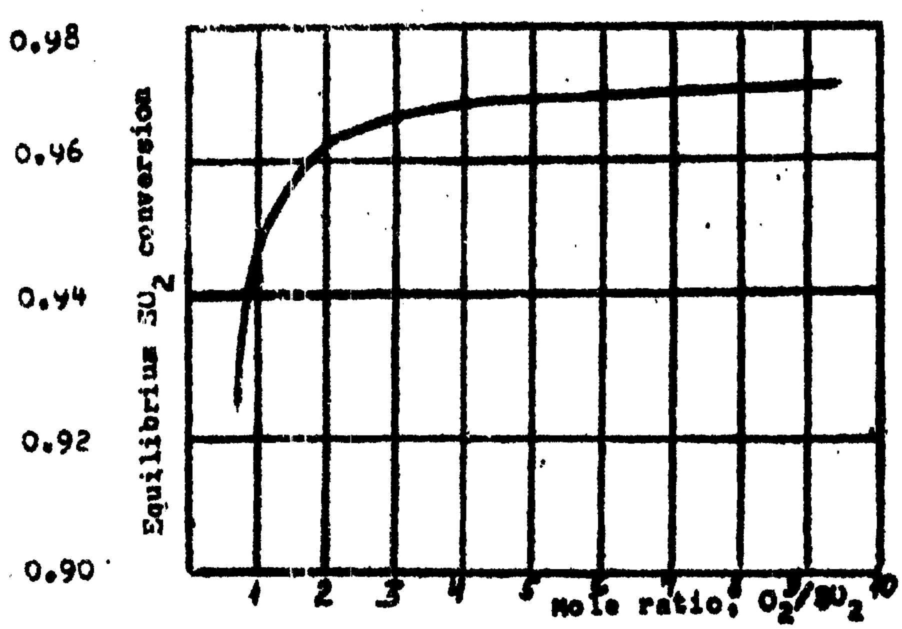


Fig. Equilibrium conversion of SO_2 as a functio
of molar O_2 : SO_2 ratio.
Temperature, 475 °C; Pressure, 0,I MPa

Table 1 [redacted] ^{1}H Chemical shifts in methyl, methylene, and methine groups

	Methyl protons	δ_H	*Methylene protons*	δ_H	*Methine protons*	δ_H
C	CH_3—R	0.9	R—CH_2—R	1.4	>CH—R	1.5
	CH_3—C—C=C	1.1	R—CH_2—C—C=C	1.7		
	CH_3—C—O	1.3	R—CH_2—C—O	1.9	>CH—C—O	2.0
	CH_3—C—N	1.1	R—CH_2—C—N	1.4		
	CH_3—C—NO_2	1.6	R—CH_2—C—NO_2	2.1		
	CH_3—C=C	1.6	R—CH_2—C=C	2.3		
	CH_3—Ar	2.3	R—CH_2—Ar	2.7	>CH—Ar	3.0
	CH_3—C=CC=O	2.0	R—CH_2—C=CC=O	2.4		
	C=C(CH_3)—C=O	1.8	C=C(CH_2—R)—C=O	2.4		
	CH_3—C≡C	1.8	R—CH_2—C≡C	2.2	>CH—C≡C	2.6
	CH_3—CO—R	2.2	R—CH_2—CO—R	2.4	>CH—CO—R	2.7
	CH_3—CO—Ar	2.6	R—CH_2—CO—Ar	2.9	>CH—CO—Ar	3.3
	CH_3—CO—OR	2.0	R—CH_2—CO—OR	2.2	>CH—CO—OR	2.5
	CH_3—CO—OAr	2.4				
	CH_3—CO—N	2.0	R—CH_2—CO—N	2.2	>CH—CO—N	2.4
			R—CH_2—C≡N	2.3	>CH—C≡N	2.7
N	CH_3—N	2.3	R—CH_2—N	2.5	>CH—N	2.8
	CH_3—N—Ar	3.0				
	CH_3—N—CO—R	2.9	R—CH_2—N—CO—R	3.2	>CH—N—CO—R	4.0
	CH_3—N^+	3.3	R—CH_2—N^+	3.3		
			R—CH_2—NO_2	4.4	>CH—NO_2	4.7
O			R—CH_2—OH	3.6	>CH—OH	3.9
	CH_3—OR	3.3	R—CH_2—OR	3.4	>CH—OR	3.7
	CH_3—O—C=C	3.8	R—CH_2—O—C=C	3.7		
	CH_3—OAr	3.8	R—CH_2—OAr	4.3	>CH—OAr	4.5
	CH_3—O—CO—R	3.7	R—CH_2—O—CO—R	4.1	>CH—O—CO—R	4.8
			RO—CH_2—OR	4.8		
Hal			R—CH_2—F	4.4		
			R—CH_2—Cl	3.6	>CH—Cl	4.2
			R—CH_2—Br	3.5	>CH—Br	4.3
			R—CH_2—I	3.2	>CH—I	4.3
Other	CH_3—Si	0.0	R—CH_2—Si	0.5	>CH—Si	1.2
	CH_3—S	2.1	R—CH_2—S	2.4	>CH—S	3.2
	CH_3—S(O)R	2.5				
	CH_3—S(O_2)R	2.8	R—CH_2—S(O_2)R	2.9		
			RS—CH_2—SR	4.2		

R = alkyl group. These values will usually be within ±0.2 p.p.m. unless electronic or anisotropic effects from other groups are strong. An obsolete scale used τ values; these are related to δ values by the simple equation $\tau = 10 - \delta$.

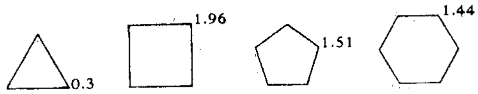
Estimation of ^{1}H chemical shifts in substituted alkanes

$$R^1R^2R^3CH \qquad \delta_H = 1.50 + \sum z_i \qquad (3.19)$$

Table 3.18 Substituent constants z for Eq. 3.19

R^i	z	R^i	z	R^i	z
H—	−0.3	HC≡C—	0.9	MeO—	1.5
alkyl—	0.0	OHC—	1.2	PhO—	2.3
CH_2=$CHCH_2$—	0.2	MeCO—	1.2	AcO	2.7
$MeCOCH_2$—	0.2	RO_2C—	0.8	Cl—	2.0
$HOCH_2$—	0.3	NC—	1.2	Br—	1.9
$ClCH_2$—	0.5	H_2N—	1.0	I—	1.4
CH_2=CH—	0.8	O_2N—	3.0	MeS—	1.0
Ph—	1.3	HO—	1.7	Me_3Si—	−0.7

Table 3.19 ^{1}H Chemical shifts of methylene groups in some cyclic compounds



at −100° H_{ax} 1.1
H_{eq} 1.6
Axial protons generally come into resonance at higher field than their equatorial counterparts.

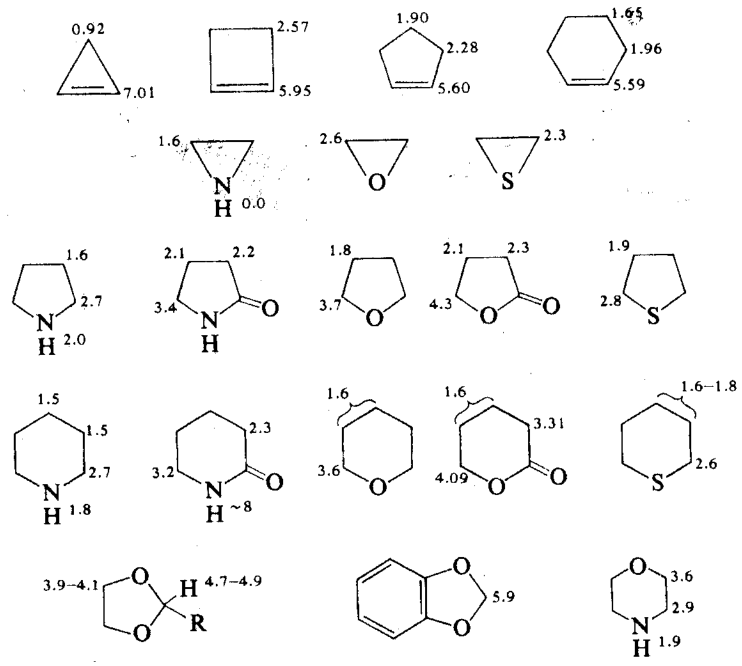
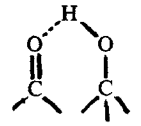


Table 2 [redacted] ^{1}H Chemical shifts of protons attached to elements other than carbon

	Structure	δ_H		*Structure*	δ_H
NH	RNH_2 and R_2NH	0.5–4.5	OH	monomeric H_2O	~1.5
	$ArNH_2$ and ArNHR	3–6		suspended HOD	~4.7
	$RCONH_2$ and RCONHR	5–12		ROH	0.5–4.5
	pyrrole NH	7–12		ArOH	4.5–10
				RCO_2H	9–13
SiH	>SiH	~3.8		>C=N—OH	9–12
SH	RSH	1–2			7–16
	ArSH	3–4			

These values are very sensitive to temperature, solvent, and concentration: the stronger the hydrogen bonding, the lower field the chemical shift.

Table 3.25 ^{13}C and residual ^{1}H chemical shifts in the common deuterated solvents

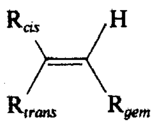
Solvent	*Deuterated solvent*				*Undeuterated solvent*
	δ_H†	*Multiplicity*‡	δ_C	*Multiplicity*‡	δ_C
Acetic acid	2.05				21.1
	11.5§				178.1
Acetone	2.05	quintet	29.8	septet	30.5
			205.7		205.4
Acetonitrile	1.95	quintet	1.2	septet	1.6
			117.8		117.8
Benzene	7.3		128.0	triplet	128.5
t-Butanol	1.28¶				
Carbon disulphide					192.8
Carbon tetrachloride					96.1
Chloroform	7.25		77.0	triplet	77.2
Cyclohexane	1.40	triplet	26.3	quintet	27.6
Water	4.7§				
Dimethylformamide (DMF)	2.75	quintet			
	2.95	quintet			
	8.05	triplet			
Dimethylsulphoxide (DMSO)	2.5	quintet	39.7	septet	40.6
water in DMSO	3.3§				
Dioxan	3.55	triplet			67.3
Hexamethylphosphoramide (HMPA)	2.60	doublet††			
		quintet			
Methanol	3.35	quintet	49.0	septet	49.9
	4.8§				
Dichloromethane (methylene dichloride)	5.35	triplet			54.0
Pyridine	7.0		123.4	triplet	123.9
	7.35		135.3	triplet	135.9
	8.5		149.8	triplet	150.3
Toluene	2.3	quintet			
	7.2				
Trifluoroacetic acid (TFA)	11.3§				115.7‡‡
					163.8§§

† Residual protons in the deuterated solvent.
‡ A singlet unless otherwise stated.
§ Variable, depents upon the solvent and its concentration.
¶ $(CH_3)_3COD$ is usually used, not the fully deuterated solvent.
†† Coupling to P, $J = 9$ Hz.
‡‡ Quartet from coupling to F, $J = 294$ Hz.
§§ Quartet from coupling to F, $J = 46$ Hz.

Table 3 [redacted] [1]H Chemical shifts of protons attached to multiple bonds

Structure	δ_H	*Structure*	δ_H
RCHO	9.4–10.0	>C=CH—	4.5–6.0
ArCHO	9.7–10.5	>C=CHCO—	5.8–6.7
—OCHO	8.0–8.2	—HC=CCO—	6.5–8.0
>NCHO	8.0–8.2	—HC=C—O—	4.0–5.0
—C≡CH	1.8–3.1	>C=CH—O—	6.0–8.1
>C=C=CH—	4.0–5.0	—HC=C—N—	3.7–5.0
ArH	6.0–9.0	>C=CH—N—	5.7–8.0

Estimation of [1]H chemical shift in alkenes



$$\delta_H = 5.25 + z_{gem} + z_{cis} + z_{trans} \quad (3.20)$$

Table 4 [redacted] Substituent constants z for Eq. 3.20

	R	z_{gem}	z_{cis}	z_{trans}
	H—	0	0	0
C	alkyl—	0.45	−0.22	−0.28
	ring-alkyl—	0.69	−0.25	−0.28
	CO—CH_2— or NC—CH_2—	0.69	−0.08	−0.06
	Ar—CH_2—	1.05	−0.29	−0.32
	N—CH_2—	0.58	−0.10	−0.08
	O—CH_2—	0.64	−0.10	−0.02
	Hal-CH_2—	0.70	0.11	−0.04
	S—CH_2—	0.71	−0.13	−0.22
	isolated C═C—	1.00	−0.09	−0.23
	conjugated C═C—	1.24	0.02	−0.05
	Ar—	1.38	0.36	−0.07
	OHC—	1.02	0.95	1.17
	isolated RCO—	1.10	1.12	0.87
	conjugated RCO—	1.06	0.91	0.74
	isolated HO_2C—	0.97	1.41	0.71
	conjugated HO_2C—	0.80	0.98	0.32
	isolated RO_2C—	0.80	1.18	0.55
	conjugated RO_2C—	0.78	1.01	0.46
	N—CO—	1.37	0.98	0.46
	Cl—CO—	1.11	1.46	1.01
	—C≡C—	0.47	0.38	0.12
	N≡C—	0.27	0.75	0.55
N	alkyl-N—	0.80	−1.26	−1.21
	conjugated alkyl or aryl-N—	1.17	−0.53	−0.99
	—CO—N—	2.08	−0.57	−0.72
	O_2N—	1.87	1.30	0.62
O	alkyl-O—	1.22	−1.07	−1.21
	conjugated alkyl or aryl-O—	1.21	−0.60	−1.00
	—CO—O—	2.11	−0.35	−0.64
Hal	F—	1.54	−0.40	−1.02
	Cl—	1.08	0.18	0.13
	Br—	1.07	0.45	0.55
	I—	1.14	0.81	0.88
Other	R_3Si—	0.90	0.90	0.60
	RS—	1.11	−0.29	−0.13
	RSO—	1.27	0.67	0.41
	RSO_2—	1.55	1.16	0.93

Use the 'conjugated' values when either the substituent or the double bond is further conjugated. Use the 'ring-alkyl' values when the double bond and the alkyl group are part of a five- or six-membered ring.

Table 5 [redacted] Geminal ($^2J_{HH}$) coupling constants (Hz)

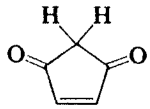
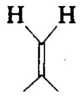
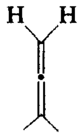
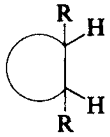
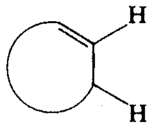
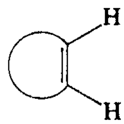
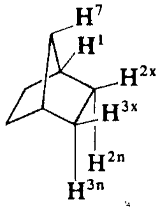
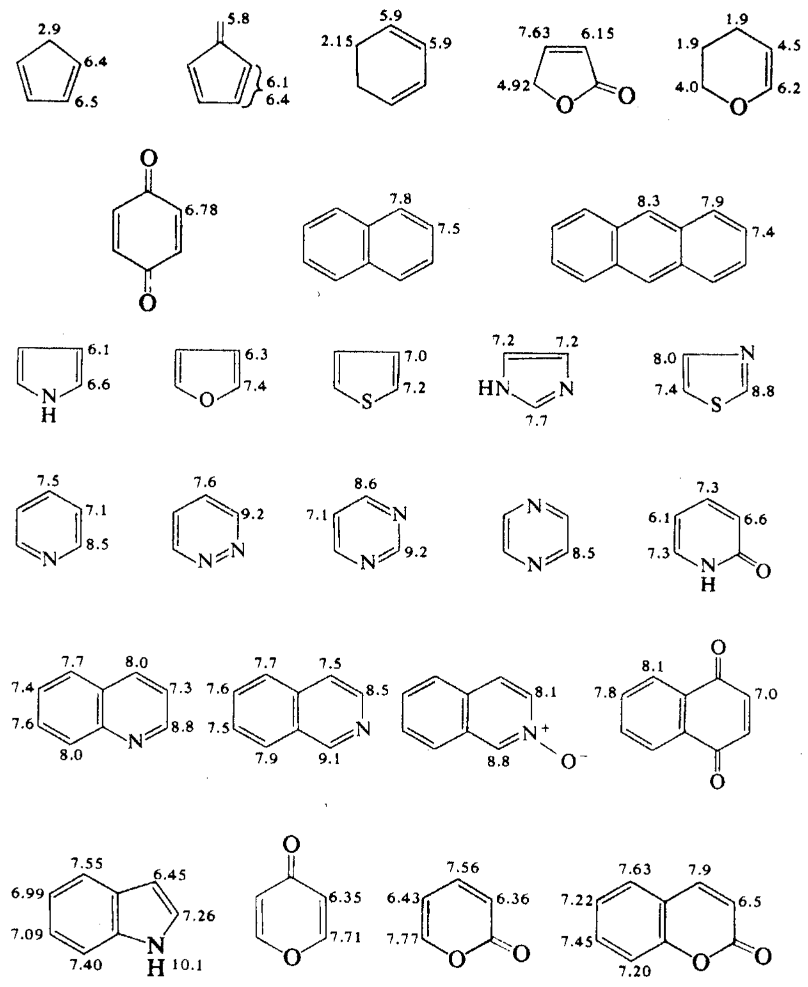
 R^1	R^2	$^2J_{HH}$	 R^1	R^2	$^2J_{HH}$
H	H	−12.4	H	CN	−16.2
R	R	−8 . . . −18	H	COMe	−14.9
—$(CH_2)_2$—		−3 . . . −9			−21.5
—$(CH_2)_3$—		−11 . . . −17			
—$(CH_2)_4$—		−8 . . . −18			
—$(CH_2)_5$—		−11 . . . −14			
H	Ph	−14.3			
					−3 . . . +3
H	OH	−10.8			−8 . . . −10
H	Cl	−10.8			
—$O(CH_2)_2O$—		~0			
—$O(CH_2)_3O$—		−5 . . . −6			

Table 6 Vicinal ($^3J_{HH}$) coupling constants in some aliphatic compounds (Hz)

Open chain compounds			*Cyclic compounds*			
Structure	$^3J_{HH}$ *range*	*Typical value*	*Structure*		*Ring size*	$^3J_{HH}$ *range*
CH_3—CH_2—	6–8	7		*cis*	3	7–13
				trans	3	4–9.5
CH_3—CH<	5–7	6		*cis*	4	4–12
				trans	4	2–10
				cis	5	5–10
—CH_2—CH_2—	5–8	7		*trans*	5	5–10
				cis	6	8–13
>CH—CH<	0–8	7		*trans*	6	2–6†
					3	1.8‡
>C=CH—CH<	4–11	6			4	−0.8‡
					5	0.5‡
					6	1.5‡
>C=CH—CH=C<	6–13	11§			7	3.7‡
					8	5.3‡
>CH—CHO	0–3	2				
					3	0.5–2
					4	2.5–4
>C=CH—CHO	5–8	7			5	5–7
					6	8.5–10.5
cis-CH=CH—	0–12	8			7	9–12.5
					8	10–13
trans-CH=CH—	12–18	15				
				1–2x		3–4
				1–2n		0–2
				2x–3x		9–10
				2n–3n		6–7
				2x–3n		2–5
				1–7		0–3

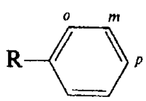
† J_{aa} = 8–13, J_{ee} = 2–5; note that J_{ee} is usually 1 Hz smaller than J_{ae}.
‡ Value for the unsubstituted cycloalkene.
§ Found in dienes adopting the *s-trans* conformation.

Table 7 ^{1}H Chemical shifts of protons attached to double bonds in some unsaturated cyclic systems†



† For simple cycloalkenes, see Table 3.19.

Estimation of proton chemical shifts in substituted benzenes



$$\delta_H = 7.27 + \sum z_i \qquad (3.21)$$

8
Table [redacted] Substituent constants for Eq. 3.21

	R	z_{ortho}	z_{meta}	z_{para}
	H—	0	0	0
C	Me—	−0.20	−0.12	−0.22
	Et—	−0.14	−0.06	−0.17
	Pr^i—	−0.13	−0.08	−0.18
	Bu^t—	0.02	−0.08	−0.21
	H_2NCH_2— or $HOCH_2$—	−0.07	−0.07	−0.07
	$ClCH_2$—	0.00	0.00	0.00
	F_3C—	0.32	0.14	0.20
	Cl_3C—	0.64	0.13	0.10
	$CH_2{=}CH$—	0.06	−0.03	−0.10
	Ph—	0.37	0.20	0.10
	OHC—	0.56	0.22	0.29
	MeCO—	0.62	0.14	0.21
	H_2NCO—	0.61	0.10	0.17
	HO_2C—	0.85	0.18	0.27
	MeO_2C—	0.71	0.1	0.21
	ClCO—	0.84	0.22	0.36
	$HC{\equiv}C$—	0.15	−0.02	−0.01
	$N{\equiv}C$—	0.36	0.18	0.28
N	H_2N—	−0.75	−0.25	−0.65
	Me_2N—	−0.66	−0.18	−0.67
	AcNH—	0.12	−0.07	−0.28
	O_2N—	0.95	0.26	0.38
O	HO—	−0.56	−0.12	−0.45
	MeO—	−0.48	−0.09	−0.44
	AcO—	−0.25	0.03	−0.13
Hal	F—	−0.26	0.00	−0.04
	Cl—	0.03	−0.02	−0.09
	Br—	0.18	−0.08	−0.04
	I—	0.39	−0.21	0.00
Other	Me_3Si—	0.22	−0.02	−0.02
	$(MeO)_2P({=}O)$—	0.48	0.16	0.24
	MeS—	0.37	0.20	0.10

These parameters are simply the shifts measured on the corresponding monosubstituted benzene ring; they are not accurately taken over to polysubstituted benzenes, but the estimation of chemical shift is usually fairly good. Errors are particularly likely to occur when substituents *ortho* to one another interfere with conjugation to the ring.

Table 9 Vicinal ($^3J_{HH}$) coupling constants (Hz) in some heterocyclic and aromatic compounds

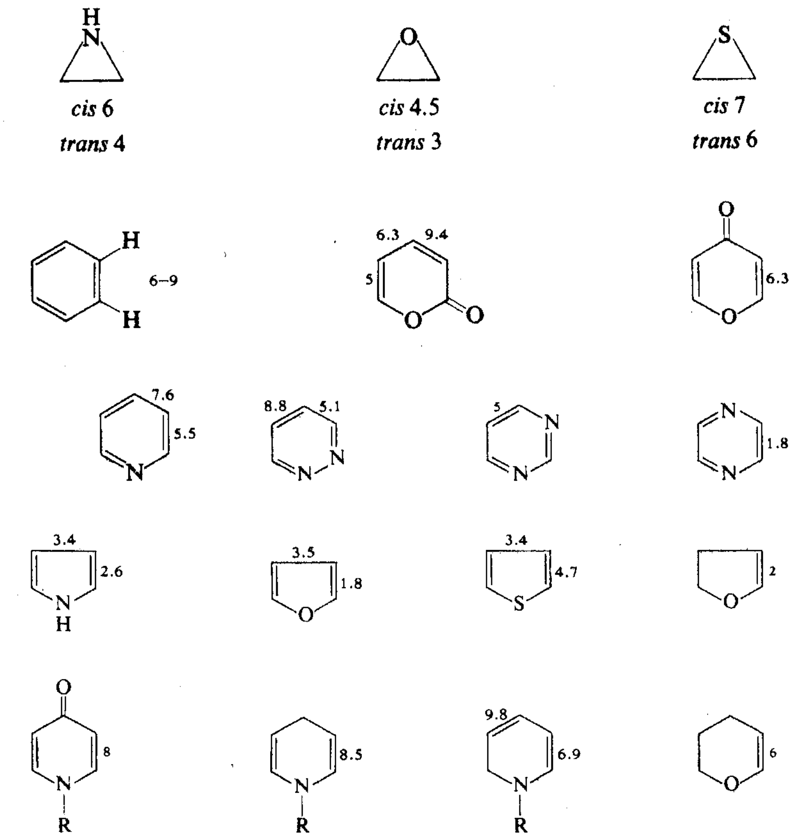
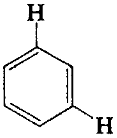
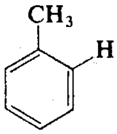
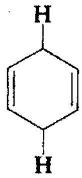
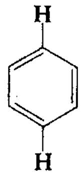
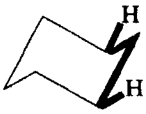
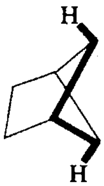
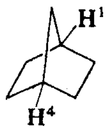
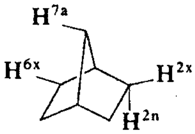
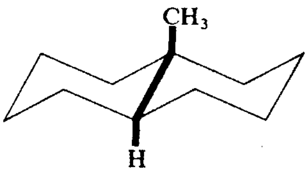


Table [redacted] 10 Long-range ($^4J_{HH}$ and $^5J_{HH}$) coupling constants (Hz)

Structure	$^4J_{HH}$	*Structure*	$^5J_{HH}$
—CH=C—CH<	0–3	>CH—C=C—CH<	0–2
	1–3	—HC=C=C—CH<	2–3
		>CH—C≡C—CH<	1–3
	0.6–0.9		8–10
—HC=C=CH—	4–6		0–1
HC≡C—CH<	1–3		
	1–2		
	7–8		1–1.5
	7a–2n 3–4 2x–6x 1–2		
	signal perceptibly broadened by ^4J coupling		

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences

CST2012 Programming II

2ND SEMESTER SESSION EXAMINATION
TUESDAY, 13TH JANUARY 2004

Instructions: Answer all questions. Take time to understand the question before answering it.

Duration: 3hrs

Part I: Multiple Choice Questions and True/False Statements [35 Marks]

1 Suppose your class method does not return any value, which of the following keyword and modifier can be used in the method definition?

- A. void
- B. int
- C. double
- D. static
- E. None of the

2 Which of the following modifiers must be present for a method to be called from the main method?

- A. public
- B. private
- C. final
- D. None of the above is necessary.

3 Arguments to methods always appear within __________.

- A. brackets
- B. parentheses
- C. curly braces
- D. quotation marks

4 All Java applications must have a method named __________.

A. Main(String[] args)

B. init()

C. main(String[] args)

D. Init()

Note: Questions 5 to 6 are based on the following method:

```
static void nPrint(String message, int n) {
  while (n > 0) {
    System.out.print(message);
    n--;
  }
}
```

5 What is the printout of the call nPrint('a', 4)?

A. aaaaa

B. aaaa

C. aaa

D. invalid call

6 What is k after invoking nPrint("A message", k)?

```
int k = 2;
nPrint("A message", k);
```

A. 0

B. 1

C. 2

D. None of the above.

7 Does the return statement in the following method cause syntax errors?

```
public static void main(String[] args) {
  int max = 0;
  if (max != 0)
    System.out.println(max);
  else
    return;
}
```

A. Yes

B. No

8 Analyze the following code:

```
public class Test {
  public static void main(String[] args) {
   System.out.println(xMethod(5, 500L));
  }

  public static int xMethod(int n, long l) {
   System.out.println("int, long");
   return n;
  }

  public static long xMethod(long n, long l) {
   System.out.println("long, long");
   return n;
  }
}
```

A. The program displays int, long followed by 5.

B. The program displays long, long followed by 5.

C. The program runs fine but displays things other than given in a and b.

D. The program does not compile because the compiler cannot distinguish which xmethod to invoke.

E. None of the above.

9 Analyze the following code:

```
class Test {
  public static void main(String[] args) {
   System.out.println(xmethod(5));
  }

  public static int xmethod(int n, long t) {
   System.out.println("int");
   return n;
  }

  public static long xmethod(long n) {
   System.out.println("long");
   return n;
  }
}
```

A. The program displays int followed by 5.

B. The program displays long followed by 5.

C. The program runs fine but displays things other than given in a and b.

D. The program does not compile because the compiler cannot distinguish which xmethod to invoke.

E. None of the above.

10 Analyze the following code.

```
public class Test {
  public static void main(String[] args) {
    System.out.println(max(1, 2));
  }

  public static double max(int num1, double num2) {
    System.out.println("max(int, double) is invoked");

    if (num1 > num2)
      return num1;
    else
      return num2;
  }

  public static double max(double num1, int num2) {
    System.out.println("max(double, int) is invoked");

    if (num1 > num2)
      return num1;
    else
      return num2;
  }
}
```

A. The program cannot compile because you cannot have the print statement in a non-void method.

B. The program cannot compile because the compiler cannot determine which max method should be invoked.

C. The program runs and prints 2 followed by "max(int, double)" is invoked.

D. The program runs and prints 2 followed by "max(double, int)" is invoked.

E. The program runs and prints "max(int, double) is invoked" followed by 2.

11 Analyze the following code.

```
public class Test {
  public static void main(String[] args) {
    System.out.println(m(2));
  }

  public static int m(int num) {
    return num;
  }
```

```
  public static void m(int num) {
    System.out.println(num);
  }
}
```

A. The program has a syntax error because the two methods m have the same signature.

B. The program has a syntax error because the second m method is defined, but not invoked in the main method.

C. The program runs and prints 2 once.

D. The program runs and prints 2 twice.

E. None of the above.

12 What is k after the following block executes?

```
{
  int k = 2;
  nPrint("A message", k);
}
```

A. 0

B. 1

C. 2

D. k is not defined.

13 Which of the following is a possible output from invoking Math.random()?

A. 3.43

B. 0.5

C. 0

D. 1

E. 1.0

14 What is Math.rint(3.6)?

A. 3.0

B. 3

C. 4

D. 4.0

E. None of the above.

15 What is Math.ceil(3.6)?

- A. 3.0
- B. 3
- C. 4
- D. 4.0
- E. None of the above.

16 What is the return value for xMethod(8) after calling the following method?

```
static int xMethod(int n) {
  if (n == 1)
    return 1;
  else
    return n - xMethod(n - 1);
}
```

- A. 6
- B. 5
- C. 4
- D. 3

17 Analyze the following two programs:

A:

```
public class Test {
  public static void main(String[] args) {
    xmethod(5);
  }

  public static void xmethod(int length) {
    if (length > 1) {
      System.out.print((length - 1) + " ");
      xmethod(length - 1);
    }
  }
}
```

B:

```
public class Test {
  public static void main(String[] args) {
    xmethod(5);
  }

  public static void xmethod(int length) {
```

```
      while (length > 1) {
        System.out.print((length - 1) + " ");
        xmethod(length - 1);
      }
    }
}
```

A. The two programs produce the same output 5 4 3 2 1.

B. The two programs produce the same output 1 2 3 4 5.

C. The two programs produce the same output 4 3 2 1.

D. The two programs produce the same output 1 2 3 4.

E. Program A produces the output 4 3 2 1 and Program B prints 4 3 2 1 1 1 .... 1 infinitely

18 Analyze the following code:

```
class Circle {
  private double radius;

  public Circle(double r) {
    radius = r;
  }
}
```

A. The program has a compilation error because it does not have a main method.

B. The program will compile, but you cannot create an object of Circle with a specified radius. The object will always have radius 0.

C. The program has a compilation error because you cannot assign radius to radius.

D. The program compiles correctly.

19 What is the output of the program below:

```
public class Test {
  public static void main(String args[]) {
    NClass nc = new NClass();
    System.out.println(++nc.t);
  }
}

class NClass {
  int t;
  public NClass() {
  }
}
```

A. 0

B.1.

C. The program compiles, but has a runtime error because t has no initial value.

D. The program does not compile because the parameter list of the main method is wrong

In the following code, suppose that f is an instance of Foo. Answer Questions 3 to 4.

```
public class Foo {
  int i;
  static int s;

  public static void main(String[] args) {
    Foo f1 = new Foo();
    System.out.println("f1.i is " + f1.i + " f1.s is " + f1.s);
    Foo f2 = new Foo();
    System.out.println("f2.i is " + f2.i + " f2.s is " + f2.s);
    Foo f3 = new Foo();
    System.out.println("f3.i is " + f3.i + " f3.s is " + f3.s);
  }

  public Foo() {
    i++;
    s++;
  }
}
```

20 What is the printout of the second println statement in the main method?

A. f2.i is 1 f2.s is 1

B. f2.i is 1 f2.s is 2

C. f2.i is 2 f2.s is 2

D. None of the above

21 What is the printout of the third println statement in the main method?

A. f3.i is 1 f3.s is 1

B. f3.i is 1 f3.s is 2

C. f3.i is 1 f3.s is 3

D. f3.i is 3 f3.s is 3

E. f3.i is 3 f3.s is 3

22 Analyze the following code.

```
public class Test {
  int x;

  public Test(String t) {
    System.out.println("Test");
  }
```

```
  public static void main(String[] args) {
    Test test = new Test();
    System.out.println(test.x);
  }
}
```

A. The program has a syntax error because System.out.println method cannot be invoked from the constructor.

B. The program has a syntax error because x has not been initialized.

C. The program has a syntax error because you cannot create an object from the class that defines the object.

D. The program has a syntax error because Test does not have a default constructor.

E. None of the above.

23 An object is an instance of a __________.

A. program

B. class

C. method

D. data

24 Analyze the following code:

```
public class Test {
  public static void main(String[] args) {
    A a = new A();
    a.print();
  }
}

class A {
  String s;

  A(String s) {
    this.s = s;
  }

  void print() {
    System.out.println(s);
  }
}
```

A. The program has a compilation error because class A is not a public class.

B. The program has a compilation error because class A does not have a default constructor.

C. The program compiles and runs fine and prints nothing.

D. None of the above.

25 What is wrong in the following code?

```
class TempClass {
  int i;
  public void TempClass(int j) {
    int i = j;
  }
}

public class C {
  public static void main(String[] args) {
    TempClass temp = new TempClass(2);
  }
}
```

A. The program has a compilation error because TempClass does not have a default constructor.

B. The program has a compilation error because TempClass does not have a constructor with an int argument.

C. The program compiles fine, but it does not run because class C is not public.

D. a and b.

26 The default value null is assigned to a data member of object type, even though the data member is not created yet.

True False

27 Java assigns a default value to a local variable in a method if the variable is not initialized.

True False

28 You can always use the default constructor even though the non-default constructors are defined in the class.

True False

29 You can access a class variable using a syntax like objectName.classVariable or ClassName.classVariable.

- True
- False

30 You cannot use the private modifier on classes.

- True
- False

31 You cannot use modifiers on local variables inside a method except final.

- True
- False

32 A static method in a class can access the instance variables in the same class.

- True
- False

33 A static method in a class can access the class variables in the same class.

- True
- False

34 You can declare a local variable in a method that has same name as an instance variable in the class.

- True
- False

35 You can declare variables of the same name in a method even though they are in the same block.

- True
- False

Part II: Short answers and filling in the blanks [15 Marks]

QII.1. A variable known only within the method in which it is declared is called a(n)________________

QII.2. The _______________ statement in a called method can be used to pass the value of an expression back to the calling method.

QII.3. A method that calls itself either directly or indirectly is a(n) _________ method

QII.4. In Java, it is possible to have various methods with the same name that each operate on different types or number of arguments. This feature is called _______________

QII.5. The ____________ modifier is used to declare constant variables.

QII.6. Members of a class specified as ___________ are accessible only to methods of the class.

QII.7. A(n) __________ method is used to retrieve values of private data of a class

QII.8. A(n ______________ is used to initialise instances variables of a class

QII.9. A(n) __________ method is used to assign values to private variables of a class.

QII.10. What is the difference between a void method and a non void method?

QII.11. Write a statement that can be used to randomly generate an integer n, which belongs to the following sets -100 <n <11

QII.12. Write a statement that declares a constant called PI with the value 3.142

QII.13. What is the value of x after the following statement is executed:

```
x = Math.floor( -Math.abs( -11 + Math.ceil(-6.5)));
```

QII.14. What is method overloading? Give an example of overloading a method.

QII.15. What do you understand by pass by value and pass by reference? When does the two occur?

Part III object-oriented concepts and programming [50 Marks]

In this section, you are required to apply the object-oriented concepts in program writing i.e. identifying the member variables of a class, identifying appropriate modifiers and accessibility of the variables.

QIII.1. [10 Marks]

a. Describe what each of the following terms is used for in Java programming
   - **i. public**
   - **ii. private**
   - **iii. static**
   - **iv. final**
   - v. ***this*** keyword

b. Give a brief description of each of the following object oriented concepts below:
   - i. Class
   - ii. Object
   - iii. Method
   - iv. Method signature
   - v. Accessors

QIII.2. Write a program RectangleWithAccessors which encapsulates the rectangle object. Suppose all rectangles created from this class are have the same colour, red and it counts the number of objects created,

a. identify all the variables with their appropriate modifiers.
b. Implement the constructors, and
c. all the accessor methods for the variables and other instance methods e.g perimeter which returns the perimeter of the rectangle. [15 Marks]

QIII.3. Write a client class that

a. creates an array of 10 instances of the RectangleWithAccessors class with randomly generated instance variables (e.g. width).
b. And the prints the information about the objects in the array: e.g.

"Circle: radius 5.0; colour is RED." and

c. print the total area of all the rectangles created. [10 Marks]

QIII.4. Write another program called Point to encapsulate a point in the x-y axis. A point is a 2-tuple – (x, y), where x is the value on the x-axis, and y is the value on the y-axis. Within the Point class:

a. Include all the instance variables with their appropriate modifiers.
b. Implement the constructors
c. Implement accessors (get and set methods) for the instance variables
d. Implement the following instance methods:
   i. origin, which returns the coordinates of the origin (0, 0)
   ii. distance which takes a Point object as its argument and calculates the distance between the current point and the argument. (Hint: the distance between $P_1(x_1,y_1)$ and $P_2(x_2,y_2)$ is $[(y_2-y_1)^2 + (x_2-x_1)^2]^{½}$
e. Test the class by creating a point (12.0, 7.0) and call the distance method to evaluate the distance between this point and the origin. [15 Marks]

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF COMPUTER STUDIES
CST2032 – FUNDAMENTALS OF COMPUTER ARCHITECTURE
SEMESTER TWO (2) EXAMINATION 2003

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

Q1. (a) Determine the Decimal Representation of the Binary number 11.11

(b) Determine the Decimal Representation of the radix 7 number 6.25

(c) Determine the Binary Representations of
(i) the radix 8 number 5.4, and
(ii) the repeating radix 3 expansion 12.2222...............

Q2. (a) Assume that we have a 4-Bit word. Using **Sign and Magnitude Representation**, determine, in Decimal,
(i) the smallest possible positive value that can be represented.
(ii) the largest possible positive value that can be represented.
(iii) the smallest possible negative value that can be represented.
(iv) the largest possible negative value that can be represented.

(b) Assume that we have a 5-Bit word. Using **One's Complement Representation**, determine, in Decimal,
(i) the smallest possible positive value that can be represented.
(ii) the largest possible positive value that can be represented.
(iii) the smallest possible negative value that can be represented.
(iv) the largest possible negative value that can be represented.

(c) Assume that we have a 6-Bit word. Using **Two's Complement Representation**, determine, in Decimal,
(i) the smallest possible positive value that can be represented.
(ii) the largest possible positive value that can be represented.
(iii) the smallest possible negative value that can be represented.
(iv) the largest possible negative value that can be represented.

Q3. (a) Consider a CPU in which the I-fetch takes three (3) microseconds to fetch an instruction, the I-unit takes two (2) microseconds to decode an instruction, and the D-unit takes one (1) microsecond to execute an instruction. Using Simple Overlap, determine how long it would take the CPU to process

(i) the first instruction
(ii) the first two instructions
(iii) the first three instructions

(b) Give a formula for determining the number of microseconds that the CPU described in (a) above would take to process n instructions for any natural number n.

(c) List down

(i) the advantages, if any, of the CPU described in (a) above as compared to a CPU in which each of the three units takes one (1) microsecond to process an instruction.
(ii) the disadvantages, if any, of the CPU described in (a) above as compared to a CPU in which each of the three units takes one (1) microsecond to process an instruction.

Q4. (a) Assume that each of the three units of the CPU involved in instruction execution (i,e the I-fetch, the I-unit, and the D-unit) takes two (2) microsecond to work on an instruction. Using **Overlap with double instruction fetch**, determine how long it would take the CPU to process

(i) the first instruction
(ii) the first two instructions
(iii) the first four instructions

(b) The formula for determining the number of microseconds that the CPU described in (a) above takes to work on n instructions is

$$\text{Time} = (1 + 3n/2)t$$

where n is a natural number and t is the time unit.

(i) Explain (one sentence) why the above formula does not work for certain values of n.
(ii) Give Two (2) examples of the values of n in (i) above.

(c) List down

(i) the advantages, if any, of using **Overlap with double instruction fetch** as compared to using **Ideal Overlap with double instruction fetch**.
(ii) the disadvantages, if any, of using **Overlap with double instruction fetch** as compared to using **Ideal Overlap with double instruction fetch**.

Q5. (a) List down two (2) factors that can prevent an instruction from being issued in **Look-Ahead and Parallelism** processing.

(b) Suppose that *Si* and *Sj* are two instructions in the same sequential block. Let *Ii* and *Ij* be their respective domains (*I* stands for Input) and *Oi* and *Oj* be their respective ranges (*O* is for Output). State the three conditions required for the two instructions to be able to be processed in parallel.

(c) Hence, consider the following three instructions:

S1: R2 = R3 * R4
S2: R5 = R3 - R6
S3: R7 = R4 * R7

Show why the three instructions can or cannot be processed in parallel.

Q6. Assuming an integrated I-fetch-I-unit time of two (2) units, a single adder with an addition time of five (5) units and a single multiplier with a multiplication time of six (6) units. Consider the following sequence of instructions:

S1: $R5 = R2 + R6$
S2: $R4 = R5 + R2$
S3: $R3 = R3 + R3$
S4: $R5 = R6 + R1$
S5: $R2 = R2 + R6$
S6: $R4 = R4 + R1$

(a) Draw a **Precedence Relationship Diagram** for the above sequence.

(b) Draw a **Transitive Relationship Diagram** for the above sequence.

(c) Determine how long it takes for the above sequence to be processed.

END(MDM)

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Computer Studies

CST3142 SOFTWARE ENGINEERING II EXAMINATION

January 2004

Time: 3 hours

Instruction

This examination has two sections. You are required to answer all questions in section A and answer three questions in section B.

Section A. Answer all the questions in this section

1. Before any planning of the project can be done, decisions must be made regarding how the work of the project is going to be approached. List examples of types of project approaches? **(3 marks)**
2. You are a Project Manager for the Environmental Information Systems (EIS) software development project. It has been agreed that the software development will be sub-contracted to a software firm. Explain how configuration management can assist in tracking down bad work by the sub-contractor. How does configuration management link with other project management techniques that would contribute to better quality? **(5 marks)**
3. Requirements engineering process covers all of the activities involved in discovering, documenting and maintaining a set of requirements for a computer-based system. What are the pitfalls of requirements engineering process and discuss the strategy you would adopt to avoid them? **(6 marks)**
4. Suppose you are building a payroll system that has three components. The first component creates forms on the screen, allowing user to type in name, address, tax identification number, salary and other financial information. The second component uses the tax tables provided by Zambia Revenue Authority (ZRA) and input information from the first component to calculate the tax due to ZRA. The third

component uses the address information to print forms for ZRA which includes the tax due. Describe the strategy you would use to test this system and outline your test cases in a test plan? **(6 marks)**

5. Discuss three challenges that the software engineers faces during systems maintenance phase? **(5 marks)**

Section B. Answer only three questions in this section

Question 1: Computer Aided Design (CAD) software project

You have just been appointed as team leader of the CAD software project. The first assignment is estimate the effort and duration of the CAD software project. The System Specification indicates that the CAD software will accept two and three-dimensional geometric data from an engineer. The engineer will interact and control the CAD system through a user interface that will exhibit characteristics of good human-machine interface design. All geometric data and other supporting information will be maintained in a CAD database. Design analysis modules will be developed to produce required output which will be displayed on a variety of graphics devices. The software will be designed to control and interact with peripheral devices such as digitizer, laser printer and plotter.

After reviewing the System Specification of the CAD software system you identify the functions and estimate the line of code (LOC) as presented in table 1 below.

Table 1. CAD software LOC estimates

Function	**Optimistic LOC estimate**	**Most likely LOC estimate**	**Pessimistic LOC estimate**
User interface and control facilities	2,100	2,600	3,800
Two-dimensional geometric analysis	4,600	5,300	7,100
Three-dimensional geometric analysis	6,700	8,400	9,300
Database management	1,600	2,400	3,600
Computer graphics display facilities	4,200	4,800	6,200
Peripheral control	1,200	1,800	3,300
Design analysis modules	7,900	8,300	9,800

Tasks

1. Calculate the estimated LOC for each function and the CAD software system based on the estimates shown in table 1 **(10 marks).**
2. Calculate the cost per line of code, estimated project cost and estimated effort (duration) for the CAD software system project if historical data indicates that the organizational average productivity for systems of this type is 528 LOC/pm and labour rate is $6000 per month **(5 marks)..**
3. It was discovered that buying the CAD software off-the-shelf cost $420,000, what factors should be used in making the decision to build or buy? When is it better to buy or build **(5 marks)**
4. Discuss how estimation affects project planning? **(5 marks)**

Question 2: Telemetry Project

You have been have been recruited as the Project Manager for a well established and successful Subaru Motor Racing Team in Zambia. The Subaru team has enjoyed a steady improvement in the previous racing seasons because of the Chief Executive Officer, Mr Musonda Mulenga and the recruitment of a top chassis designer and very experienced chief engineer. Investment has also been made in IT, basic telemetry and engine performance analysis. A big Zambia oil company has signed up to sponsor the Subaru team up to the end of next season. However, the focus for Musonda is to be among the top three in the race so that sponsorship can be assured for the next three years. To achieve this objective the team must develop the telemetry system and this why you have been recruited. Although sufficient sponsorship money is available for the project, budget over-runs will cause Musonda real problems with funding other projects he wishes to start up.

Telemetry provides a vital element to the performance of the team. The pace of technology means that it is all too easy to fall behind the leading contenders for the championship. Data is collected in real time from each component of the racing car while testing or racing. This data is then flashed back from the racing track to the team's main laboratory in the Industrial area, Lusaka, where the team's main computers simulate the road conditions against specific chassis designs and configurations. This allows the engineers to recommend changes to the tuning of the car and the adjusted settings are sent back to the racing track. The proposed platform for development of the Telemetry system is UNIX and the supplier are well known for their heavy financial demand.

The Telemetry Manager was recruited two months ago and is a very capable IT specialist with over ten years experience of the subject, mainly from Formula One racing teams in the UK. The Telemetry Team includes two support analysts and three programmers as well as the deputy Telemetry Manager. Musonda is concerned that you the project manager may become focused on technical issues. Also that the Telemetry Manager may not be sufficiently experienced in the specific technical issues that will present themselves during the project. The tension between the technical engineering people and the business management side of the Subaru team also give Musonda some cause of concern. Musonda believes that those involved should take responsibility for sensible communication between them and that the matter would probably be better left to those involved to sort out themselves

Changes to motor racing rules in Zambia are done to improve the competition. Each season sees the introduction of new rules and constraints issued by the controlling body and it is possible that elements of the Telemetry Project might be made illegal to use in future. Also some of the recommended changes to car settings coming out of the Telemetry system might not be legal and some potential benefits lost.

Your contract has been agreed and authorized by the Contracts Manager and you have been told that you report directly to Musonda who also gives immediate direction to the

Chief Engineer, Chassis Designer, Telemetry Manager and Sponsorship Manager. A small administrative team is also available.

Tasks

1. Identify how many people are in the Telemetry software development team giving reasons for your answer and calculate the maximum possible lines of communication in the team **(5 marks)**
2. Draw the overall project management team organization structure chart for the Telemetry project **(5 marks)**
3. Identify 3 risks to the Project (state why you have selected the particular risk) **(5 marks)**
4. Carry out a risk analysis on each of the risks identified (give reasons for the scores for Probability and Impact) **(5 marks)**
5. Describe the responses you would recommend (give reasons for recommending the course of action and what the expected result will be) **(5 marks).**

Question 3: Financial Management System (FMS) Project

The Financial Management Systems (FMS) project is aimed at computerization of the accounting and reporting systems so as to improve the management of financial resources in ABC Company Limited. The project is divided into three phases namely FMS application development, FMS data centre development and FMS deployment (see table 1 below). The activities in each phase follow each other but as project manager you have made the following exceptions:

- Activity A1.1 (install application) will start on the same date as activity A1.2 (Gap analysis and Design).
- Activity B1.7 (Data centre user acceptance testing) will be done in parallel with activity B1.8 (Deliver Data Centre Training).
- Activity C1.4 (Parallel Run – Manual and new system) will be done in parallel with activity C1.5 (FMS User acceptance test).

Please note that activity B1.1 (Delivery of Hardware and Software for the LAN) will follow activity A1.4 (configuration and customization). Furthermore that activity C1.1 (FMS forms design) will start immediately after activity B1.2 (Installation of LAN) has been completed.

Table 1. Schedule for FMS development

Reference	**Activity**	**Time Estimate (in Days)**
A1	**FMS Application Development**	
A1.1	Install application	3
A1.2	Gap Analysis and Design	15
A1.3	Design	10
A1.4	Configuration and Customisation	10

Reference	Activity	Time Estimate (in Days)
B1	**FMS data centre development**	
B1.1	Delivery of Hardware and Software for the LAN	15
B1.2	Installation of LAN	20
B1.3	Installation of Configured and Customised application	10
B1.4	Test script and test data development	10
B1.5	Unit testing for the data centre only	8
B1.6	Integrated testing for the data centre only	5
B1.7	Data Centre User Acceptance Testing	6
B1.8	Deliver Data Centre Training	9
C1	**FMS Deployment**	
C1.1	FMS forms design	12
C1.2	Data migration	15
C1.3	Prepare test data/plan	9
C1.4	Parallel Run (Manual and new system)	18
C1.5	FMS User acceptance test	11
C1.6	FMS handover and sign off	7

Tasks

1. Draw the project logic or network diagram for the FMS project **(5 marks)**
2. Calculate the slack time or float for each activity for the FMS project **(5 marks)**
3. Identify the critical path using the PERT method for the FMS project **(10 marks)**
4. The project is behind schedule by 4 weeks, discuss how adding personnel to the project can be counterproductive **(5 marks)**

Question 4: Selecting a Geographic Information System (GIS) software

You have just been appointed as IT Manager for a Water Utility company in Kitwe and your first assignment is to procure a Geographic Information System (GIS) software for the company. A GIS is an information system that is designed to work with data referenced by spatial or geographic co-ordinates. You have constituted an evaluation team comprising of IT experts as well as technical experts to evaluate and select the appropriate GIS software. Three products were identified and evaluated by the organisation: ArcView, MapInfo, ArcInfo.

The evaluation team has agreed that the major functionality of the GIS software should include the following: (a) the system shall allow various techniques to capture the information such as digitized maps to collect the coordinates of features and electronic scanning devices to convert map lines and points to digits; (b) the system shall provide for features that make it possible to link, or integrate, information that is difficult to associate through any other means for example the system must use combinations of mapped variables to build and analyze new variables; (c) the system shall support map projection and registration (a projection is a mathematical means of transferring information from the Earth's three-dimensional curved surface to a two-dimensional medium - paper or a computer screen); (d) the system shall support data restructuring and must be able to convert data from one structure to another (raster and vector formats); (e) the system shall support data and topological modelling as well as support map overlays. Table 1 below provides a summary of the evaluation team assessment of the identified GIS software functional requirements (1 poorly meets requirements and 5 more than meets requirements) and the weight (1 not very important and 9 extremely important).

Table 1. GIS software functional requirements

Requirements	**Weight**	**ArcView**	**MapInfo**	**ArcInfo**
1. Data Capture	8	3	4	5
2. Integrate	6	4	4	5
3. Projection and registration.	8	5	3	5
4. Data restructuring	5	4	4	3
5. Data and topological modelling	9	2	3	4
6. Information retrieval capability	5	5	4	4
7. Map overlays	6	5	4	5
8. Data Output	6	5	4	4
9. Internet and ODBC	4	5	4	3
10. ODBC	7	5	4	4

The evaluation team also identified the non-functional requirements, which were assessed and ranked as shown in the table 2 below.

Table 2. GIS software non-functional requirements

Requirements	**Weight**	**ArcView**	**MapInfo**	**ArcInfo**
1. Interoperability	6	5	3	4
2. Efficiency/ Resource utilisation	5	5	4	4
3. Usability	4	5	4	3
4. Vendor reputation	6	5	5	5
5. User experience	3	4	4	3
6. Local support	7	3	3	4

Tasks

1. Use the weighted sum method to select the GIS software with the best functional requirements score? **(5 marks)**
2. Use the weighted sum method to select the GIS software with the best non-functional requirements score? **(5 marks)**
3. Use the weighted sum method to select the GIS software with the best technical score? The technical score comprise of functional requirements score and non-functional requirements score. Assume that the weight for the functional requirements is 70% while the weight for the non-functional requirements is 30%. **(5 marks)**
4. The cost of ArcInfo is \$200, MapInfo costs \$160 and ArcView costs \$150. Which GIS software provides the best combined technical and financial score assuming that the technical score is 60% and the financial score is 40%? **(5 marks)**
5. Describe some of the problems of the weighted sum method? **(5 marks)**

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCE

DEPARTMENT OF COMPUTER STUDIES

DATA COMMUNICATIONS AND COMPUTER NETWORKS

(CST3012)

SESSIONAL EXAMINATIONS 2003/2004

TUESDAY, 6^{TH} JANUARY 2004

DURATION THREE(3) HOURS

ANSWER <u>FIVE (5)</u>

No reference material of any kind may be brought in the examination room
Cross out excess solutions, failure to do so will result in the first five being marked

Question One

(a) Distinguish between the concept of data communications and data transmission. Illustrate y answer with suitable examples. [5 marks]

(b) (i) What are the basic requirements of a data communications system? Write a short note (4) of these. [8 marks]

(ii) Distinguish between analog signal and digital signal. [2 marks]

(c) Briefly describe 2 peer-to-peer and 3 client/server Network Operating Systems currently on Market. [5 marks]

Question Two

(a) What is the difference between Packet-Switching network and Circuit Switching network? [8 Marks]

(b) Two options are available for implementing Packet switching and these are the use of a Virtual circuit and the Data gram.

Draw diagrams to show the way packets are transmitted in Virtual Circuit and Data gram options given above. [8 Marks]

(c) Give and briefly explain an example for each of the switching types, Packet switching and Circuit switching. [4 Marks]

Question Three

a) Write a short note on each of the following data communication concepts:-

i) End-nodes vs. Intermediate nodes
ii) Modes of transmission (simplex, half-duplex, full-duplex)
iii) Synchronous vs. Asynchronous transmission
iv) Baseband vs. Broadband
v) Concentration vs. Multiplexing

Illustrate your answer with suitable diagrams where appropriate. [20 marks]

Question Four

(a) A LAN (Local Area Network) is often installed by a business or organization to achieve any or all of the following objectives. By reference to a typical business carefully explain each of these objectives;

i) sharing peripherals [3 marks]
ii) sharing of data [3 marks]
iii) user communications [2 marks]

(b) Outline THREE possible problems of sharing data within a network. [6 marks]

(c) Discuss the importance of standards to:
   (i) Users of computer networks [2 marks]
   (ii) Manufacturers of network equipment [2 marks]
   (iii) Vendors and maintainers of networking equipment [2 marks]

Question Five

(a) List the seven layers of the OSI Reference model. List two functions of each of these. Illustrate your answer with a practical example. [10 marks]

(b) Carrier Sense multiple Access with Collision Detection(CSMA/CD) is the most common implementation of contention access. Explain the meaning of the following;

   (i) Carrier Sense [2 marks]
   (ii) Multiple Access [2 marks]
   (iii) Collision detection [2 marks]

(c) What is attenuation? In what way can it be overcome within the context of data transmissio Over a WAN. [4 marks]

Question Six

(a) Distinguish between peer-to-peer and client/server LAN configuration. [4 marks]

(b) What is a network topology? Identify and describe (with suitable diagrams) the various typ LAN topologies. [5 marks]

(c) Write a detailed note on types, use and suitability of guided and unguided media used withi communication systems. Illustrate your answers with suitable diagrams where Appropriate. [6 marks]

(d) What is meant by the term Internetworking. Describe the functionality of each of the followi internetworking devices: Repeaters, routers, and brouters. Include in your answer the suitabi each of these within a given network configuration.(For example where a router is better tha repeater). [5 marks]

Question Seven

(a) Explain the following features, which a network must offer

(i) Privacy [2 marks]
(ii) Integrity [2 marks]
(iii) Availability [2 marks]

(b) There are several threats to Network security i.e. Eaves dropping, man-in-the-middle, replay, Trojan horse , virus and physical attacks.

(i) Choose FOUR of these threats and define what they are [8 marks]
(ii) Write short notes on the counter measures that can be implemented to address the threats selected in (i) [6 marks]

Question Eight

A college currently uses two separate local area networks, one for its administration and one for teaching.

(a) The Administration network consists of 12 workstations and a dedicated File Server. One of the workstations also acts as a Print Server.

(i) Explain the functions of a Print Server and the File Server [4 marks]
(iii) State two possible disadvantages of using a workstation as a Print Server [4 marks]

(b) Ring and Star are common topologies for local area networks

Describe these topologies; using clearly labeled diagrams to illustrate your answer [6 marks]

(c) The college wishes to connect the two networks so that teaching staff can have access to student records. This connection can be made using a bridge.

(i) When would it be necessary to use a gateway, rather than a bridge to connect the two networks? [3 marks]
(ii) State two functions provided by a gateway that would not be provided by a bridge [3 marks]

END OF EXAMINATION

GROUP 3: ENTITY RELATIONSHIP MODELING.

Answer either question 3A or 3B. Each of them has 30% weight in the final mark.

Question 3A:

3A-1 (10%) Describe what relationship types represent in an ER model, and provide examples of unary, binary, ternary and quaternary relationships.
3A-2 (30%) Describe how fan and chasm traps can occur in an ER model and how they can be resolved.

Question 3B:

3B-1 (10%) Describe what attributes represent in an ER model, and provide examples of simple, composite, single-value, multi-value and derived attributes.
3B-2 (10%) Describe how strong and weak entity types differ and provide an example of each.
3B-3 (20%) How does multiplicity represent both the cardinality and participation constraints of a relationship type?

Company

(Example database from: *Ramez Elmasri & Shamkant Navathe*, Fundamentals of Database Systems, 2nd edition, 1994)

Employee

Fname	Minit	Lname	SSN	Bdate	Address	Sex	Salary	SuperSSN	DNO
James	E	Borg	888665555	10/11/1927	450 Stone, Houston, TX	M	55,000		1
Joyce	A	English	453453453	31/07/1962	5631 Rice, Houston, TX	F	25,000	333445555	5
Ahmad	J	Jabbar	987987987	29/03/1959	980 Dalla, Houston, TX	M	25,000	987654321	4
Ramesh	K	Narayan	666884444	15/09/1952	975 Fire Oak, Humble,	M	38,000	333445555	5
John	B	Smith	123456789	09/01/1955	731 Fondren, Houston,	M	30,000	333445555	5
Jennifer	S	Wallace	987654321	20/06/1931	291 Berry, Bellaire, TX	F	43,000	888665555	4
Franklin	T	Wong	333445555	08/12/1945	638 Voss, Houston, TX	M	40,000	888665555	5
Alicia	J	Zelaya	999887777	19/07/1958	3321 Castle, Spring, TX	F	25,000	987654321	4

Department

Dname	Dnumber	MgrSSN	Mgrstartdate
Headquarters	1	888665555	22/05/1978
Administration	4	987654321	01/01/1985
Research	5	333445555	22/05/1978

Dept_Locations

Dnumber	Dlocation
1	Houston
4	Stafford
5	Bellaire
5	Houston
5	Sugarland

Works_on

ESSN	PNO	Hours
123456789	1	32.5
123456789	2	7.5
333445555	2	10.0
333445555	3	10.0
333445555	10	10.0
333445555	20	10.0
453453453	1	20.0
453453453	2	20.0
453453453	3	10.0
666884444	3	40.0
888665555	20	0.0
987654321	20	15.0
987654321	30	20.0
987987987	10	35.0
987987987	30	5.0
999887777	10	10.0
999887777	30	30.0

Project

Pname	Pnumber	Plocation	Dnum
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorgaqnization	20	Houston	1
Newbenefits	30	Stafford	4

Dependent

DName	ESSN	Bdate	Relationship	Sex
Alice	123456789	31/12/1978	Daughter	F
Elizabeth	123456789	05/05/1957	Spouse	F
Michael	123456789	01/01/1978	Son	M
Alice	333445555	05/04/1976	Daughter	F
Joy	333445555	03/05/1948	Spouse	F
Theodore	333445555	25/10/1973	Son	M
Abner	987654321	29/02/1932	Spouse	M

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences

CST3022 Programming Languages Paradigms

UNIVERSITY EXAMINATION 2ND SEMESTER
05TH JANUARY 2004

Instructions: There are SIX (6) questions in this examination. You are required to answer only **FIVE (5)** of them. Good Luck!

Duration: 3hrs

Q.1.

a. What is compilation?
b. How does compilation differ from interpretation?
c. Describe the stages through which a program written in a high-level language goes through during the process of Compilation.
d. What is the purpose of having a compiler which generates intermediate code?

Q.2. Programming Languages are divided into categories depending on how they perceive the process of computing. At a high level, the languages are divided into imperative and declarative paradigms. These categories have sub-categories.

a. What distinguishes the imperative paradigm from the declarative paradigm?
b. Give the sub-categories of the imperative and declarative paradigms.
c. Using diagrams illustrate how each of the categories above perceives the process of computation.
d. What makes a programming language more successful than others?

Q.3.

a. Describe six kinds of tools that commonly support the work of a compiler within a large programming environment.
b. What distinguishes the front-end of the compiler from the back-end?
c. What are the advantages of designing a compiler in terms of the front-end and the back-end?

Q.4. A computer executes instructions that are expressed in its native machine language. Writing programs in machine language is tedious and error-prone.

a. How has this problem been addressed to make program writing to be easier, less error prone and more bearable?
b. What is the difference between an assembler and a compiler?
c. When does it still become necessary to write programs in machine language?

Q.5. Errors in a computer program can be classified according to when they are detected and if they are detected at compile time, what part of the compiler detects them. Using your favourite programming language, give an example of a

a. Lexical error, detected by the parser.
b. Syntax error, detected by the parser.
c. A static semantic error, semantic analysis.
d. Dynamic semantic error detected by the code generated by the compiler.

Q.6.

a. Distinguish between syntax and semantics of a language.
b. How is the syntax and semantics of a programming language specified?
c. What is the difference between static semantics and dynamic semantics? Give some examples using your favourite programming language.
d. Why is it that there are several programming languages in use today?

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF COMPUTER STUDIES
CST3032 – ARTIFICIAL INTELLIGENCE
SEMESTER TWO (2) EXAMINATION 2003

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

Q1. (a) Artificial Intelligence (AI) is defined as the study of how to make computers do things which, at the moment, people do better.

(i) What does the above definition provide?

(ii) What does the above definition avoide?

(b) Some of the Artificial Intelligence Tasks are Mundane Tasks, Formal Tasks, and Expert Tasks.

(i) Natural Language Plocessing falls under Mundane Tasks. List down three (3) examples.

(ii) Mathematics falls under Formal Tasks. List down Four (4) examples.

(iii) Engineering falls under Espert Tasks. List down three (3) examples..

(c) List down five (5) points (one sentence each) that describe how an AI Technique exploits knowledge.

Q2. Suppose that you want to write a program to play the game of Tic-Tac-Toe. The program should meet all the requirements of a good AI Technique.

(a) Describe the Data Structures required

(b) Describe the Algorithm required

(c) (i) Give one (1) disadvantage of such a program

(ii) Give two (2) advantages of such a program

Q3. (a) List down two (2) advantages of the **Depth-First Search Algorithm** over the **Breath-First Search Algorithm.**

(b) List down two (2) advantages of the **Breath-First Search Algorithm** over the **Depth-First Search Algorithm.**

(c) Suppose that you are given two empty jugs, a 4-gallon one and a 3-gallon one. Neither has any measuring markers on it. There is a pump that can be used to fill the jugs with water. Use the **Breath-First Search Algorithm** to show how you can get exactly two (2) gallons of water into the 4-gallon jug, if possible.

Q4. (a) What is a Heuristic Function?

(b) A Salesman has a list of cities, each of which he must visit only once. There are direct roads between each pair of cities on the list. Suppose that you want to find the route that the Salesman should follow for the shortest possible round trip that starts and finishes at any one of the cities. Give the *nearest neighbor heuristic* procedure that the Salesman should use.

(c) Consider the following distances among the cities A, B, C, D, and E:

A to B = 100Km	B to C = 150Km	C to D = 120Km
A to C = 150Km	B to D = 150Km	C to E = 90Km
A to D = 50Km	B to E = 150Km	D to E = 80Km
A to E = 70Km		

Use the procedure in (b) above to determine the shortest round trip for the Salesman, assuming that he starts from city A.

Q5. (a) Consider the following **Missionaries and Cannibals Problem**:

Three missionaries and three cannibals find themselves on one side of a river. They have agreed that they would all like to get to the other side of the river. But the missionaries are not sure what else the cannibals have agreed to do. So the missionaries want to manage the trip across the river in such a way that the number of missionaries on either side of the river is never less than the number of the cannibals who are on the same side. The only boat available holds only two people at a time. How can everyone get across the river without the missionaries risking being eaten?

(b) List down the seven (7) Problem Characteristics for analyzing a problem.

(c) Analyze the Missionaries and Cannibals Problem with respect to the seven (7) Problem Characteristics in (b) above.

Q6. (a) List down two (2) advantages of a **Search Tree** over a **Search Graph**.

(b) List down two (2) advantages of a **Search Graph** over **Search Tree**.

(c) Suppose that you are given two empty jugs, a 5-gallon one and a 3-gallon one. Neither has any measuring markers on it. There is a pump that can be used to fill the jugs with water. Use a **Search Graph** to show how you can get exactly four (4) gallons of water into the 5-gallon jug, if possible.

END(MDM)

THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF COMPUTER STUDIES
SECOND SEMESTER EXAMINATION 2003

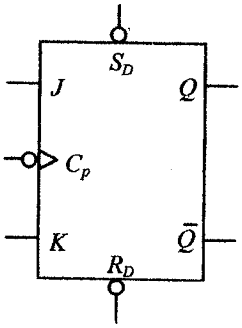
CST 3252: ELECTRONICS FOR COMPUTING II

TIME: 3 HOURS
INSTRUCTIONS: ANSWER ANY FOUR QUESTIONS
TOTAL MARKS 100
ALL QUESTIONS CARRY EQUAL MARKS

Truth table for 74LS76 flip-flop

Operating Mode	$\overline{S}_D$	$\overline{R}_D$	$\overline{C}_p$	J	K	Q	$\overline{Q}$
Assyncronous Set	L	H	×	×	×	H	L
Assyncronous Reset	H	L	×	×	×	L	H
Syncronous Hold	H	H	↓	l	l	q	$\overline{q}$
Syncronous Set	H	H	↓	h	l	H	L
Syncronous Reset	H	H	↓	l	h	L	H
Syncronous Toggle	H	H	↓	h	h	$\overline{q}$	q

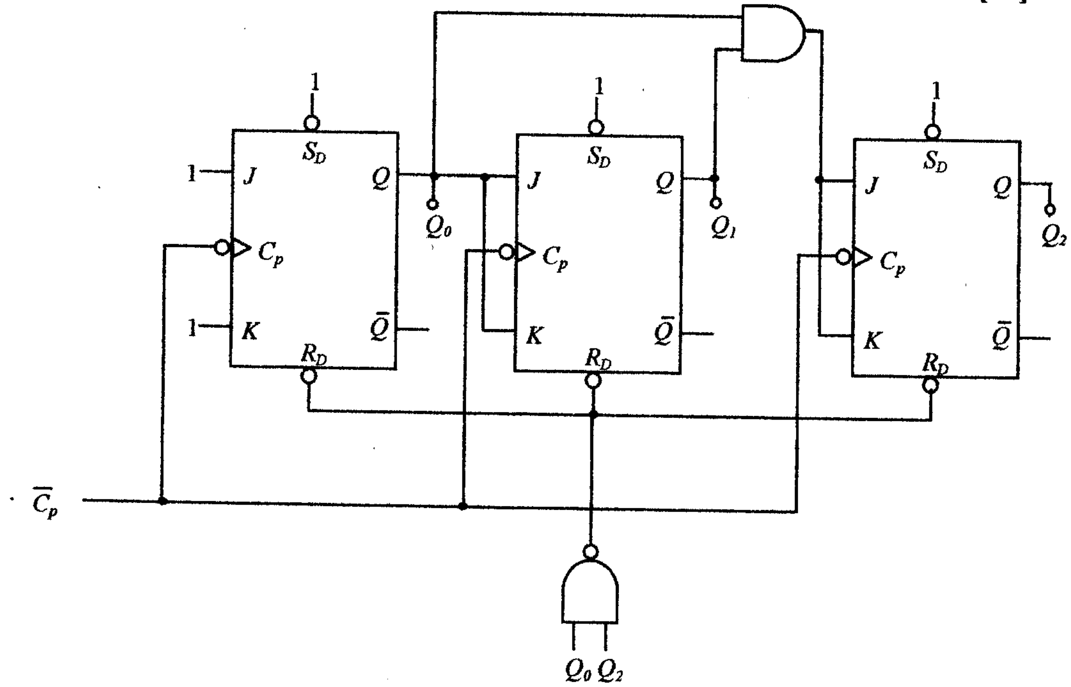
***lower case means state just before negative clock edge.**



74LS76 JK FLIP FLOP

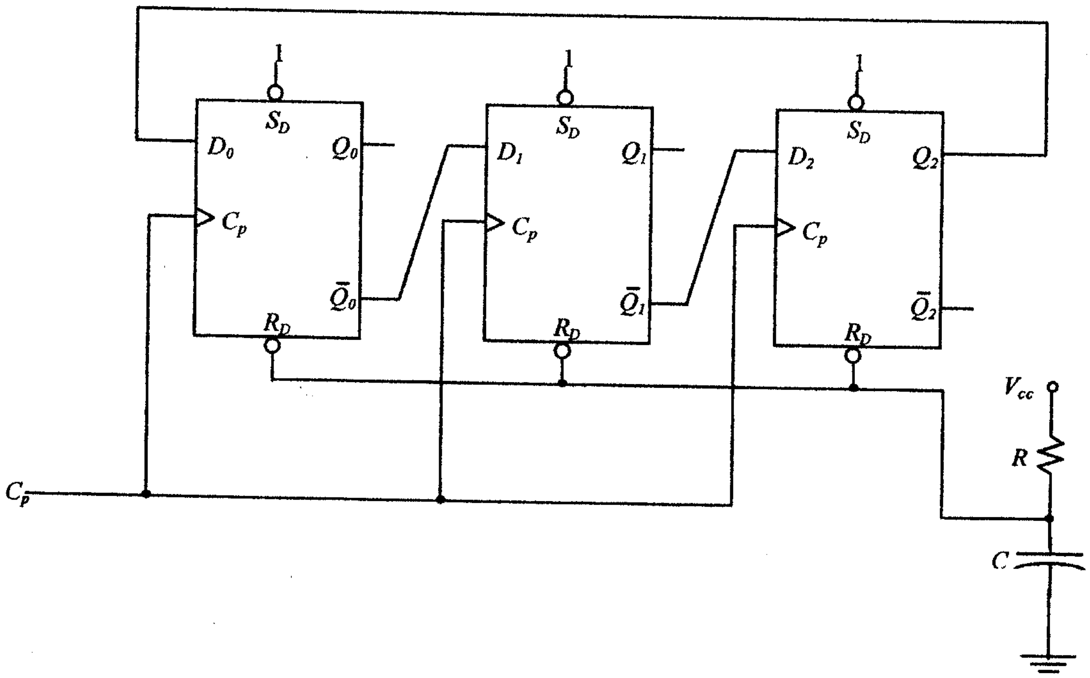
Q.1. a) Draw the transfer function of a Schmitt trigger inverter. The following specifications apply: $V_{T+} = 1.8$ V, $V_{T-} = 0.8$ V, $V_{OH} = 3.8$ V, $V_{OL} = 0.2$ V. [7]

b) Sketch the waveforms at $\overline{C}_p$, Q_0, Q_1 and Q_2 for 10 clock pulses for the 3-bit synchronous counter shown below. Assume all Q outputs are 0 at the start. [10]



c) Design and sketch a 3-bit ripple counter using the 74LS76 J-K flip flop. [8]

Q.2. a) Sketch the waveform of Q_2 for the first 5 clock pulses generated by the circuit below. [10]



b) Draw a 4-bit Serial to Parallel shift register using the 74LS76 flip-flop. [9]

c) Draw the waveforms for the shift register in part b) if the serial input is the binary number 1101. [6]

Q.3. a) Define the following memory terms [8]

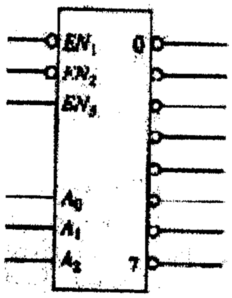
i) EEPROM
ii) Address Decoding
iii) DRAM
iv) Non-volatile memory

b) i) How many address lines are required to select a specific location within RAM having 4096 locations. [2]

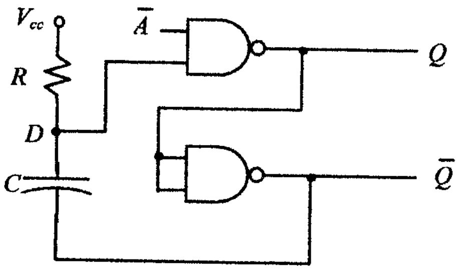
ii) How many memory locations do the following RAM configurations have? [2]

I) $2K \times 4$
II) 8192×8

c) Design and sketch an address decoding scheme for an $8K \times 8$ EPROM memory system using 2716 EPROMS ($2K \times 8$). Starting address of the scheme is 4000H. Use the 3 to 8 decoder given below. [13]

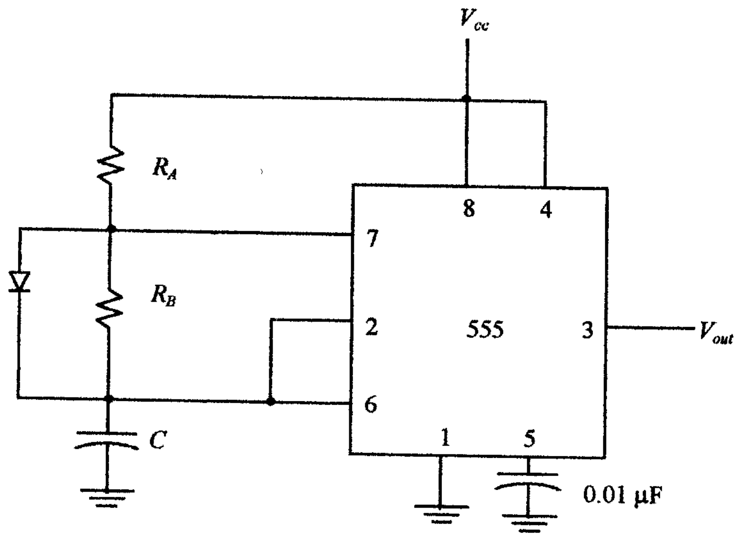


Q.4. a) i) For the circuit given, draw the waveforms if the circuit is operated as a Monostable multivibrator. Assume that at the start the capacitor is discharged, $\bar{A}$ is HIGH, Q is LOW and therefore point D is HIGH. Three waveforms should be drawn; $\bar{A}$, V_D and Q. [8]



ii) For the circuit given above, determine the values of C such that a negative going 4 μs input trigger pulse will create a 100 μs positive going output pulse. Given that $V_{IH} = 3$ V, $V_{cc} = 5$V, $R = 10$ kΩ. **[9]**

b) The circuit below uses the 555 IC timer in astable mode to achieve a 100 kHz square wave with 50% duty cycle. Calculate R_A and R_B given that $C = 1$ nF. **[8]**

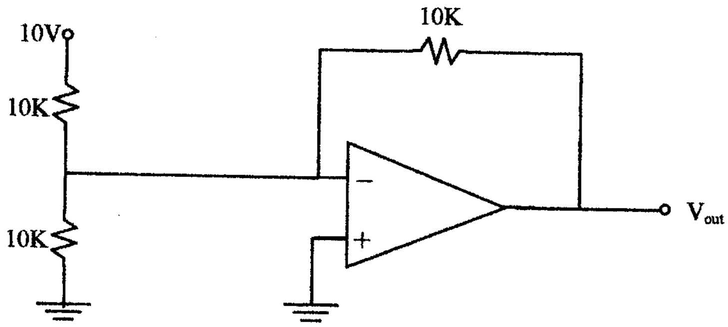


Q.5. a) Define the following terms related to ADCs and DACs. **[4]**

i) Bistable

ii) Op-amp

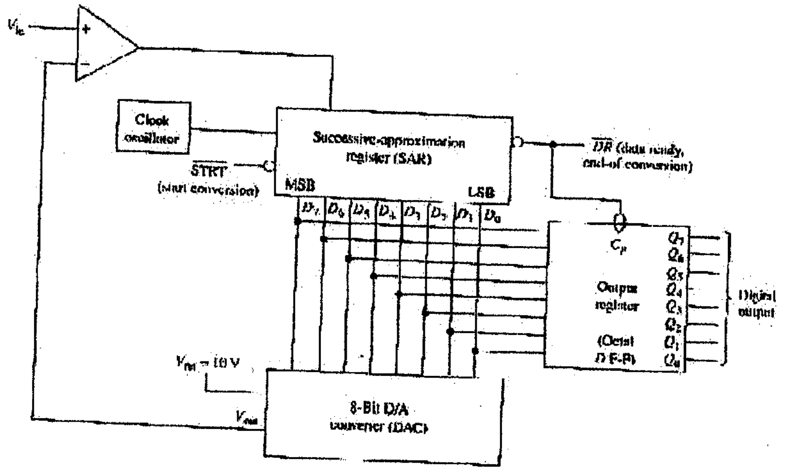
b) For the circuit below determine V_{out}. **[6]**



c) i) Determine the conversion time for an 8 bit Analog to Digital Converter that uses the successive approximation method (like the one provided below) if its clock frequency is 100 kHz. **[5]**

ii) Convert the analog voltage 5.36V to 8 bit binary if $V_{ref} = 20$V. **[5]**

iii) Draw the circuit diagram of a binary weighted Digital to Analog converter. **[5]**



Q.6. a) Define **[8]**

i) Control bus
ii) Data Bus
iii) Operand
iv) Instruction Decoder

b) What is the function of the following registers in the 8085A microprocessor? **[8]**

i) Accumulator
ii) Instruction Register
iii) Program Counter
iv) H and L registers

c) Outline, in point form, how the instruction **LDA 4000H** is executed by the 8085A microprocessor. Assume the instruction is in address 1000H. **[9]**

END OF EXAMINATION

The University of Zambia
School Of Natural Sciences
Computer Studies Department

CST4012 Distributed Systems **Second Semester** Final Examination

Duration: 3 Hours **Date: Monday 12th January 2003(AM)**

Answer any five questions **All questions carry equal marks**

1 (a) Define a distributed system
(b) Discuss the advantages and the disadvantages of a Distributed system Over a Centralized one

2. (a) Security is vital in Distributed Systems what measures should be taken to keep away intruders to the system?
(b) What are some common causes of data loss and what preventive measures must be put in place to prevent this?

3. Write brief notes on
(i) Protection Domains
(ii) Access Control Lists

4. What is the difference between a connection-oriented and connectionless communication and in what situation can each of these be used?

5. *Draw* an Open System Interconnection (OSI) model showing layers, interfaces and protocols and *explain* briefly the functions of each layer.

6. In a client-server model ***explain*** three possible methods for addressing processes

Please Turn Over

7. In a Distributed System there are several different ways in which hardware can be organized in terms of interconnection and communication. *Describe* the interconnection and communication on a Bus-Based *Multiprocessors* and distinguish this with Bus-Based *Multicomputers.*

8. When designing Distributed systems the following design issues have to be taken into consideration in order to achieve the single system image this;- Transparency, Flexibility, reliability, performance and scalability. *Explain* briefly on any three of these issues.

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

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF COMPUTER STUDIES

MULTIMEDIA AND HUMAN COMPUTER INTERACTION

(CST4112)

SESSIONAL EXAMINATIONS 2003/2004

MONDAY, 5TH JANUARY 2004

DURATION THREE(3) HOURS

ANSWER FOUR (4) QUESTIONS

No reference material of any kind may be brought in the examination room
Cross out excess solutions, failure to do so will result in the first four being marked

Question One

(a) (i) Define what Multimedia is. 3 marks
(ii) Which two(2) features make an application Multimedia? 2 marks

(b) Explain the following in terms of their use in multimedia applications
(i) Text 2 marks
(ii) Graphics 2 marks
(iii) Audio 2 marks
(iv) Video 2 marks
(v) Animation 2 marks

(c) Several business, educational, entertainment and training benefits of Multimedia have been claimed. List and explain five(5) of these benefits. 10 marks

Question Two

(a) Write brief notes on each of the following descriptions regarding compression.

(i) Compression ratio 2 marks
(ii) Image quality 4 marks
(iii) Compression/decompression speed 2 marks

(b) Define the following terms
(i) Pixel depth 2 marks
(ii) Aspect ratio 2 marks
(iii) Sampling rate(Nyquist rate) 3 marks
(iv) Rasta scan 3 marks
(v) Flicker 2 marks
(vi) Audio/video codec 2 marks

(c) Multimedia authoring tools fall into three general categories. These are;

- Card or page-based tools
- Icon based tools
- Time based tools

Give an example of a tool that falls in each of the categories listed above.
3 marks

Question Three

(a) File-compression programs simply get rid of redundancy. Instead of listing a piece of information over and over again, a file-compression program lists that information once and then refers back to it whenever it appears in the original program.

Consider the statement below from John F. Kennedy's 1961 inaugural address:

"Ask not what your country can do for you ask what you can do for your country."

Explain using patterns based on Lempel and Ziv dictionary-based algorithm how you would reduce this statement to 18 units or characters. Ensure to show your steps clearly.(the dictionary can take up to 42 units or characters) 20 marks

(b) Explain the following acronyms, giving type of media they are used for.
JPEG, MPEG, MP3 5 marks

Question Four

(a) 'There are costs associated with good HCI design but the cost of bad HCI design are much greater'. Give your overall opinion of this statement and justify your opinion by explaining what costs (of both good and bad design) you think the writer is referring to. 13 marks

(b) Human beings have a number of physical and mental characteristics that need to be taken into account in HCI design. Outline three characteristics of human vision that need to be taken into account when designing information systems.
6 marks

(c) Health and safety at work are an extremely important aspect of office and workstation design. Name and briefly describe three (3) different types of injury that users of badly designed computer systems may be susceptible to.
6 marks

Question Five

(a) In HCI we consider both the human end of the interaction and the computer side of interaction.
Give the advantage of each of the following computer side interaction devices

(i)	Chord keyboard	2 marks
(ii)	Touch sensitive screens	2 marks
(iii)	Trackballs	2 marks
(iv)	LCD over CRT	2 marks

(question Five continued..)

(b) Draw a stylized diagram which illustrate the goals of the study of Human Computer Interaction(HCI). 8 marks

(c) What is meant by the following terms in relation to memory?
(i) Closure 2 marks
(ii) Chunking 2 marks

(d) Define ergonomics, clearly outlining what it seeks to achieve with examples. State also how it differs from HCI. 5 marks

Question Six

(a) User interfaces can be analyzed according to the interaction style/s(eg menus etc) they use. Describe three interaction styles giving an example of each and discuss their advantages and disadvantages. 15 marks

(b) Guidelines and Standards vary in a number of ways e.g. generality, areas covered and originators.
(i) Identify five(5) possible or types of originators of guidelines and standards which builders would be required to adhere to. 5 marks
(ii) List advantages of using Guidelines and Standards 3 marks
(iii) Identify possible problems of Guidelines and Standards 2 marks

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
University Examination

CST4122 Fundamentals of Compilers
9th January 2004

Instructions: Answer **ANY FIVE(5)** questions out of the given SEVEN (7) questions. Attached to this examination are copies of the syntax of the P language and the M instructions. Good luck!

Duration: 3hrs

Q.1. Consider the P program below.

```
VAR N, p;
BEGIN
    N = READ;
    WHILE N > 0 DO
    BEGIN
            P = P + N;
            N = N – 1;
    END;
    WRITE(P);
END.
```

a. The writer of this program forgot to instantiate P to 0 after the read statement before entering the while loop, identify the errors in the program and state the component of the compiler that catches each of the identified error. Note that identifiers are uppercase alphabet letters.

b. Correct the errors and give the output of the program by showing how the variables change their values if the user entered:
   i. 4
   ii. 10
   iii. 0
   iv. -3
   v. -2

c. What can you conclude the program is meant to do?

d. Rewrite the program so that it can work the same for negative numbers as well?

Q.2. The compiler is usually designed as a series of passes called the front-end and back-end.

a. Distinguish between a pass and a phase.
b. Distinguish between the tasks performed by the front-end and back-end of the compiler.
c. Briefly describe the phases that comprises the front-end and the back-end
d. Why is it necessary to have a compiler that generates intermediate code?

Q.3. The P language is a subset of the Pascal language. In Pascal a program starts with the **Program** keyword, then the name of the program, followed by a semi-colon, followed by the user defined procedures and functions, the variable declarations, and the main **begin..end** block, terminated by a full stop. We want to improve the P language to include user-defined functions whose structure should be as follows:

function functionname **(** parameterlist **)** : returntype;

the returntype here is the type of value that the function is to return, the parameterlist is the declaration of the list of formal parameters that are required by the function to perform its task, and the functionname is simply an identifier. Below is an example of a program that defines a function called square, which takes an integer as its argument and returns the square of that number

```
program example;
function square(var a: real): real;
begin {function body}
        square = a*a;
end {function body}
var i: real;
begin { main program}
......
        i = square(3.0); {function call assigns i the value 3*3 = 9}
        write(i); {write down 9.0 the value of i}
......
end.
```

Change the syntax charts of the P language so that it supports

a. Variables of real and integer types.
b. The use of alphanumeric identifiers which are sequences of a combination of alphabets and numbers always starting with an alphabet, e.g. dmz23, Dmz28, e.t.c. identifiers like 45xy are not legal.
c. The implementation of a program described above, which includes the user defined functions.
d. Hence write a P program named test which has an function called factorial which takes an integer as argument and returns the factorial of that number. You may leave the body of the function empty. In the main block demonstrate how this function can be called.

Q.4.

a. Write a program which reads in two integers B, and P (>=0) and the program prints out the value of P^N(P to the power of N). (Hint P^N is adding P to itself N times)
b. Hand-translate this code to simple stacking M instructions.
c. Rewrite the program so that it can work for negative powers.

Q.5. Suppose you have the following P statement A = B + C*60;

a. Describe how the statement gets compiled to M instructions by showing how each component of the compiler transforms the statement.
b. Suppose P has variables which are of type integer and real and A, B, and C are declared as real numbers. Which part of the compiler will ensure that the correct multiplication is effected between C and the constant 60 which is assumed to be of integer type? How do you suggest the compiler should do in cases where there is an operation between different types as above?

Q.6. Consider the simple M instructions below:

```
0: call read
1: acc => N
2: acc = 1
3: acc => F
4 acc = N
5:accom 0
6: brlt 16
7: acc = F
8: acc* N
9: acc => F
10: acc = N
11: acc- 1
12: acc => N
13: br 4
14: acc = F
15: call write
16: stop.
```

a. By showing how the values of the variables N and F change, show the output of the above instructions if the user enters
   i. 4
   ii. 5
   iii. 0
   iv. -1
b. What does the program do once given the correct input?
c. Hence write a program in the P language that performs the same task as the above M code.

Q.7. Draw the corresponding tree representation and stacking M instructions for the following P statements:

a. A = B + C;
b. A = A + B/C;
c. A = A*B – C/D;
d. A = B + D*E – F/G;

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

Function	*Meaning of function*
acc=	load acc with operand
acc=>	store acc to operand
>acc=	store acc to stack, then load acc with operand
acc+	acc := acc + operand
acc–	acc := acc – operand
–acc	acc := operand – acc
acc*	acc := acc * operand
acc/	acc := acc / operand
/acc	acc := operand / acc
accom	compare acc and operand

In the above instructions the allowed operands are constant, variable or special.

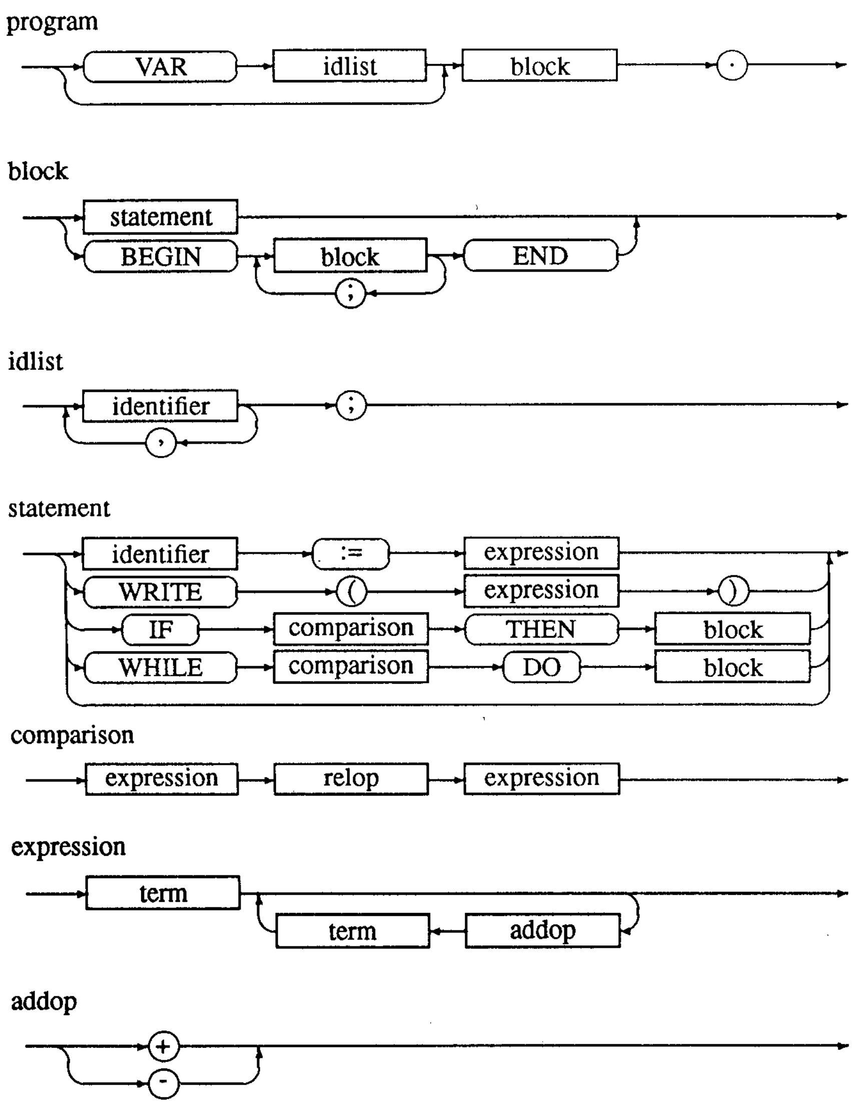
br	branch to label operand
breq	branch to label operand if acc = operand in last compare
brne	branch to label operand if acc <> operand in last compare
brlt	branch to label operand if acc < operand in last compare
brle	branch to label operand if acc <= operand in last compare
brge	branch to label operand if acc >= operand in last compare
brgt	branch to label operand if acc > operand in last compare
call	procedure (or function) call of label operand

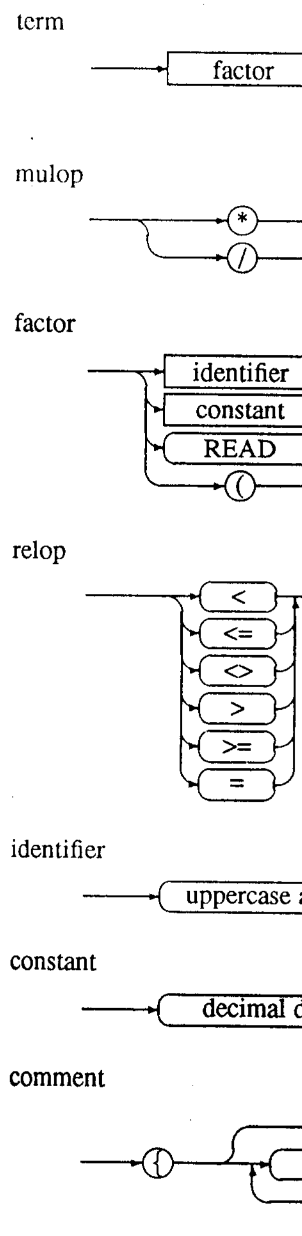
In the above instructions the operand must be a label.

stop	stop execution of program

Operand type	*Operand specification*
constant	value of integer constant
variable	address of integer variable in data area
special	stack or unstack
label	address in code for branch, or procedure for call

Figure 2.3 Functions and operands in the M computer


program
VAR
idlist
block
·
block
statement
BEGIN
block
END
;
idlist
identifier
,
;
statement
identifier
:=
expression
WRITE
(
expression
)
IF
comparison
THEN
block
WHILE
comparison
DO
block
comparison
expression
relop
expression
expression
term
term
addop
addop
+
-


term
factor
mulop
*
/
factor
identifier
constant
READ
(
relop
<
<=
<>
>
>=
=
identifier
uppercase
constant
decimal
comment
{

Figure

THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF MATHEMATICS AND STATISTICS

UNIVERSITY SECOND SEMESTER EXAMINATIONS-
9th JANUARY 2004

EM 212 ENGINEERING MATHEMATICS

INSTRUCTIONS:

a. You must write your **Computer Number** on each answer booklet used.
b. Indicate the number of each question attempted in the first column on the main answer booklet.
c. There are **SIX** (6) questions in this paper. Candidates must answer any **FIVE** (5) questions only. All questions carry equal Marks.
d. Calculators may be used

TIME ALLOWED: Three **(3)** Hours

1. (a) Find the domain of the function

$$f(x,y) = \frac{\sqrt{x^2+y^2-9}}{x}$$

Sketch this domain and state its range

(b) Given the function

$$f(x,y) = \begin{cases} \dfrac{-3xy}{x^2+y^2} & , \text{ if } (x,y) \neq (0,0) \\ 0 & , \text{ if } (x,y) = (0,0) \end{cases}$$

Show that f(x,y) is not differentiable at (0,0).

(c) Use the differential dz to approximate the change in $z = \sqrt{x^2+y^2}$ as (x,y) moves from the point (1,2) to the point (1.05 , 2.1). Compare this approximation with the exact change in z.

2. (a) Find the general solution of the Differential Equation

$$y'' - 2y' - 3y = 2\sin x$$

(b) Show that the function given by $f(x,y) = x^2 + 3y$ is differentiable at every point in the plane.

(c) The possible error involved in measuring each dimension of a rectangular box is ±0.1mm. The dimensions of the box are x = 50cm, y = 20cm and z = 15cm. Use the total differential to estimate the propagated error and the relative error in the calculated volume of the box.

3. (a) Determine whether the following M_{22} vectors are linearly independent or linearly dependent.

$$\begin{pmatrix} 1 & -1 \\ 0 & 6 \end{pmatrix}; \begin{pmatrix} -1 & 0 \\ 3 & 1 \end{pmatrix}$$

(b) If w = f(u,v), u =x + y and v = x – y . Show that

$$\frac{\partial w}{\partial w} \cdot \frac{\partial w}{\partial y} = \left(\frac{\partial f}{\partial u}\right)^2 - \left(\frac{\partial f}{\partial v}\right)^2$$

(c) Find the general solution of the following differential equations

(i) $(2xy^4 + \text{Sin } y)\, dx + (4x^2y^3 + x \text{ Cos } y)\, dy = 0$

(ii) $y' - y \tan t = 1 \qquad -\frac{\pi}{2} < t \leq \frac{\pi}{2}$

4. (a) Find the inverse of a combination of Transformation TV.

$$T: \begin{pmatrix} x \\ y \\ z \end{pmatrix} \rightarrow \begin{pmatrix} x \\ x+y \\ x+z \end{pmatrix}$$

$$V: \begin{pmatrix} x \\ x \\ y \end{pmatrix} \rightarrow \begin{pmatrix} x+y \\ y \\ y+z \end{pmatrix}$$

Hence, find the matrix representing this inverse.

(b) Let $W(x,y) = y^3 - 3x^2y, \quad x(s,t) = e^s, y(s,t) = e^t$

Find $\frac{\partial w}{\partial s}$ and $\frac{\partial w}{\partial t}$ at $s = 0, t = 1$.

(c) Find $\frac{\partial z}{\partial x}$ and $\frac{\partial z}{\partial y}$ given: $x\ln y + y^2 z + z^2 = 8$.

5. (a) Determine whether the transformation

$$T: R^2 \rightarrow R^2 : T\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 1 \\ y \end{pmatrix}$$

is linear.

(b) Given the function $w = \frac{xy}{z}$,

$x = r + \theta, \; y = r - \theta, \; z = \theta^2$

find $\frac{\partial w}{\partial r}$ and $\frac{\partial w}{\partial \theta}$

i. Using the appropriate chain rule and

ii. By converting w to a function of r and before differentiating

(c) (i) Show that $\lim_{(x,y)\to(0,0)} \left(\frac{x^2 - y^2}{x^2 + y^2}\right)^2$ does not exist.

(ii) Find the second partial derivatives of

$$f(x,y) = 3xy^2 - 2y + 5x^2y^2$$

and determine the value of $f_{xy}(-1,2)$.

6. (a) Find the eigenvalues of matrix

$$A = \begin{pmatrix} 6 & 2 & -3 \\ 2 & 0 & 0 \\ -3 & 0 & 2 \end{pmatrix}$$

(b) Find the normalized eigen vectors corresponding to the largest eigen value of matrix A given in part (a)..

(c) Given that $\begin{pmatrix} \frac{1}{\sqrt{14}} \\ \frac{2}{\sqrt{14}} \\ \frac{3}{\sqrt{14}} \end{pmatrix}$ and $\begin{pmatrix} \frac{1}{\sqrt{6}} \\ \frac{-2}{\sqrt{6}} \\ \frac{1}{\sqrt{6}} \end{pmatrix}$ are eigen vectors corresponding to the two eigenvalues, other than the largest eigen value of matrix A given in part (a), write down a matrix P such that P^TAP is a diagonal matrix.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY DISTANCE EDUCATION SEMESTER EXAMINATIONS – JANUARY 2004

GEO 111

INTRODUCTION TO HUMAN GEOGRAPHY I

TIME : Three hours

ANSWER : Question 1 (40%) and any other three questions

NOTE : Credit will be given for use of relevant illustrations. Use of electronic calculator and a Philips' University atlas is allowed.

Q1. Table 1 shows population sizes of the ten largest American cities. Critically examine the population figures and answer the questions that follow:

Table 1: The population of the ten largest American cities (1975)

CITY	POPULATION (000's)
Detroit	1,335
Houston	1,397
Baltimore	852
Philadelphia	1,817
Los Angeles	2,727
Chicago	3,099
Dallas	822
San Diego	712
San Antonio	773
New York	7,482

Source: Geographical Digest 1980

(a) Using any two methods determine whether or not the above data set conforms to the Rank-Size rule.

(b) Comment on the results

Q2. Outline the three major approaches in Geography and explain the trends in the development of Human Geography.

Q3. 'Zambia is among the highly urbanised countries in the developing world. Discuss.

Q4. Give a critical account of Central Place Theory

Q5. Outline the contributions of T. Hagerstrand on the diffusion process.

Q6 Write short explanatory notes on all of the following:-

(a) Von Thünen's Model

(b) Distribution pattern of rural settlements in Zambia

(c) Weber's Industrial Location Model

(d) Determinism

(e) Processes of cultural development

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY DISTANCE EDUCATION EXAMINATIONS – JANUARY 2004

GEO 112

INTRODUCTION TO HUMAN GEOGRAPHY II

TIME	:	Three hours
ANSWER	:	Four questions
NOTE	:	All questions carry equal marks. Use of a Philips University Atlas is allowed. Candidates are encouraged to use illustrations wherever appropriate.

Q1. Write short explanatory notes on all of the following:-

(a) 'World view.'

(b) Culture and resources.

(c) Communal versus private tenure.

(d) 'Assembling'

(e) The African elite.

Q2. Explain the population question from both the Malthusian and Marxist Perspectives.

Q3. How did inventions, innovations and capital accumulation contribute to industrialization of England?

Q4. Why is it necessary to study land tenure in any given country?

Q5. In what ways is Rostow's model of Economic Growth applicable to Africa?

Q6. 'Africa was developing in the cultural sphere before the coming of colonialism.' Discuss.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY DISTANCE EDUCATION EXAMINATIONS – JANUARY 2004

GEO155
INTRODUCTION TO PHYSICAL GEOGRAPHY

TIME: THREE HOURS.

INSTRUCTIONS: ANSWER ANY FOUR QUESTIONS.

NOTE: ALL QUESTIONS CARRY EQUAL MARKS. CANDIDATES ARE ENCOURAGED TO MAKE USE OF ILLUSTRATIONS WHEREVER APPROPRIATE.

Q1. Explain the pattern of global surface winds.

Q2. Outline any THREE ways in which the earth's crust can be raised to form mountains.

Q3. Explain the soil forming factors.

Q4. Describe the nature of biogeochemical cycles using the example of **EITHER** the Nitrogen cycle **OR** the Carbon cycle.

Q5. Outline the stages in stream development, giving illustrative landforms for each stage.

Q6. Write short explanatory notes on ALL of the following:

(a) The natural greenhouse effect.
(b) Evidence of the big bang theory.
(c) Types of sediment load in streams.
(d) Sources of soil colour.
(e) Ecosystem homeostasis.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY DISTANCE EDUCATION EXAMINATIONS – JANUARY 2004

GEO 175

INTRODUCTION TO MAPPING TECHNIQUES

PAPER II

STATISTICAL MAPPING AND DIAGRAMS

TIME : Three hours

ANSWER : Any Four Questions

NOTE : The use of a Philips' Atlas and Calculators is allowed. Candidates are encouraged to use illustrations wherever useful.

Q.1. Write short explanatory notes on all of the following:-

(a) Line Graphs

(b) Three-entry tables

(c) Isopleth maps

(d) Scatter diagrams

(e) Desire line maps

Q.2. The Ministry of Education in Eastern Province has just released the final scores obtained by eighty students in a Scholastic Aptitude Test (SAT). The SAT scores are given in Table 1 below:

Table 1

SAT Scores

68	84	75	82	68	90	62	88	76	93
73	79	88	73	60	93	71	59	85	75
61	65	75	87	74	62	95	78	63	72
66	78	82	75	94	77	69	74	68	60
96	78	89	61	75	95	60	79	83	71
79	62	67	97	78	85	76	65	71	75
65	80	73	57	88	78	62	76	53	74
86	67	73	81	72	63	76	75	85	77

Source: Imaginary

Using the data given in Table 1 above, answer all the questions that follow:-

(a) Construct a frequency distribution of scores obtained in the SAT using a class interval of four scores and begin the first class at 50.

(b) What are the class boundaries of the first class?

(c) What is the class mark of the fourth class?

(d) What is the frequency of the sixth class?

(e) Name the class having the largest frequency?

(f) How many students received a score of 75 scores?

(g) What percentage of students scored higher than 65 but less than 85?

(h) How should the first class be written so that it becomes an open class?

Q.3. An analysis of population size by district in Lusaka Province for the year 2000 according to the 2000 Census of Population and Housing is shown in Table 2 below:-

Table 2: <u>Population by District in Lusaka Province for the year 2000.</u>

District	Male	Female	Total
Chongwe	43,021	47,717	95,735
Kafue	59,668	57,606	117,354
Luangwa	8,363	8,707	17,070
Lusaka	382,663	378,412	761,064
Total	**498,704**	**492,522**	**991,226**

Source: 2000 Census data.

(a) Use the most appropriate statistical diagram to show the distribution of population in Lusaka Province.

(b) Explain the merits of the method you have used.

Q.4. Examine the data given in Table 3 below and then answer the questions that follow:-

Table 3: Population size by Province, 2000.

Province	Size (Km^2)	Male	Female	Total
Central	94,394	510,501	501,756	1,012,257
Copperbelt	31,328	799,402	781,819	1,581,223
Eastern	69,106	648,676	657,497	1,306,173
Luapula	50,567	387,825	387,528	775,353
Lusaka	21,896	705,778	685,551	1,391,329
Northen	147,826	629,976	628,720	1,258,696
Northwestern	125,826	290,856	292,494	583,350
Southern	85,283	601,440	610,684	1,212,124
Western	126,386	371,664	393,244	765,088
Total	**752,612**	**4,946,298**	**4,939,293**	**9,885,591**

Source: Census of Population and Housing 2000.

(a) Use the most appropriate statistical mapping technique to show the data given in Table 3 above on the outline map (Fig 1) of Zambia provided.

(b) What are the limitations of the technique that you have used?

Q.5. The Central Statistical Office has released data showing the number of households in Munali Constituency for the year 2000. Munali Constituency comprises 34,280 households and their distribution is shown in Table 4 below: -

Table 4: Munali Constituency Households Distribution by Ward, 2000

Ward	No. of Households
Chainda	4,650
Chakunkula	3,747
Kalingalinga	6,475
Mtendere	12,271
Munali	7,137
Total	**34,280**

Source: 2000 Census Data

(a) Use the most appropriate statistical diagram to show how the households of Munali Constituency are distributed over the five wards.

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

Q.6. Examine Figure 2 and then answer the questions that follow: -

Figure 2 shows part of the Chonzi River Basin with the Chonzi River and its tributaries and spot heights marked.

(a) Interpolate contours at a hundred-metre intervals.

(b) What are the limitations of the technique you have used?

END OF EXAMINATION

Computer No.................................

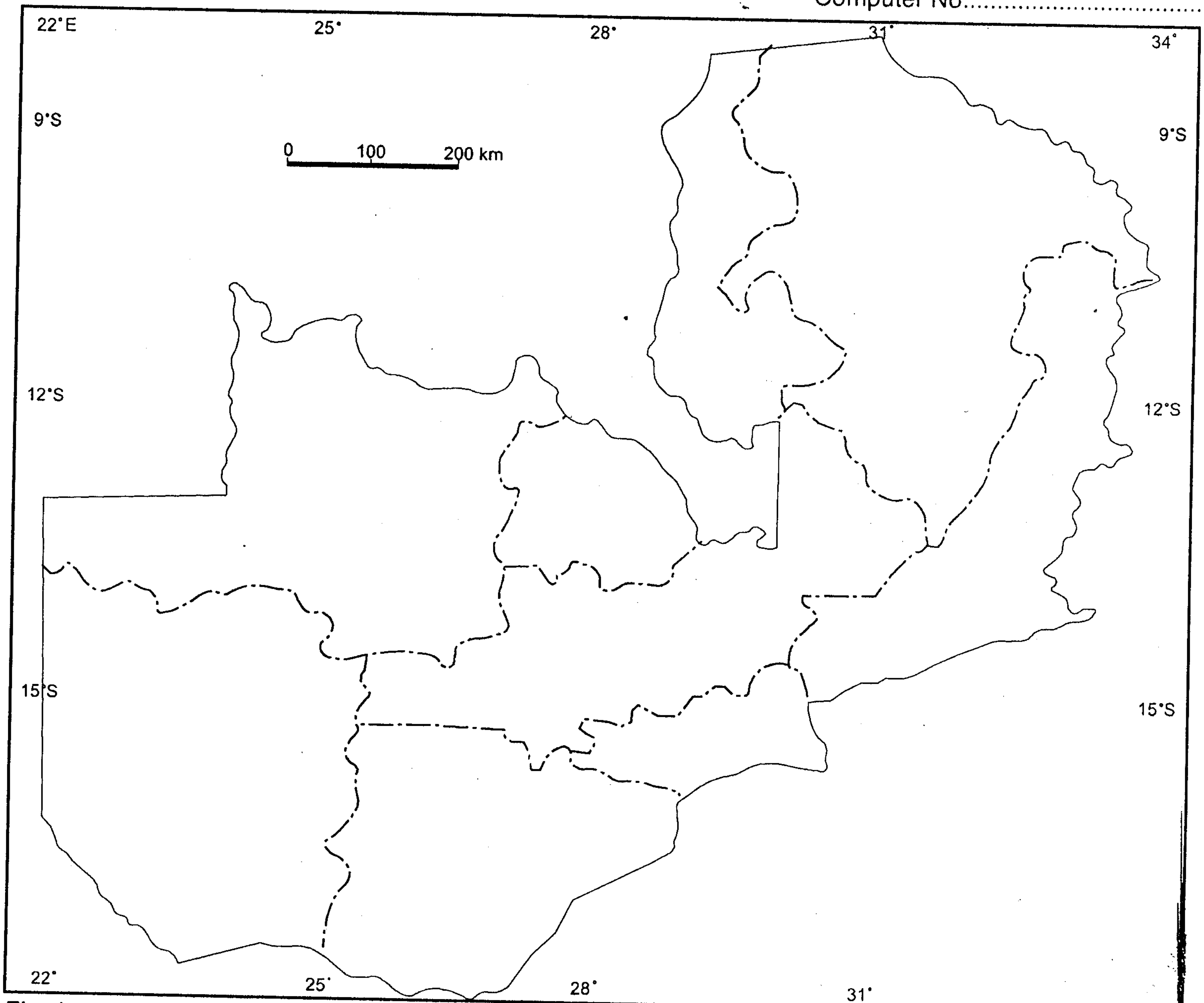


Fig. 1

COMPUTER No. ....

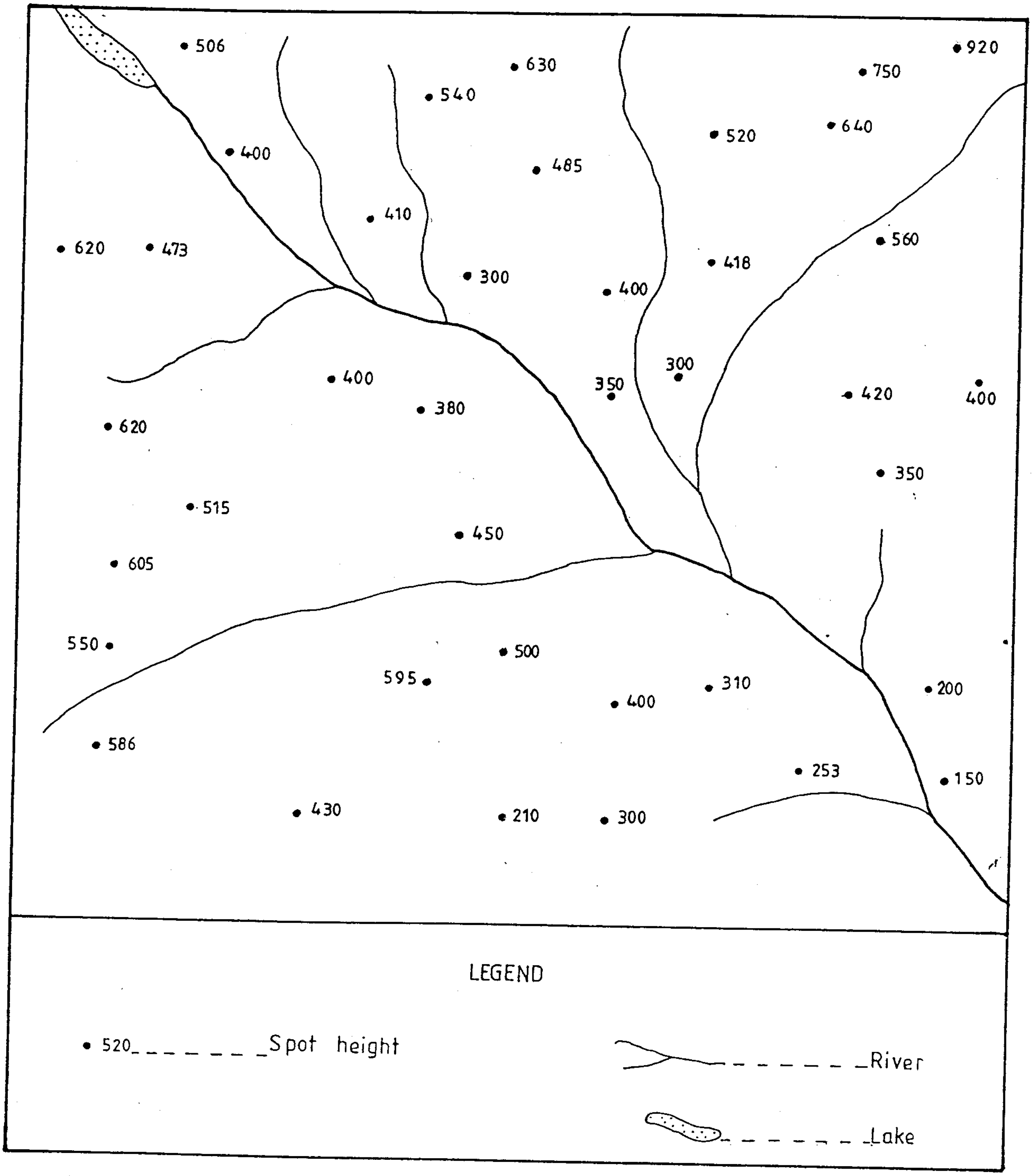


Fig. 2

UNIVERSITY OF ZAMBIA

UNIVERSITY DISTANCE EDUCATION EXAMINATIONS – JANUARY 2004

GEO 175

INTRODUCTION TO MAPPING TECHNIQUES

PAPER I

TIME	:	Three hours
ANSWER	:	All Questions
NOTE	:	The use of a Philips' University and calculators is allowed. Candidates are encouraged to use illustrations wherever useful.

<u>SECTION A</u>

Q.1. An aerial photo survey was carried out at a height of 1,140 metres above the mean altitude of the terrain in the lower Zambezi National Park and the camera used has a focal length of 152 millimetres.

(a) What is the mean scale of the aerial photograph? [3 marks]

(b) What is the scale of the photograph at the bottom of the Zambezi Valley situated at 57 metres below the mean altitude of the National Park? [3 marks]

(c) What is the scale of the photograph at the summit of the Zambezi Escarpment situated approximately 95 metres above the mean altitude of the National Park? [3 marks]

(d) Assume that the distance between the two banks of the Zambezi River is 300 metres, and the same camera is used, how long will it measure in the photograph? [4 marks]

(e) A Safari Lodge in the airphotograph is 0.3 millimetres long. Assume that the same camera is used, what is the length of the lodge on the ground? [3 marks]

Q.2. The scale of any given map can be expressed in three different ways. Thus, if a given map does not have its scale expressed in the desired form, it may be necessary to convert such a given scale from one form to another using the formula;

GD	=	MD x SF
Where		
GD	=	Ground distance
MD	=	Map distance
SF	=	Scale Factor

(a) Express 2 centimetres to a kilometre as a scale in figures. [3 marks]

(b) Express 1:1 000,000 as a scale in words. [3 marks]

(c) What is the total ground area represented by a square measuring 2 centimetres by 2 centimetres (2cm x 2cm) on a 1:10,000 map sheet? [3 marks]

(d) Using a scale of 1:25,000, calculate the dimensions to scale of a rectangle measuring 12 kilometres by 4 kilometres (12 km x 4 km). [4 marks]

(e) Draw a line scale in metric units for a map drawn at the scale of 1:25,000 given that the maximum space available is 17 centimetres. [5 marks]

Q.3. (a) Draw a sketch map depicting all the five essential elements of a good map. [6 marks]

(b) With the aid of a diagram, draw a radial drainage pattern and briefly comment on its major characteristics and the areas on which it develops. [5 marks]

(c) Using the contour method, draw an isolated hill at a 20 metre contour interval with a river flowing down hill with its source near the summit. [5 marks]

SECTION B

Using Topographic map sheet 1628 B3 provided, answer all the questions in this section.

Q.4. (a) When was map sheet 1628 B3 first revised and by whom? [2 marks]

(b) When and where was this map sheet printed? [2 marks]

(c) How many districts are covered by this map sheet? [1 mark]

(d) If you were driving northwards to Kafue along the Kariba North Access Road, what other Map sheet would you require? [1 mark]

(e) What is the vertical interval used on this map sheet and what does it mean? [2 marks]

(f) Using map evidence only, state any three different methods of showing relief quantitatively which have been used on map sheet 1628 B3. [3 marks]

(g) Using map evidence only, state as precisely as possible how one could read grid references on this map sheet. [4 marks]

(h) What type of drainage pattern is generally exhibited by the Mbendele River and its tributaries? [1 mark]

(i) Using map evidence only, identify any three human activities which have had an effect on vegetation in the area covered by map sheet 1628 B3. [3 marks]

(j) What was the magnetic variation at sheet centre as at January 1992 annual change? [1 mark]

(k) If you were interested in buying a copy of map sheet 1628 B3, where exactly would you obtain one? [3 marks]

(l) What is the height of the highest point on map sheet 1628 B3? [1 mark]

Q.5. (a) What is the direction of Simamba village in grid square 8284 from the Kariba North Access Road (RD 502) road junction in grid square 8485 as:

(i) a compass direction? [1 mark]

(ii) a bearing from grid north? [1 mark]

(b) Calculate the average gradient along the Trustland boundary between grid reference point 790964 and 780975 as:

(i) a ratio. [2marks]

(ii) an angle. [1 mark]

(c) Calculate the total area covered by Lukwechele Local Forest Reserve and state the method you have used. [3 marks]

(d) How long is the regularly maintained road (D501) from the edge of the map in grid square 6001 to the northern edge in grid square 6102 in Kilometres? [1 mark]

(e) What physical feature is found in grid square 7100 and briefly describe its physiographic location? [3 marks]

(f) Mulenga's walking speed is 10 kilometres per hour, how long will it take him to walk from the edge of the map in grid square 8678 to Kariba? [3 marks]

Q.6. Using the most appropriate method, draw a map at a scale of 2 cm to a kilometre to show the area extending from eastings 70 – 86 and northings 80 – 96 and on it show the following [11 marks]:

(a) the Mbendele River and its tributary the Lukwechele.

(b) the Lukwechele Local Forest Reserve No. 184.

(c) the Kariba North Access Road.

(d) the 330 Kv powerline.

(e) the RD 502 maintained road.

(f) the store in grid square 8485.

(g) shade all the areas above 600 metres.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GEO 212

GEOGRAPHY OF ZAMBIA

TIME	:	Three hours
ANSWER	:	Any four questions
NOTE	:	All questions carry equal marks. Use of a Philips University Atlas is allowed. Candidates are encouraged to use illustrations wherever appropriate.

Q1. Account for the factors that influence the distribution of rainfall in Zambia?

Q2. 'After more than thirty years of government declaration of intentions to diversify the economy into agriculture and raise agricultural exports, Zambia's economy still remains firmly entrenched in its dependence on minerals and mineral exports.' Discuss.

Q3. The emergence of Zambia as a nation suggests 'unity in diversity.' Discuss this contention in relation to pre-colonial migrations.

Q4. Evaluate the measures taken by the Zambian government to reverse the downward trend in the performance of the mining sector from 1991 to date.

Q5. 'Population dynamics is a factor of socio-economic development in Zambia.' Discuss.

Q6. Discuss the uses of any four energy sources in Zambia, and show their advantages and disadvantages.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY DISTANCE EDUCATION EXAMINATIONS - JANUARY 2004

GEO 271

QUANTITATIVE TECHNIQUES IN GEOGRAPHY 1

TIME	:	Three Hours
ANSWER	:	Any four questions
NOTE	:	All questions carry equal marks. Use of a Philips University Atlas is allowed. Candidates are encouraged to use illustrations wherever appropriate.

Q1. Distinguish the non-scientific method of research from the scientific one.

Q2. 'Scales of measurement are an important aspect in research.' Justify.

Q3. Discuss the advantages and disadvantages of using a Focused Group Discussion.

Q4. Justify why the various stages of data processing are important?

Q5. Compare and contrast the experimental and the quasi-experimental methods of project impact evaluation.

Q6. Outline the necessary steps in formulation of a research proposal with emphasis on a 'problem statement', 'literature review' and 'methodology'.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GEO 272
QUANTITATIVE TECHNIQUES IN GEOGRAPHY II

TIME : Three hours

ANSWER : Question 1 and any three others

NOTE : Question 1 carries 40% and the rest carry 20% each. All your calculations must be shown on the answer script. Use of an approved calculator is allowed.

Q1. In an experiment to investigate the relationship between yield of potatoes and level of fertilizer application, a field was divided into twelve plots of equal size and differing amounts of fertilizer were applied to each. The yield of potatoes (Kg) and the fertilizer application (Kg) are recorded for each plot. The data are as follows: Note that both data sets are normally distributed.

Table 1: Amount of fertilizer and yield of potatoes

Amount of Fertilizer (Kg)	Yield of Potatoes (Kg)
1.0	25
1.5	31
2.0	27
2.5	20
3.0	36
3.5	35
4.5	32
5.4	30
3.8	33
6.0	25.1
8.5	23.5
7.8	30

(a) Draw a scatter diagram based on data presented in Table 1.

(b) Calculate the linear regression equation and interpret it.

(c) Use your regression equation to draw the line of best fit in your scatter diagram.

(d) What yield (Kg) of potatoes would one expect if they applied 5.8 kg of fertilizer?

Q2. A survey was conducted on a random sample of 40 small-scale farmers in Mikango Settlement in Chongwe District to find out whether or not participation in decision-making with respect to the enhancement of household food security is related to gender. The findings are in Table 2.

Table 2: Participation in decision-making and the gender dimension in Mikango Settlement.

RESPONSE	GENDER	
	Female	Male
Participating	04	03
Non participating	21	12

Is there any relationship between the type of response regarding participation in decision-making and gender in this study area at 0.05 level of significance?

Q3. In order to find out the impact of an agricultural project on small-scale farmers in Mpeni Village, 15 participants in the project and 15 non-participants were randomly selected and their maize yields were recorded as shown in Table 3.

Table 3: Participants in the Project and Non-participants in Mpeni Village.

Participants Yield (50kg bags)	Non-participants yields (50kg bags)
28	08
31	21
12	09
28	04
08	21
06	08
08	14
17	21
09	10
06	02
15	13
10	06
18	07
36	11
14	08

Is it justifiable to argue that the agricultural project had a significant impact on yields in this village at 0.01 level of significance?

Q4. Dr. Syambololo claimed that seed germination depends on the different months during the rain season. An experiment was conducted for three contrasting months to test the claim and the following results were recorded as shown in Table 4.

Table 4: Germination (Seeds/row) of Seeds for three months

November:	6, 8, 7, 9, 8, 4, 5, 7, 5, 9.
December:	4, 7, 5, 4, 6, 4, 5, 5, 6.
January:	3, 4, 5, 3, 6, 4, 3, 3.

Given that the normality of the populations from which these values were obtained is not known, verify the hypothesis at 0.05 level of significance.

Q5. The Member of Parliament for Tala Constituency made statement to the effect that all the irrigation equipment donated by an International Organisation had been distributed to the small-scale farmers in his constituency. He further claimed that 64% of the farmers had received these irrigation facilities. Prof. Chilima, an agricultural officer got alarmed by this claim and conducted a survey on 82 farmers randomly selected in the area and found that only 20 farmers had received this equipment.

(a) Validate this claim by the Member of Parliament at 0.01 level of significance.

(b) Estimate the true fraction of the farmers who received irrigation equipment in the constituency at 90% confidence level.

Q6. Table 5 shows October rainfall for a West African Town for 15 days.

Table 5: October rainfall (mm) for the town.

28.4	2.0
0.3	1.0
19.6	3.0
0.5	26.9
27.2	7.9
6.1	1.3
5.1	
7.1	
4.6	

(a) Use any two methods to determine the skewness of the data in Table 5.

(b) Comment on the skewness values generated in 6 (a)

(c) Is the skewness of the data in Table 5 significant at 1% probability level?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GEO 415

SETTLEMENT GEOGRAPHY

TIME	:	Three hours
ANSWER	:	Any four questions
NOTE	:	Credit will be given for use of relevant illustrations. Use of electronic calculator and a Philips' University atlas is allowed.

Q1 Define Rural Settlement Geography and elucidate the growth of its study critically.

Q2 'Settlement patterns are a product of the area which they occupy.' Discuss.

Q3 In the light of the statement 'Nature prepares the site and man organises it to enable him to satisfy his desires and his needs,' explain the morphological growth of rural settlements in any region.

Q4 Explain the role of rural and urban centres in the transformation of rural habitat in post-colonial Zambia.

Q5 Berry (1962: 12) hypothesizes that "There is a negative correlation between degree of urban primacy and both socio-economic development and territorial size." Discuss.

Q6 Write short explanatory notes on all of the following: -

(a) Village community

(b) Spacing vis-à-vis density of rural settlements

(c) Location theory

(d) Rural-urban continuum

(e) Site of settlements.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GEO 482

ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT II

TIME	:	Three hours
ANSWER	:	Two questions from Section A and two questions from Section B.
NOTE	:	All questions carry equal marks. Candidates are advised to make use of illustrations where relevant.

SECTION A

Q1. **Either**

(a) Show how environmental impact assessment as a planning tool can both be an information gathering and decision support tool.

Or

(b) Outline and discuss the purpose of the environmental assessment process.

Q2. 'Waste is a function of end-user demographic characteristics': Discuss.

Q3. With respect to the rationale for wildlife management in Africa, assess Norman Carr's statement that 'governments won't conserve an impala just because it is pretty' (Norman Carr).

SECTION B

Q4. Compare and contrast the fresh water and marine fisheries resources management and utilization strategies.

Q5. Discuss the role of the Red Data Books in the conservation of Biodiversity.

Q6. Outline and explain ways in which pollution is beneficial to mankind.

Q7. Describe how the sustainable use of the components of wetlands can contribute to their conservation.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GEO 495

ENVIRONMENTAL HAZARDS AND DISASTERS

TIME : Three hours

ANSWER : Any four questions

NOTE : The use of Philips' University Atlas is allowed.

You are encouraged to use the illustrations wherever appropriate.

Q1. Write short explanatory notes on all of the following:-

(a) The classification of hazards according to origin.

(b) Sheehan and Hewitt (1969) quantitative criteria for assessing disasters.

(c) The potential impact of environmental hazards in terms of direct gains and losses.

(d) Vasely (1984) descriptive event tree technique.

(e) The relationship between national wealth and disaster-related deaths.

Q2. Explain how a community in the remote area of the Gwembe Valley can react to irregular environmental hazards such as droughts in between events.

Q3. Outline and discuss the problems that may arise in any attempt to assess the scale of global environmental disasters.

Q4. Lusaka does experience severe flooding which appears to follow a cyclic pattern of occurrence since 1917 when records started to be kept. The 1956 and 1977 – 78 above normal rainy seasons are on record as the most catastrophic flooding in the city. Some human life and property were destroyed, and all traffic and business activities were grounded for days.

Outline and explain the various chronological stages that were followed by the authorities to ensure that normality returned to the city.

Q5. With the help of a diagram, explain and show the theoretical relationships between the severity of environmental hazard, probability and risk.

Q6. "The world has listened to several years of acrimonious and zealous debate about Genetically Modified Organism (GMO's) in which some politicians, scientists, consumers and corporations have done little justice to truth or to themselves". (Spores 88, 2000:4).

Evaluate and analyze the above statement in relation to food crisis in Africa.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GEO 912

GEOGRAPHY OF MIGRATION AND REFUGEES

TIME : Three hours

ANSWER : Any four questions

NOTE : All questions carry equal marks. Use of a Philips University Atlas is allowed. Candidates are encouraged to use illustrations wherever appropriate.

Q1. Discuss with examples the three durable solutions to the refugee problem in the world. Which of them is the best and why?

Q2. While considering both internal and international migration, discuss the problems that scholars have encountered in defining 'migration.'

Q3. Analyse the repatriation and resettlement of the southern sudanese refugees after the Addis Ababa Agreement.

Q4. Bearing in mind Petersen's (1958) typology of migration with special emphasis on the innovativeness of human beings, discuss the selectivity of migration with special emphasis on Zambia.

Q5. 'The refugee crisis is a problem as well as an opportunity for the host country's economic development.' Discuss.

Q6. Analyse the assertion that 'Mabogunje's (1970) systems approach to migration is irrelevant in the African Context.'

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GEO 922

GEOGRAPHY OF REGIONAL PLANNING AND DEVELOPMENT

TIME : Three hours

ANSWER : Any four questions

NOTE : All questions carry equal marks. Use of a Philips University Atlas is allowed. Candidates are encouraged to use illustrations wherever appropriate.

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

(a) Social Surplus
(b) Gross National Product
(c) Trickle down effect
(d) Health
(e) The backwash effect in regional development planning

Q2. 'The now developed countries were themselves not underdeveloped even though they were undeveloped.' Discuss.

Q3. Critically analyse the Marxist model of economic development and show its relevance to Africa.

Q4. Examine how the Strengths, Weaknesses, Opportunities and Threats (SWOT) annalysis can help in the socio-economic planning of any peripheral area of your choice in Zambia.

Q5. With special reference to Zambia, to what extent do Structural Adjustment Programmes (SAPs) enhance the dependency theory?

Q6. 'Dimensions of socio-economic inequalities are dominantly structural rather than spatial in nature.' Explain.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GEO 932

URBAN GEOGRAPHY

TIME : Three hours

ANSWER : Any four questions

NOTE : Credit will be given for use of relevant illustrations. Use of electronic calculator and a Philips' University atlas is allowed.

Q1 Compare and contrast the genetic growth of the urban system in the United States of America and in any developing country.

Q2 'Urban poverty is simply rural poverty displaced.' Discuss the statement giving examples from developing countries.

Q3 Elucidate location theories of urban growth with special reference to central place theory.

Q4 "Urban disorder was not in fact disorder at all; it represented the spatial organisation created by the market, and derived from the absence of social control of the industrial activity" (Castells, 1977:14-15). Discuss.

Q5 (a) "The detailed future of the Third World City is in doubt, but there is little reason to believe that the urban poor are about to disappear" (Gilbert, 1994:32). Elucidate.

OR

Q5 (b) With reference to Zambia explain how city urban planning is an important instrument for balanced regional development.

Q6 Write short explanatory notes on all of the following:-

(a) Primate City

(b) Classification of towns

(c) Critical urban density

(d) Culture of Poverty

(e) Staple Theory.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATION – JANUARY 2004

GEO 962

BIOGEOGRAPHY

TIME : Three hours

ANSWER : Any four questions

NOTE : The use of Philip's University Atlas is allowed.

You are encouraged to use illustrations wherever appropriate.

Q1. Write short explanatory notes on all the following:-

(a) Relict and refugia

(b) Ecological compensation

(c) Behavioural adaptation

(d) Allelopathy

(e) Relationship between size of island and species diversity.

Q2. Discuss the role of fire in the management of the tropical savanna.

Q3. Provide an informed critique of the "Pleistocene overkill hypothesis."

Q4. Describe and explain the factors which influence the productivity, distribution and abundance of species on earth.

Q5. Outline and discuss the factors that may lead to the final extinction of endangered species.

Q6. "Distinctions between biomes are not necessarily related to the taxonomic classification of the organism they contain but rather to the life form of their plants and animals." (Mackenzie et al., 2001). Based on the statement above, answer the following questions:

(a) Explain how climate-biome models can provide a means of predicting the outcome of climate on the plants and animals.

(b) What are the implications of climate-biome models on both conservation of species and agricultural activities.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – JANUARY 2003

GEO 972

SATELLITE REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS

TIME : THREE HOURS

ANSWER : QUESTION ONE AND ANY THREE OTHERS

NOTE : ALL QUESTIONS CARRY EQUAL MARKS. CANDIDATES ARE ADVISED TO MAKE USE OF ILLUSTRATIONS WHERE RELEVANT.

Q 1. Write short explanatory notes on ALL of the following

(a) Vector data representation

(b) Ground truthing and ground control points

(c) Linear contrast stretching

(d) Principal components analysis

(e) Image understanding

Q 2. 'The objective of any data analysis exercise is to distinguish effects and/or events in the data'. Show the relevance of this statement to image analysis.

Q 3. Evaluate the assertion that satellite remote sensing applications are a function of the pixel size.

Q 4. 'Remote sensing is simply pattern recognition, a sophisticated product of experience and expectation'. Discuss.

Q 5. 'In its simplicity, GIS is a spatial analysis tool'. Discuss

Q 6. Using a defined earth resource satellite system show how the reflectance level in each of the spectral bands tells us something about the 'object' being sensed.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GEO 975

CARTOGRAPHY

TIME : Three hours

ANSWER : Any four questions

NOTE : The use of a Philips' University Atlas is allowed. You are encouraged to use illustrations wherever they help explain your answers.

Q1. Write short explanatory notes on all of the following:-

(a) Cartography as a communication system

(b) Conformal projections

(c) Metric system

(d) Statistical Mapping

(e) Graphic elements of Map Design

Q2. 'The association between a feature and its label depends largely on both proximity and typographic coding.' Discuss.

Q3. With the help of examples, outline and explain the four classes of ordering spatial data.

Q4. Explain the <u>five</u> possible phases in digital mapping.

Q5. With the help of examples and diagrams, explain the three classes of representation and show how they might be used to portray ordinal and interval data.

Q6. Analyse the contention that accuracy is often sacrificed for the benefit of generalisation.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GEO 995

ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT I

TIME : Three hours

ANSWER : Any four questions

NOTE : The use of Philips' University Atlas is allowed.

You are encouraged to use the illustrations wherever appropriate.

Q1. Describe how the logistic growth model $\left[\frac{dN}{dt} = r\frac{N(K-N)}{K}\right]$ is derived from a Population of an organism.

Q2. Demonstrate how degradation occurs in shifting cultivation systems.

Q3. Write short notes on all of the following

(a) Resurgence

(b) Secondary Pest Outbreak

(c) Resistance

(d) Integrated Pest Management

(e) Biological Control

Q4. Discuss the development of Coral Reefs and environmental problems they face when used for human development

Q5. Explain the situations that have resulted in episodes of rapid spread of weeds in Southern, Central and Eastern Africa and how the spread of these weeds can now be controlled.

Q6. Discuss how development in animal and crop production in agriculture has affected biodiversity and explain the role of gene banks in biodiversity erosion.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATIONS

DISTANCE EDUCATION

JANUARY 2004

MATHEMATICS M111

INSTRUCTIONS :
i) Attempt ***five (5)*** questions only.
ii) Show all ***essential working*** clearly.
iii) Indicate the ***number*** of each question attempted in the first column on your main answer book.
iv) Use of calculators and tables ***is not*** allowed .

TIME ALLOWED : Three (3) **Hours.**

---

1. a). i. State the De Morgan's laws for the union of two sets A and B.

ii. Show that $\left[(A \cup B) \cup (A \cup B')\right]' = \phi$

b). Let $X = \{-5, -\frac{1}{5}, -\sqrt{5}, 0.\bar{7}, \frac{1}{\sqrt{5}}, \sqrt{5}, 5\}$.

List the elements of X which are :

i. Natural numbers
ii. Integers
iii. Rational numbers
iv. Irrational numbers

c). Given that $P = [-4, 3)$, $Q = (1, 6)$ and $R = \{-3, 3\}$ are sets on the set of reals, find :

i. $P \cap Q$
ii. $P' \cap R$
iii. $P \cup (Q \cap R)$

2. a). i. Solve for x and y given that :

$$x + iy = \frac{3+2i}{(1+i)^2}$$

ii. Find the integer p and q with $q \neq 0$ given that

$$\frac{p}{q} = 3.1\dot{2}$$

b). Express in the form $a + b\sqrt{c}$ where a , b and c are rational numbers: $\frac{3\sqrt{5}-4}{2\sqrt{5}+1}$.

c). The polynomial $f(x) = x^3 + ax + bx + 12$ has a remainder 12 when divided by x+1 and a remainder -30 when divided by x+3.

i Calculate the value of a and the value of b

ii Using the values found in i) solve f(x) = 0.

3. a). Given that $f(x) = \frac{1}{x-2}$.

i. Show that f(x) is one-to-one .

ii. find $f^{-1}(x)$

iii. find $(f \circ f)(x)$.

b). Complete the square of the quadratic function

$$f(x) = 3x^2 - 7x + 2$$

Hence

i. find the turning point , the x and y intercepts.

ii. On the same diagram , sketch the graph of $y = f(x)$ and $y = |f(x)|$.

c). Given that α and β are roots of the equation $x^2 + 2x - 4 = 0$ find value of $\frac{1}{\alpha^2} + \frac{1}{\beta^2}$.

4. a). Find the integer k, given that :

i. $$\frac{\sin x}{\operatorname{cosec} x - \cot x} + \frac{\sin x}{\operatorname{cosec} x + \cot x} = k$$

ii. Solve each of the following equation for $0 \leq x \leq 360^0$

$$2\sin^2 x = 4 - 5\cos x$$

b). If $\cos\alpha = -\frac{3}{5}$ and $\tan\beta = \frac{5}{12}$ where α is in the third quadrant and β is acute. Find $\cos(\alpha+\beta)$

5. a). Compute the following limits:

i. $\lim_{x\to 1}\left(x^2+4x-1\right)$

ii. $\lim_{x\to 16}\frac{x-16}{4-\sqrt{x}}$

iii. $\lim_{x\to +\infty}\frac{4x^2-2x+3}{x^2+3x+1}$

b). Find the $\frac{dy}{dx}$ of the following:

i. $y=(x^2+1)^7$ ii. $y=\frac{x^3}{x^2+1}$ iii. $y=x\sqrt{x^2+3}$

Hence find the equation of the tangent line at the point P(1,1).

6. a). i. Find the values of the constants A,B and C given that

$$\frac{12x^2-3x-9}{(x-1)(2x+1)} = A+\frac{B}{x-1}+\frac{C}{2x+1}.$$

ii. Solve the following inequality :

$$\frac{3}{3+x} < \frac{2}{x-1}$$

b). i. Solve for x given that:

$$\sqrt{x} = \sqrt{2x-1}+2$$

ii. $|2x-3| = |x+3|$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SECOND SEMESTER EXAMINATIONS - JANUARY 2004

M112 MATHEMATICAL METHODS IIA

INSTRUCTIONS: 1. You must write your **computer number** on each answer booklet used.
2. Indicate the **number** of each question attempted in the first column on the main answer booklet.
3. There are seven (7) questions in this paper. Candidates must answer any **five (5)** questions only. All questions carry equal marks.

TIME ALLOWED: Three (3) hours.

---

1. (a) Prove by mathematical induction that for all positive integers n,

$$3+6+9+\cdots+3n=\frac{3n(n+1)}{2}$$

(b) Obtain the term inependent of x in the expansion of $\left(2x^3-\frac{1}{x}\right)^{20}$

[You may leave your answer in terms of factorials.]

(c) In the expansion of $(1+ax)^n$, the first three terms are

$$1-\frac{5}{2}x+\frac{75}{8}x^2+\cdots.$$

Find n and a, and state the range of values of x for which the expansion is valid.

2. (a) The line $4x-3y+4=0$ is tangent to the circle with centre $(3,2)$.
   (i) Find the equation of the circle.
   (ii) Show that the circle touches the x - axis.

(b) Sketch the graph of the hyperbola

$$36x^2-9y^2=144,$$

stating (i) the centre
(ii) the points where the curve cuts the x or y - axis.
(iii) the foci
(iv) equation of the directrices
(v) equations of the asymptotes.

3. (a) Given the vectors $\mathbf{u} = 2\alpha\,\mathbf{i} + 4\mathbf{j} - 3\mathbf{k}$ and $\mathbf{v} = 4\mathbf{i} + \beta\,\mathbf{j} + 3\mathbf{k}$, find

(i) the values of α and β if the vector are parallel

(ii) a relation between α and β if the vectors are perpendicular.

(b) Find a unit vector that is perpendicular to both vectors $\mathbf{a} = 3\mathbf{i} - 6\mathbf{j} - 4\mathbf{k}$ and $\mathbf{b} = -3\mathbf{i} + 2\mathbf{j} - 2\mathbf{k}$

(c) Find the area of the triangle ABC given that its vertices are $A(2,1,-1)$, $B(1,-7,3)$ and $(C(-2,5,1)$.

4. (a) Given the matrix

$$A = \begin{pmatrix} 1 & 2 & 3 \\ 3 & 1 & 0 \\ 2 & 2 & 1 \end{pmatrix},$$

find A^{-1}, the inverse of A.

(b) Use Cramer's rule to solve the system of equations

$$\begin{aligned} x - 2y + z &= 6 \\ 2x + y - 3z &= 5 \\ 2y + z &= 1 \end{aligned}$$

(c) Find the dimensions of the largest open box which can be made from a sheet of cardboard of sides 60 cm by 28 cm by cutting equal squares from the corners and turning up the sides.

5. (a) (i) Use de Moivre's theorem to prove that

$$\sin 5\theta = 16\sin^5\theta - 20\sin^3\theta + 5\sin\theta$$

(ii) Express $\dfrac{(\cos\phi - i\sin\phi)^3}{(\cos 2\phi + i\sin 2\phi)(\cos\phi - i\sin\phi)^5}$

in the form $\cos n\phi + i\sin n\phi$, where n is an integer

(b) Given that $y = x\sqrt{x+1}$, show that

$$\frac{dy}{dx} = \frac{3x+2}{2\sqrt{x+1}}.$$

Hence or otherwise evaluate $\displaystyle\int_3^8 \frac{3x+2}{\sqrt{x+1}}dx$

6. (a) Find $\frac{dy}{dx}$:

(i) $y = (\ln x)^2$

(ii) $y = \frac{4x+3}{\sqrt{2x-1}}$

(iii) $y = \tan^{-1}(x^3)$

(b) Find the gradient of the curve with equation

$$5x^2 + 5y^2 - 6xy = 13$$

at the point (1,2).

(c) $f(x) = \frac{3x}{(x+2)(x-1)}$, $x \neq -2$, $x \neq 1$.

Use partial fractions to evaluate $\int_{-1}^{0} f(x)dx$.

7. (a) Differentiate the function $f(x) = \frac{x^2+9}{x^2-1}$ with respect to x.

Hence, find the value of x at which the function has a maximum and/or minimum and determine which of these it is.

(b) Evaluate the integrals:

(i) $\int \frac{(\ln x)^2}{x} dx$

(ii) $\int xe^{2x} dx$

(iii) $\int_0^3 \frac{x}{\sqrt{x+1}} dx$

(c) On the same diagram, sketch the graphs of the curves $y = 2x^2 + 3$ and $y = 10x - x^2$ and state their points of intersection. Hence, find the area between the two curves.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS

JANUARY 2004

M162 - INTRODUCTION TO MATHEMATICS, PROBABILITY AND STATISTICS

INSTRUCTIONS:

1. There are two sections A and B in this question paper.
2. Answer any FIVE(5) questions .
3. Show your work to earn full marks.
4. Graph paper and normal distribution tables are provided.
5. No calculators or mathematical tables are to be used.

TIME ALLOWED: Three (3) hours.

SECTION A

1. (a) Evaluate the following limits:

(i) $\lim_{x \to 4} \frac{x^2 - 16}{x - 4}$

(ii) $\lim_{x \to +\infty} \frac{3x^2 + 6x + 1}{5x^2 + 4x - 7}$

(iii) $\lim_{x \to 1} \frac{(2x - 3)(\sqrt{x} - 1)}{2x^2 + x - 3}$

(b) If $f(x) = x^3$,

(i) Find $f(x + h)$

(ii) Express $\frac{(x + h) - f(x)}{h}$ in its simplest form.

(iii) Using (ii) above, find $f'(x)$

(c) Given the equation of the curve $2xy^2 + y + 2x = 8$,

(i) Find $\frac{dy}{dx}$ in terms of x and y.

(ii) Using (i), find the gradient of the curve at the points where $x = 1$.

2. (a) Find $\frac{dy}{dx}$:

(i) $y = \frac{e^{-x}}{x+1}$

(ii) $y = x\sqrt{x^2+1}$

(iii) $y = x^x$

(b) The equation of the curve is given by $y = x^3 + 6x^2 + 9x$.

(i) Find the coordinates of the stationary points.

(ii) Find the coordinates of the point of inflection.

(c) When a certain car factory produces x cars per day its profit \$x is given by $P(x) = 5x^2 - 100x$.

How many cars per day must the factory produce :

(i) to make a profit ?

(ii) to make a profit of \$ 4,800 ?

(iii) to make the most possible loss ?

3 (a) Given $y = \frac{x^2}{1+x}$

(i) find $\frac{dy}{dx}$

(ii) Using (i) above , evaluate $\int_1^3 \frac{x(x+2)}{(1+x)^2}\,dx$

(b) (i) Find $\int x^2 \ln x \; dx$

(ii) Find the area bounded by the curves $f(x) = x^2$ and $g(x) = x$ and the x- axis.

(c) An evergreen nursery usually sells a certain shrub after 6 years of growth and shaping. The growth rate during those 6 years is approximated by

$$\frac{dh}{dt} = 1.5t + 5$$

where t is the time in years and h is the height in centimetres. The seedlings are 12 centimetres tall when planted (t = 0)

(i) Find the height after t years.

(ii) How tall are the shrubs when they are sold?

SECTION B

4. (a) A manufacturing process produces defective parts randomly at a rate of 80 %. In a sample of 400 parts,

(i) What is the mean number of defective parts expected ?
(ii) What is the standard deviation ?

(b) The probability distribution for a random variable X is given below:

x	p(x)
20	.08
21	.16
22	.21
23	.29
24	.12
25	.14

Determine the probability that the random variable will assume a value:

(i) greater than 21.

(ii) between 20 and 23.

(c) A random variable X is randomly distributed with a mean of 9.8 and a standard deviation of 1.6

Determine the following:

(i) $P(x \geq 5)$

(ii) $P(5 \leq x \leq 12.2)$

5 (a) Define the following :

(i) A and B are independent events

(ii) A and B are mutually exclusive events

(iii) Given that $P(A) = 0.3$ $P(B) = 0.4$ and A and B are independent events, find :

(α) $P(A \cup B)$
(β) $P(A' \cap B)$

(b) You are at Manda Hill with two friends trying to buy a Pizza. You agree to the following rule to decide who will pay the bill:

Each person will toss a coin. The person who gets a result that is different from the other two will pay the bill. If all three tosses yield the same result, the bill will be shared by all.

(i) Construct a tree diagram showing the outcomes of the three tosses.

(ii) Write down the sample space S for this experiment.

(iii) Find the probability that only you will have to pay the bill.

(iv) Find the probability that all three will share the bill.

(c) The table below shows the results of a recent survey of attitudes regarding nuclear war.

The question asked was "How likely do you believe it is that a nuclear war will occur during the next 10 years?

	RESPONSE			
RESPONDENT AGE	VERY LIKELY	LIKELY	UNLIKELY	TOTAL
20 - 29	550	1,300	150	2,000
30 - 39	350	900	250	1,500
40 and over	100	300	1,100	1,500
TOTAL	1,000	2,500	1,500	5,000

If a respondent is selected at random from the sample of 5,000, find the probability that:

(i) the respondent is 30 years or older.
(ii) the respondent believes nuclear war is "likely"
(iii) the respondent is between the ages of 20 and 39 and believes that nuclear war is "very likely"
(iv) the respondent believes that nuclear war is "unlikely" given that he or she is between the ages of 20 and 29.

6. (a) For the data set

18.3	15.1	14.4	14.3	17.1	14.4	13.1
9.7	9.6	26.4	18.8	21.7	18.0	15.8
14.1	24.6	18.0	14.4	16	14.2	9.7
25.4	21.8	29.4	23.4			

(i) Construct a grouped frequency distribution using a class width of 4 starting with 9.5 - 13.5, 13.5 - 17.5 etc.
(ii) Using (i) above, draw a cummulative frequency curve. (on the graph, take 1cm to represent 2 units)

(b) For the sample data set, $\Sigma x^2 = 420$ $\Sigma x = 10$ $n = 5$, find :

(i) the mean

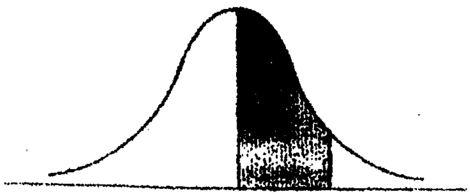
(ii) the standard deviation

(c) (i) For two events A and B define $P(A \backslash B)$.

(ii) A firm has 80% of its service calls made by a local contractor (L) and 10% of these calls result in customer complaint (C)

The other 20% of the service calls are made by their employees (E) and these calls have a 5% complaint rate (C).
Find the probability of a complaint.

END OF EXAMINATION



z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

Source: Abridged from Table I of A. Hald, *Statistical Tables and Formulas* (New York: John Wiley & Sons, Inc.) 1952. Reproduced by permission of A. Hald and the publisher.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER DEFERRED EXAMINATIONS

JANUARY 2004

M162 - INTRODUCTION TO MATHEMATICS, PROBABILITY AND STATISTICS

INSTRUCTIONS:
1. There are two sections A and B in this question paper.
2. Answer any FIVE(5) questions .
3. Show your work to earn full marks.
4. Graph paper and normal distribution tables are provided.
5. No calculators or mathematical tables are to be used.

TIME ALLOWED: Three (3) hours.

SECTION A

1. (a) Evaluate the following limits:

(i) $\lim_{x \to 1} \frac{4x^2 + 3}{2x - 1}$

(ii) $\lim_{x \to +\infty} \frac{2x^2 - 3x + 6}{3x^2 - 6}$

(iii) $\lim_{x \to 9} \frac{3 - \sqrt{x}}{x - 9}$

(b) If $f(x) = x^2 + 2x - 3$

(i) Find $f(x + h)$

(ii) Express $\frac{f(x+h) - f(x)}{h}$ in its simplest form.

(iii) Using (ii) above, find $f'(x)$

(c) Given the equation of the curve $xy^2 + 3x = 8 - 4y$,

(i) Find $\frac{dy}{dx}$ in terms of x and y.

(ii) Using (i), find the gradient of the curve at the point A(1,1) .

2. (a) Find $\frac{dy}{dx}$:

(i) $y = x^3 e^x$

(ii) $y = x^2 (x+1)^{10}$

(iii) $y = \frac{x}{x^2 + 1}$

(b) The equation of the curve is given by $y = x^3 - 6x^2 + 9x$.

(i) Find the coordinates of the stationary points.

(ii) Find the coordinates of the point of inflection.

(c) The cost in thousands of kwacha of making x articles per day is $C(x) = \frac{1}{2}x^2 + 50x + 50$ and the selling price of each one in thousands of Kwacha is $S(x) = 80 - \frac{1}{4}x$.

i). Find the daily profit in terms of x.

ii). the value of x to give the maximum profit.

3 (a) Given that $y = (x+1)\ln(x+1) - x$

(i) find $\frac{dy}{dx}$

(ii) Using (i) above , evaluate $\int \ln(x+1)dx$

(b) (i) Find the value of A and B given that

$$\frac{1}{x^2 - 4x + 5} = \frac{A}{x+1} + \frac{B}{x-5}$$

(ii) Hence evaluate $\int_2^3 \frac{1}{x^2 - 4x + 5}dx$

SECTION B

4. (a) A small insurance company has determined that on average it receives five death claims per day. What is the probability that the company will receive one claim per day?

(b) The probability distribution for a random variable X is given below:

x	p(x)
10	.02
11	.31
12	.01
13	.01
14	.52
15	.13

Determine the probability that the random variable will assume a value:

(i) less than 12

(ii) between 10 and 13 inclusive.

(iii) grater than 14

(c) Use the standard normal table to find the following:

(i) $P(z \geq 2)$

(ii) $P(-1 \leq z \leq 1)$

(iii) $P(z \geq -3)$

5 (a) Define the following :

(i) A and B are independent events

(ii) A and B are mutually exclusive events

(iii) Given that P(A) = 0.8 P(B) = 0.1
find $P(A \cup B)$ if :

(α) A and B are mutually exclusive events

(β) A and B are independent events

(b) Toss three fair coins and let X equal the number of heads observed.

(i) Identify the possible outcomes associated with this experiment.
(ii) Construct P(x) for each value of x.
(iii) Construct a probability histogram P(x).
(iv) Find the P(x =2).

(c) If the probability of a customer responding to one of your questionnaire is 0.6,what is the probability that of 10 questionnaires, none will be returned?

6. (a) For the data set

20.4	17.2	16.4	16.4	19.8	16.6	19.3
11.8	18.7	21.3	20.9	23.2	20.9	17.3
12.3	22.1	20.3	12.2	13.4	13.1	13.4
21.2	20.6	21.1	22.2			

(i) Construct a grouped frequency distribution using a class width of 4 starting with 10.5 - 14.5, 14.5 - 18.5 etc.

(ii) Using (i) above, draw a cumulative frequency curve.
(on the graph, take 1cm to represent 2 units)

(b) For the sample data set, $n = 11$, $\sum(x-\bar{x})^2 = 108$, $\sum x = 121$

find :

(i) the mean

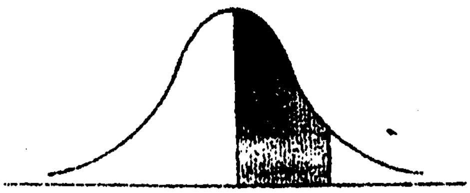
(ii) the standard deviation

(c) (i) Define $P(A \mid B)$ for two events A and B

(ii) An instructing firm uses two types of methods A and B to teach its new students.
40% use method A. The rest use method B.

If the student uses method A, the probability of passing on first attempt is 55%.
If the student uses method B, the probability of passing on first attempt is 70%.
Given that the student has passed on first attempt, what is the probability that the student used method A?

END OF EXAMINATION



0 z

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

Source: Abridged from Table I of A. Hald, *Statistical Tables and Formulas* (New York: John Wiley & Sons, Inc.) 1952. Reproduced by permission of A. Hald and the publisher.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - JANUARY 2004

M211 MATHEMATICAL METHODS IV

INSTRUCTIONS: 1. Write your **computer number** on each answer booklet used.

2. There are six (7) questions in this paper. Candidates must **answer any five (5) questions.** All questions carry equal marks.

2. Indicate the number of each question you have attempted in the the first column on the main answer booklet.

TIME ALLOWED: Three (3) hours.

---

1. The equation of the conic section is given by

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

(a) Transform the conic section into standard form and identify the conic section.

(b) Find the vertex (vertices), focus (foci) and directrix (directrices).

Hence,

(c) sketch the curve.

2. (a) Discuss the graph of the given curves and sketch them:

(i) $r = \dfrac{5}{1+\sin\theta}$

(ii) $r = \dfrac{8}{2+3\cos\theta}$

(b) The orbit of Halley's comet is an ellipse with the sun at one focus. In terms of astronomical units (AU), the major and minor axes of this elliptical orbit are 18.09 AU and 4.56 AU respectively.

(i) What are the maximum and minimum distances from the sun to halley's comet?

(ii) State the eccentricity for the comet's orbit.

3. (a) (i) Sate Rolle's theorem.

(ii) Show that the function f defined by

$$f(x) = x^{\frac{1}{2}} - x^{\frac{3}{2}}$$

on the interval [0,1] satisfies the hypothesis of Rolle's theorem on the given interval.
Hence, find the number c that satisfies the conclusion of the theorem.

(b) (i) State the Mean Value theorem without proof. Hence use it with the function

$$f(x) = \sqrt[6]{x}$$

on the interval [64,65] to approximate the value of $\sqrt[6]{65}$.

(ii) Use the the Mean Value theorem to show that $\sin x < x$ for $x > 0$.

4. (a) Compute the following limits:

(i) $\lim\limits_{x \to 3} \dfrac{x^2 + 2x - 15}{x^2 - 5x + 6}$

(ii) $\lim\limits_{x \to 0^+} x^{\frac{1}{x-1}}$

(iii) $\lim\limits_{x \to +\infty} \dfrac{\ln x^3}{x}$

(b) Find the equation of the circle of curvature of $y = 2x^2 + 1$ at the point (0,1).

5. Evaluate the integrals:

(a) $\int x \tan^{-1} x \, dx$

(b) $\int \dfrac{x^2}{\sqrt{4 - x^2}} dx$

(c) $\int \dfrac{1}{\sin x - \cos x} dx$.

6. (a) Given that $I_n = \int \cos^n x dx$, $I_{n-1} = \int \cos^{n-1} x dx$, $etc, n \geq 2$ show that

$$nI_n = \cos^{n-1} x \sin x + (n-1)I_{n-2}.$$

Hence, evaluate I_8 for $I_n = \int_0^{\frac{\pi}{2}} \cos^n x dx$.

(b) (i) By revolving the semi-circle for which $y \geq 0$, from the circle with equation $x^2 + y^2 = a^2$ completely about the x - axis, show that the volume of the sphere, of radius a, is $\frac{4}{3}\pi a^3$.

(ii) Find the area of surface of revolution generated by revolving a loop of the curve $8a^2y^2 = a^2x^2 - x^4$ about the x - axis from $x = 0$ to $x = a$.

7. (a) Find the unknown coefficients a_0, a_1, a_2, a_3, a_4 given that

$$\int x^4 e^{2x} dx = e^{2x}(a_0x^4 + a_1x^3 + a_2x^2 + a_3x + a_4) + c$$

(b) Use Maclaurin's theorem to show that if x^5 and higher powers of x are neglected, then

$$\ln[x + \sqrt{1+x^2}] = x - \frac{1}{6}x^3.$$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - JANUARY 2004

M212 MATHEMATICAL METHODS IV

INSTRUCTIONS: 1. Write your **computer number** on each answer booklet used.

2. There are six (6) questions in this paper. Candidates must **answer any five (5) questions.** All questions carry equal marks.

2. Indicate the number of each question you have attempted in the first column on the main answer booklet.

TIME ALLOWED: Three (3) hours.

---

1. (a) Investigate the relative maxima and minima of the function

$$f(x,y) = x^3 + y^2 + 3xy$$

(b) Solve the differential equation

$$(xy + x + x^3)dx - (1 + x^2)dy = 0$$

(c) Let $f(x,y,z) = w = xz + ze^{y^2} + \sqrt{xy^2 - z^3}$. Find

(i) $\frac{\partial w}{\partial x}$ (ii) $\frac{\partial w}{\partial y}$

2. (a) If $\bar{R}(t) = (t^2 - 4t)i + (t^3 - 3t^2)j + 5tk$ is a position vector for a moving particle and t denotes time in seconds, find the time and where the particles is when the velocity vector is parallel to the zy - plane.

(b) Find the first four non - zero terms in the series solution of the given differential equation

$$y'' + xy = e^x$$

(c) Describe the curve given by the vector equation

$$f(t) = (\cos t)i + (\sin t)j$$

where $0 \le t \le 2\pi$.

3. (a) Solve the differential equation

$$\frac{dy}{dx} + 2xy = 4x$$

(b) Use the total differentials to estimate the number

$$A = \frac{3.01}{5.97}$$

correct to 4 decimal places.

(c) Use the chain rule to find $\frac{\partial f}{\partial u}$ and $\frac{\partial f}{\partial v}$, given that

$$f(x,y) = x^2 + xy + y^2; \quad x = 2u + v, \quad y = u - 2v$$

4. (a) Find the parametric equations of a straight line through the point (3, -1, 2) that is perpendicular to the plane

$$x - 2y + 3z = 5$$

(b) The space curve is defined parametrically by

$$x = e^t \cos t; \quad y = e^t \sin t; \quad z = e^t$$

Find at $t = 0$ its

(i) unit tangent vector $\bar{T}$

(ii) principle unit normal vector $\bar{N}$

(iii) curvature κ

(iv) binormal vector $\bar{B}$.

5. (a) Solve the Bernoulli's equation

$$\frac{dy}{dx} - \frac{y}{x} = -\frac{5}{2}x^2y^3$$

(b) Show that the differential equation

$$\frac{2x}{y^3}dx + \frac{2y - 3x^2}{y^4}dy = 0$$

is exact.
Hence, find its general solution.

(c) Prove that if $z = f(u,v)$ when $u = x + \lambda y$ and $v = x - \lambda y$, then

$$\left(\frac{\partial z}{\partial u}\right)^2 - \left(\frac{\partial z}{\partial v}\right)^2 = \frac{1}{\lambda}\frac{\partial z}{\partial x}\frac{\partial z}{\partial y}$$

6. (a) Find the equation of the plane which passes through the points $P_0(2,1,6)$, $P_1(5,-2,0)$ and $P_2(4,-5,-5)$.

(b) Solve the differential equations

(i) $4\frac{d^2y}{dx^2} - 12\frac{dy}{dx} + 9y = 0$

(ii) $y'' + 2y' - 15y = 10\sin x$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SESSIONAL EXAMINATIONS JANUARY 2004

MATHEMATICS M222

TIME ALLOWED: THREE(3) HOURS

INSTRUCTIONS : ANSWER ANY FOUR(4) QUESTIONS

---

1. What is meant by an *inner product space*

(a) (i) Show that the map (,) given by

$(u,v) = \alpha_1\beta_1 - \alpha_1\beta_2 - \alpha_2\beta_1 + 3\alpha_2\beta_2,$ where

$u = (\alpha_1\alpha_2)$ and $v = (\beta_1\ \beta_2)$

is an inner product on $V_2(\mathbf{R})$

(ii) Given the vectors v_1, v_2, v_3, where

$v_1 = (1,1,1), v_2 = (0,1,1), v_3 = (0,0,1)$

Find an orthonormal basis $\{u_1,u_2,u_3\}$ for $V_3(\mathbf{R})$

(b) Find all the vectors which are orthogonal to the vector (3, -2, -3, 1, 1, -1) in $V_6(\mathbf{R})$.

---

2. What is meant by the term an *orthogonal complement* of a subspace U of a vector space V.

(a) (i) Show than an orthogonal complement of a subspace U of a vector space V is a subspace of V, and that $V = U \oplus U^{\perp}$

(ii) Prove that an orthonormal set $\{u_1,\ldots,u_r\}$ is linearly independent

(b) Let W be a subspace of $V_5(\mathbf{R})$ generatal by

$u = (1,2,3, -t, 2)$, $v = (2, 4, 7, 2, -1)$

Find a basis for an orthogonal complement $W^{\perp}$ of W.

3. What is meant by each of the following

(i) an *eigen value* of a matrix A

(ii) a matrix A is *diagonalizable*

(a) Find an orthogonal matrix P for which P^tAP is diagonal, where

$$A = \begin{pmatrix} 2 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 2 \end{pmatrix}$$

(b) Determine whether the matrix

$$A = \begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix}$$

Is diagonalizable

---

4. What is the meaning of the statement *v lies in the eigenspace* of the matrix A.

(a) (i) Let λ be an eigenvalue of a linear map $T: V \to V$ and let $V(\lambda)$ denote the set of all eigenvectors of T. Then show that $V(\lambda)$ is a subspace of V.

(ii) Show that if $\lambda_1, \lambda_2, \ldots, \lambda_r$ are distinct eigenvalues of a linear transformation T and $v_1, v_2, \ldots, v_r$ are the corresponding eigenvectors, then $\{ v_1, v_2, \ldots, v_r \}$ is a linearly independent set of vectors.

(b) For each of the following matrices, find all eigenvalues and a real basis for each eigenspace:

$$A = \begin{pmatrix} 1 & -3 & 3 \\ 3 & -5 & 3 \\ 6 & -6 & 4 \end{pmatrix};$$

Determine whether A can be diagonalized. Justify your answer

5. What is meant by the statement f *is a bilinear form on the space* V?

(a) Prove that if f is a bilinear form on V relative to a basis $\{e_1, e_2, \ldots, e_n\}$ of V and df denotes its matrix relative to this basis, then the mapping $f \rightarrow df$ is an isomorphism.

(b) Show that the map f on **R**(2) given by

$$f((x_1, x_2), (y_1, y_2)) = 3x_1y_1 - 2x_1y_2 + 4x_1y_1 - x_2y_2$$

is a bilinear form.

Hence find its matrix relative to the following bases,

(i) $\{(1, -1), (3,1)\}$ (ii) $\{(1, 1), (1,2)\}$

---

6. What is meant by saying q is a quadratic form on the space V?

(a) Let A be an element of $M_n(K)$ given by

$$f(X,Y) = X^tAY$$

is a bilinear form

(b) (i) Find the symmetric matrix belonging to the quadratic form

$$q(x,y,z) = xy + yz$$

(ii) Find a nonsingular matrix P such that P^tHP is diagonal, where

$$H = \begin{pmatrix} 1 & i \\ -i & 2 \end{pmatrix}$$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - 2003

M232 REAL ANALYSIS II

JANUARY 2004

INSTRUCTIONS: (i) ANSWER ANY FIVE QUESTIONS

TIME ALLOWED: THREE (03) HOURS

Question 1

(a) (i) Find a formular for the sum of the first n terms of the geometric progression

$$1 + x + x^2 + x^3 + \dots$$

(ii) Hence or otherwise determine all values of x for which the series $\sum_{n=0}^{\infty} x^n$ converges.

(b) A rubber ball is dropped vertically from a height of 6 metres. Each time it bounces it rises to a height two thirds of the height from which it falls. What is the total distance travelled by the ball?

Question 2

(a) State the following,

(i) Cauchy's Condensation Test for convergence.

(ii) D'Alembert's Ratio Test for convergence.

(b) Let $a_n \geq 0$ for all n and suppose that $S_n = \sum_{k=1}^{n} a_k$ is bounded for all n. Show that the series $\sum_{n=1}^{\infty} a_n$ converges.

(c) Determine the convergence or divergence of the series

(i) $\sum_{n=1}^{\infty} \frac{(2n)!}{7^n (n!)^2}$ (ii) $\sum_{n=1}^{\infty} \frac{3^n + 5^n}{n4^n}$

Question 3

(a) (i) Define a decreasing function, f.

(ii) Suppose that f(x) is defined for all $x \in [1, \infty)$ and that f is positive, decreasing and continuous on $[1, \infty)$.

Let $I_n = \int_1^n f(x)dx$ $(n \geq 1)$ and

$S_n = f(1) + f(2) + \ldots + f(n) = \sum_{k=1}^{n} f(k)$. Prove that $I_n - S_n$ is bounded above.

(b) (i) State the Integral Test for convergence of series.

(ii) Use the Integral test to determine whether or not the series $\sum_{n=1}^{\infty} ne^{-n^2}$ converges.

Question 4

(a) Define the following

(i) Conditional convergence of series

(ii) Radius of convergence of power series.

(b) Suppose that $\sum_{n=1}^{\infty} a_n$ is convergent conditionally. Let $b_n = \max(a_n, 0)$ and $c_n = \min(a_n, 0)$, so that $a_n = b_n + c_n$ and $|a_n| = b_n - c_n$.

Prove that $\sum_{n=1}^{\infty} b_n$ and $\sum_{n=1}^{\infty} c_n$ both diverge.

(c) Discuss the convergence of the series $\sum_{n=1}^{\infty} \frac{x^{3n}}{2^n n}$ for all real values of x.

Question 5

(a) Define the limit of a function f at a point x_0.

(b) Suppose $\lim_{x \to x_0} f(x) = L$, show that there is some $\delta > 0$ such that if x is such that $x_0 - \delta < x < x_0 + \delta$ then f(x) is bounded, i.e. $|f(x)| \leq K$ for some positive real number K.

(c) Compute

(i) $\lim_{x \to 0} x^2 \sin\left(\frac{1}{x}\right)$

(ii) $\lim_{x \to \infty}\left(\sqrt{x - \sqrt{x}} - \sqrt{x + \sqrt{x}}\right)$

Question 6

(a) Define the continuity of a function f at a point x.

(b) Let the function $f : \mathbf{IR} \to \mathbf{IR}$ be defined by

$$f(x) = \begin{cases} x & \text{if } x \text{ is rational} \\ 0 & \text{if } x \text{ is irrational} \end{cases}$$

Show that f(x) is continuous at the origin.

(c) Let f(x) be defined for all x on some open interval I containing a point x_0 Suppose that f is continuous at the point x_0 and that $f(x_0) > 0$. Show that there is some $\delta > 0$ such that $f(x) > \frac{1}{2} f(x_0)$ for all x such that $x_0 - \delta < x < x_0 + \delta$

Question 7

(a) Let f: **IR** → **IR** and g: **IR** → **IR** be two functions defined on the set of real numbers. Suppose

(i) f is continuous at a.

(ii) f(a) = b

(iii) g is continuous at b.

Prove that (g o f) given by (g o f) (x) = g (f(x)) is continuous at a.

(b) Consider the function h:**IR** → **IR** defined by

$$h(x) = \begin{cases} \sin\left(\frac{1}{x}\right) & x \neq 0 \\ 0 & x = 0 \end{cases}$$

Determine all values of x for which h(x) is continuous.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS

JANUARY 2004

M292 – INTRODUCTION TO PROBABILITY

INSTRUCTIONS

1. Answer question 1 in Section A and any four (4) questions in Section B.
2. Show ***all your work*** to earn full credit.
3. You may use a calculator and tables.

TIME ALLOWED: Three (3) hours

SECTION A

Answer the question below, provide brief but concise answers where descriptions are requested

[1] (a) If S is a sample space and A and B are events, when are A and B
- (i) Mutually exclusive?
- (ii) Exhaustive?
- (iii) Independent?

(b) Write down all the subsets of the set X = {a, b, c}

(c) State the name given to following type of selection or arrangement:
- (i) Picking something from a box, observing it and then putting it back before selecting another.
- (ii) Deciding a sitting arrangement for dignitaries and minding who will seat where.

(d) A probability is thought of as a function because it has an input and produces an output.
- (i) What is the input of a probability function?
- (ii) What is the output of a probability function?

(e) If f(x) is a continuous function for $a< x < b$ and zero elsewhere, state
- (i) the first property f(x) must satisfy to be a probability density function.
- (ii) the second property f(x) must satisfy to be a probability density function.

(f) For each of the following probability density functions, state whether it is discrete or continuous.
- (i) Binomial
- (ii) Gamma
- (iii) Geometric
- (iv) Chi-square
- (v) Hypergeometric

(g) A certain random variable X with probability density functions f(x) satisfies the property that for any a, b >0, $P(X > a + b \mid X > a) = P(X > b)$
- (i) What special name is given to this property?
- (ii) Name one such probability density function (pdf) which has this property.
- (iii) Show that the pdf in (ii) has the property in (i)

SECTION B

Answer any four (4) questions in this Section, provide brief but concise answers where descriptions are requested.

[2] (a) A train arriving at a station is pulling eight passenger couches. Six people at the station are waiting to board the train, determine the following:

(i) the total number of ways in which the six can board the train
(ii) the total number of ways in which the six will board separate couches
(iii) the total number of ways in which exactly three people will board the same couch.
(iv) the total number of ways in which all six will board the same couch.
(v) the total number of ways in which none of the six will board the train.

(b) Let $Pr(A) = 0.4$ and $Pr(A \cup B) = 0.6$

(i) For what value of $Pr(B)$ are A and B mutually exclusive?
(ii) For what value of $Pr(B)$ are A and B independent?
(iii) For what value of $Pr(B)$ is $A \subset B$?

(c) A virus test predicts that a person has the virus (positive) with probability 0.99 if the person truly has the virus. The same test will predict that the person is free of the virus (negative) with probability 0.98 if the person is truly free of the virus.
In a certain community, the prevalence of the virus is believed to be 0.16.

(i) A person is randomly tested in this population and is found to be negative, what are the chances the person is truly free of the virus?
Prevalence = the probability that a randomly chosen individual in the community has the virus.
(ii) If a randomly tested person in this population is found to be positive, what are the chances the person has the virus?

[3] (a) A random variable X has probability density function given by

$$f(x) = \binom{n}{x} p^x q^{n-x}, \qquad x = 0, 1, 2, \ldots, n. \text{ and zero otherwise.}$$

(i) Derive the moment generating function $M_X(t)$ for $f(x)$.
(ii) Using $M_X(t)$, show that the expected value of X is $E(X) = np$
(iii) Using $M_X(t)$, show that the variance for X is $Vr(X) = npq$

(b) A missile protection system has 10 radar sets operating independently, each with probability of 0.6 of detecting a missile entering a zone that is covered by all of the units. Let Y be the number of radar sets that detect a missile that enters the zone.

(i) Name the probability distribution function for Y.
(ii) What is the probability that exactly 5 sets detect a missile that enters the zone.
(iii) If two sets have detected a missile that has entered the zone, what are the chances that more than 2 more sets will detect the missile?
(iv) What is the expected number of sets that would detect a missile within the zone?

(c) A box contains 5 mangoes, 3 guavas and 2 oranges. A child is asked to pick 3 fruits without returning any once picked. The child's interest is in picking mangoes.

(i) What are the chances that at least two fruits picked are mangoes?
(ii) What are the chances that none of the fruits picked are mangoes?

[4] (a) The change in depth of a river from one day to the next, measured (in centimeters) at a specific location is a random variable Y with the following continuous density function:

$$f(x) = \begin{cases} k, & -61 \le x \le 61 \\ 0, & \text{elsewhere} \end{cases}$$

(i) Determine the value of k
(ii) Obtain the distribution function (CDF) F(y)
(iii) Determine the probability that the change in depth is beyond 50 cm.
(iv) Find the average change for Y.

(b) Mrs. Banda is a manager of an exclusive shop that sells women's hats and accessories. From past experience, she knows that demand for the hats in peak-fashion-season has the following probability distribution.

Number of hats	8	10	12	14	16
Probability	0.10	0.20	0.25	0.30	0.15

(i) Find the expected number of hats she is likely to sell within a given season.
(ii) Find the variance in sales of the number of hats sold.

Let $Y = 10 + 30X$ be the revenue function, where X is the number of hats sold, 10 is a fixed cost in dollars and 30 is the price of one hat in dollars.

(iii) Determine her expected revenue.
(iv) What is the variance of sales in dollars (i.e. find the variance of Y)
(v) What value of X gives the highest expected revenue for Y?

[5] (a) If X is a random variable that follows a normal distribution, state the following:

(i) two properties of the normal distribution
(ii) a property that allows us to work out probabilities using half of the distribution.

(b) The annual stock of cereal (maize plus others) per household in Zambia is believed to follow a normal distribution with a mean of 373 kg and a standard deviation of 185 kg.

(i) What is the probability that a randomly chosen household will stock at least 400 kg of cereal?
(ii) If it has been shown that a normal household will not run out of cereal in any given year if it has stock of at least 250 kg of cereal, what proportion of households would not run out?
(iii) If 6.94% of households have stocks below a certain value, the government calls such a value critical, determine the critical value.
(iv) Determine the proportion of households who have stocks within 100kg the of mean.

(c) The annual stock, in a certain province, of the same cereal in (a) also follows a normal distribution with mean μ kg and variance σ^2 sq kg.

(i) If it is believed that the standard deviation σ, is around 190kg, what are the chances that in a sample of 16 households, the sample variance of stocks will exceed 200^2 sq kg?

(ii) If it is also believed that the mean is around 350 kg and that the standard deviation σ is truly unknown. A sample of size 16 yields a sample standard deviation of 180 kg, what are the chances that the sample mean will be within 95.89 kg of the true mean 350kg?

[6] (a) Suppose the joint density of [X, Y] is

$$f(x,y) = \begin{cases} \frac{1}{8}(6-x-y) & 0 \le x \le 2,\ 2 \le y \le 4 \\ 0, & \text{otherwise} \end{cases}$$

(i) Find the conditional density $f_{X/y}(x)$

(ii) Using (i) find the probability that $X > 1$ given $Y = 3$.

(iii) Find the conditional expectation $E_{X/y=3}(X)$ of X given $Y = 3$.

(b) Consider the probability distribution of the discrete random vector $[X_1, X_2]$, where X_1 represents the number of orders for chickens in August at a neighbouring supermarket and X_2 represents the number of orders in September. The joint distribution is shown in the following table:

		X_1				
		51	52	53	54	55
	51	0.06	0.05	0.05	0.01	0.01
	52	0.07	0.05	0.01	0.01	0.01
X_2	53	0.05	0.10	0.10	0.05	0.05
	54	0.05	0.02	0.01	0.01	0.03
	55	0.05	0.06	0.05	0.01	0.03

(i) Find the probability that $X_1 \geq 53$ and $X_2 \geq 53$

(ii) Find the marginal distribution of X_2

(iii) Find the expected sales for September, i.e., $E(X_2)$

(iv) Find the conditional distribution of $X_2 | X_1 = 55$

(v) Find the probability that $X_2 \geq 53$ given $X_1 = 55$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS

JANUARY 2004

M332 REAL ANALYSIS IV

TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS: ATTEMPT ANY FOUR (4) QUESTIONS

---

1. (a) Let $f: [a, b] \to \mathbf{R}$. When is f said to be differentiable on $[a, b]$?

 (b) Let $f: [a, b] \to \mathbf{R}$. Prove that f has a derivative L at $c \in [a, b]$ if for each sequence $\{x_n\}_{n=1}^{\infty}$ in $[a, b]$ with $x_n \neq c$, $\forall n \in \mathbf{N}$, such that $\lim_{n\to\infty} x_n = c$,

 then $\lim_{n\to\infty} \frac{f(x_n) - f(c)}{x_n - c} = L$

 (c) $$f(x) = \begin{cases} x^2 \sin(1/x), & x \neq 0 \\ 0 & x = 0 \end{cases}$$

 Show that f is differentiable at all points x, but f' is not continuous at 0.

2. (a) Let $f: [a, b] \to \mathbf{R}$

 (i) Define a relative maximum of f.

 (ii) Define a relative minimum of f.

 (b) State and prove Rolle's Theorem.

 (c) If $c_0 + c_1/2 + c_2/3 + \ldots + c_n/(n+1) = 0$ where $c_0, c_1, \ldots, c_n \in \mathbf{R}$, prove that the equation $c_0 + c_1 x + c_2 x^2 + \ldots + c_n x^n = 0$ has at least one real root between 0 and 1.

3. (a) Let $m, n \in \mathbf{N}$ and $P_1 = \{x_0, x_1, ..., x_m\}$, $P_2 = \{y_0, y_1, ..., y_n\}$ be partitions of [a, b]. When is P_2 said to be a refinement of P_1?

(b) Let $f: [a, b] \to \mathbf{R}$ be bounded. Let $m, n \in \mathbf{N}$ and $P_1 = \{x_0, x_1, ..., x_m\}$, $P_2 = \{y_0, y_1, ..., y_n\}$ be partitions of [a, b]. If P_2 is a refinement of P_1, prove that

(i) $$\sum_{i=1}^{n}\left(\sup_{y\in[y_{i-1},y_i]} f(y)\right)(y_i - y_{i-1}) \le \sum_{j=1}^{m}\left(\sup_{x\in[x_{-1},x_j]} f(x)\right)(x_j - x_{j-1})$$

(ii) $$\sum_{i=1}^{m}\left(\inf_{x\in[x_{i-1},x_i]} f(x)\right)(x_i - x_{i-1}) \le \sum_{j=1}^{n}\left(\inf_{y\in[y_{-1},y_j]} f(y)\right)(y_j - y_{j-1})$$

(c) Let $a < b$ and Q be the set of rational numbers.

$$g(x) = \begin{cases} 0 & \text{if } x \in [a,b]\cap Q \\ 1 & \text{if } x \notin [a,b]\cap Q \end{cases}$$

Prove that f is not Riemann integrable over [a, b]

4. (a) Let $f: [a, b] \to \mathbf{R}$. When is f said to be Riemann integrable on [a, b]?

(b) Suppose $a < c < b$. If f is Riemann integrable over [a, c] and is also Riemann integrable over [c, b], prove that f is Riemann integrable over [a, b]

(c) Let f and g be Riemann integrable over [a, b] and that for $x \in [a, b]$, $g(x) \ge 0$. Prove that there exists $\mu \in R$ such that

$\inf\{f(x) : a \le x \le b\} \le \mu \le \sup\{f(x): a \le x \le b]$ and
$\int_a^b (fg)(x)dx = \mu \int_a^b g(x)dx$

5. (a) Let f: [a, b] → **R** be bounded.

   (i) Let P be a partition of [a, b]. Define the upper and lower Riemann sums of f corresponding to P.

   (ii) Define the upper and lower Riemann integrals of f over [a, b].

   (b) If f is Riemann integrable over [a, b], prove that $|f|$ is Riemann integrable over [a, b] and that

$$\left|\int_a^b f(x)dx\right| \leq \int_a^b |f(x)|dx$$

6. (a) Let α:[a, b] → **R** be monotonically increasing and f:[a, b] → **R**. When is f Riemann integrable with respect to α on [a, b]?

   (b) Let α: [a, b] → **R** be monotonically increasing and f: [a, b] → **R** be bounded. Suppose that the upper Riemann-Stieltjes integral $\overline{\int_a^b} f(x)d\alpha(x)$ and the lower Riemann-Stieltjes integral $\underline{\int_a^b} f(x)d\alpha(x)$ are equal. Prove that f is Riemann integrable with respect to α on [a, b].

   (c) Suppose $x \in [a, b]$ and f: [a, b] → **R**. Give the definition of f(x+) and of f(x-)

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS

JANUARY 2004

M335: TOPOLOGY

TIME ALLOWED: THREE(3) HOURS

INSTRUCTIONS : QUESTION ONE IS COMPULSORY

ANSWER FOUR QUESTIONS IN ALL

---

1. (a) Define the following terms:

   (i) An equivalence relation

   (ii) A metric space

   (iii) An open set in a metric space

   (b) Prove the following:

   (i) If $\{A_\lambda : \lambda \in \Lambda\}$ is an indexed family of sets where $\Lambda \neq \phi$ and B is any set then $B \cap \left(\bigcup_{\lambda \in \Lambda} A_\lambda \right) = \bigcup_{\lambda \in \Lambda} (B \cap A_\lambda)$.

   (ii) The intersection of any finite number of open sets in a metric space is open.

   (iii) If (A, d) is a metric space and x_o is a limit point of E a subset of A, then every neighbourhood of x_0 contains infinitely many points of E.

   (c) (i) If (A,d) is a metrix space show that

   $$d^*(x,y) = \frac{d(x,y)}{1+d(x,y)} \text{ is a metric.}$$

   (ii) Show that x = 1 is a limit point for the set

   $E = \{x: x \in \mathrm{IR}, x = 1 \text{ or } x = 1 + \frac{1}{n}, n \in J\}$,

   with the usual metric on IR.

2. (a) Define the following terms:

(i) An open sphere

(ii) Neighbourhood of a point in a metric space.

(iii) Limit point of a set in a metric space.

(b) Prove the following:

(i) The intersection of any collection of closed sets in a metric space is closed.

(ii) Let (A, d) be a metric space, then F a subset of A is closed if and only if F contains all its limit points.

(iii) Let (IR, d) be a metric space with $d(x, y) = |x-y|$ for any $x, y \in IR$ and let Q be the set of rational numbers. Define $d^* : Q \times Q \rightarrow IR$ by $d^*(a, b) = |a-b|$, then (Q, d*) is a subspace of (IR, d).

(c) (i) Let $A = \{x \in IR: 0<x<1\}$, and £ be a collection of the following subsets of A, $A_k = \{x \in A: 0 < x < k, \text{ where } 0 \leq k \leq 1\}$. Show that £ is a topology on A.

(ii) Let $d(x,y) = \text{maximum } \{|x_1 - y_1|, |x_2 - y_2|\}$ for any $x, y \in IR^2$. Construct and display the open sphere centered at (2, -2) with radius 1.

3. (a) Define the following terms:

(i) Subspace of a metric space

(ii) Metrically equivalent metric spaces

(iii) Topological space.

(b) Prove the following:

(i) A necessary and sufficient condition that two metric spaces (B, d) and (D, d*) be metrically equivalent is that $\exists$ a bijection function $f: B \to D$ and for each pair $x, y \in B$, $d^*(f(x), f(y)) = d(x, y)$.

(ii) If A and B are subsets of a topological space (X, £) then $Int(A \cap B) = Int(A) \cap Int(B)$.

(iii) If (X, £) is a topological space, then a subset F of X is closed if and only if $\overline{F} = F$.

(c) Let the closed intervals [0, 1] and [a, b] be given the usual topology on IR, and let $f: [a, b] \to [0, 1]$ defined by $f(x) = \frac{x-a}{b-a}$. Is f a homomorphism? Justify your answer.

4. (a) Define the following terms:

(i) Neighbourhood of a point in a topological space.

(ii) An interior point of a set in a topological space.

(iii) Continuity of a function at a point in a topological space.

(b) Prove the following:

(i) If (A, £) is a topological space, then a non-empty subset E of A is open if and only if E is a neighbourhood of each of its points.

(ii) Let $(X, £_x)$ and (Y, £) be two topological spaces. A function $f: (X, £_x) \to (Y, £_y)$ is continuous if and only if for each $E \in £_y$, $f^{-1}(E) \in £_x$

(c) Let X = {1, 2, 3, 4, 5} and
$£ = \{\phi, \{1,2\}, \{3\}, \{3,4\}, \{1,2,3\}, \{1,2,3,4\}, X\}$
be a topology on X.

(i) List three non-open sets which are neighbourshoods of element 4.

(ii) Find the interior of A = {1,3,4}.

(iii) Find the closure of B = {1,2,5}.

(iv) Find the relative topology for C = {3,4,5}.

(v) Is the topological space $(X, £_x)$ connected?

5. (a) Define the following terms:

(i) Identification topology
(ii) Connected topological space.
(iii) Locally connected topological space.

(b) Prove the following

(i) Let (X, £) be a topological space, and ~ be a relation on the set X defined by a ~ b if and only if a and b are both contained in a connected subset of X. Then ~ is an equivalence relation on X.

(ii) The image of a connected set under a continuous function is connected.

(iii) Let f: [a, b] $\rightarrow$ IR be a continuous function with $f(a) \neq f(b)$, then for each $y \in$ IR in between f(a) and f(b) $\exists$ a point $x \in [a, b]$ such that $f(x) = y$.

(c) (i) State the Fixed-point theorem.

(ii) Prove the Fixed-point theorem.

END OF EXAMINATIONS

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SECOND SEMESTER EXAMINATIONS

JANUARY 2004

M362 - LINEAR MODELS AND DESIGN OF EXPERIMENTS

TIME ALLOWED: THREE(3) HOURS

INSTRUCTIONS: (i) ANSWER ANY FOUR(4) QUESTIONS

(ii) STATISTICAL TABLES WILL BE PROVIDED

---

1. (a) An engineer is interested in learning whether three different primers differ in their adhesion properties. Three specimens were painted with each primer using each application method (Dipping and Spraying) and the adhesion force measured. The resulting data are shown below:

Application Method	**Primer type** I	II	III
Dipping	4.0 4.5 4.3	5.6 4.9 5.4	3.8 3.7 4.0
Spraying	5.4 4.9 5.6	5.8 6.1 6.3	5.5 5.0 5.0

(i) Write the appropriate model giving meaning to the terms in the model.

(ii) What type of design was used?

(iii) Complete the following ANOVA table.

Source of variation	**sum of squares**	**df**	**ms**
Primer types	4.58		
Application method			
Interaction	0.24		
Error	0.99		
	10.72		

(iv) Test for differences among primer types.

(v) Test if there is interaction between primer types and Application method.

(b) Given the linear model $Y = X\beta + \varepsilon$, where X is full column rank matrix and $COV(\varepsilon) = \sigma^2 W^{-1}$, where W is a diagonal matrix.

(i) Show that the least squares normal equations are $X^t W X \hat{\beta} = X^t W Y$

(ii) Find the least squares estimator for β.

(iii) Show that the least squares estimator in (ii) is unbiased.

(iv) Find the variance-covariance matrix of the least squares estimator of β.

(c) (i) A latin square design is an incomplete block design. Explain why?

(ii) A student remarked, "when covariance analysis is used, there is danger that the treatments may be related to the covariate "

Comment on this statement.

2. (a) Let $Y_{ij} = \mu_j + \beta(X_{ij} - \bar{X}_{..}) + e_{ij}$, $i = 1, 2, ..., n_j$, $j = 1, 2, 3, ..., k$
$e_{ij} \sim^{IID} n(0, \sigma^2)$

(i) Find the least squares estimators for the parameters in the model given.

(ii) Show that the least squares estimator in (i) are unbiased.

(b) In an experiment to determine the effect of C_2F_6 flow rate on each uniformity on silicon wafer used in integrated - circuit manufacturing, three flow rates were tested and the resulting uniformity (in percent) is observed for six test units at each flow rate. The data are shown in the table below.

C_2F_6 Flow							Total
125	2.7	2.6	4.6	3.2	3.0	3.8	19.9
160	4.6	4.9	5.0	4.2	3.6	4.2	26.5
200	4.1	4.6	5.1	2.9	3.4	3.5	23.6

(i) Write the linear model with the design matrix full column rank.

(ii) Complete the ANOVA table below.

Source of variation	Sum of squares	df	ms
Treatments	3.648		
Error			
Total	11.278		

(iii) Test for treatment differences.

(c) For the data in (b)

(i) Find the 95% simultaneous confidence intervals for the parameters using Scheffe's method.

(ii) Find the 95% simultaneous confidence intervals for all the simple contrasts using Tukey's method.

(iii) Find the 94% simultaneous confidence intervals for the parameters using Bonferroni method.

3. (a) What do you understand by the following terms:

(i) Influential point

(ii) Multi-collinearity

(iii) Coefficient of multiple determination.

(b) The heat evolved in calories per gram of cement (y) as a function of the amount of each of four ingredients in the mix: Tricalcium aluminate (x_1), Tricalcium silicate (x_2), Tetracalcium alumino ferrite (x_3), and dicalcium silicate (x_4). The fitted regression model on thirteen (13) data points is

$$\hat{Y} = 62.41 + 1.55x_1 + 0.51x_2 + 0.10x_3 - 0.14x_4$$

(i) State the interpretations of the estimates of the parameters in the model.

(ii) Complete the ANOVA table below.

Source of variation	**sum of squares**	**df**	**ms**	**F**
Regression	2667.90			
Error				
Total	**2715.76**			

(iii) Compute the unadjusted and adjusted coefficient of multiple determination.

(iv) Test for the significance of the model at 0.05 level of significance.

(c) Consider the multiple regression model in (b) above, the reduced models with their respective sum of squares are given below:

Model	**Regression sum of squares**
$Y = \beta_0 + \beta_4 x_4 + \varepsilon$	1831.90
$Y = \beta_0 + \beta_1 x_1 + \beta_4 x_4 + \varepsilon$	2641.00
$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$	2657.86
$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_4 x_4 + \varepsilon$	2667.79

(i) Test whether x_3, and x_4 are needed in the model when x_1 and x_2 and already in the model at 0.05, level of significance.

(ii) Test whether x_3 is needed in the model when x_1, x_2, and x_4 are already in the model at 0.05 level of significance.

(iii) Computed the unadjusted and adjusted coefficient of multiple determination for the model

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$$

4. (a) Let $Y = X\beta + \varepsilon$ be a linear model where the design matrix X is full column rank and $\mathrm{cov}(\varepsilon) = \sigma^2 I$.

(i) Derive the normal equations for the least squares estimation.

(ii) Find the least squares estimator for β from the normal equations in (i).

(iii) Find the variance-covariance matrix of the least squares estimator of β.

(b) A study was conducted in Lusaka following the dramatic increase in Tea prices during the final quarter of 2002. The objective was to compare the mean supermarket prices of four leading brands of Tea at the end of the year. Ten supermarkets were selected and the price per gram was recorded for each brand.

(i) Write the appropriate model giving meaning to the terms.

(ii) Complete the following ANOVA table.

Source of variation	**Sum of squares**	**df**	**ms**	**F**
Tea brands	0.05000			
Supermarket	0.17451			
Error				
Total	0.22936			

(iii) Is the mean prices for the four brands of Tea sold in Lusaka the same at the end of the year 2002 at 0.05 level of significance?

(iv) Are there differences in mean prices among the supermarkets at 0.05 level of significance?

(v) Analyse the data as one-way, what are the conclusions?

(c) A management information systems consultant conducted a study of five different daily summary reports (A; greatest among of detail; B, C, D, E: least amount of detail). She used five sales executives in the study. Each was given one type of daily report for a month and was then asked to rate its helpfulness on a 25 point scale (0 : not helpful; 25: extremely helpful). Over a five-month period each executive received each type of report for one month according to the Latin square below:

	Month					
Executive	**January**	**February**	**March**	**April**	**May**	**Totals**
Banda	21(D)	8(A)	17(C)	9(B)	16(E)	71
Mumbi	5(A)	10(E)	3(B)	12(C)	15(D)	45
Moono	20(C)	10(B)	15(E)	22(D)	12(A)	79
Mudenda	4(B)	17(D)	3(A)	9(E)	10(C)	43
Bwalya	17(E)	16(C)	20(D)	7(A)	11(B)	71
Totals	**67**	**61**	**58**	**59**	**64**	**309**

Type of report	**A**	**B**	**C**	**D**	**E**
Total score	35	37	75	95	67

The total sum of squares (SST) is 777.76

(i) Write the appropriate model.

(ii) Test for differences for all the three factors at 0.01 level of significance.

5. (a) In an experiment on pig feeds an arrangement was done with 15 young pigs. Five were randomly allocated to one of the three treatments. The feeding treatments denoted by A, B, and C contained increasing proportions ($P_A < P_B < P_c$) of protein were used. The pigs were individually weighed each week for 16 weeks and the growth rate for the (period) was calculated (Y). The weight at the beginning of the experiment for each pig was recorded (X) because it could have an influence on the growth rate.

The following are given.

Treatment	$\sum_{i=1}^{5} Y_{ij}$	$\sum_{i=1}^{5} Y_{ij}^2$	$\sum_{i=1}^{5} X_{ij}$	$\sum_{i=1}^{5} X_{ij}^2$	$\sum_{i=1}^{5} Y_{ij}X_{ij}$
1	48.03	464.99	205	8503	1986.2
2	45.05	407.32	203	8281	1824.8
3	44.78	401.63	209	8801	1875.4
Totals	**138.86**	**1273.94**	**617**	**25585**	**5686.4**

(i) Write the appropriate model, giving meaning to each term in the model.

(ii) Test for treatment differences at 0.05 level of significance.

(iii) Test for significance of the slope at 0.05 level of significance.

(b) For the data in (a) above

(i) Compute the adjusted means.

(ii) Find the 90% simultaneous confidence intervals for the simple contrasts using Tukey's method.

(iii) Using the confidence intervals found in (ii) above which pairs of the three feeding treatments differ significantly at 0.10 level of significance.

(iv) Re-analyse the data as one-way analysis of variance and test for treatment differences at 0.05 level of significance.

(v) What is your comment on the finding in a(iii) and b(iv).

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

2003/2004 SECOND SEMESTER EXAMINATIONS

M432 - REAL ANALYSIS VI

TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS: ATTEMPT ANY FIVE (5) QUESTIONS

---

1. (a) Let (X, d) be a metric space. When is X said to be complete?

   (b) The usual metric on **R** is d: **R** x **R** → **R** defined by d(a, b) = | a-b |. Prove that **R** is a complete metric space.

   (c) If (X, d) is a metric space and $\{x_n\}_{n=1}^{\infty}$ and $\{y_n\}_{n=1}^{\infty}$ are Cauchy sequences in X, prove that the sequence $\{d(x_n, y_n)\}_{n=1}^{\infty}$ converges in **R**, with usual metric.

2. (a) Define a fixed point space.

   (b) Let (X, d) be a metric space. Let r ∈ **R**, 0 < r < 1 and T: X → X such that d(T(x), T(y)) ≤ rd(x, y), for x, y ∈ X. Prove that T has a unique fixed point.

3. (a) (i) Let X be a linear space over a field **F**. Define a norm on X.

   (ii) Let X and Y be linear spaces over the same field **F**.

   α) When is a mapping L: X→ Y called a linear transformation.

   β) Define a norm on a linear transformation L: X→ Y.

   (b) Let X and Y be normed linear spaces over the same field **F** and L: X → Y a linear transformation. Prove that if L is continuous on X then $\| L \| < \infty$.

(c) Let $X = C([0,1])$, the set of continuous real functions defined on [0, 1]. Define $\|\cdot\| : X \to \mathbf{R}$ by $\| f \| = \sup\{|f(x)| : x \in [0,1]\}$. For each $x \in [0, 1]$ define $\Lambda_x : X \to R$ by $\Lambda_x(f) = f(x)$. Prove that Λ_x is a linear transformation and that $\| \Lambda_x \| < \infty$.

4. (a) Let X be a normed linear space. Define the dual space of X.

(b) Let $y \in \ell^1$. Define $\Lambda_y(x) = \sum_{n=1}^{\infty} x_n y_n$ for $x \in \ell^\infty$. Show that $\Lambda_y \in (\ell^\infty)^*$ and $\| \Lambda_y \| = \| y \|_1$.

(c) Let X be a normed linear space over the field **R**, M a linear subspace of X and $U \in M^*$. Let $x \in X \setminus M$ (the complement of M) and $M_0 = \{x + \alpha x_0 : x \in M \text{ and } \alpha \in R\}$. Show that there exists $u_0 \in M_0^*$ such that

(i) $u_0(x) = u(x), \forall x \in M$, and (ii) $\| u_0 \| = \| u \|$.

5. (a) Let X be a linear space over **C**. When is X an inner product space?

(b) State and prove the Schwarz's inequality in a inner product space.

6. (a) Let X be an inner product space. When is X called a Hilbert space?

(b) Let X be an inner product space and A be a subset of X. Suppose A is convex and complete, prove that there exists a unique x_0 in A such that

$$\| x_0 \| = \inf\{\| x \| : x \in A\}$$

7. (a) Let $\{u_\alpha : \alpha \in I\}$ be an orthonormal set in an inner product space X. Define the Fourier coefficient of x in X.

(b) Let $\{u_n : n \in \mathbf{N}\}$ be an orthonormal set in a Hilbert space H. $\forall\, n \in \mathbf{N}$ let $\alpha_n \in \mathbf{C}$ and assume that $\sum_{n=1}^{\infty} |\alpha_n|^2 < \infty$. Prove that $\sum_{n=1}^{\infty} \alpha_n u_n$ converges to an element in H.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS
DEPARTMENT OF MATHEMATICS AND STATISTICS
SECOND SEMESTER 2003
M412 THEORY OF FUNCTIONS OF A COMPLEX VARIABLES II

TIME: THREE HOURS
ANSWER ANY FIVE QUESTIONS
ALL QUESTIONS CARRY EQUAL MARKS
TOTAL MARKS: 100

Useful formulae:

$$f(w) = T_0 + \frac{1}{\pi}[(T_1 - T_0)\arg(w - u_0) + (T_2 - T_1)\arg(w - u_1) + \\ .. + (T_{n+1} - T_n)\arg(w - u_n)]$$

---

1. (a) State and prove the residue theorem for multiply-connected regions. [6]

(b) Evaluate the integral $I = \oint \frac{dz}{z \sin z}$ around the circle $|z| = 4$. [14]

You may need L'Hospital's rule for evaluating limits: $\lim_{z \to z_0} \frac{f(z)}{g(z)} = \frac{f'(z_0)}{g'(z_0)}$

2. Show that $\int_0^{\infty} \frac{1}{1+x^6} dx = \frac{\pi}{3}$. [20]

3. (a) Evaluate the integral $I = \int_0^{2\pi} \frac{d\theta}{3 - 2\cos\theta + \sin\theta}$. [8]

(b) Show that under the transformation $w = \frac{z-i}{z}$ every circle that passes through the origin is turned into a straight line. [6]

(c) A figure is translated and then rotated anti-clockwise through 30° while being expanded. Thus, the point $z = 2$ is mapped onto the point $4 + 4i$. What is the transformation? [6]

4.(a) Obtain a bilinear transformation which maps the upper half plane $\text{Im } z \geq 0$ onto the disk $|w| \leq 1$. [8]

(b) Hence show that the transformation $w = -\frac{z-i}{z+i}$ maps the interior of the unit circle $|w| = 1$ onto the upper half plane $\text{Im } z \geq 0$ in such a way that the upper half of the circle is mapped onto the first quadrant of the z plane. [6]

(c) Find a transformation that maps a 30° sector of the unit circle onto the upper half of the w plane. [6]

5. (a) Prove that in the mapping defined by an analytic function $w = f(z)$, the lengths of infinitesimal segments, regardless of their directions, are altered by a factor $|f'(z)|$ which depends only on the point from which the segments are drawn. [4]

(b) A transformation is given by $w = z - \sin z$.

(i) Find the critical points of the transformation. [4]

(ii) Find the locus of points at which the magnification of infinitesimal segments equals 1. [5]

(iii) Find the locus of points at which infinitesimal segments are rotated through 60°. [3]

(iv) Find the area of the region into which the square with vertices $z = 0$, 1, $1+i$, i is transformed by the mapping $w = 2z^2$. [4]

6. A sheet of metal lies in the first and fourth quadrants of the z plane, i.e., it coincides with the half plane $x \geq 0$. The temperature along the y axis is such that $T = 0$°C for $y > 3$ and $T = 50$°C for $y < -2$, while $T = 100$°C for $-2 \leq y \leq 3$. Find the steady-state temperature distribution in the metal sheet. [20]

7. (**a**) Show that if $\phi(x,y)$ is a solution of Laplace's equation

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = 0$$

then when $\phi(x,y)$ is transformed into $\phi(u,v)$ by a conformal transformation, it satisfies Laplace's equation

$$\frac{\partial^2\phi}{\partial u^2} + \frac{\partial^2\phi}{\partial v^2} = 0$$

in the w plane. [8]

(**b**) Explain how the Schwarz-Christoffel transformation

$$w = K\int [z - x_1)^{\frac{\alpha_1}{\pi}-1}(z - x_2)^{\frac{\alpha_2}{\pi}-1}...(z - x_n)^{\frac{\alpha_n}{\pi}-1}dz + C$$

maps the real axis onto a polygon with angles α_1, α_2,..,α_n. [6]

(**c**) Use the Schwarz-Christoffel transformation to show that the transformation that maps the first quadrant onto the upper half plane is $w = z^2$. [6]

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

UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS
DEPARTMENT OF MATHEMATICS AND STATISTICS
SECOND SEMESTER 2003
M412 THEORY OF FUNCTIONS OF A COMPLEX VARIABLES II

TIME: THREE HOURS
ANSWER ANY FIVE QUESTIONS
ALL QUESTIONS CARRY EQUAL MARKS
TOTAL MARKS: 100

Useful formulae:

$$\begin{aligned} f(w) &= T_0 + \frac{1}{\pi}[(T_1 - T_0)\arg(w-u_0) + (T_2 - T_1)\arg(w-u_1) + \\ &\quad .. + (T_{n+1} - T_n)\arg(w-u_n)] \end{aligned}$$

---

1. (a) State and prove the residue theorem for multiply-connected regions. [6]

(b) Evaluate the integral $I = \oint \frac{dz}{z \sin z}$ around the circle $|z| = 4$. [14]
You may need L'Hospital's rule for evaluating limits: $\lim_{z \to z_0} \frac{f(z)}{g(z)} = \frac{f'(z_0)}{g'(z_0)}$

2. Show that $\int_0^\infty \frac{1}{1+x^6} dx = \frac{\pi}{3}$. [20]

3. (a) Evaluate the integral $I = \int_0^{2\pi} \frac{d\theta}{3 - 2\cos\theta + \sin\theta}$. [8]

(b) Show that under the transformation $w = \frac{z-i}{z}$ every circle that passes through the origin is turned into a straight line. [6]

(c) A figure is translated and then rotated anti-clockwise through 30° while being expanded. Thus, the point $z = 2$ is mapped onto the point $4 + 4i$. What is the transformation? [6]

4.(a) Obtain a bilinear transformation which maps the upper half plane $\text{Im } z \geq 0$ onto the disk $|w| \leq 1$. [8]

(b) Hence show that the transformation $w = -\frac{z-i}{z+i}$ maps the interior of the unit circle $|w| = 1$ onto the upper half plane $\text{Im } z \geq 0$ in such a way that the upper half of the circle is mapped onto the first quadrant of the z plane. [6]

(c) Find a transformation that maps a 30° sector of the unit circle onto the upper half of the w plane. [6]

5. (a) Prove that in the mapping defined by an analytic function $w = f(z)$, the lengths of infinitesimal segments, regardless of their directions, are altered by a factor $|f'(z)|$ which depends only on the point from which the segments are drawn. [4]

(b) A transformation is given by $w = z - \sin z$.
(i) Find the critical points of the transformation. [4]

(ii) Find the locus of points at which the magnification of infinitesimal segments equals 1. [5]

(iii) Find the locus of points at which infinitesimal segments are rotated through $60°$. [3]

(iv) Find the area of the region into which the square with vertices $z = 0$, 1, $1 + i$, i is transformed by the mapping $w = 2z^2$. [4]

6. A sheet of metal lies in the first and fourth quadrants of the z plane, i.e., it coincides with the half plane $x \geq 0$. The temperature along the y axis is such that $T = 0°\text{C}$ for $y > 3$ and $T = 50°\text{C}$ for $y < -2$, while $T = 100°\text{C}$ for $-2 \leq y \leq 3$. Find the steady-state temperature distribution in the metal sheet. [20]

7. **(a)** Show that if $\phi(x, y)$ is a solution of Laplace's equation

$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = 0$$

then when $\phi(x, y)$ is transformed into $\phi(u, v)$ by a conformal transformation, it satisfies Laplace's equation

$$\frac{\partial^2 \phi}{\partial u^2} + \frac{\partial^2 \phi}{\partial v^2} = 0$$

in the w plane. [8]

(b) Explain how the Schwarz-Christoffel transformation

$$w = K \int [z - x_1)^{\frac{\alpha_1}{\pi}-1}(z - x_2)^{\frac{\alpha_2}{\pi}-1}...(z - x_n)^{\frac{\alpha_n}{\pi}-1}dz + C$$

maps the real axis onto a polygon with angles α_1, α_2,..,α_n. [6]

(c) Use the Schwarz-Christoffel transformation to show that the transformation that maps the first quadrant onto the upper half plane is $w = z^2$. [6]

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

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS

JANUARY 2004

M465 – NONPARAMETRIC METHODS

INSTRUCTIONS

1. Answer any five (5) questions.
2. Show ***all your work*** to earn full credit.
3. You may use a calculator and tables.

TIME ALLOWED: Three (3) hours

---

[1] (a) Let (X_j, Y_j), $j = 1, 2, \ldots, n$, be a random sample of a pair of measurements from a match-paired experiment. Suppose X_j, Y_j are from continuous distributions F_x, F_y, respectively.

$$\text{Let } Z_j = \begin{cases} 1 & \text{if} \quad X_j > Y_j \\ 0 & \text{if} \quad X_j < Y_j \end{cases},$$

where we ignore $X_j = Y_j$ and the sample size n is reduced accordingly.
We wish to test the hypothesis:
$H_0 : F_X = F_Y$ versus $H_a: F_x > F_Y$

(i) If $\Pr(X_j > Y_j) = p$, formulate H_0 and H_a in terms of p.

(ii) Name a nonparametric test you would use to test the hypothesis in (i).

(iii) If $\Pr(X_j > Y_j) = p$ and $U = \sum_{j=1}^{n} Z_j$, find expressions for E(U) and Var(U).

(iv) Construct a statistic of the form $T(U) = \dfrac{U - E(U)}{\sqrt{Var(U)}}$, where E(U) and Var(U) are expression from (iii) above.

(b) A chemical supplier wishes to determine whether a new preservative will provide a longer shelf life for the bread of its bakery customers. Twenty bakeries have used the new preservative in a batch of dough, and have then provided the supplier with two fresh loaves of standard brand, one baked with their regular preservative and the other with the new one. After a week, the supplier discovers that for 11 bakeries the loaves using the new preservative lasted longer on the shelf, for 4 bakeries the loaves baked using the old preservative lasted longer, and for the rest 5 bakeries there was no difference in the shelf life.

(i) Using $\alpha = 0.05$ level of protection, test the hypothesis that the new preservative provides longer shelf life, using the test in (a) (ii).

(ii) Using $\alpha = 0.05$ level of protection, test the same hypothesis using the test in (a) (iv), where $T(U) \sim N(0, 1)$.

(iii) How do the result in (b) (i) and (b) (ii) compare?.

(c) A turbocharger wheel is manufactured using an investment casting process. The shelf fits into a wheel opening, and this wheel opening is a critical dimension. As wheel wax patterns are formed, the hard tool producing the wax pattern wears. This may cause growth in the wheel-opening dimension. Ten wheel-opening measurements, in time order of production, are shown below:

4.00 (in mm), 4.02, 4.03, 4.01, 4.00, 4.03, 4.04, 4.02, 4.03, 4.03.

(i) Suppose that p is the probability that observation X_{i+5} exceeds observation X_i. If there is no upward or downward trend, the X_{i+5} is no more or less likely to exceed X_i or lie below X_i, what is the value of p?

(ii) Let V be the number of values of i for which $X_{i+5} > X_i$. If there is no upward or downward trend in the measurements, what is the probability distribution of V?

(iii) Use the data above and the results of part (c) (i) and (ii) to test:
H_0: There is no trend versus H_a: there is upward trend. Use $\alpha = 0.05$.

[2] (a) An electrical engineer must design a circuit to deliver the maximum amount of current to a display tube to achieve sufficient image brightness. Within his allowable design constraints, he has developed two candidate circuits and tests prototypes of each. The resulting data (in microamperes) is shown below:

Circuit 1	249	250	251	252	253	256	259	
Circuit 2	248	250	250	251	251	254	255	257

Let μ_1, μ_2 be the true mean currents produced by circuit 1 and 2, respectively.

Use $\alpha = 0.05$ and the Wilcoxon rank sum to test:
H_0: $\mu_1 = \mu_2$ versus H_a: $\mu_1 > \mu_2$

(b) Consider a general case of the experiment in (a).

- Let $X_1, X_2, \ldots, X_m$ be a random sample of current measurements for circuit 1 from a continuous distribution F_X. Let $Y_1, Y_2, \ldots, Y_n$ be a random sample of current measurements for circuit 2 from a continuous distribution F_Y, μ_1 and μ_2 are as defined earlier.
- Let $N = m + n$ and R_j, $j = 1, 2, \ldots, N$ be the rank of the j^{th} ordered observation in the combined sample.
- Let $Z_j = \begin{cases} 1 & \text{if} \quad R_j \quad \text{is assigned to circuit 1} \\ 0 & \text{if} \quad \text{not} \end{cases}$

(i) Obtain the expected value, of $U = \sum_{j=1}^{N} R_j Z_j$ assuming the distributions of current for the two circuits are the same.

(ii) Given that $\sum_{j=1}^{N}\sum_{k\neq j}^{N} R_j R_k \mathrm{Cov}(Z_j, Z_k) = -\frac{m(N-m)(N+1)(3N+2)}{12N}$

and $\sum_{j=1}^{N} R_j^2 = \frac{N(N+1)(2N+1)}{6}$,

derive an expression for Var(U) under the same assumption as in (b) (i).

(iii) Using results in (i) and (ii) above construct a large sample test of the form $R(U) = \frac{U - E(U)}{\sqrt{Var(U)}}$ where $R(U) \sim N(0, 1)$

(iv) Carry out a large sample test of the hypotheses in (a) at $\alpha = 0.05$.

[3] An experiment involving 4 girls and 4 boys, matched on age, was conducted to determine which gender has better memory recall of biological terms. The experiment involved teaching the boys and girls a certain number of biological terms in accordance with their age group. After an appropriate period of time, the number of terms correctly recalled was recorded for each boy and girl. The results together with relevant statistics are shown below:

Pair	Girls Recall	Boys recall	Girls – Boys recalls	Rank
1	6	7	-1	1
2	9	7	2	2
3	13	10	3	3
4	15	11	4	4

- Let R^+ be the sum of ranks assigned to positive differences (Girl's – Boy's recall values) and R^- be the sum of ranks assigned to the negative differences.
- Let X be the score for a randomly chosen girl and Y the score for a randomly chosen boy.
- Let R_1, R_2, R_3, and R_4 correspond to ranks for the differences in recall values for the pairs 1, 2, 3, and 4, respectively.

(a) (i) What assumption is necessary for any rank to equally be positive (+) or negative (-)?

(ii) How many permutations are possible of the (+) and (-) signs under the assumption in (i), where a (+) and a (-) represents positive or negative rank, respectively?

(iii) In a tabular form, enumerate all the possible permutations using (+) and (-) signs, for each permutation obtain the value of R^+ and its probability, still under the assumption in (i).

(b) Suppose that in a (iii) we define the critical value associated with H_0: Median(X – Y) = 0 versus H_a: Median(X – Y) > 0 to be R^*_α such that we reject H_0 if $R^+ > R^*_\alpha$

(i) Determine R^*_α where $\alpha = 0.05$

(ii) Determine the observed R^+ and state whether or not there is sufficient evidence against H_0 for the data above.

(iii) Show that the results of this permutation test are equivalent to that of the Wilcoxon Signed rank test.

[4] Three different brands of magnetron tubes (the key components in microwave ovens) were subjected to stressful testing, and the number of hours each operated without repair was recorded. Although these times do not represent typical life length, they do indicate how well the tubes can withstand extreme stress.

	Brand		
	A	B	C
	36	49	71
	48	33	31
	5	60	140
	67	2	59
	53	55	42
Mean	41.8	39.8	68.6
St. Deviation	23.38	23.44	42.77
N	5	5	5

(a) (i) State the experimental design associated with this sort of experiment.

(ii) What parametric test would you use to test:
H_0: $\mu_A = \mu_B = \mu_C$ versus H_a: Not all the means are equal,
where μ_A , μ_B , and μ_C are, respectively, the true means for time to first repair for brands A, B, and C.

(iii) Mention <u>three</u> assumptions necessary to carry out the test in (ii).

(iv) For <u>each</u> assumption, comment on its validity with respect to the data above.

(b) (i) Use the Kruskal_Wallis test to determine whether evidence exists to conclude that the brands of magnetron tubes tend to differ in length of life under stress. Test using $\alpha = 0.05$

(ii) We would like to carry out three pair-wise comparison tests irrespective of the outcome in (i). If you had to do just one test, which one seems sensible to carry out?

(iii) Given your findings in (i) should such a test be carried out?

[5] (a) Consider the Friedman statistic:

$$F_r = \frac{12n}{g(g+1)} \sum_{i=1}^{g} (\overline{R}_i - \overline{R})^2 \quad i = 1, 2, \ldots g$$

where $\overline{R}_i = \frac{R_i}{n}$ and R_i is the sum of the ranks for group/treatment i,

$\overline{R} = \frac{(g+1)}{2}$ the overall mean, $\sum_{i=1}^{g} R_i = \frac{ng(g+1)}{2}$ and n is the number of blocks.

Show that an alternative form of F_r is $F_r = \frac{12}{ng(g+1)} \sum_{i}^{g} R_i^2 - 3n(g+1)$

(b) Corrosion of different metals is a problem in many mechanical devices. Three sealers used to help retard the corrosion of metals were tested to see whether there were any differences among them. Samples of fifteen different metal composition were treated with each of the three sealers and the amount of corrosion was measured after exposure to the some environmental conditions for 1 month, the data are given below.

		Sealer	
Metal	I	II	III
1	4.6	4.2	4.9
2	7.2	6.4	7.0
3	3.4	3.5	3.6
4	6.2	5.3	5.9
5	8.4	6.5	7.8
6	5.6	4.8	5.7
7	3.7	3.8	4.1
8	6.1	6.2	6.4
9	4.9	4.1	4.2
10	4.4	4.2	4.9
11	7.2	6.5	7.1
12	3.3	3.2	3.4
13	6.4	5.3	5.7
14	4.5	5.2	3.9
15	6.2	5.4	7.5

(i) State the null and alternative hypotheses

(ii) Carry out the Friedman's test at $\alpha = 0.05$

(iii) State, with reasons, whether or not multiple comparisons would be necessary here.

[6] The following data show the number of thousands of miles traveled by buses before the first engine failure. The buses were fitted with the same type of engine.

Thousands Of miles	Frequency of Engine failure
0 – 20	6
20 – 40	11
40 – 60	16
60 – 80	25
80 – 100	34
100 – 120	46
120 – 140	33
140 – 160	16
160 – 180	2
180 - 200	2

(a) (i) Mention one major disadvantage the the Kolmogorov – Smirnov test has over the Chi-Square goodness-of-fit test.

(ii) Mention two major advantages the the Kolmogorov – Smirnov test has over the Chi-Square goodness-of-fit test.

(b) Test the following hypotheses using the Kolmogorov – Smirnov test at $\alpha = 0.05$:

H_0: Time to first engine failure has a normal distribution with mean 96 thousands of miles and a standard deviation of 38 thousands of miles.

versus the alternative

H_a: Time to first engine failure has some other distribution.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS - 2003

M912 MATHEMATICAL METHODS VI

INSTRUCTIONS: (i) ANSWER ANY FIVE QUESTIONS

TIME ALLOWED: THREE (03) HOURS

Question 1

(a) Let f be a function defined by

$$f(x, y) = \begin{cases} x^2y + y^3 & \text{if } \{0 \le x \le 1, \quad 0 \le y \le 1\} \\ x^3y + x & \text{if } \{1 < x \le 2, \quad 0 \le y \le 1\} \end{cases}$$

Show that f(x,y) is integrable over the region D: $\{(x,y): \quad 0 \le x \le 2, \quad 0 \le y \le 1\}$

(b) (i) Let P(x,y) and Q(x,y) be continuous on a set S containing a smooth curve C given by

$$C: \ \mathbf{X}(t) = f(t)\mathbf{i} + g(t)\mathbf{j} \qquad t \in [a, b]$$

Let the vector field F be given by

$$\mathbf{F}(x, y) = P(x,y)\mathbf{i} + Q(x, y)\mathbf{j}$$

Define the line integral of **F**(x, y) over the curve C.

(ii) Evaluate the integral

$$\iint_S (x^2 + y^2)dxdy$$

as a line integral, where S in the region enclosed by the ellipse

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

Question 2

(a) State Stokes Theorem

(b) Compute the surface area of the surface S given by

$$S:\ Z = x^2 + y^2$$

over the region $D: \{(x,y) : x^2 + y^2 \leq 1\}$

(c) Let $\mathbf{F}(x, y, z) = xy^2\mathbf{i} + \mathbf{k}$ be a vector field on the surface S given by

$$S:\ x^2 + y^2 + z^2 = 1$$

Calculate the surface integral of **F** over the surface S by an application of divergence theorem.

Question 3

(a) Let $H_o(x) = 1$, $H_1(x) = 2x$ $H_2(x) = 4x^2 - 2$

Show that the polynomials $\{H_o(x), H_1(x), H_2(x)\}$ are pairwise orthogonal on the interval $(-\infty, \infty)$ with respect to the weight function $\omega(x) = e^{-x^2}$

(b) (i) Using the formular $e^{ix} = \cos x + i\sin x$, show that

$$2e^{inx}\cos nx = e^{2inx} + 1 \text{ and}$$

$$2ie^{inx}\sin n x = e^{2inx} - 1$$

(ii) Let $f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty}(a_n \cos nx + b_n \sin nx)$ be the Fourier Series of f(x) in the interval $-\pi \leq x \leq \pi$ where a_0, a_n and b_n are constants. Show that this series can be written in the form

$$f(x) = \frac{c_0}{2} + \sum_{n=1}^{\infty}(c_n e^{inx} + k_n e^{-inx})$$

where c_0, c_n and k_n are constants. Hence assuming term by term integration of the series, obtain explicitly in terms of f(x), the formulars for c_n and k_n.

Question 4

(a) State the Fourier Integral Theorem.

(b) Let f(t) be a periodic function whose definition in one period is

$$f(t) = t \qquad -1 < t < 1$$

(i) Obtain the Fourier Series expansion of f.

(ii) Sketch the graph of f in the interval $-3 < t < 3$.

(iii) Assuming term by term integration of series use (i) to obtain in terms of a_0 the Fourier Series of the function whose definition in one period is

$$f(t) = t^2 \qquad -1 \le t \le 1$$

(iv) Use the definition to find a_0 and hence find the sum of the series

$$1 - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} + - \ldots.$$

Question 5

(a) Suppose that f is a function defined for all $t \ge 0$ and that f is of exponential order on $[0, \infty)$. Assuming that $\int_0^t f(x)dx$ is also of exponential order on $[0, \infty)$, prove that $L\left[\int_0^t f(x)dx\right] = \frac{1}{s}L(f)$

(b) Let f(t) be a function defined by

$$f(t) = \begin{cases} 0, & t < 1 \\ 2(t-1) & 1 \le t \le 2 \\ 4-t & 2 < t \le 4 \\ 0 & 4 < t \end{cases}$$

Use the Unit Step function to give an algebraic representation of this function. Be sure to simplify the expression.

(c) Find the solution of the function y(t) satisfying the integral equation

$$y(t) = t^3 + \int_0^t \sin(t-\lambda)y(\lambda)d\lambda$$

Question 6

(a) Calculate the Wronskian of the functions

$$y_1(x) = \sin^3 x \ \text{ and } y_2(x) = \sin x - \frac{1}{3}\sin 3x$$

(b) Suppose also that the functions $y_1(x) = \sin^3 x$ and $y_2(x) = \sin x - \frac{1}{3}\sin 3x$ are both solutions of the differential equation $\frac{d^2y}{dx^2} + (\tan x - 2\cot x)\frac{dy}{dx} = 0$ on any interval I where tan x and cot x are both defined find the general solution of the differential equation. $\frac{d^2y}{dx^2} + (\tan x - 2\cot x)\frac{dy}{dx} = 0$

(c) Find the particular solution of the differential equation

$$y'' - y = \frac{2}{1+e^x}$$

by method of variation of parameters.

Question 7

(a) Find the general solution of the system of differential equations

$$\begin{cases} \dfrac{dx}{dt} = -3x + 4y \\ \dfrac{dy}{dt} = -2x + 3y \end{cases}$$

(b) Use the method of power series to find two linearly independent solutions of the differential equation

$$y'' + y = 0$$

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS

JANUARY 2004

M962 - TIME SERIES ANALYSIS

INSTRUCTIONS: **(i) ANSWER ANY FIVE QUESTIONS**
(ii) STATISTICAL TABLES WILL BE PROVIDED

TIME ALLOWED: THREE(3) HOURS

---

1. (a) Define a covariance stationary stochastic process.

(b) Let $\{Z_t\}$ be a sequence of independent random variables alternately following a Normal distribution N(5,4) and Binomial distribution $B(n=25, p=\frac{1}{5})$. Determine if the process $\{Z_t\}$ is covariance stationary.

(c) The first ten autocorrelations of a time series consisting of 100 observations are

$r_1 = 0.31$,	$r_2 = 0.37$,	$r_3 = -0.05$,	$r_4 = 0.06$,
$r_5 = -0.21$,	$r_6 = 0.11$,	$r_7 = 0.08$,	$r_8 = 0.05$,
$r_9 = 0.05$,	$r_9 = 0.12$,	$r_{10} = -0.01$	

Suggest with reasoning an ARMA model which may be appropriate.

(d) (i) Define a white noise process and determine its autocovariance function.

(ii) Let $\{Z_t\}$ be a white noise process with mean μ and variance σ_z^2. Define a process $\{X_t\}$ by $X_t = X_{t-1} + Z_t$

Assuming the process $\{X_t\}$ starts at $X_1 = Z_1$, show that $\{X_t\}$ is a non stationary process. Make a sketch of the correlogram of the process $\{X_t\}$. State if the process of the first differences is stationary or not.

2. (a) Let $\{Z_t\}$ be a purely random discrete process with mean zero and variance σ_z^2. Show that the following two stationary processes $\{X_t\}$ have the same autocorrelation functions.

$$X_t = Z_t + \theta Z_{t-1}$$
$$X_t = Z_t + \frac{1}{\theta} Z_{t-1}$$

Determine which of the two processes stated above is invertible for $\theta = -\frac{1}{2}$

(b) Let ρ_k be the kth autocorrelation coefficient of an MA(1) process. Show that $|\rho_k| < .5$ for $k > 0$.

(c) Find an invertible process which has the following autocorrelation function. $\rho_0 = 1, \rho_1 = 0.4, \rho_k = 0$ for $k \geq 2$.

(d) Sketch the correlograms of autocorrelation function and partial autocorrelation function of an MA(1) with parameter θ satisfying $\theta < 0$.

3. (a) Define a second order autoregressive AR(2) process.

(b) Given the process $\{Z_t\}$ defined by $Z_t = Z_{t-1} + \alpha Z_{t-2} + a_t$

(i) Express the process in terms of operator B where $Z_{t-1} = BZ_t$

(ii) Assuming polynomial equation in operator B has real roots, find the range of values of α for which the process is stationary where $\{a_t\}$ is a zero mean white noise process.

(c) Given the process

$$Z_t = Z_{t-1} - .25Z_{t-2} + a_t$$

(i) Calculate ρ_1

(ii) Use ρ_0, ρ_1 as starting values and the difference equation for ρ_k to find the general expression for ρ_k.

4. (a) Show that the process $\{X_t\}$ defined by $X_t = Z_t + C(Z_{t-1} + Z_{t-2} + \ldots)$ where C is a constant and $\{Z_t\}$ is a zero mean white noise process, is non stationary. Identify the process represented by the series of the first differences of $\{X_t\}$ and find the range of values of C for which the process of first differences is invertible.

(b) Let $Z_1, Z_2, ..., Z_n$ be independently distributed Poisson random variables with $E(Z_t) = \mu_t$.

(i) Show that the variance of Z_t depends on its mean μ_t.

(ii) If the transformation $T(Z_t)$ where $T'(\mu_t) = \frac{1}{\sqrt{f(\mu_t)}}$ and

$f(\mu_t) = V(Z_t)$

stabilizes the variance of the transformed series $T(Z_t)$, show that a square root transformation of the given series of independently distributed Poisson random variables is required so that variance of the transformed variable becomes constant.

5. (a) The stationary process $\{w_t\}$ is generated from the white noise process $\{a_t\}$ via

$$w_t = \lambda w_{t-1} + a_t - \frac{1}{2}a_{t-1}$$

(i) Discuss the stationarity and invertibility of the above model.

(ii) Show that the one lag autocorrelation of $\{w_t\}$ is given by

$$\rho_1 = \frac{(2\lambda - 1)(2 - \lambda)}{5 - 4\lambda}$$

(b) 100 observations from an ARMA(1,1) process $\{Z_t\}$ defined by $Z_t - \phi_1 Z_{t-1} = a_t - \theta_1 a_{t-1}$ gave the following estimates:

$\sigma_z^2 = 10$, $\hat{\rho}_1 = .523$ and $\hat{\rho}_2 = .418$

(i) Estimate the first two partial autocorrelations of this series.

(ii) Show that $\rho_k = \phi_1 \rho_{k-1}$, $k \geq 2$

(iii) Find initial estimate of ϕ_1.

(iv) Describe the pattern that would have been exhibited by the autocorrelations of $\{Z_t\}$.

6. (a) Suppose the model

$(1 - \phi B)(Z_t - \mu) = a_t$

is found to be appropriate for the observations $z_n, z_{n-1}, z_{n-2}, \ldots$

(i) State the minimum mean square error forecast of Z_{n+l}

(ii) Find the ℓ – step ahead forecast $\hat{z}_n(\ell)$ of Z_{n+l} from the fitted model.

(b) Given the model

$(1 - .6B)(Z_t - 19) = a_t$

where $\{a_t\}$ is a purely random process with mean zero and variance 0.1. Suppose that we have observations
$z_{100} = 18.9, \; z_{99} = 19, \; z_{98} = 19, z_{97} = 19.6$

(i) Forecast $Z_{101}, \; Z_{102}, \; Z_{103}$

(ii) Find the 95% forecast limits for $Z_{101}, \; Z_{102},$ and Z_{103}.

(iii) Suppose that the observation at t = 101 turns out to be $z_{101} = 18.8$. Update the forecasts for Z_{102} and Z_{103}.

You may use the following formulae

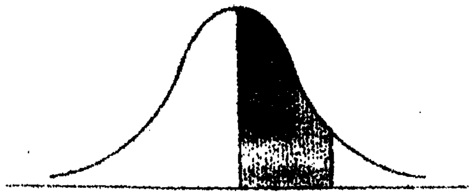
(i) $\text{Var}\,(\hat{Z_n}(\ell)) = \sum_{j=0}^{\ell-1} \Psi_j^2$

where $\psi_0 = 1$ and ψ_j are the weights associated with the moving average representation of the given model.

(ii) The forecast update equation is

$$\hat{z}_{n+1}(\ell) = \hat{z}_n(\ell+1) + \psi_\ell(\; z_{n+1} - \hat{z}_n(1) \;)$$

END OF EXAMINATION



z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

Source: Abridged from Table I of A. Hald, *Statistical Tables and Formulas* (New York: John Wiley & Sons, Inc.) 1952. Reproduced by permission of A. Hald and the publisher.

The University of Zambia
Physics Department
University Examinations 2003
Second Semester
P-192 : Introductory Physics- II
(Option A)

All questions carry equal marks. The marks are shown in brackets. Question 1 is compulsory. Attempt four more questions. Clearly indicate on the answer script cover page which questions you have attempted.

Time : Three hours. **Maximum marks = 100.**

Do not forget to write your computer number clearly on the answer book as well as on the answer sheet for Question 1. Tie them together !!

==

Wherever necessary use :

$g = 9.8 m/s^2$ — 1 metric ton = 1000 kg

$P_A = 1.01 \times 10^5$ N/m^2

1 cal. = 4.18 J

$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/Nm^2

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ J-s

1 Pascal =1 N/m^2

1eV = 1.6×10^{-19} J

$e = 1.6 \times 10^{-19}$ C

$m_e = 9.11 \times 10^{-31}$ kg

$k = 9 \times 10^9$ Nm^2/C^2

$\mu_0 = 4\pi \times 10^{-7}$ N/A^2

$\rho_{water} = 1000$ kg/m^3

$G = 6.67 \times 10^{-11}$ Nm^2/kg^2

Efficiency of a Carnot engine, $e = 1 - T_2/T_1 = \dfrac{\textit{work done}}{\textit{input heat at high temperature}}$

Question 1 : Sample answers : F(a), G(d).... etc. **DO NOT <u>guess</u>** the answer. For <u>each</u> correct answer, 2 marks. For <u>each</u> wrong answer, 0.67 will be deducted. No answer, zero mark.The minimum total mark for Question 1 is zero. [$10 \times 2 = 20$]

(A) Sound of frequency 256 Hz travels with a speed of 330 m/s in a medium. The speed of sound of frequency 512 Hz in the same medium is:

(a) 330 m/s (b) 660 m/s
(c) 165 m/s (d) $330\sqrt{2}$ m/s

(B) Given four capacitors each of 12 μF capacitance, how does one connect them to obtain an equivalent capacitance of 9 μF:

(a) all in series
(b) all in parallel
(c) two in parallel and the other two in series
(d) three in parallel and one in series

(C) A current carrying loop is placed in a uniform magnetic field. The torque acting on it does not depend upon:
(a) the shape of loop
(b) the area of loop
(c) the value of current
(d) the magnetic field

(D)
(E) In a cyclic process the amount of heat given to a system is equal to:

(a) The net increase in the internal energy
(b) The net work done by the system
(c) The net increase in internal energy
(d) The net change in volume

(F) The thermal conductivity of a metal plate depends on:

(a) the temperature difference between the two sides
(b) the thickness of the metal plate
(c) the area of the plate
(d) the none of the above

(G) The motion of a particle describing uniform circular motion is:

(a) periodic and simple harmonic
(b) periodic but not simple harmonic motion
(c) simple harmonic but not periodic
(d) neither periodic nor simple harmonic

(H) The distance between two consecutive crests in a wave train produced in a string is 5 cm. If two complete waves pass through any point per second, the velocity of the wave is:

(a) 2.5 cm/s
(b) 5.0 cm/s
(c) 10.0 cm/s
(d) 15.0 cm/s

(I) The force between two electrons separated by distance r varies as:

(a) r^2
(b) r
(c) r^{-1}
(d) r^{-2}

(J) If the difference between the frequencies of two sound sources is more than 10 Hz, then the beats are:

(a) are not formed at all
(b) cease to be indistinguishable
(c) are not audible
(d) are heard with increased clarity

(K) The resistivity of a wire depends upon:

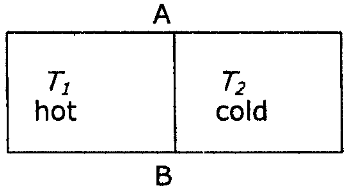
(a) its length
(b) its cross-sectional area
(c) its dimensions
(d) its material

ATTEMPT ANY FOUR QUESTIONS FROM BELOW:

Q.2 (a) Define (a) total internal reflection (b) critical angle. [3]

(b) A car of mass 1300 kg has four springs. Each spring has a force constant of 20,000 N/m. If two people riding in the car have a combined mass of 160 kg, find:
(i) the frequency of vibration of the car when it is driven over a pothole in the road.
(ii)How long it takes the car to excute 3 complete vibrations. [9]

(c) A container is separated into two equal-volume compartments. The two compartments contain equal masses of the same gas, 0.74 g in each, and C_V for the gas is 0.178cal/g ^{0} C. At the start, the hot gas is at 67^0 C, while the cold gas is at 20^0 C. No heat can leave or enter the compartments except slowly through the partition AB. Find the entropy change of each compartment as the hot gas cools from 67^{0}C to 65^{0}C. [8]



Q.3 (a) State Lenz's law. On which conservation principle is it based? [3]

(b) A horizontal telephone wire 1 x 10^3m long is lying along the eastern direction in the earth's magnetic field. It falls freely to the ground from a height of 10 m. Calculate the emf induced in the wire when the wire strikes the ground, assuming that the horizontal component of the earth's magnetic field has flux density 0.32 x 10^{-4}T. [8]

(c) The temperature of 90g of N_2 gas is raised from 10^0 C to 100^0 C at a constant pressure of 1 atm. Find ΔU, W and Q for this process. [9]

Q.4 (a) A dielectric material is placed between the plates of a parallel capacitor. What effect does it have on :

(i) the electric field between the plates; and

(ii)the capacitance of the capacitor? [2]

(b) The current in an air-core solenoid is increasing at the rate of 1.5 A/s. There are 10^6 turns of wire for each meter length of the solenoid, and its cross-sectional area is 2.0 cm^2. A secondary coil of 10^4 turns is wound over the solenoid. How large an emf is induced in the secondary? [7]

(c) Sound travels at 340 m/s. A source of sound of frequency 256 Hz is moving rapidly towards a wall with a velocity of 5 m/s. How many beats per second will be heard by an observer:

(i) between the wall and the source?

(ii) behind the source?

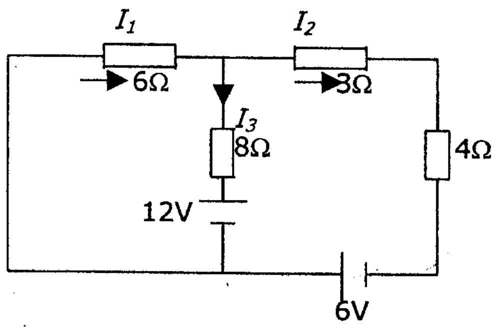
(iii) moving with the source? [11]

Q.5 (a) Define:

(i) emf of a battery

(ii) absolute potential. [3]

(b) Find the currents I_1, I_2 and I_3 in the figure below: [10]



(c) An iron furnace radiates 90 W through an opening of cross-sectional area 10^{-4} m^2. If the emissivity of the furnace is 0.4, calculate the temperature of the furnace. ($\sigma = 5.67 \times 10^{-4}$ $W.m^{-2} K^{-4}$). [7]

Q.6 (a) What is a wavefront? What is the relationship between a light ray and the wavefronts whose motion it is used to describe? [3]

(b) A door-bell transformer for use on a 240 V line has 8000 turns in the primary and 200 turns in the secondary. What is:

(i) the output voltage when 2 A current flows through the secondary; and

(ii) the current through the primary. [5]

(c) A weighted glass tube is floating in a liquid with 20 cm of its length immersed. It is pushed down a little and released.

(i) Show that the motion is S.H.M

(ii) Calculate the time period of its vibration. [12]

Q.7 (a) If hot air rises, why is it cooler at the top of a mountain than near sea level? [3]

(b) Two equal and opposite charges of magnitude 2.0×10^{-7} C are 15cm apart.

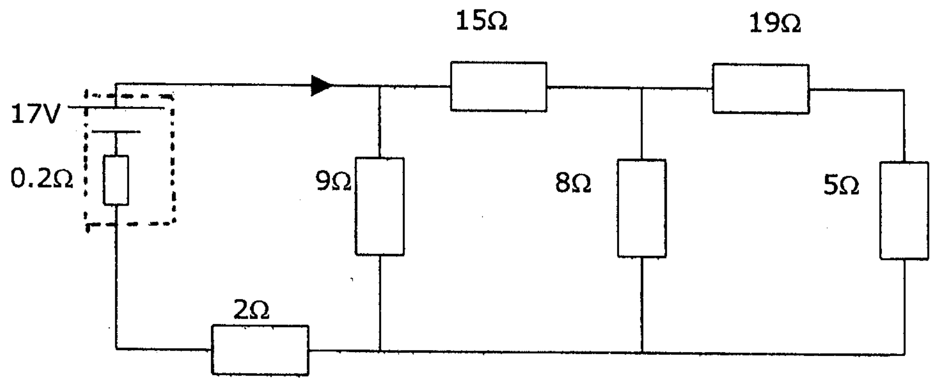
(i) What are the magnitude and direction of the electric field E at a point midway between the charges?

(ii) What force would act on electron placed there? [9]

(c) A charged particle with charge q moving with velocity v enters a region perpendicular to a uniform magnetic field B and follows a circular path of radius r. Show that the kinetic energy of the particle can be expressed as $KE = q^2r^2B^2/2m$, where m is the mass of the particle. [8]

Q.8 (a) One end of a long metal pipe is struck a blow. Does the listener at the other end of the pipe hear two sounds? Explain. [4]

(b) Determine the current I through the battery of internal resistance 0.2Ω. [8]



(c) An object 2 cm high is placed 30 cm in front of a convex mirror of radius 50 cm. Locate the position, nature and the magnification of the image. [8]

Some equations you may find useful :

$v_f = v_o + at$: $v_f^2 = v_o^2 + 2ax$: $x = v_o t+(1/2)at^2$: $W = mg$: $x = v_{avg.}t$: $p = mv$

$f = \mu F_N$: $Ft = m(v_f - v_o)$: work $= Fs \cos\theta$: kinetic energy $= (1/2)mv^2$: $Ft = \Delta p$

g. p.energy $= mgh$: $v_{avg.} = (1/2)(v_o + v_f)$: power = work/time : $t = 2u \sin\theta/g$

$\Delta PE + \Delta KE + \Delta TE = 0$: $F = ma$: $P = Fv$: $R = (2u^2 \sin\theta \cos\theta)/g$: $a_T = \alpha r$: $L = I\omega$

$v_T = \omega r$: $\omega_f = \omega_0 + \alpha t$: $\omega_f^2 = \omega_0^2 + 2\alpha\theta$: $\theta = \omega_0 t+(1/2)\alpha t^2$: $p = mv$: $F_C = mv^2/r$

kin. $energy_{total} = (1/2)mv^2 + (1/2)I\omega^2$: $I = \Sigma mr^2$: $\tau = I\alpha = Fr$: $B = -\Delta P/(\Delta V/V_0)$

kin. $energy_{rot.} = (1/2)I\omega^2$: $F = (Gm_1 m_2)/r^2$: $Y = (F/A)/(\Delta L/L_0)$: $Q/\Delta t = (kA\Delta T)/\Delta L$

$W_{app.} = mg - B.F.$: $P = \rho gh$: $W_{app.} = W[1 - \rho_{fl}/\rho]$: $F = -kx$: $f = 1/\tau$: $\omega = 2\pi f$

$[(1/2)mv^2]_{avg.} = (3/2)kT$: $\Delta Q = mc\Delta T = nC\Delta T$: $\Delta L = \alpha L\Delta T$: $\Delta V = \gamma V\Delta T$: $\Delta W = P.\Delta V$

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$: $Q = \Delta U + W$: $\Delta W = nRT.\ln(V_f/V_i)$: $PV = nRT$: $f = (1/2\pi)\sqrt{(k/m)}$

$I_1\omega_1 = I_2\omega_2$: $\Delta T.E. = f.s$: area of a right cylinder $= 2\pi rL$: $v = \pm\sqrt{[(k/m)(x_0^2 - x^2)]}$

$a_{max} = kx_0/m$: $a_c = \omega^2 x_0$: $P.E. = (1/2)kx^2$: $(1/2)kx^2 + (1/2)mv^2 = (1/2)kx_0^2$

$a = -kx/m$: $\omega = \sqrt{(k/m)}$: $v = \sqrt{(Y/\rho)}$: $v = \sqrt{(T/(m/L))}$: 1 rev $= 360^0 = 2\pi$ rads

$v = \sqrt{(B/\rho)}$: $f = (1/2\pi)\sqrt{(g/L)}$: $v = \sqrt{(\gamma RT/M)}$: $0\ K = 273^0C$: $q = CV$: $\mathbf{F} = qvB_\perp$

$x = x_0 \cos(\omega t)$: $\rho = (RA)/L$: $E = (1/2)qV$: $P = IV = I^2R$

$F = (k\, q_1 q_2)/r^2$: $\mathbf{F} = q\mathbf{E}$: $qV = (1/2)mv^2$: $W = qV_{AB}$: $v = f\lambda$: $\mathbf{F} = (\mu_0 I_1 I_2 L)/(2\pi b)$

$V_{AB} = Ed$: $C = (\varepsilon_0 A)/d$: $\Delta R = R_o\alpha\Delta T$: $B = (\mu_0 I)/(2\pi r)$: $1/p + 1/i = 1/f$: $X_L = 2\pi fL$

$I_o = 10^{-12}\ W/m^2$: $I(dB) = 10 \log(I/I_o)$: $qvB = mv^2/r$: $V = v_o/\sqrt{2}$: $q(t) = q_f(1 - e^{-t/\tau})$

$F = BIL \sin\theta$: torque $=$ (area)$NIB\sin\theta$: $\Sigma\Delta A.E = q_{encl}/\varepsilon_0$: $W = (1/2)Li_f^2$: $X_C = 1/(2\pi fC)$

$f / f' = [1 - (v_l/v_w)] / [1 - (v_s/v_w)]$: $f' = f(v/(v \pm v_s))$: $f' = f(v \pm v_l)/(v)$

$B = \mu_0 nI$: $B = (\mu_0 I)/(2a)$: $X_L = 2\pi fL$: $n_1 \sin\theta_1 = n_2 \sin\theta_2$:

$v = v_o \sin(2\pi ft)$: $I = i_o/\sqrt{2}$: $V(t) = V_o\, e^{-t/RC}$:

$f_o = (1/2\pi)\sqrt{(1/LC)}$: $1/f = 1/f_1 + 1/f_2$: $n\lambda = d \sin\theta_n$: e.m.f. $= L(\Delta I/\Delta t)$: $I(t) = I_f(1 - e^{-t/(L/R)})$

$P = IV \cos\varphi$: e.m.f. $= B_\perp vd$: e.m.f.$_{sec} = M(\Delta I_p/\Delta t)$: $\mu =$ (area)I : $\eta = (F/A)/(V/L)$

$Q/\Delta t = A\sigma T^4$: $C_v = 3/2R$(mono)$= 5/2R$(diatomic) : $C_p = 5/2R$(mono) $= 7/2R$(diatomic)

$C_p/R(N_2) = 3.48$: $C_v/R(N_2) = 2.48$: $M(N_2) = 28$

volume of a sphere $= (4/3)\pi r^3$: $Z^2 = R^2 + (X_L - X_C)^2$: $\varphi = B.A \cos\theta$: e.m.f. $= N(\Delta\varphi/\Delta t)$

area of a sphere $= 4\pi r^2$: $f' = f(v \pm v_L)/(v + v_s)$: $\Sigma B_{\parallel}\Delta L = \mu_o.I_{enclosed}$: $E_s/E_p = N_s/N_p$

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2003 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

P 198 : INTRODUCTORY PHYSICS-II (OPTION B)

All questions carry equal marks. The marks are shown in brackets. Question 1 is compulsory. Attempt four more questions. Clearly indicate on the answer script which questions you have attempted.

Time : Three Hours. **Maximum Marks : 100.**

Do not forget to write your computer number clearly on the answer script as well as on the answer sheet for Question 1. Tie them together !!

Wherever necessary use :

$g = 9.8 m/s^2$

$P_A = 1.01 \times 10^5 N/m^2$

1 cal. = 4.18 J

$\varepsilon_0 = 8.85 \times 10^{-12} C^2/Nm^2$

$c = 3 \times 10^8 m/s$

$h = 6.63 \times 10^{-34}$ J-s

1 Pascal =1 N/m^2

$1eV = 1.6 \times 10^{-19}$ J

$e = 1.6 \times 10^{-19}$ C

$m_e = 9.11 \times 10^{-31}$ kg

$k = 9 \times 10^9 Nm^2/C^2$

$\mu_0 = 4\pi \times 10^{-7} N/A^2$

$\rho_{water} = 1000 kg/m^3$

$G = 6.67 \times 10^{-11} Nm^2/kg^2$

Efficiency of a Carnot engine,

$$e = 1 - T_2/T_1 = \frac{\textit{work done}}{\textit{input heat at high temperature}}$$

Question 1 : Sample answers : F(a), G(d).... etc. DO NOT guess the answer. For each correct answer, 2 marks. For each wrong answer, 0.67 will be deducted. No answer, zero mark. Minimum total mark for Question 1 is zero. [$10 \times 2 = 20$]

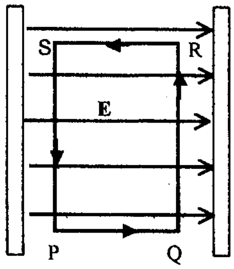
(A) Two sound waves are $y = a \sin(\omega t - kx)$ and $y = a \cos(\omega t - kx)$. The phase difference between the two waves is :

(a) $\pi/2$ (b) $\pi/4$
(c) π (d) zero

(B) The volume of a liquid flowing per second out of an orifice at the bottom of a tank does not depend on :

(a) the density of the liquid
(b) the value of the acceleration due to gravity
(c) the height of the liquid above the orifice
(d) the area of the orifice

(C) The amount of work done (in joules) in carrying a charge +q along the closed path PQRSP between the oppositely charged metal plates is (where **E** is the electric field between the plates) :



(a) zero (b) q
(c) q/ε_0 (d) qE(PQ+QR+RS+SP)

(D) If a unit charge is taken from one point to another over an equipotential surface, then :

(a) work is done on the charge
(b) work is done by the charge
(c) work on the charge is constant
(d) no work is done

(E) You are given three equal resistors. How many different combinations can you make with them ?

(a) 2 (b) 3
(c) 4 (d) 6

(F) A current carrying loop is placed in a uniform magnetic field. The torque acting on it does not depend on :

(a) the shape of the loop
(b) the area of the loop
(c) the value of current
(d) the magnetic field

(G) When a wire loop is rotated in a magnetic field, the direction of the induced emf changes once per :

(a) 1 revolution
(b) 1/2 revolution
(c) 1/4 revolution
(d) 2 revolutions

(H) The voltage cannot be exactly in phase with the current in a circuit that contains:

(a) only inductance
(b) only resistance
(c) inductance and capacitance
(d) inductance, capacitance, and resistance

(I) The impedance of a circuit does not depend on :

(a) f
(b) C
(c) R
(d) I

(J) A concave mirror produces an upright image when the object distance is :

(a) equal to f
(b) less than f
(c) between f and 2f
(d) greater than 2f.

Attempt any four questions from below :

Q2.(a) Water in streamline flow is moving with a speed of 5m/s through a pipe with a cross section of $4cm^2$. The water gradually descends 10m and the pipe increases in cross sectional area to $8cm^2$ at the bottom.

Find :

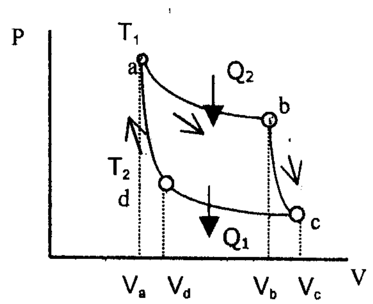
(i) The speed of flow at the lower level, and

(ii) The pressure at the lower level if the pressure is 1.5×10^5 newtons/m^2 at the higher level. [9]

(b). A Carnot cycle is performed (from *a* to *b* to *c*...) between temperatures T_1 and T_2 by 1 litre of air ($\gamma = 1.4$) initially at 327^0C and at a pressure of 12 atmospheres (at *a*). Each step represents a compression or expansion of the gas in the ratio of 1:6.

Calculate the lowest temperature and the efficiency of the cycle. [9]

[On the same adiabatic, $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$.]



(c). Differentiate between laminar flow and turbulent flow in a fluid. [2]

Q3(a). An ice chest made of plastic foam in the form of a rectangular box has outside dimensions of 45cm × 35m × 30cm. The chest's wall thickness is 3.75cm.

If the box is to maintain an inside temperature of 0^0C when the outside temperature is 30^0C, how much ice will melt inside the box each hour ?

Given, k_{foam} = 0.03W/K.m, H_f of water = 335,000 J/kg. [Hint : Draw a figure !] [9]

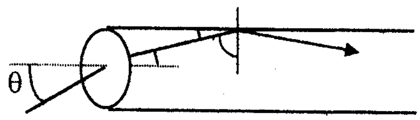
(b). A transmitter radiates electromagnetic waves uniformly in all directions with a power of 100W. At a distant point the maximum value of the magnetic field due to this source is found to be 6.67×10^{-11} T.

How far is this point from the transmitter ? [Given I = P/A = $\frac{c E_0^2 \varepsilon_0}{2} = \frac{c B_0^2}{2 \mu_0}$] [8]

(c). Place the following waves in order of wavelength, starting with the longest : light, audible sound, gamma rays. [3]

Q4(a). A ray of light enters one end of a glass fiber at an angle of incidence of θ.

(i) If the refractive index of glass is n_g, what is the maximum value of θ that will permit the ray to be totally reflected from the wall of the fiber ?



(ii) What is the value of $\theta_{maximum}$ for n_g = 1.4 ? [8]

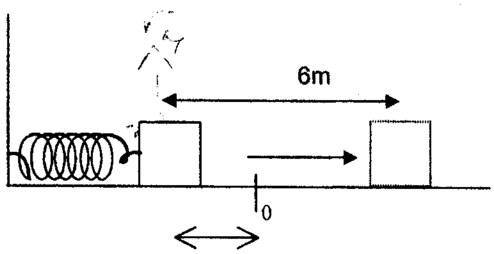
(b). A circuit connected to 200volt, 50Hz a.c. mains has a resistor of 10Ω in series with an inductance of 0.5 henry.

(i) Find the value of the capacitor which when connected in series in the circuit will produce resonance in the circuit.

(ii) Calculate the potential difference across the resistance, inductance, and the capacitor in the resulting circuit. [10]

(c). Define capacitive reactance. State its ability to impede a current in terms of the frequency. [2]

Q5(a). A 5.0kg block is used to compress a spring of force constant 200N/m. When released, the block leaves the spring and travels over a horizontal surface whose coefficient of friction is 0.25. The block travels 6.0m before coming to a stop.



(i) What is the maximum velocity of the block ?

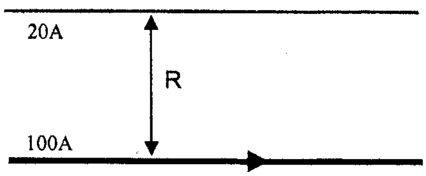
(ii) How far was the spring compressed before being released ? [10]

(b). A 5-ohm coil of 150 turns and diameter 5cm is placed between the poles of a magnet so that the flux is maximum through its area. The coil is suddenly removed from the field of the magnet, and a charge of 10^{-4}C is found to flow through a 595-ohm galvanometer connected in series to the 5-ohm coil.

Find the value of B between the poles of the magnet. [8]

(c). State Lenz's law of electromagnetic induction. On which principle is it based ? [2]

Q6(a). A long horizontal rigidly supported wire carries a current I_a of 100A. Placed above it and parallel to it is a fine wire that carries a current I_b of 20A; the fine wire weighs 0.073N/m.



(i) If we wish to support the second wire by magnetic repulsion, how far above the lower wire would it be kept?

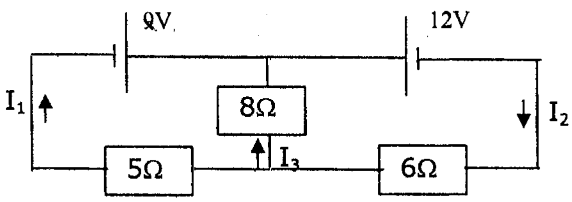
(ii) Are the two currents in the same direction ? Explain

[Given $\mu_0 = 4\pi \times 10^{-7}$ weber/amp-m.] [7]

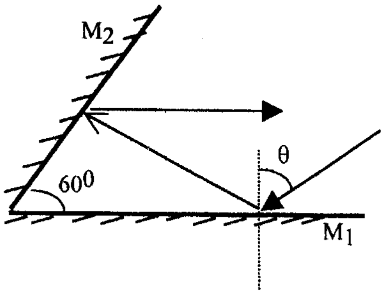
(b). A stone is dropped into a well and its splash is heard at the mouth of the well after an interval of 1.50 seconds. Find the depth of the well. Given the velocity of sound in air = 335m/s. [Hint : quadratic equation !] [10]

(c). Write short notes on magnetic field and magnetic flux. [1.5 + 1.5]

Q7(a). (a) Find the currents I_1, I_2, and I_3 in the figure. [11]



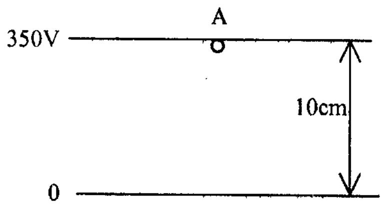
(b). Two plane mirrors are inclined to each other at an angle of 60^0. A ray of light is incident on one mirror at an angle θ. The ray reflected from this mirror falls on the second mirror, from which it is reflected parallel to the first mirror.



Find the value of the angle θ. [7]

(c). Explain the difference between a real image and a virtual image. [2]

Q8(a). A small particle of mass 4×10^{-12} kg, carrying a positive charge of 3×10^{-14} C is released at the point *A* close to the upper plate.



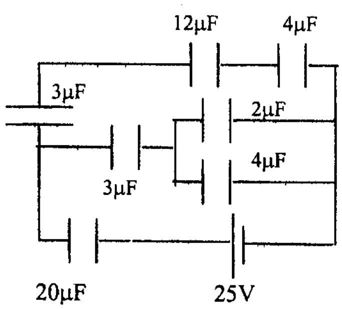
(i) Calculate the total force acting on this particle,

(ii) Calculate the kinetic energy (in joules) of the particle when it reaches the lower plate. [10]

(b). For the given circuit find :

(i) The equivalent capacitance across the 25V battery, and

(ii) The energy stored in the 20μF capacitor. [8]



(c). Explain why a charge placed on a solid conducting sphere must reside on the outer surface of the sphere. [Use Gauss's law]. [2]

== End of P-198 Examination ==

Some equations you may find useful :

$v_f = v_o + at$: $v_f^2 = v_o^2 + 2ax$: $x = v_o t + (½) at^2$: $W = mg$: $x = v_{avg.}t$: $p = mv$

$f = \mu F_N$: $Ft = m(v_f - v_o)$: work = Fs cos θ : kinetic energy = (½) mv^2 : $Ft = \Delta p$

g. p. energy = mgh : $v_{avg.} = (½)(v_o + v_f)$: power = work/time : t = 2u sin θ/g

$\Delta PE + \Delta KE + \Delta TE = 0$: $F = ma$: $P = Fv$: $R = (2u^2 \sin\theta \cos\theta)/g$: $a_T = \alpha r$: $L = I\omega$

$v_T = \omega r$: $\omega_f = \omega_0 + \alpha t$: $\omega_f^2 = \omega_0^2 + 2\alpha\theta$: $\theta = \omega_0 t + (½)\alpha t^2$: $p = mv$: $F_C = mv^2/r$

kin. $energy_{total} = (½) mv^2 + (½) I\omega^2$: $I = \Sigma mr^2$: $\tau = I\alpha = Fr$: $B = -\Delta P/(\Delta V/V_0)$

kin. $energy_{rot.} = (½) I\omega^2$: $F = (Gm_1m_2)/r^2$: $Y = (F/A)/(\Delta L/L_0)$: $Q/\Delta t = (kA\Delta T)/\Delta L$

$W_{app.} = mg - B.F.$: $P = \rho gh$: $W_{app.} = W[1 - \rho_{fl.}/\rho]$: $F = -kx$: $\omega = 2\pi f$

$[(½) mv^2]_{avg.} = (3/2)kT$: $\Delta Q = mc\Delta T = nC\Delta T$: $\Delta L = \alpha L\Delta T$: $\Delta V = \gamma V\Delta T$: $\Delta W = P.\Delta V$

$P_1V_1^\gamma = P_2V_2^\gamma$: $Q = \Delta U + W$: $\Delta W = nRT.\ln(V_f/V_i)$: $PV = nRT$: $f = (1/2\pi)\sqrt{(k/m)}$

$I_1\omega_1 = I_2\omega_2$: $\Delta T.E. = f.s$: $v = \pm\sqrt{[(k/m)(x_0^2 - x^2)]}$: $f = (1/2\pi)\sqrt{(g/L)}$: $f = 1/\tau$:

$a_{max} = kx_0/m$: $a_c = \omega^2 x_0$: $P.E. = (½) kx^2$: $(½) kx^2 + (½) mv^2 = (½) kx_0^2$: $q = CV$

$a = -kx/m$: $\omega = \sqrt{(k/m)}$: $v = \sqrt{(Y/\rho)}$: $v = \sqrt{(T/(m/L))}$: 1 rev = 360^0 = 2π rads : $v = f\lambda$

$v = \sqrt{(B/\rho)}$: : $v = \sqrt{(\gamma RT/M)}$: 0 K = 273^0C: $F = qvB_\perp$: area of a right cylinder = 2πrL

1 metric ton = 1000kg : $x = x_0 \cos(\omega t)$: $\rho = (RA)/L$: $E = (½)qV$: $F = (\mu_o I_1 I_2 L)/(2\pi b)$

$P = IV = I^2R$: $qV = (½)mv^2$: $W = qV_{AB}$: $F = (k\, q_1\, q_2)/r^2$: $F = qE$: $F = BIL \sin\theta$

$V_{AB} = Ed$: $C = (\varepsilon_o A)/d$: $\Delta R = R_o\alpha\Delta T$: $1/p + 1/i = 1/f$: $X_L = 2\pi fL$: $X_C = 1/(2\pi fC)$

$I_o = 10^{-12}$ W/m^2 : $I(dB) = 10 \log(I/I_o)$: $qvB = mv^2/r$: $V = v_o/\sqrt{2}$: $q(t) = q_f(1 - e^{-t/\tau})$

torque = (area)NIB sin θ : $\Sigma\Delta A.E = q_{encl.}/\varepsilon_o$: $W = (1/2)Li_f^2$: $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$f / f' = [1 - (v_l/v_w)] / [1 - (v_s/v_w)]$: $f' = f(v/(v \pm v_s))$: $f' = f(v \pm v_l)/(v)$

$B = \mu_o nI$: $B = (\mu_o I)/(2a)$: $B = (\mu_o I)/(2\pi r)$: $f_n = (2n - 1)f_1$: $f_b = f_2 - f_1$: $f_n = nf_1$

$v = v_o\sin(2\pi ft)$: $I = i_o/\sqrt{2}$: $V(t) = V_o e^{-t/RC}$: $\tan\varphi = (X_L - X_C)/R$: $i(t) = i_o e^{-t/RC}$

$f_o = (1/2\pi)\sqrt{(1/LC)}$: $1/f = 1/f_1 + 1/f_2$: $n\lambda = d \sin\theta_n$: e.m.f. = $L(\Delta I/\Delta t)$: $E = c.B$

$P = IV \cos\varphi$: e.m.f. = $B_\perp vd$: μ = (area)I : $\eta = (F/A)/(V/L)$: $I(t) = I_f(1 - e^{-t/(L/R)})$

$(kin.\ en.)_{max.} = (hc/\lambda - hc/\lambda_o) = V_o e$: $\sin(2\varphi) = 2\sin\varphi\cos\varphi$: $\sin(90 - \theta) = \cos\theta$

$(\lambda' - \lambda) = [h/(m_e c)](1 - \cos\varphi)$: $\lambda = hc/E$: $hc/\lambda' = hc/\{\lambda + [h/(m_e c)](1 - \cos\varphi)\}$

$A_1v_1 = A_2v_2$: $F_D = 6\pi\eta rv$: $6\pi\eta av_T = (4\pi/3)a^3(\rho - \sigma)g$: $Q = (\pi R^4/8\eta L)(P_1 - P_2)$

$P_1 + (½)\rho v_1^2 + \rho gh_1 = P_2 + (½)\rho v_2^2 + \rho gh_2$: $N_R = \rho vd/\eta$: $V = IZ$: e.m.f.$_{sec} = M(\Delta I_p/\Delta t)$

volume of a sphere = $(4/3)\pi r^3$: $Z^2 = R^2 + (X_L - X_C)^2$: $\varphi = B.A \cos\theta$: e.m.f. = $N(\Delta\varphi/\Delta t)$

area of a sphere = $4\pi r^2$: $f' = f(v \pm v_L)/(v + v_s)$: $\Sigma B_\parallel.\Delta L = \mu_o.I_{enclosed}$: $E_s/E_p = N_s/N_p$

THE UNIVERSITY OF ZAMBIA

Physics Department

UNIVERSITY EXAMINATIONS

SECOND SEMESTER-2003

P212-ATOMIC PHYSICS

TIME ALLOWED: THREE HOURS

INSTRUCTIONS:

ATTEMPT ANY FIVE (5) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS. MARKS ARE INDICATED FOR EACH QUESTION.

Useful Data:

Speed of light in vacuum: $c = 3.0 \times 10^8 \text{ ms}^{-1}$ Electron rest mass: $m_0 = 9.11 \times 10^{-31}\text{kg}$

Positron rest mass $m_0 = 9.11 \times 10^{-31}\text{kg}$ Electron charge: $e = 1.602 \times 10^{-19}\text{C}$

Rydberg constant $R = 1.0974 \times 10^7 \text{m}^{-1}$ Planck constant: $h = 6.626 \times 10^{-34}\text{J.s}$

Boltzmann constant $k = 1.38 \times 10^{-23}\text{JK}^{-1}$ Mass of neutron: $m_n = 1.00897u$

Mass of proton: $m_p = 1.00758u$

Atomic mass unit: $1u = 1.660566 \times 10^{-27}\text{kg}$

Avogadro constant: $N_A = 6.023 \times 10^{23}\text{mole}^{-1}$

Permittivity of free space: $\varepsilon_0 = 8.854 \times 10^{-12}\text{C}^2\text{N}^{-1}\text{m}^{-2}$

Atomic mass unit: $1u = 1.66 \times 10^{-27}\text{kg} \equiv 931\text{MeV}$

$1eV = 1.602 \times 10^{-19}\text{J}$ $1\text{MeV} = 1.602 \times 10^{-13}\text{J}$

Acceleration due to gravity: $g = 9.8\text{ms}^{-2}$

Wien's displacement constant: $b = 2.90 \times 10^{-3}\text{m} \cdot \text{K}$

$1\text{Å} = 10^{-10}\text{m}$

$1\text{nm} = 10^{-9}\text{m}$

Photoelectric equation: $\frac{1}{2}mv^2 = h\nu - \phi$ (eV)

Einstein energy relation: $E = mc^2$

Rydberg equation: $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

Compton equation: $\Delta\lambda = \lambda' - \lambda = \frac{h}{m_0 c}(1 - \cos\theta)$

n	$\int_0^\infty x^n e^{-ax^2} dx$ $\int_0^\infty x^n e^{-\alpha x^2} dx$
0	$\frac{1}{2}\sqrt{\frac{\pi}{a}}$
1	$\frac{1}{2a}$
2	$\frac{1}{4}\sqrt{\frac{\pi}{a^3}}$
3	$\frac{1}{2a^2}$
4	$\frac{3}{8}\sqrt{\frac{\pi}{a^5}}$
5	$\frac{1}{a^3}$

$$\int_0^\infty \frac{x^3}{e^x - 1} dx = \frac{\pi^4}{15}$$

Q.1(a) When $500\,nm$ light is incident on a particular metal surface, the stopping potential for photoelectrons is found to be $0.44\ V$.

(i) Find the work function for this material. [4]

(ii) Find the longest wavelength that will eject electrons from its surface. [2]

(iii) Using the table below what might you conclude the material is? [1]

Material	Work function eV	Work function 10^{-19} J	Threshold wavelength nm	Spectral region
Caesium	2.14	3.42	581	Visible
Rubidium	2.10	3.36	592	Visible
Potassium	2.30	3.68	541	Visible
Gold	5.10	8.18	244	Ultraviolet
Platinum	5.65	9.04	220	Ultraviolet
Aluminium	4.28	6.85	290	Ultraviolet
Copper	4.65	7.44	267	Ultraviolet
Tungsten	4.55	7.28	273	Ultraviolet

b(i) What is the energy of a photon in a beam of infrared radiation whose wavelength is 1240nm? [2]

(ii) By using your answer in b(i) above or otherwise, predict the energies of photons of light with wavelengths of $\frac{1240}{4}$ nm and $\frac{1240}{8}$ nm [2]

(iii) Show that the photons in a $1240\,nm$ infrared light beam have energies of $1\,eV$. [2]

(c) Compute the energy of a photon of blue light of wavelength $450\,nm$. [2]

(d) In order to break a chemical bond in the molecule of human skin, causing sunburn, a photon of energy of about $3.5\,eV$ is required. To what wavelength does this correspond? [2]

Q.2(a) Determine the value of the longest wavelength found in the Paschen series. [5]

(b) Consider a hypothetical one-electron atom that does not have the hydrogen energy levels but obeys Bohr's second postulate. The wavelengths of first four lines of the spectral series terminating on $n = 1$ are $1200\,Å$, $1000\,Å$, $900\,Å$, and $840\,Å$. The shortest wavelength limit of this series is $800\,Å$.

(i) Find the value of the first five energy levels of this atom in eV and construct the energy-level diagram. [10]

(ii) What is the ionization potential of this atom? [2]

(iii) What is the wavelength of the line emitted for the transition $n = 3$ to $n = 2$? [5]

(iv) What is the minimum energy that must be supplied to the electron in the ground state so that it can make the transition in part (iii)? [3]

Q.3(a) State Bohr's two postulates concerning the hydrogen atom. [3]

(b) (i) Calculate the radius of the first, second and third Bohr orbits for the hydrogen atom. [6]

(ii) Predict the radius for an electron in the $n = 8$ orbit. [1]

(c) Calculate the classically predicted speed of an electron in the fourth Bohr orbit. Compare this speed with the speed of light. [3]

(d) X-rays with wavelength $\lambda = 1.00\,\text{Å}$ are scattered from a carbon block. The scattered radiation is viewed at 90^0 to the incident beam.

(i) Calculate the Compton shift in the wavelength. [3]

(ii) Calculate the kinetic energy imparted to the recoiling electron. [4]

Q.4(a) (i) State Kirchhoff's law of radiation. [3]

(ii) What is the relationship between the most intense radiation and its temperature? [2]

(iii) At what wavelength does the maximum intensity of radiation from blackbody occur at: 600K [3]

(b) The intensity of radiation emitted by a blackbody is given by

$$W = \frac{c}{4}\int_0^\infty \psi_\lambda d\lambda$$

where

$$\psi_\lambda = \frac{8\pi ch\lambda^{-5}}{e^{\frac{ch}{\lambda kT}} - 1}$$

(i) Show that the given integral evaluates to [8]

$$W = \sigma T^4.$$

(ii) Determine σ to two decimal places. [4]

Q5(a) If a radioactive material initially contains $3.0\,\text{mg}$ of ^{234}U, how much will remain after 62,000yrs? $\left(T = 2.48\times10^5\,\text{yrs}, \lambda = 8.8\times10^{-14}s^{-1}\right)$. [7]

(b) What will be its ^{234}U activity at the end of this time? $\left(T = 2.48\times10^5\,\text{yrs}, \lambda = 8.8\times10^{-14}s^{-1}\right)$ [3]

(c) Ninety percent of a sample of a certain radioactive substance remains after 12hrs. What are the decay constants and the half-life for this substance? [7]

(d) The binding energy per nucleon for ^{238}U is about 7.5 MeV, while it is about 8.5 MeV for nuclei of half that mass. If ^{238}U nucleus were to split into two equal-size nuclei Calculate the approximate energy that would be released in the process [3]

Q.6(a) The atomic mass of ^4_2He is 4.002604u. Determine the total binding energy of its nucleus and the average binding energy per nucleon. [8]

(b) Strontium 90 has a half-life of 28yrs and is a dangerous product of nuclear explosion. What is the activity of 1 gm of ^{90}Sr? [6]

(c) A radioactive material has a half-life of T seconds. Assuming that there are A_0 atoms at the start. Sketch a graph of time as a multiple of the half-life T against the number of atoms remaining as a multiple of the original atoms A_0. (You may use percentage of the remaining atoms as a fraction of the original atoms.) [6]

Q.7(a) Define fission and fusion. [4]

(b) Explain why Radon-222 gas is considered a health risk. [4]

(c) A fossil has been found to contain 50% of Carbon-14 compared to a living sample. Given that the half-life of Caron-14 is 5,700 years, compute the age of the fossil using Carbon dating technique. [4]

(d) Name four types of detectors used in observing or measuring radiation. [2]

(e) Complete the following table by writing down the atomic mass, atomic number of the resulting element(s) and the atomic mass, atomic number of the particle(s) given off or absorbed in each radioactive decay process. [4]

Radioactive decay	Resulting elements
α	${}^{238}_{92}U \rightarrow \quad Th +$
β	${}^{14}_{6}C \rightarrow \quad N +$
Positron Emission	${}^{64}_{29}Cu \rightarrow \quad Ni +$
Electron Capture	${}^{64}_{29}Cu + \cdots \rightarrow Ni$

(f) Identify the following radioactive series

(i) Series beginning with ${}^{238}_{92}U$ and ending with ${}^{206}_{82}Pb$. [1]

(ii) Series beginning with ${}^{235}_{92}U$ and ending with ${}^{207}_{82}Pb$. [1]

END OF P212 EXAMINATION

****

THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF PHYSICS

SECOND SEMESTER UNIVERSITY EXAMINATIONS 2003

P252 - CLASSICAL MECHANICS II AND SPECIAL RELATIVITY

TIME: THREE (3) HOURS

ANSWER ANY FIVE QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

MAXIMUM MARK : 100

Q1 (a) For a mass m oscillating with small amplitude about a position of stable equilibrium x_0, derive an expression for the frequency in terms of the force F. [4]

(b) A particle of mass m with a potential energy given by $V = ax^2(b-x)$ experiences a slight disturbance. If a and b are positive constants, find the equilibrium position and the frequency of oscillation about the equilibrium position of the particle. [6]

(c) A simple harmonic oscillator which would oscillate in vacuum with frequency of $\sqrt{5}$ s^{-1} is immersed in a fluid which resists the motion with a force proportional to the velocity, the proportionality constant being $K = 4\pi$. Its position at $t = 0$ is $x = 0.89$ m from the equilibrium position while the velocity at this time is zero. Find the position at any time t. [10]

Q2 (a) State briefly the cases that arise from the solution of the damped simple harmonic motion equation. [3]

(b) Derive the steady state solution for a forced damped oscillator with a sinusoidal driving force $F \cos pt$, and hence explain the phenomenon of resonance. [9]

(c) (i) An object of mass 0.1 kg is hung from a spring whose spring constant is 40 N/m. The body is subjected to a resistive force given by $-bv$, where v (in m/s) is its velocity and $b = 2$ $Nm^{-1}s$. Which case as described in (a) does this represent? Explain your answer quantitatively. [3]

(ii) The object in (i) is subjected to a sinusoidal driving force $F \cos pt$ where $F = 2$ N and $p = 30$ s^{-1}. In the steady state, find the position at any time t. [5]

Q3 (a) What is a harmonic wave? [2]

(b) Derive the expression for the velocity of progressive waves in:

(i) a stretched string [4]

(ii) a solid rod. [4]

(c) The displacement y at any time t and position x on a horizontally stretched string is given by

$$y = A \sin k(x-vt)$$

where $k = n\pi$ with n being a positive integer. If the linear mass density of the string is μ, find an expression for the energy per unit length of the vibrating string. [10]

Q4 (a) Distinguish briefly between group velocity and phase velocity. [3]

(b) The following two waves in a medium are superposed:

$$y_1 = A \sin (8x-12t)$$

$$y_2 = A \sin (4x-4t)$$

where x is in meters and t in seconds.

(i) Derive an equation for the combined disturbance. [6]

(ii) What is its group velocity? [2]

(iii) What is the distance between a point of maximum amplitude and the nearest point of minimum amplitude in the combined disturbance? [3]

(c) Show quantitatively how the superposition of two identical progressive waves travelling in opposite directions gives rise to standing waves and sketch the first two modes of vibration. [6]

Q5 (a) State what is meant by the terms

(i) holonomic constraints [1.5]

(ii) virtual displacement. [1.5]

(b) Derive Lagrange's equation from D' Alembert's principle. (You do not have to derive D'Alembert's principle). [11]

(c) A mass m is held on the end of a vertical spring having negligible mass and a force constant k. If this mass is slightly disturbed from its equilibrium position, find its acceleration as a function of its displacement from the equilibrium position using Lagrange's equations. [6]

Q6 (a) What do you understand by the terms

(i) generalised coordinates, [1]

(ii) generalised force [1]

(iii) generalised momentum. [1]

(b) (i) Show how the Hamiltonian $H = \sum_j \dot{q}_j p_j - L$ gives the sum of the kinetic and potential energies. [4]

(ii) Derive Hamilton's canonical equations from the definition of the generalised momentum and the Hamiltonian. [5]

(c) A uniform rod of length 2 meters and mass m is free to swing in a vertical plane as a compound pendulum. Find the period of small oscillations using Hamilton's canonical equations and the definition of the generalised momentum, given that the moment of inertia of a uniform rod about one end is given by $I = ml^2/3$, where l is the length of the rod. [8]

Q7 (a) State the two fundamental postulates on which the theory of relativity is based. [2]

(b) Derive the relativistic mass-energy relationship by considering the hypothetical experiment (gedanken or mind experiment) known as Einstein's box. [7]

(c) At what velocity is a free particle moving if its total energy is n times its rest mass energy? [4]

(d) A rigid rod of rest length L_0 makes an angle θ' with the x' axis and is fixed in the S' frame as it translates with a constant velocity V relative to S. Find the length of the rod and the angle between the rod and the x-axis, as viewed by an observer in the inertial frame S. [7]

END OF EXAMINATION

The University of Zambia
Physics Department
University Examinations 2003
Second Semester

P-272 : Geometrical and Physical Optics

All questions carry equal marks. The marks are shown in brackets. Attempt any five questions. Clearly indicate on the answer script cover page which questions you have attempted.

Time : Three hours. **Maximum marks = 100.**

Do not forget to write your computer number clearly on the answer book.

Q1(a).(i). Prove that the optical path Δ of a ray of light passing through media of refractive indices n, n' and n'' of paths d, d' and d'' respectively is given by:

$$\Delta = nd + n'd' + n''d''$$ [2 Marks]

(ii). State Fermat's principle and prove that a ray path along which a disturbance travels from one point to another is such that the time taken is at a stationary value.

[3 Marks]

(b). Derive the Gaussian formula

$$\frac{n}{s} + \frac{n'}{s'} = \frac{n' - n}{r}$$

for incident and refracted arrays which are paraxial. Here s is the distance between the vertex of a spherical surface and an axial object point, and s' is the distance between the image point and the vertex. The refractive index of the first medium is denoted as n while that of the second medium is n'.

[10 Marks]

(c). One end of a glass rod of refractive index 1.50 is ground and polished with a convex spherical surface of radius 10 cm. An object is placed in air on the axis 40 cm to the left of the vertex. Find:

(i). the power of the surface,
(ii). the position of the image, and
(iii). the magnification [5 Marks]

Q2. **(a).** Define with the aid of diagrams the following terms in geometrical optics.

(i). Primary focal point
(ii). Secondary focal point
(iii). Primary focal length
(iv). Secondary focal length
(v). Focal plane
(vi). Conjugate points and planes.

(b). Show, using the theorem of the proportionality of corresponding sides of similar triangles, that lateral magnification m is given by:

$$m = -\frac{(s' - r)}{(s + r)}$$

where s' is the distance of an axial image point from the vertex, s is the distance between the vertex of a spherical surface and an axial point object, and r is the radius of curvature of a spherical surface.

(c). A concave surface with a radius of 4 cm separates two media of refractive indices n = 1.00 and n' = 1.50. An object is located in the first medium at a distance of 10 cm from the vertex. Find:

(i). the primary focal length [3 Marks]
(ii). the secondary focal length, and [3 Marks]
(iii). the image distance [3 Marks]

Q3. (a). A lens has the following specifications:

r_1 = +1.5 cm, r_2 = + 1.5 cm, d = 2.0 cm, n = 1.00, n' = 1.60 and n'' = 1.30. Find

(i). The primary and secondary focal lengths of the separate surfaces,
(ii). The primary and secondary focal lengths of the system, and
(iii). The primary and secondary principal points

[12 Marks]

(b). An equi-convex lens 2 cm thick and having radii of curvature of 2 cm is mounted in the end of a tank. An object in air is placed on the axis of the lens 5 cm from its vertex. Find the position of the final image. Assume refractive indices of 1.00, 1.50 and 1.33 for air, glass and water respectively.

[8 Marks]

Q4. (a). A thick mirror has as one component a thin lens of refractive index n' = 1.50, radii r' = +50.0 cm, and r_2 = -50.0 cm. This lens is situated 10.0 cm in front of a mirror of radius −50.0 cm. Find

(i). the power of the combination,
(ii). the focal length and
(iii). the principal points.

Assume air surrounds both components. [12 Marks]

(b). A Fresnel bi-prism with angles of 130^0 is used to form interference fringes. The refractive index is 1.52. Find the fringe separation for red light of wavelength 656 nm when the distance between the slit and the prism is 20 cm, and that between the prism and the screen is 80 cm.

[7 Marks]

Q5. **(a).** A convex spherical surface of radius r = 5.0 cm is ground and polished on the end of a large cylindrical glass rod of refractive index 1.6720.

Calculate the axial distance assuming incident light parallel to the axis, and using rays at heights of :

(i). 3.0cm
(ii). 2.0cm
(iii). 0cm

[12 Marks]

(b). An equi-convex lens with radii of 4 cm and refractive index $n' = 1.50$ is located 2 cm in front of an equi-concave lens with radii of 6.0 cm and refractive index $n_1 = 1.60$. The lenses are to be considered as thin. The surrounding media have refractive indices $n = 1.00$, $n' = 1.33$, and $n'' = 1.00$. Find

(i). the focal lengths,
(ii). the focal points, and
(iii). the principal points of the system

[8 Marks]

Q6. **(a).** If an optical flat plate is placed in contact with a shallow convex spherical surface, a thin air film of varying thickness results. This air film causes interference fringes which become concentric circles centred on the point of contact. These are called Newton's rings.

If R is the radius of the spherical surface and d is the thickness of the air film a distance r from the point of contact, show that the radius R is given by:

$$R = \frac{r^2 + d^2}{2d}$$

[8 Marks]

(b). A thin equi-convex lens of focal length 4 m and refractive index $n' =$ 1.52 rests on and in contact with an optical flat plate and, using light of wavelength 5.46 x 10^{-4} mm, Newton's rings are viewed normally by reflection.

(i). What is the diameter of the fifth bright ring?
(ii). What would be observed if a liquid of refractive index n were introduced between the lens and the flat plate?
(iii). What would be observed if the lens were lifted slowly off the flat plate?

[12 Marks]

Q7. **(a).** The superposition principle states that the resultant displacement of any two waves is merely the sum of the displacements due to individual waves. Using this principle show that the intensity I of light at any point will be proportional to the square of the resultant amplitude for coherent light sources and is given by:

$$I \approx A^2$$
$$= 4a^2 \cos\frac{2\delta}{2}$$

where δ is the phase difference.

(b). Show that the path difference Δ in Young's experiment is given by:

$$\Delta = d\sin\theta = \frac{dx}{D}$$ [7 Marks]

where d is the distance between the two slits s_1 and s_2, D is the distance between the screen and the plane in which slits s_1 and s_2 lie, and x is the distance between the centre point of the screen and the point where the maximum bright fringe is observed.

(c). Dispersion is the separation of any two colours such as sodium light of wavelengths λ_1 and λ_2. Dispersion increases with the order number. To express this separation, the quantity frequently used is the angular dispersion, which is defined as the rate of change of angle with change of wavelength. Show that the angular dispersion is given by:

$$\frac{d\theta}{d\lambda} = \frac{m}{d\cos\theta}$$ [5 Marks]

== End of P-272 Examination ==

The University of Zambia

Physics Department

Second Semester University Examinations 2003

P332

Statistical Physics and Thermodynamics

Time: Three (3) Hours **Marks:**100

Instructions

ATTEMPT ANY FOUR(4) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS. MARKS ARE INDICATED FOR EACH OF THE QUESTIONS

Useful formulas

Stirling's formula: $\ln n! \approx n \ln n - n$

$$S = k \ln \Omega; \quad kT = \frac{1}{\beta}; \quad \beta = \frac{\partial \ln \Omega}{\partial E};$$

$$\frac{\partial \ln \Omega}{\partial x_\alpha} = \beta \overline{X}_\alpha; \quad S = k(\ln Z + \beta \overline{E})$$

$$pV = \nu RT; \quad S = k \ln \Omega; \quad dQ = dE + pdV$$

Gas constant $R = 8.314$ J/mole. K

1. (a) State the fundamental statistical postulate and explain its importance in statistical mechanics.

[4 marks]

(b) A "drunk sailor" stands at a lamp post in the middle of the street leading to his house up the hill. Since the sailor is very drunk, the probability of taking a step up the hill is not the same as that of taking a step down the slope. Assuming that the sailor takes steps of equal length and that the probability of an upward step is 1/4:

(i) What is the probability that his first five steps are all down the slope and the next five steps are up the slope?

(ii) What is the probability that he is back at the lamp post after 10 steps?

(iii) What is the expected position of the man after 10 steps?

[15 marks]

(c) Consider a gas of N_o noninteracting molecules enclosed in a container of volume V_o. Focus attention on any sub-volume V of this container and denote by N the number of molecules located within this sub-volume. Each molecule is equally likely to be located anywhere within the container; hence the probability that a given molecule is located within the sub-volume V is simply equal to V/V_o

(i) What is the mean number $\overline{N}$ of molecules located within V? Express your answer in terms N_o, V_o and V.

(ii) Find the relative dispersion $\frac{\overline{N-\overline{N}}}{\overline{N}^2}$ in the number of molecules located within V. Express your answer in terms N_o, V_o and V. What does the relative dispersion $\frac{\overline{N-\overline{N}}}{\overline{N}^2}$ become when $V \ll V_o$?

[10 marks]

2. (a) (i) Explain the importance of quasi-static processes in statistical mechanics.

(ii) The number of states Ω of a system between E and $E + \delta E$ is $\Omega(E; x_1, ..., x_n)$ where x_i $(i = 1, 2, ..., n)$ are external parameters. Show that when the mean energy and the external parameters of a system are changed quasi-statically by any amount, the change in entropy of the system is

$$dS = \frac{dQ}{T}$$

You may need the result

$$\frac{\partial \ln \Omega}{\partial x_\alpha} = \beta \overline{X}_\alpha$$

[12 marks]

(b) The number of states Ω of a system between E and $E + \delta E$ has the following approximate dependence on the energy:

$$\Omega = AE^f$$

where A is a constant and f is the number of degrees of freedom.

(i) Prove that the temperature of such a system is always positive.

(ii) Show that when two such systems are in weak thermal interaction, they achieve equilibrium when the energies per degree of freedom of the systems are equal.

[6 marks]

(c) The tension in a wire is increased quasi-statically from F_1 to F_2. If the wire has length L, cross-sectional area A, and Young's modulus Y, calculate the work done.

[7 marks]

3. (a)An arbitrary system is in contact with a heat reservoir at absolute temperature $T = 1/k\beta$. Considering the energy of the system and its fluctuation;

(i) Show that the average energy $\overline{E}$ of the system is

$$\overline{E} = -\frac{\partial \ln z}{\partial \beta}.$$

(ii) Obtain an expression for $\overline{E^2}$ in terms of the derivatives of $\ln z$.

(iii) Calculate the dispersion of the energy, $\overline{(\Delta E)^2} = \overline{E^2} - \overline{E}^2$.

(iv) Show that the standard deviation $\widetilde{\Delta E} = \overline{((\Delta E)^2)}^{1/2}$ can be expressed in terms of the heat capacity of the system and the absolute temperature.

(v) Use the result in (iv) to derive an expression for $\widetilde{\Delta E}/\overline{E}$ for an ideal monatomic gas.

[15 marks]

(b) A one-dimensional harmonic oscillator has energy levels given by

$$E_n = (n + \frac{1}{2})\hbar\omega$$

where ω is the characteristic angular frequency of the oscillator and where the quantum number n can assume the possible integral values $n = 0, 1, 2.....$ Suppose that such an oscillator is in thermal contact with a heat reservoir at temperature T low enough so that $kT/\hbar\omega \ll 1$,

(i) Find the ratio of the probability of the oscillator being in the first excited state to the probability of its being in the ground state.

(ii) Assuming that only the ground state and the first excited state are appreciably occupied, find the mean energy of the oscillator as a function of the temperature T.

[10 marks]

4. (a) The partition function of a real gas of N molecules in a volume V in equilibrium at absolute temperature T is given by

$$Z = A\left(\frac{V - Nb}{N}\right)^N \left(\frac{2\pi mkT}{h^2}\right)^{3N/2} \exp\left(\frac{N^2 a}{VkT}\right)$$

Where A is a constant and a and b are small positive constants.

(i) Obtain the equation of state of the gas.

(ii) Obtain the mean energy and the entropy.

(iii) In what limit does this gas behave like an ideal gas?

[15 marks]

(b) An ideal gas of N molecules is cooled at constant volume from temperature T_1 by placing it in contact with a heat bath at temperature T_2. What is the maximum useful work which can be obtained from this process?

[10 marks]

5. (a) (i) Give the thermodynamic definition of the Helmholtz free energy F, the classical statistical mechanical definition of the partition function Z, and the relationship between these quantities.

(ii) Using the expressions in (i) and some thermodynamic arguments, show that the heat capacity at constant volume C_V is given by

$$C_V = kT\left[\frac{\partial^2}{\partial T^2}(T\ln Z)\right]_V .$$

(iii) Supposed we are dealing with a classical system that has two discrete total energy states E_1 and E_2. Estimate the heat capacity at constant volume.

[15 marks]

(b) The only external parameter of a system is the volume V. Prove the following results:

(i) $dW = \frac{1}{\beta}\frac{\partial \ln Z}{\partial V}dV$

(ii) $S = k(\ln Z + \beta\overline{E})$

[10 marks]

6. (a) Derive an equation showing the change in temperature accompanying a change in pressure occurring in a system containing two phases of a pure substance in equilibrium. Discuss the significance of this equation.

[10 marks]

(b) One mole of liquid water at 1 atm pressure (10^5 pa)and 100°C is evaporated to water vapor at the same temperature and pressure. The molar volume of the liquid is 18.8 cm^3 and that of vapor under these conditions is 3.02×10^4 cm^3. The latent heat of vaporization is 4.06×10^4 j/mol.

(i) Calculate the change in the internal energy E, the Helmholtz free energy F and the Gibbs free energy G of the water.

(ii) Explain why the Helmholtz free energy and the Gibbs free energies have the values you have found.

[8 marks]

(c) Liquid helium-4 has a normal boiling point of 4.2 K. However, at a pressure of 1 mm of mercury, it boils at 1.2 K. Estimate the average latent heat of vaporization of Helium in this temperature range.

[7 marks]

End of P332 Examination

University of Zambia

University Examinations Second Semester, 2003

P342 - Introductory Digital Electronics

Instructions to Candidates: Answer four (4) questions only. They are of equal marks. The marks are shown in brackets.

Time allowed: three (3) hours only. Maximum marks 100

Q1 (a) (i) State three desirable features of TTL circuits as opposed to their RTL and DTL counter parts. **[3 marks]**

(ii) Explain how the following two input DTL circuit works. Draw its truth table and hence determine the logic operation it performs. **[6 marks]**

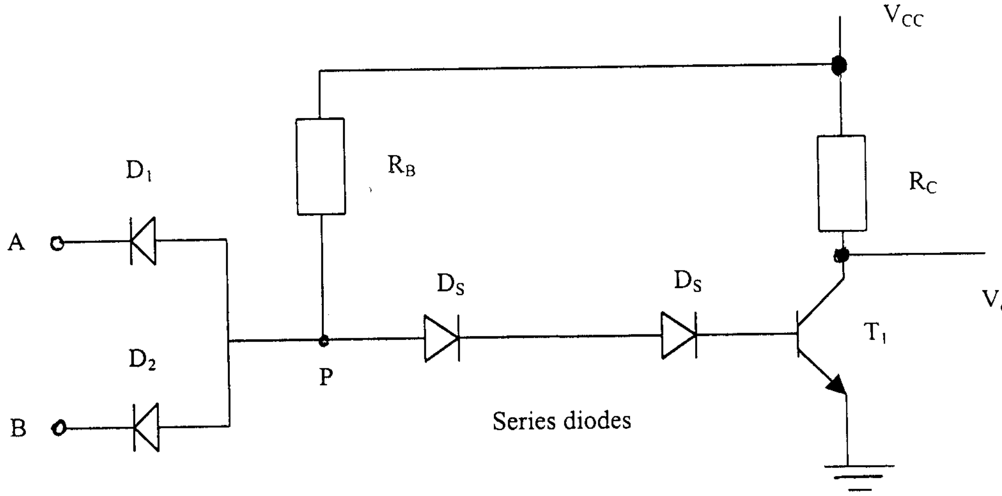


Figure 1

(b) (i) Using laws of Boolean algebra, show that the following network of NAND gates perform the Ex-OR logic. **[10 marks]**

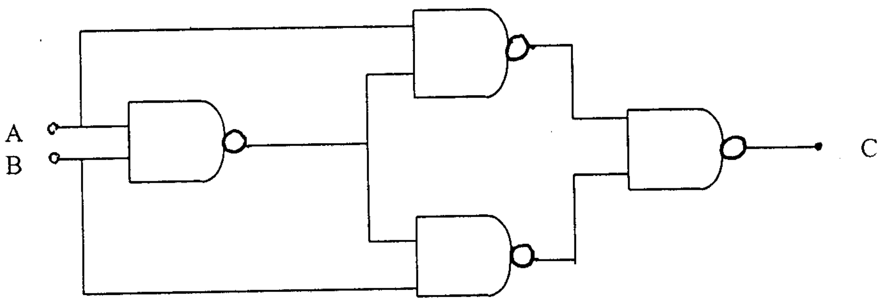


Figure 2

(ii) Copy and complete (indicate output waveforms) the following diagram for a two input Ex-OR gate . **[6 marks]**

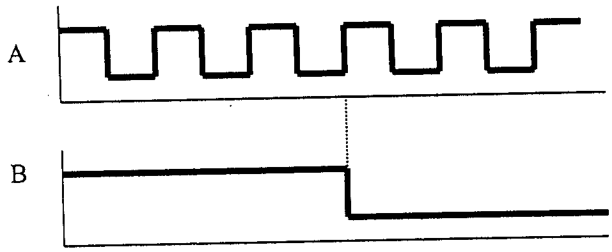


Figure 3

Q2 (a) (i) What is the essential difference between a half-adder and full adder?

[4 marks]

(ii) Distinguish between the One's and Two's complement of a binary number.

[2 marks]

(iii) Use the 1's and 2's complements to perform the following binary subtractions: 1111 – 1011

[4 marks]

(b) (i) Use the BCD to convert the hexadecimal number 7AF4 to binary number.

[2 marks]

(ii) In a certain system of counting a total of 520 characters are required to specify numbers and alphanumerics. How many bits (per character) do we need to specify all of them? State how you arrive at your answer. How many bit combinations will remain unused?

[3 marks]

(c) (i) Distinguish between parallel and serial addition of binary numbers and state the reason why the former is much more used than the latter. **[3 marks]**

(ii) Draw a well labeled diagram of a parallel chain of adders capable of adding two four bit binary numbers and use it to add the following numbers: 1011 and 1001.

[7 marks]

Q3 (a) (i) What is a flip-flop and why is it called a frequency divider? **[2 marks]**

(ii) Study the following diagram of a master-slave flip-flop and answer the questions that follow:

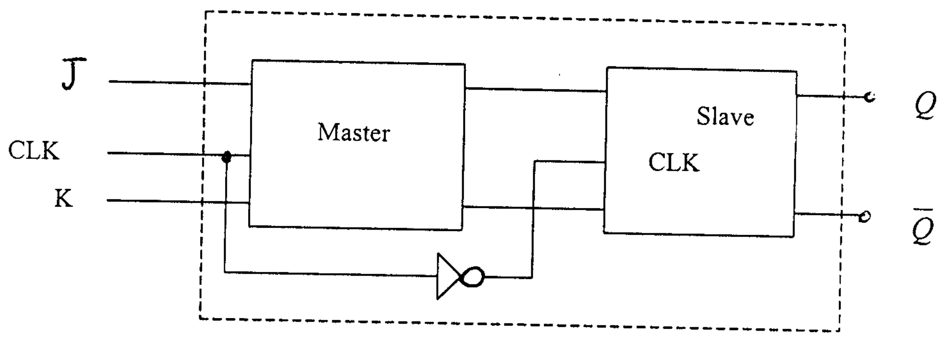


Figure 4

- One of the reasons for using the master-slave flip-flop is to avoid the race problem. Explain what is meant by the race problem and how it is avoided in this arrangement? **[4 marks]**
- What is the function of the inverter gate? **[2 marks]**

- In the JK clocked flip-flop used in this arrangement, the Q output is connected (fed back) to the S input gate while the $\overline{Q}$ output is connected to the R input gate. Explain what happens on the next positive clock edge when

  - J = K = 0 (low)
  - J = 0 and K = 1
  - J = 1 and K = 0
  - J = K = 1 (high)

  [6 marks]

(b) Explain what is meant by the following terms as understood in digital electronics:

(i) Leading edge and trailing edge triggering **[3 marks]**

(ii) Asynchronous and synchronous signals **[3 marks]**

(c) Copy and complete the following diagram for a positive edge triggered data latch (or D-latch)

[5 marks]

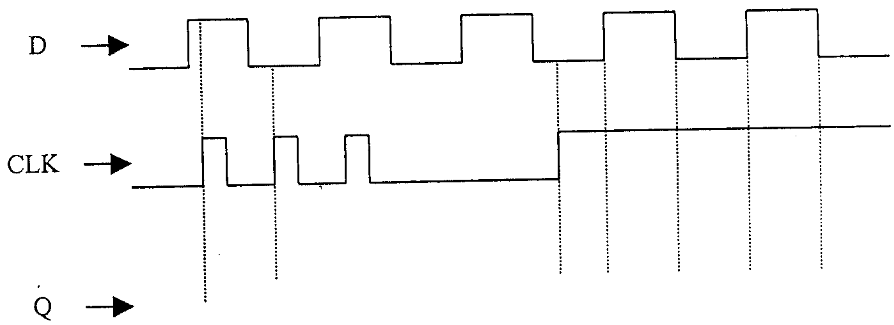


Figure 5

Q4 (a) (i) State the two principal functions of a register. **[2 marks]**

(ii) Show the states of the four-bit **positive-edge** triggered register for the data input and clock wave-forms in figure 7. Assume that the register initially contains all 1s. **[4 marks]**

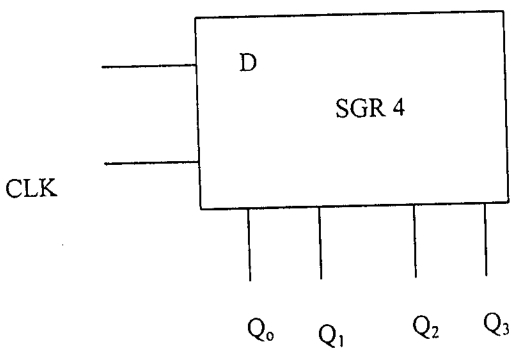


Figure 6

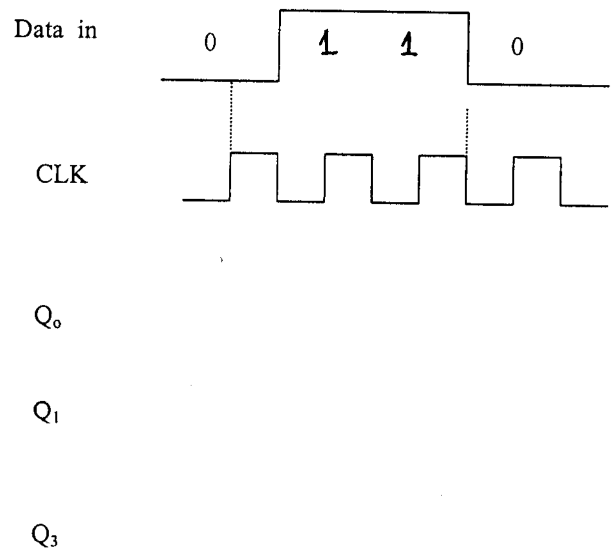


Figure 7

(b) Shown in figure 8 is a three-bit **positive edge triggered** asynchronous binary counter wired for toggle operation.

(i) What is the modulus of this counter? **[1 mark]**

(ii) Why is the counter classified as Asynchronous? **[2 marks]**

(iii) Draw the timing diagram for the counter for one cycle. **[8 marks]**

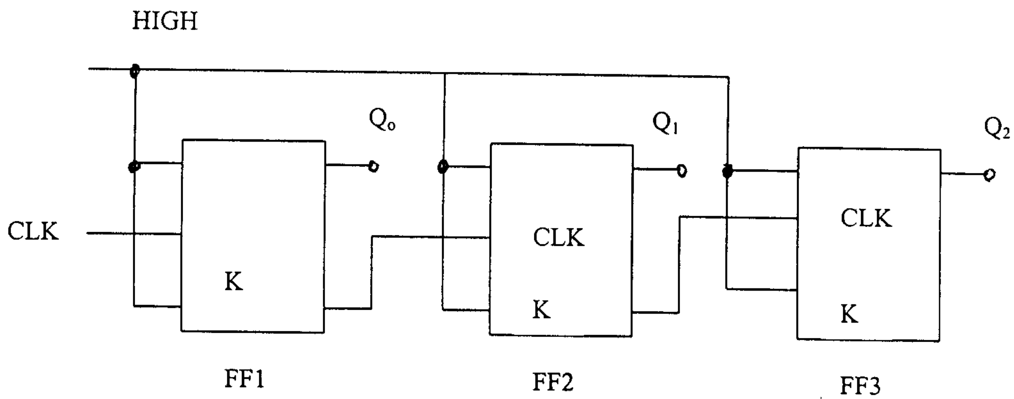


Figure 8

(c) Study the simple 1 of 4 data selector / multiplexer and its accompanying truth table shown in figure......

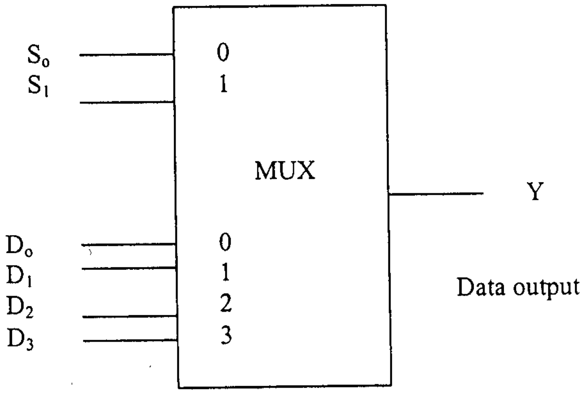


Figure 9

Truth table

Data select inputs		Input selected
S_1	S_0	
0	0	D_0
0	1	D_1
1	0	D_2
1	1	D_3

(i) Derive logical expressions for the outputs in terms of the data input and the select inputs. **[4 marks]**

(ii) How many logic gates are required to implement your expression and of what kind? **[4 marks]**

Q5 (a) (i) Differentiate between **analog** and **digital** quantities and state the reason why the former are sometimes referred to as **real world** quantities. **[3 marks]**

(ii) Explain what is meant by the following terms in varying analog signal conversion: **sampling** and **conversion** times. Which of these quantities must be larger than the other in order for the digital signal to be a faithful replica of the analog signal? **[4 marks]**

(b) Draw a well labeled diagram of the Analog – to – Digital Converter that utilizes the digital-ramp or counter method of conversion and write a brief account of how it works. Due attention must be given to the functions of the following components:

(i) the comparator;
(ii) the AND gate
(iii) the counter and
(iv) the D/A [10 marks]

(c) (i) By means of a well labeled block diagram, state the main parts of a micro-computer [5 marks]

(ii) Discuss the functions of the following buses:

- data bus
- address bus and
- control bus [3 marks]

Q6 (a) Discuss the following types of memories clearly showing how they differ, their behavior on power off, access time and give one example of each :

(i) Sequential memory;
(ii) Random access memory (RAM) and
(iii) Read only memory (ROM)

[8 marks]

(b) (i) Explain what is meant by the term "addressing" as understood in ROM and RAM [2 marks]

(ii) What is the total memory capacity of a 2048 bit ROM in bytes and in kilobits? [3 marks]

(iii) Study the generalized logic diagram for a static RAM cell in figure 10. and answer the questions below giving reasons for your answers.

- Suppose the cell initially has 0 stored (RESET) in it. What is its state after each of the following conditions

(1) ROW = 1, COLUMN = 1, DATA IN = 1, READ/$\overline{\text{WRITE}}$ = 1

(2) ROW = 0, COLUMN = 1, DATA IN = 1, READ/ $\overline{\text{WRITE}}$ = 1

(3) ROW = 1, COLUMN = 1, DATA IN = 1, READ/ $\overline{\text{WRITE}}$ = 0? [6 marks]

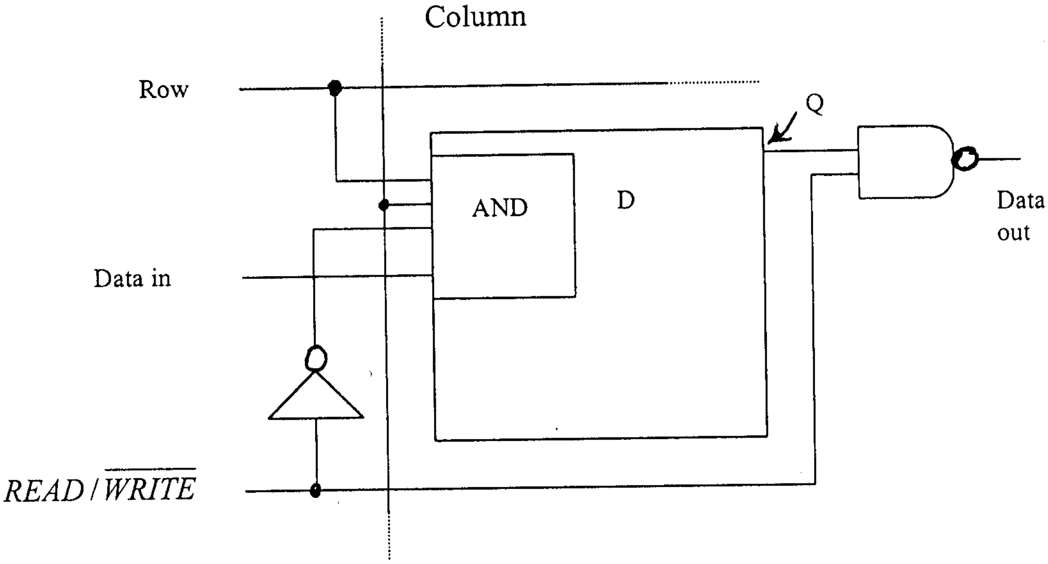


Figure 10

(c) Suppose you are asked to design a sixteen word four bit RAM. Using a clearly labeled block diagram, indicate how many of the following you would need to accomplish your task:

- data input lines
- data output lines
- memory cells

[6 marks]

END OF EXAMINATION

The University of Zambia
Physics Department
University Examinations 2003
Second Semester
P-412 : Nuclear Physics

All questions carry equal marks. The marks are shown in brackets. Attempt <u>any four</u> questions. Clearly indicate on the answer script cover page which questions you have attempted.

Time : Three hours. **Maximum marks = 100.**

Do not forget to write your computer number clearly on the answer book.

==

Wherever necessary use :

$g = 9.8 \text{m/s}^2$

$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2/\text{Nm}^2$

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ J-s

$\hbar = 6.58 \times 10^{-22}$ MeV-s $= 1.05 \times 10^{-34}$ J-s

$1eV = 1.6 \times 10^{-19}$ J

$e = 1.6 \times 10^{-19}$ C

$m_e = 9.11 \times 10^{-31}$ kg $= 0.511$ MeV

1 *a.m.u.* $= 931.15$ MeV $= 1.6604 \times 10^{-27}$ kg

$m_p = 1.67 \times 10^{-27}$ kg $= 938.28$ MeV

$m_n = 1.008665$ a.m.u. $= 939.551$ MeV

$m_{alpha} = 4.002603$ a.m.u.

$m_{hydrogen\ atom} = 1.007825$ a.m.u.

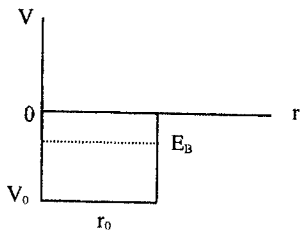
Q1(a). Derive an expression for the electrostatic energy of a uniform distribution of charge on the surface of a sphere of radius R if q is the total charge.

[9 marks]

(b). The tabulated masses of ${}^{13}_{5}B$, ${}^{13}_{6}C$, *and* ${}^{13}_{7}N$ are 13.0178, 13.0033, and 13.0057 a.m.u. respectively. Calculate the values in MeV of the Coulomb and asymmetry coefficients in the semi-empirical mass formula :

$$M(A,Z) = ZM_H + NM_N - \alpha A + \beta A^{2/3} + \frac{\gamma (A-2Z)^2}{A} + \frac{\varepsilon Z^2}{A^{1/3}} + \delta (A,Z)$$ [8 + 8]

Q 2. A neutron is bound in the lowest possible state ($l = 0$) to a heavy nucleus. The binding energy is E_B = 20 MeV ($\boldsymbol{E}$ = - 20 MeV). The potential acting on the neutron is V_0 = 40 MeV; the radius r_0 of the well is not known :



i) solve the radial wave equation for $l = 0$ inside and outside the well,

ii) apply boundary conditions at $r = r_0$ to obtain an equation between the pertinent wave numbers and r_0

iii) find the numerical values of the wave numbers and solve the equation mentioned under (ii) for r_0.

(For the reduced mass use $m = 1$ *a.m.u.*). [8+8+9]

Q 3 (a). The ground state spins and parities of the following nuclei are given in parentheses :

(i) ${}^{11}_{5}B\,(\frac{3}{2}^-)$ (ii) ${}^{16}_{7}N\,(2^-)$ (iii) ${}^{27}_{13}Al\,(\frac{5}{2}^+)$

Compare these values with the predictions made on the basis of the single particle shell model. [6]

(b). What multipole types of gamma ray transitions are likely to be predominant if the J^π of the initial and final nuclei are given as below :

(i) $\frac{1}{2}^+ \rightarrow \frac{1}{2}^+$ (ii) $\frac{3}{2}^- \rightarrow \frac{5}{2}^+$ (iii) $1^+ \rightarrow 0^+$ (iv) $\frac{3}{2}^+ \rightarrow \frac{1}{2}^+$ [8 marks]

(c). Show that an alpha particle with total energy E_0 incident on a potential barrier of energy V $(V>E_0)$ and of thickness b has a quantum probability of penetrating it.

Sketch the energy diagram showing the incident and transmitted waves of the particle. [9 + 2]

Q 4(a). Describe briefly the rotational and vibrational motions in nuclei, indicating which types of nuclei exhibit rotational and which types exhibit vibrational spectra as their low-lying states. [9]

(b). Three rotational levels of $^{238}_{92}U$ have the following excitation energies : 1100 keV, 785 keV, and 522 keV.

Determine the quantum number J corresponding to these levels and make an estimate of the moment of inertia I corresponding to this type of rotation. [10]

$$\text{Given, } E = \frac{\hbar^2 J(J+1)}{2I} - BJ^2(J+1)^2$$

(c). $^{108}_{47}Ag$ has spin and parity 1^+. It is beta unstable with a mean lifetime of 3.4 minutes. It has an excited state at 109 keV excitation energy, spin and parity 6^+, which is an isomeric state with a mean life of 180 years.

Explain how an excited state of a nucleus can be more stable than the ground state. [6 marks]

Q 5(a). Show that the inclusion of a strong spin-orbit coupling leads to the splitting of a state of given ***L***. Also show that the splitting is proportional to $(2l + 1)$. What properties and types of nuclei are reasonably explained using the shell model ? [11]

(b). The semi-empirical mass formula is given as :

$M(Z,A) = ZM_p + (A-Z)M_n - c_V A + c_C Z(Z-1)A^{-1/3} + c_a A^{2/3} + c_S A^{-1} (A-2Z)^2 \pm \delta$

with the usual interpretation of the various terms.

Show that it can be written in the form for a given A :

$M(Z,A) = \alpha A + \beta Z + \gamma Z^2 \pm \delta$ where $\alpha, \beta,$ and γ are appropriately defined constants. δ is the pairing energy contribution. [4]

(c). Hence show that the reaction energy Q for $Z \rightarrow (Z \pm 1)$ at constant even A becomes :

$$Q = 2\gamma\ (\pm(Z_0 - Z) - \frac{1}{2}) \pm 2\delta$$ where Z_0 is the charge of the most stable isobar.

[10]

Q6(a). Describe and explain the principles of the various methods for the determination of nuclear radii. [10]

(b). The difference in Coulomb energy ΔE_C between the mirror nuclei $({}^{29}_{14}Si - {}^{29}_{15}P)$ is equal to 4.96 MeV.

Assuming the same value for the radius for both nuclei, calculate the value of the nuclear radius R, and the constant r_0. Given, $\frac{e^2}{4\pi\varepsilon_0}$ = 1.44 MeV-F. [8]

(c). What do you understand by "super-allowed" transitions. ? [3]

Obtain the nature of the beta decay (Fermi, G-T, and allowed/forbiddenness) in the following transitions : [4]

$${}_4Be^{10}\,(3^+) \rightarrow {}_5Be^{10}\,(0^+) \qquad {}_{39}Y^{91}\,(\tfrac{1}{2}^-) \rightarrow {}_{40}Sr^{91}\,(\tfrac{5}{2}^+)$$

== End of P-412 Examination ==

UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS
2ND SEMESTER UNIVERSITY EXAMINATIONS 2003

P422
SOLID STATE PHYSICS II

DURATION: Three (3) hours

INSTRUCTIONS: Answer only four (4) questions in total. *All questions carry equal marks as indicated by the numbers in parentheses next to the questions.*

MAXIMUM MARKS: 100 %

Use, where necessary:

Electron mass, $m = 9.1 \times 10^{-31}$ kg
Electron charge, $e = 1.6 \times 10^{-19}$ C
Planck's constant, $h = 6.63 \times 10^{-34}$ J.s
Speed of light in vacuum, $c = 3.0 \times 10^{8}$ m/s
Permittivity of free space, $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2.J^{-1}.m^{-1}
Boltzmann's constant, $k_B = 1.38\,07 \times 10^{-23}$ J K^{-1}

$$\Delta\left(\frac{1}{B}\right) = \frac{2\pi e}{\hbar c S} \qquad A_n = \left(\frac{\hbar c}{eB}\right)^2 S_n \qquad k_F = \left(3\pi^2 n\right)^{\frac{1}{3}} \qquad k_F = \left(2\pi n\right)^{\frac{1}{2}}$$

$$v = \frac{1}{\hbar}\frac{d \in (k)}{dk} \qquad \frac{1}{m^*} = \frac{1}{\hbar^2}\frac{d^2 \in (k)}{dk^2} \qquad \hbar\frac{dk}{dt} = F$$

$$\mathbf{E} = \rho\mathbf{j}, \quad \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}, \quad \nabla \times \mathbf{B} = \mu_0\left(\mathbf{j} + \varepsilon_0\frac{\partial \mathbf{E}}{\partial t}\right), \quad \mathbf{j} = -\frac{1}{\mu_0 \lambda_L^2}\mathbf{A}, \quad \mathbf{j} = ne\mathbf{v}$$

$$\cosh x = \frac{e^x + e^{-x}}{2} \qquad \sinh x = \frac{e^x - e^{-x}}{2}$$

$$e^x = 1 + x + \frac{x^2}{2} + \frac{x^3}{3} + \ldots\ldots\ldots$$

$$(1+x)^n = 1 + nx + \frac{n(n-1)}{2!}x^2 + \frac{n(n-1)(n-2)}{3!}x^3 + \ldots\ldots\ldots$$

Q1. (a). Show that along the principal symmetry directions shown in the figure below, the tight binding expression

$$\in(\mathbf{k}) = \in_0 - \beta - 4\gamma\left(\cos\tfrac{1}{2}k_x a\cos\tfrac{1}{2}k_y a + \cos\tfrac{1}{2}k_y a\cos\tfrac{1}{2}k_z a + \cos\tfrac{1}{2}k_z a\cos\tfrac{1}{2}k_x a\right)$$

for the energies of an s-band in a face-centred cubic crystal reduces to the following:

(i) Along ΓX $(k_y = k_z = 0,\quad k_x = \mu 2\pi/a,\quad 0 \le \mu \le 1)$

$$\in = \in_0 - \beta - 4\gamma(1 + 2\cos\mu\pi).$$

(ii) Along ΓL $(k_x = k_y = k_z = \mu 2\pi/a,\quad 0 \le \mu \le \tfrac{1}{2})$

$$\in = \in_0 - \beta - 12\gamma\cos^2\mu\pi.$$

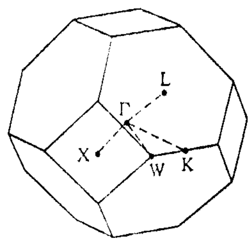
(iii) Along ΓK $(k_z = 0,\ k_x = k_y = \mu 2\pi/a,\quad 0 \le \mu \le \tfrac{3}{4})$

$$\in = \in_0 - \beta - 4\gamma(\cos^2\mu\pi + 2\cos\mu\pi).$$

(iv) Along ΓW $(k_z = 0,\ k_x = \mu 2\pi/a,\ k_y = \tfrac{1}{2}\mu 2\pi/a,\quad 0 \le \mu \le 1)$

$$\in = \in_0 - \beta - 4\gamma(\cos\mu\pi + \cos\tfrac{1}{2}\mu\pi + \cos\mu\pi\cos\tfrac{1}{2}\mu\pi).$$

(17)



The first Brillouin zone for face- centred cubic crystals. The point Γ is at the centre of the zone. The names K, L, W, and X are widely used for the points of high symmetry on the zone boundary.

(b). Show that on the square faces of the zone, the normal derivative of ∈ vanishes. **(4)**

(c). Show that on the hexagonal faces of the zone, the normal derivative of ∈ vanishes only along lines joining the centre of the hexagon to its vertices. **(4)**

Q2. (a). Give an explanation of the physical interpretation of negative effective mass. **(6)**

(b). A 1-D solid, with lattice spacing a, lies along the x-axis. It has a band with the following dispersion relation

$$E(k) = E_0 - 2I\cos(ka)$$

where E_0 is a constant and I accounts for the scattering rate of the electrons. The band contains just one electron which is at rest at $x = 0$ at time $t < 0$. At $t = 0$ an electric field is switched on in the x-direction. Sketch the

(i) electron's position x,
(ii) velocity v and
(iii) effective mass m^*

as a function of time t. **(19)**

Q3. (a). Explain what is meant by the following terms as applied to a crystalline lattice:

(i) reduced zone scheme, **(3)**
(ii) periodic zone scheme, and **(3)**
(iii) extended zone scheme. **(3)**

(b). A two-dimensional metal has one atom of valence one in a simple rectangular primitive cell $a = 2$ Å; $b = 4$ Å.

(i) Draw the first Brillouin zone, and give its dimensions in cm^{-1}. **(6)**
(ii) Calculate the radius of the free electron Fermi sphere, in cm^{-1}. **(3)**
(iii) Sketch this sphere to scale on a drawing of the first Brillouin zone. **(3)**
(iv) Make another sketch to show the first few periods of the free electron band in the periodic zone scheme, for both the first and second energy bands. **(4)**

Assume there is a small energy gap at the zone boundary.

Q4. (a). Briefly describe the de Haas-van Alphen effect, and explain how it is applied in the experimental studies of Fermi surfaces. **(9)**

(b). (i) Calculate the period $\Delta(1/B)$ expected for potassium on the free electron model. **(10)**
(ii) What is the area in real space of the extremal orbit for $B = 1$ T? **(6)**
The same period applies to oscillations in the electrical resistivity, known as the Shubnikow-de Haas effect.

Q5. (a). Define the following terms:

(i) the dielectric function, and **(4)**
(ii) the plasma frequency. **(4)**

(b). Consider a semi-infinite plasma on the positive side of the plane $z = 0$. A solution of Laplace's equation $\nabla^2\varphi = 0$ in the plasma is $\varphi_i(x,z) = A\cos kx e^{-kz}$, whence $E_{zi} = kA\cos kx e^{-kz}$; $E_{xi} = kA\sin kx e^{-kz}$.

(i) Show that in the vacuum $\varphi_o(x,z) = A\cos kx e^{kz}$ for $z < 0$ satisfies the boundary condition that the tangential component of **E** be continuous at the boundary; that is, find E_{xo}. **(6)**

(ii) Note that $\mathbf{D}_i = \epsilon(\omega)\mathbf{E}_i$; $\mathbf{D}_o = \mathbf{E}_o$. Show that the boundary condition that the normal component of **D** be continuous at the boundary requires that $\epsilon(\omega) = -1$, so that from the relation

$$\in(\omega) = 1 - \frac{\omega_p^2}{\omega^2}$$

we have the Stern-Ferrell result $\omega_s^2 = \frac{1}{2}\omega_p^2$ for the frequency ω_s of a surface plasma oscillation.

(6)

(c). We consider the plane interface $z = 0$ between metal 1 at $z > 0$ and metal 2 at $z < 0$. Metal 1 has bulk plasmon frequency ω_{p1}; metal 2 has ω_{p2}. The dielectric constants in both metals are those of free electron gases. Show that surface plasmons associated with the interface have the frequency

$$\omega = \left[\frac{1}{2}(\omega^2{}_{p1} + \omega^2{}_{p2})\right] 1/2.$$

(5)

Q6. (a). Show from Lenz's law that the Meissner effect implies perfect conductivity, but that perfect conductivity does not imply Meissner effect. [*Lenz's law* states that when the flux through an electrical circuit is changed, an induced current is set up in such a direction as to oppose the flux change.]

(5)

(b). Consider an infinite superconducting slab bounded by two parallel planes perpendicular to the y-axis at $y = \pm d$. Let a uniform magnetic field of strength H_0 be applied along the z-axis.

(i) Taking as a boundary condition that the parallel component of B be continuous at the surface, deduce from the London equation

$$\nabla \times \mathbf{j} = -\frac{n_s e^2}{mc}\mathbf{B}$$

and the Maxwell equation

$$\nabla \times \mathbf{B} = \frac{4\pi}{c}\mathbf{j}$$

that within the superconductor

$$\mathbf{B} = B(y)\hat{\mathbf{k}} \;; \quad B(y) = H_0 \frac{\cosh(y/\lambda)}{\cosh(d/\lambda)}$$

(8)

(ii) Show that the diamagnetic current density flowing in equilibrium is

$$\mathbf{j} = j(y)\hat{\mathbf{i}} \;; \quad j(y) = \frac{c}{4\pi\lambda} H_0 \frac{\sinh(y/\lambda)}{\cosh(d/\lambda)}$$

(6)

[N.B. n_s is the density of superconducting electrons and λ is the London penetration depth. Also $\text{curl}\,\text{curl}\,\mathbf{B} = -\nabla^2\mathbf{B}$ and $\text{curl}\,\text{curl}\,\mathbf{j} = -\nabla^2\mathbf{j}$.]

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

The University of Zambia

University Examinations 2003
Department Of Physics
Second Semester

P-442 : Digital Electronics II

Attempt any four questions.
All questions carry equal marks.
The marks are shown in brackets.

Time : Three hours.

Maximum marks = 100

Do not forget to write your computer number clearly on the answer book.

8085 / 8080A Instruction summary by Functional Groups

DATA TRANSFER (COPY)

Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic
40	MOV B,B	58	MOV E,B	70	MOV M,B	1A	LDAX D
41	MOV B,C	59	MOV E,C	71	MOV M,C	2A	LHLD
42	MOV B,D	5A	MOV E,D	72	MOV M,D	3A	LDA
43	MOV B,E	5B	MOV E,E	73	MOV M,E	2	STAX B
44	MOV B,H	5C	MOV E,H	74	MOV M,H	12	STAX D
45	MOV B,L	5D	MOV E,L	75	MOV M,L	22	SHLD
46	MOV B,M	5E	MOV E,M	77	MOV M,A	32	STA
47	MOV B,A	5F	MOV E,A	78	MOV A,B	01	LXI B
48	MOV C,B	60	MOV H,B	79	MOV A,C	11	LXI D
49	MOV C,C	61	MOV H,C	7A	MOV A,D	21	LXI H
4A	MOV C,D	62	MOV H,D	7B	MOV A,E	31	LXI SP
4B	MOV C,E	63	MOV H,E	7C	MOV A,H	F9	SPHL
4C	MOV C,H	64	MOV H,H	7D	MOV A,L	E3	XTHL
4D	MOV C,L	65	MOV H,L	7E	MOV A,M	EB	XCHG
4E	MOV C,M	66	MOV H,M	7F	MOV A,A	D3	OUT
4F	MOV C,A	67	MOV H,A	06	MVI B	DB	IN
50	MOV D,B	68	MOV L,B	0E	MVI C	C5	PUSH B
51	MOV D,C	69	MOV L,C	16	MVI D	D5	PUSH D
52	MOV D,D	6A	MOV L,D	1E	MVI E	E5	PUSH H
53	MOV D,E	6B	MOV L,E	26	MVI H	F5	PUSH PSW
54	MOV D,H	6C	MOV L,H	2E	MVI L	C1	POP B
55	MOV D,L	6D	MOV L,L	36	MVI M	D1	POP D
56	MOV D,M	6E	MOV L,M	3E	MVI A	E1	POP H
57	MOV D,A	6F	MOV L,A	0A	LDAX B	F1	POP PSW

ARITHMETIC

Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic
80	ADD B	CE	ACI	D6	SUI	23	INX H
81	ADD C	90	SUB B	DE	SBI	33	INX SP
82	ADD D	91	SUB C	09	DAD B	05	DCR B
83	ADD E	92	SUB D	19	DAD D	0D	DCRC
84	ADD H	93	SUB E	29	DAD H	15	DCR D
85	ADD L	94	SUB H	39	DAD SP	1D	DCR E
86	ADD M	95	SUB L	27	DAA	25	DCR H
87	ADD A	96	SUB M	04	INR B	2D	DCR L
88	ADC B	97	SUB A	0C	INR C	35	DCR M
89	ADC C	98	SBB B	14	INR D	3D	DCR A
8A	ADC D	99	SBB C	1C	INR E	0B	DCX B
8B	ADC E	9A	SBB D	24	INR H	1B	DCX D
8C	ADC H	9B	SBB E	2C	INR L	2B	DCX H
8D	ADC L	9C	SBB H	34	INR M	3B	DCX SP
8E	ADC M	9D	SBB L	3C	INR A		
8F	ADC A	9E	SBB M	03	INX B		
C6	ADI	9F	SBB A	13	INX D		

LOGICAL

Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic
37	STC	A9	XRA C	B3	ORA E	BD	CMP L
A0	ANA B	AA	XRA D	B4	ORA H	BE	CMP M
A1	ANA C	AB	XRA E	B5	ORA L	BF	CMP A
A2	ANA D	AC	XRA H	B6	ORA M	FE	CPI
A3	ANA E	AD	XRA L	B7	ORA A	07	RLC
A4	ANA H	AE	XRA M	F6	ORI	0F	RRC
A5	ANA L	AF	XRA A	B8	CMP B	17	RAL
A6	ANA M	EE	XRI	B9	CMP C	1F	RAR
A7	ANA A	B0	ORA B	BA	CMP D	2F	CMA
E6	ANI	B1	ORA C	BB	CMP E	3F	CMC
A8	XRA B	B2	ORA D	BC	CMP H		

BRANCHING

Hex	Mnemonic	Hex	Mnemonic	Hex	Mnemonic
C3	JMP	D7	RST 2	EC	CPE
C2	JNZ	DF	RST 3	F4	CP
CA	JZ	E7	RST 4	FC	CM
D2	JNC	EF	RST 5	C9	RET
DA	JC	F7	RST 6	C0	RNZ
E2	JPO	FF	RST 7	C8	RZ
EA	JPE	CD	CALL	D0	RNC
F2	JP	C4	CNZ	D8	RC
FA	JM	CC	CZ	E0	RPO
E9	PCHL	D4	CNC	E8	RPE
C7	RST 0	DC	CC	F0	RP
CF	RST 1	E4	CPO	F8	RM

CONTROL

Hex	Mnemonic
00	NOP
76	HLT
F3	DI
FB	EI
20	RIM
30	SIM

Q 1 (a) Draw the logic circuit for the following equation

$$X = \overline{A\,\overline{B}\cdot(A+C)} \;+ \overline{A}\,B\cdot\overline{A+\overline{B}+\overline{C}}$$

Use De Morgan's theorem and Boolean algebra to simplify the equation. Draw the simplified circuit.

[12]

(b) Draw the functional diagram and logic symbol for a 7483 4-bit full adder and briefly explain how it operates. What is the purpose of the fast look ahead carry in the 7483 IC?

[13]

Q 2 (a) Simplify the circuit shown in figure 1 down to its SOP form, then draw the logic circuit of the simplified form using a 74LS54 AOI gate.

[9]

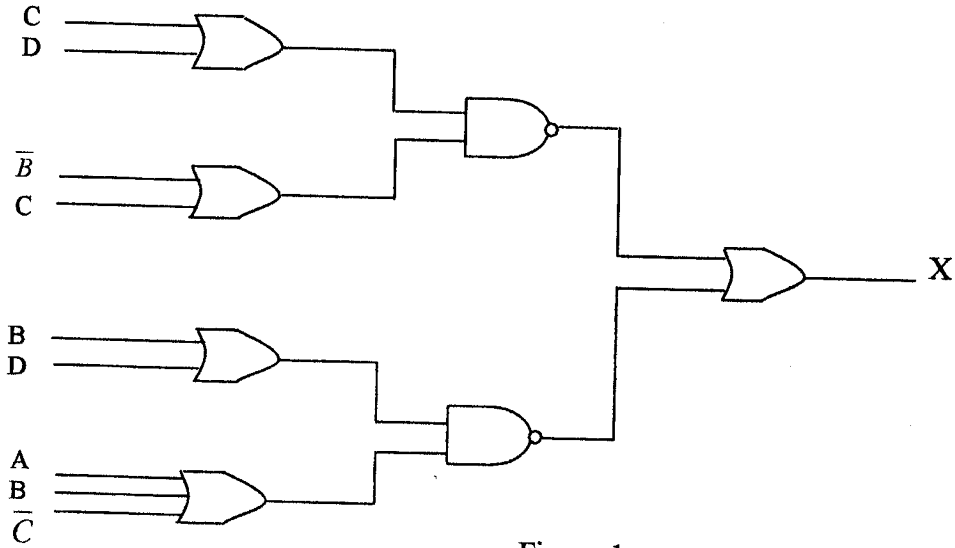


Figure 1

(b) Six bytes of data are stored in memory locations starting at XX50H. Add all the data bytes. Use register B to save any carries generated, while adding the data bytes. Display the entire sum at PORT 1 and PORT 2. Draw the flow chart and write the program.

[16]

Q 3 (a) Simplify the following equation using the Karnaugh mapping procedure.

$$X = \overline{A}\,\overline{B}\,\overline{D} + A\,\overline{C}\,\overline{D} + \overline{A}\,B\,\overline{C} + A\,B\,\overline{C}\,D + A\,\overline{B}\,C\,\overline{D}$$

[7]

(b) What are microprocessor-initiated operations? Explain with figure the bus organization of the 8085/8080A microprocessor.

[14]

(c) What is the total number of bits that can be stored in the following RAM configurations?

(i) $1K \times 8$ (ii) $4K \times 4$

[4]

Q 4 (a) Design a two's complement adder/subtractor circuit for performing the operation 42-23 and briefly explain how it operates. [15]

(b) (i) Convert 1001 1010_2 to hex. [2]

(ii) Convert 232_8 to decimal. [2]

(iii) Convert the two's complement number 1110 0100 to decimal. [3]

(iv) Add A7C5 and 2DA8 in hex. [3]

Q 5 (a) Explain the internal architecture of 8085/8080A programmable registers. [10]

(b) Sixteen bytes of data are stored in memory locations at XX50H to XX5FH. Transfer the entire block of data bytes to new memory locations starting at XX70H.

Data (H):	37	A2	F2	82	57	5A	7F	DA	E5	8B
	A7	C2	B8	10	19	98				

Draw the flow chart and write the program. [15]

Q 6 (a) The available user memory of 8085 ranges from 2000H to 23FFH. A program of data transfer and arithmetic operations is stored in memory locations from 2000H to 2050H, and the stack pointer is initialized at location 2400H. Two sets of data are stored, starting at locations 2150H and 2280H. Registers HL and BC are used as memory pointers to the data locations. A segment of the program is shown below.

```
2000    LXI SP, 2400H
2003    LXI H, 2150H
2006    LXI B, 2280H
2009    MOV A, M
200A    PUSH H
200B    PUSH B
200C    PUSH PSW
200D      |
201F      v
2020    POP PSW
2021    POP H
2022    POP B
```

(i) Explain how the stack pointer can be initialized at one memory location beyond the available user memory. [3]

(ii) Illustrate the contents of the stack memory and registers when PUSH and POP instructions are executed. [6]

(iii) Explain the various contents of the user memory. [2]

b) Define memory map. Illustrate the memory map of the 1K (1024×8) memory shown in figure 2, and explain the changes in the memory map if the hardware of the chip select line is modified. [8]

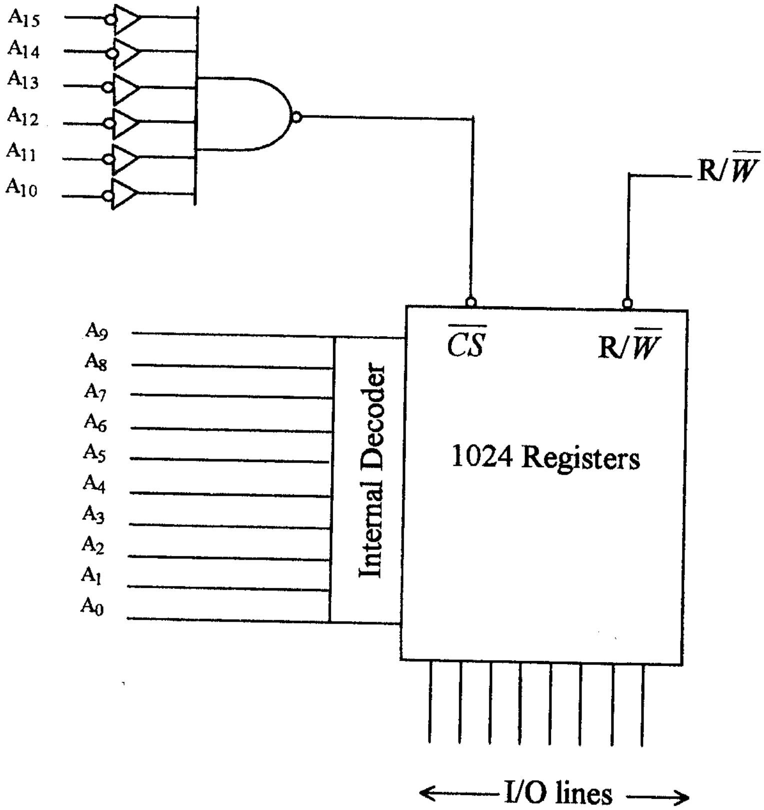


Figure 2

c) Write short notes on [6]

(i) SRAM and DRAM

(ii) Memory mapped I/O and peripheral I/O

(iii) Maskable and non maskable interrupts

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY OF ZAMBIA
SECOND SEMESTER EXAMINATIONS 2003/2004
P455 QUANTUM MECHANICS II

TIME: THREE HOURS
ANSWER: ANY FOUR QUESTIONS
MAXIMUM MARKS: 100

---

1. **(a)** **(i)** Show that the expression for the first-order energy correction in non-degenerate time-independent perturbation theory is

$$E_n^{(1)} = \left\langle \psi_n^{(0)} \left| H' \right| \psi_n^{(0)} \right\rangle$$

where H' is the perturbation. [10]

(ii) A particle moving in a one-dimensional potential well with walls at $x = 0$ and $x = L$ is acted upon by the perturbation $H' = \lambda p_x$. Find the first-order correction to the energy of the states.

Note that the eigenfunctions are given by

$$\psi_n(x) = \sqrt{\frac{2}{L}} \sin \frac{n\pi x}{L}, \quad n = 1, 2, 3, \ldots.. \quad [5]$$

(b) If a system is initially in the state $\psi_a^{(0)}$ of the Hamiltonian H_0 and if the perturbation $\lambda H'(t)$ acts from t_0 to t on the system, transitions will occur to other states $\psi_b^{(0)}$ of H_0 with transition probability amplitudes given to first order by

$$c_{ba}^{(1)} = (i\hbar)^{-1} \int_{t_0}^{t} H'_{ba}(t') \exp(i\omega_{ba} t') dt'$$

where

$$H'_{ba}(t) = \left\langle \psi_b^{(0)} \left| H'(t) \right| \psi_a^{(0)} \right\rangle \text{ and } \omega_{ba} = \frac{E_b^{(0)} - E_a^{(0)}}{\hbar}.$$

A one-dimensional harmonic oscillator of mass m and force constant k is in a uniform electric field whose time dependence is

$$\varepsilon(t) = \frac{A}{\tau\sqrt{\pi}} \exp(-\frac{t}{\tau}),$$

so that it is subject to the perturbation

$$H' = -ex\varepsilon(t),$$

where the quantities A and τ are constants and e is the electronic charge. If the oscillator is in the ground state at $t_0 = 0$ when the perturbation is switched on and the pertubation acts until time T,

(i) what are the excited states to which the oscillator can make transitions? [4]
(ii) What is the probability of excitation to these states? [6]
Note that for the harmonic oscillator, the matrix elements of x are

$$x_{nm} = \begin{cases} 0, & m \neq n \pm 1 \\ \frac{1}{\alpha}(\frac{n+1}{2})^{1/2}, & m = n+1 \\ \frac{1}{\alpha}(\frac{n}{2})^{1/2}, & m = n-1 \end{cases}$$

where $\alpha = \left(\frac{m\omega}{\hbar}\right)^{1/2}$

2.(a) When a time-independent perturbation H' acts on a system, the first order change $E^{(1)}$ in the energy of an α-degenerate level is obtained from the determinantal equation

$$\begin{vmatrix} H'_{11} - E^{(1)} & H'_{12} & \cdots & H'_{1\alpha} \\ H'_{21} & H'_{22} - E^{(1)} & \cdots & H'_{2\alpha} \\ \cdots & \cdots & \cdots & \cdots \\ H'_{\alpha 1} & H'_{\alpha 2} & \cdots & H'_{\alpha\alpha} - E^{(1)} \end{vmatrix} = 0$$

where $H'_{ij} = \left\langle \psi_i^{(0)} | H' | \psi_j^{(0)} \right\rangle$ and $\psi_i^{(0)}$ are the degenerate eigenfunctions. Explain the circumstances under which the first-order energy correction for each state is

$$E_\alpha^{(1)} = \left\langle \psi_\alpha^{(0)} | H' | \psi_\alpha^{(0)} \right\rangle,$$

the same result as would obtain from non-degenerate perturbation theory. [5]

(b) A two-dimensional harmonic oscillator has the Hamiltonian

$$H = \frac{p_x^2}{2m} + \frac{1}{2}kx^2 + \frac{p_y^2}{2m} + \frac{1}{2}ky^2$$

Hence the eigenfunctions are given by

$$\Psi_{n_1 n_2}(x,y) = X_{n_1}(x) Y_{n_2}(y), \quad n_1, n_2 = 0, 1, 2, 3....$$

where $X_{n_1}(x)$ and $Y_{n_2}(y)$ are eigenfunctions of the one-dimensional harmonic oscillator, and the energy eigenvalues are

$$E_{n_1 n_2} = (n_1 + n_2 + 1)\hbar\omega$$

Such an oscillator is in the first excited state, and is acted upon by the perturbation $H' = \lambda x p_y$, where λ is a constant. Obtain the first-order corrections to the energies. [20]

Note that the harmonic oscillator eigenfunctions are

$$\psi_n(x) = \left(\frac{\alpha}{\sqrt{\pi} 2^n n!}\right)^{1/2} e^{-\frac{1}{2}\alpha^2 x^2} H_n(\alpha x),$$

with

$$H_0(\alpha x) = 1 \text{ and } H_1(\alpha x) = 2\alpha x$$

where

$$\alpha = \left(\frac{m\omega}{\hbar}\right)^{1/2}.$$

3. **(a)** The use of the variational method for estimating ground-state energies and eigenfunctions is based on the result

$$\langle E \rangle \geq E_0$$

where E_0 is the ground-state energy and $\langle E \rangle$ is the expectation value of the Hamiltonian for a selected trial function. Prove this result. [5]

(b) A particle of mass m moves in the one-dimensional square-well potential

$$\begin{aligned} V &= 0; \ 0 < x < L \\ V &= \infty; \ x < 0, x > L \end{aligned}$$

(i) Consider the variational function

$$\phi_\alpha(x) = x^\alpha (1-x)^\alpha$$

Write down an expression for the expectation value $\langle E \rangle_\alpha$ of the energy, but do not attempt to evaluate the integrals. [3]

(ii) The integrals may be evaluated to give

$$\langle E \rangle_\alpha = \frac{\hbar^2}{2mL^2} \frac{2\alpha(4\alpha+1)}{2\alpha-1}$$

where only positive values of α are allowed. Use the variational principle to obtain an estimate of the ground-state energy and compare with the exact value. Comment on your result. [7]

(c) Given the commutation relations

$$[L_i, L_j] = i\hbar L_k \quad (i, j, k \text{ taken in cyclic order})$$

for the components of the orbital angular momentum, show that $L_+ = L_x + iL_y$ is a raising operator. [10]

4. **(a)** One of the dynamical variables A of a certain system satisfies the eigenvalue equation

$$A\phi_n = a_n\phi_n.$$

(i) Prove that this can be transformed into the matrix eigenvalue equation

$$[A][\phi_n] = a_n[\phi_n] \qquad [8]$$

(b) In a certain basis, a physical system has the Hamiltonian

$$[H] = \begin{pmatrix} \lambda_1 & 0 & 0 \\ 0 & \lambda_2 & 0 \\ 0 & 0 & \lambda_3 \end{pmatrix}.$$

where the constants λ_1, λ_2 and λ_3 are all different from one another.

(i) What are the possible results when the energy of the system is measured? [5]

(ii) In view of the answers above, what can you say about the basis used to make the transition from wave to matrix mechanics. [2]

(iii) Obtain the eigenvectors of the Hamiltonian. [5]

(iii) Show that the eigenvectors are orthonormal. [2]

(iv) Show that the eigenvectors satisfy

$$\sum_i |u_i\rangle \langle u_i| = \mathbf{1}. \quad \textbf{[3]}$$

5.(a) (i) The Hamiltonian of the harmonic oscillator is

$$H = \frac{p^2}{2m} + \frac{1}{2}kx^2$$

If the ladder operators

$$a_{\pm} = \frac{1}{\sqrt{2}}[\frac{p}{(m\hbar\omega)^{1/2}} \pm i(\frac{m\omega}{\hbar})^{1/2}x]$$

satisfy the commutation relations

$$[H, a_{\pm}] = \pm\hbar\omega a_{\pm}$$

show that the ground state ψ_0 of the harmonic oscillator satisfies the equation

$$\frac{1}{\sqrt{2}}[-i\left(\frac{\hbar}{m\omega}\right)^{1/2}\frac{d}{dx} - i(\frac{m\omega}{\hbar})^{1/2}x]\psi_0 = 0 \quad [7]$$

(ii) Prove that the solution of this equation is

$$\psi_0 = \left(\frac{m\omega}{\pi\hbar}\right)^{1/4} \exp(-\frac{m\omega}{2\hbar}x^2) \quad [2]$$

(iii) Explain how to generate all the states of the harmonic oscillator and show that their energies are given by

$$E_n = (n + \frac{1}{2})\hbar\omega. \quad [4]$$

(b) N identical non-interacting spin-1/2 fermions are confined in a cubic box of dimension L at absolute temperature $T = 0$. Given that the energy levels of a particle of mass m in a cube of side L are

$$E_n = \frac{\hbar^2\pi^2}{2mL^2}n^2,$$

where

$$n^2 = n_x^2 + n_y^2 + n_z^2,$$

and that the wave function for such a state is

$$\psi_{n_x,n_y,n_z,m_s}(q) = \psi_{n_x,n_y,n_z}(x,y,x)\chi_{\frac{1}{2},m_s},$$

(i) show that the total number of individual particle states for energies up to E is

$$N_s = \frac{1}{3\pi^2}\left(\frac{2m}{\hbar^2}\right)^{3/2} VE^{3/2}, \quad [8]$$

where $V = L^3$;

(ii) prove that the highest value of energy occupied by the N particles at absolute temperature $T = 0$, i.e., the Fermi energy, is

$$E_F = \frac{\hbar^2}{2m}(3\pi^2\rho)^{2/3}, \quad [4]$$

where $\rho = N/V$.

6. **(a)** In coordinate space, the operator for the x component of momentum is $p_x = -i\hbar\frac{\partial}{\partial x}$ while in momentum space, the operator for the position coordinate is $x = i\hbar\frac{\partial}{\partial p_x}$. Given that the Hamiltonian for the harmonic oscillator

$$H = \frac{p_x^2}{2m} + \frac{1}{2}kx^2$$

(i) Write down the time-dependent Schroedinger equation in momentum space. [2]

(ii) Hence, obtain the time-independent Schroedinger equation in momentum space. [5]

(iii) Knowing that the ground-state eigenfunction for the harmonic oscillator in coordinate space has the form

$$\Psi_0 = Ae^{-\lambda x^2}$$

deduce the functional form of the ground-state eigenfunction in momentum space. [3]

(iv) Hence write down the total wave function for the ground state in momentum space. [5]

(b) The momentum-space eigenfunction $\Phi(p_x)$ of a system is related to its coordinate-space eigenfunction $\Psi(x)$ by

$$\Phi(p_x) = (2\pi\hbar)^{-1/2}\int_{-\infty}^{\infty} e^{-ip_x x/\hbar}\Psi(x)dx$$

(i) What is the interpretation of $|\Phi(p_x)|^2\, dp_x$? [2]

(ii) Obtain the momentum-space eigenfunction corresponding to the ground state of the harmonic oscillator

$$\Psi_0(x) = \left(\frac{\alpha}{2\sqrt{\pi}}\right)^{1/2} e^{-\alpha^2 x^2/2},$$

where $\alpha = \left(\frac{m\omega}{\hbar}\right)^{1/2}$. [8]

Note that

$$\int_{-\infty}^{\infty} e^{-x^2}dx = \sqrt{\pi}$$

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

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS – SECOND SEMESTER 2003
P485 - PHYSICS OF RENEWABLE ENERGY RESOURCES AND ENVIRONMENT

TIME: 3 HOURS

MAX MARKS: 100

ATTEMPT ANY **FOUR** QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS. THE MARKS ARE SHOWN IN SQUARE BRACKETS

You may use the following information:

Boltzmann constant $k = 1.38 \times 10^{-23}$ JK^{-1}
Gas constant R = 8314 J/kmol.K
1 electron volt = 1.6×10^{-19} J
Stefan's constant σ = 5.67×10^{-8} W/m^2K^4
Sun's radius R_s = 6.96×10^8m
Mean Earth-Sun distance $r_0 = 1.496 \times 10^{11}$m
Solar constant I_{sc} = 1367 Wm^{-2}
Earth's radius $R_e = 6.37 \times 10^6$m
Planck's constant $h = 6.6 \times 10^{-34}$J.s
Speed of light $c = 3 \times 10^8 m.s^{-1}$

In the usual notation

$$E_0 = \left(\frac{r_0}{r}\right)^2 = 1 + 0.033\cos\left(\frac{360\, d_n}{365}\right)$$

$$\delta = 23.45° \sin\left[\frac{360}{365}(d_n + 284)\right]$$

$$\cos\theta_z = \sin\delta\sin\phi + \cos\delta\cos\phi\cos\omega$$

$$\tan\psi = \frac{\cos\delta\sin\omega}{\cos\delta\sin\phi\cos\omega - \sin\delta\cos\phi}$$

$$\cos\theta = (\sin\varphi\cos\beta - \cos\varphi\sin\beta\cos\gamma)\sin\delta + (\cos\varphi\cos\beta + \sin\varphi\sin\beta\cos\gamma)\cos\delta\cos\omega + \cos\delta\sin\beta\sin\gamma\sin\omega$$

$$\omega = 15^\circ(12 - t\,); \quad \omega_s = \cos^{-1}(-\tan\phi\tan\delta)$$

Solar time = clock time + $4(L_l - L_s)$ min + EOT

Wien's Law

$\lambda_{max}\,T = 2898$ μm.K

The emissive power of a black body $B_\lambda(T)$ (in W/m^2 per unit wavelength range) is

$$B_\lambda(T\,) = \frac{2\pi h\,c^2}{\lambda^5\left(e^{\frac{hc}{\lambda kT}} - 1\right)}$$

Direct flux on an inclined surface

$$F^{dir} = \cos\theta\exp\left(-\frac{\tau}{\cos\theta_z}\right)I_{sc}$$

Fresnel's equations

$$r_{\parallel} = \left[\frac{n_r^2\cos\theta_i - n_i\sqrt{n_r^2 - n_i^2\sin^2\theta_i}}{n_r^2\cos\theta_i + n_i\sqrt{n_r^2 - n_i^2\sin^2\theta_i}}\right]^2$$

$$r_{\perp} = \left[\frac{n_i\cos\theta_i - \sqrt{n_r^2 - n_i^2\sin^2\theta_i}}{n_i\cos\theta_i + \sqrt{n_r^2 - n_i^2\sin^2\theta_i}}\right]^2$$

Overall reflectance and transmittance of a single glazing are

$$R = r\left[1 + \frac{\alpha^2(1-r)^2}{1-\alpha^2r^2}\right]$$

$$T = \frac{\alpha(1-r)^2}{1-\alpha^2r^2}$$

In a single current heat exchanger the exit temperature is

$$T_{f,e} = T_B - (T_B - T_{f,i})\exp\left(-\frac{\overline{U}_L L}{\dot{m} C_f}\right),$$

and the heat extraction rate is

$$Q = \dot{m} C_f (T_B - T_{f,i})\left[1 - \exp\left(-\frac{\overline{U}_L L}{\dot{m} C_f}\right)\right].$$

The carrier concentration in an intrinsic semiconductor is

$$n_i = p_i = AT^{3/2} exp\left(-\frac{\varepsilon_g}{2kT}\right)$$

The resistivity of an extrinsic material is

$$\rho = \frac{1}{e(n\mu_n + p\mu_p)}$$

The reverse saturation current density is

$$J_0 = DT^3 exp\left(-\frac{\varepsilon_g}{kT}\right)$$

The forward current density is

$$J = J_0(e^{\frac{eV}{kT}} - 1)$$

The J-V characteristic equation for a single cell is

$$J = \overline{K}F - J_0\left(e^{\frac{eV}{kT}} - 1\right).$$

Yearly variation of the equation of time

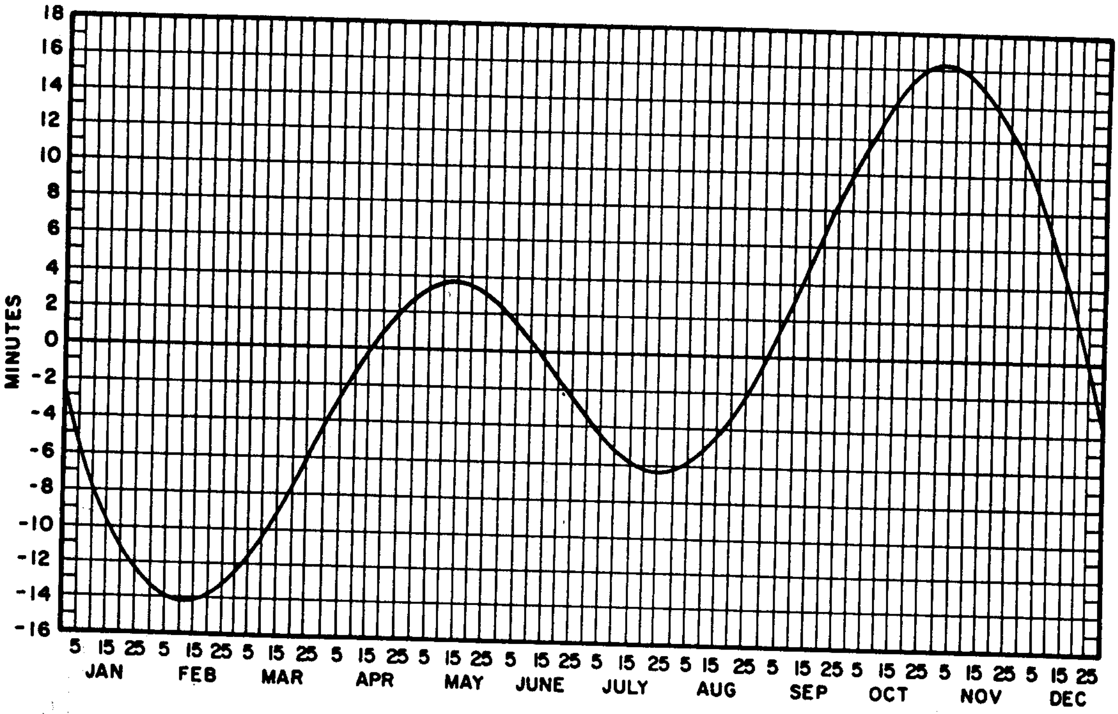


Table for the function $f(x) = f(\lambda T)$

$x(\mu m\text{-}K)$	$f(x)$	$x(\mu m\text{-}K)$	$f(x)$	$x(\mu m\text{-}K)$	$f(x)$
1100	0.001	4600	0.580	8100	0.860
1200	0.002	4700	0.594	8200	0.864
1300	0.004	4800	0.608	8300	0.868
1400	0.008	4900	0.621	8400	0.871
1500	0.013	5000	0.634	8500	0.875
1600	0.020	5100	0.646	8600	0.878
1700	0.029	5200	0.658	8700	0.881
1800	0.040	5300	0.669	8800	0.884
1900	0.052	5400	0.680	8900	0.887
2000	0.067	5500	0.691	9000	0.890
2100	0.083	5600	0.701	9100	0.893
2200	0.101	5700	0.711	9200	0.895
2300	0.120	5800	0.720	9300	0.898
2400	0.140	5900	0.730	9400	0.901
2500	0.161	6000	0.738	9500	0.903
2600	0.183	6100	0.746	9600	0.905
2700	0.205	6200	0.754	9700	0.908
2800	0.228	6300	0.762	9800	0.910
2900	0.251	6400	0.770	9900	0.912
3000	0.273	6500	0.776	10000	0.914
3100	0.296	6600	0.783	11000	0.932
3200	0.318	6700	0.790	12000	0.945
3300	0.340	6800	0.796	13000	0.955
3400	0.362	6900	0.802	14000	0.963
3500	0.383	7000	0.808	15000	0.969
3600	0.404	7100	0.814	16000	0.974
3700	0.424	7200	0.819	17000	0.978
3800	0.443	7300	0.824	18000	0.981
3900	0.462	7400	0.830	19000	0.983
4000	0.483	7500	0.834	20000	0.986
4100	0.499	7600	0.840	30000	0.995
4200	0.516	7700	0.844	40000	0.998
4300	0.533	7800	0.848	50000	0.999
4400	0.549	7900	0.852		
4500	0.564	8000	0.856		

Q. 1 (a) Assuming the Earth and the Sun to be black bodies and the value of the solar constant to be 1367 W/m^2, calculate

(i) the black body temperature of the sun

(ii) the equilibrium temperature of the earth, if the earth's albedo is 0.3 and there is no atmosphere.

[5+5]

(b) An orbiting probe is being launched to orbit Venus. The probe's electronic equipment is to be powered by silicon photovoltaic cells that are 12% efficient. If a total of 1 kw of electrical power is required, find the area of the photocells necessary (assume the photocells always remain normal to the solar beam). What will be the area required of the photocells for a similar probe orbiting the earth? Comment if solar power is feasible for Venus missions. (Use r_{venus}=108x10^6km).

[7]

(c) A solar panel consists of an absorber plate placed under a glazing. The glazing only transmits wavelength smaller than 1.0 μm. The absorber absorbs all wavelengths except those in the interval 0.40 μm < λ < 0.50 μm which it reflects. If the collector is 2 m^2 in area, is above the atmosphere and is oriented toward the Sun so that the Sun's radiation is incident normally on it, find the heating power produced in the absorber due to the absorption of solar radiation. (You may use the black body temperature of the Sun to be 5800 K).

[8]

Q.2 (a) Define or briefly describe what you understand by the following terms

(i) Astronomical Unit
(ii) ecliptic plane
(iii) equatorial plane
(iv) solar constant
(v) solar declination
(vi) equinoxes
(vii) solstices

[7]

(b) A horizontal solar heating panel with an area of 2m^2 is located in Lusaka (φ=15°19'S, L=28°27'E). On 5 February at 10 a.m., the average optical thickness of the atmosphere is 0.2. Find

(i) solar declination [2]
(ii) solar time [4]
(iii) hour angle [2]
(iv) angle of incidence of solar beam [5]
(v) direct radiation flux incident on the panel [5]

Q.3 For air, the ratio of the two specific heats is γ = 1.4 and the molecular weight is 29. Assuming the atmosphere to be plane stratified, containing no water and behaving like an ideal gas

(a) Obtain an expression for its density profile. [7]

(b) Obtain an expression for the adiabatic lapse rate and use this result to calculate the temperature differential for Lusaka with respect to the temperature at sea level. The elevation of Lusaka above sea level is 1153 m. [9]

(c) Use the result in (b) to obtain an expression for the variation in pressure as a function of height. Taking sea level pressure as 760 mm of Hg, the elevation of Lusaka as 1153 m above sea level and the temperature at sea level as 300 K, calculate the atmospheric pressure in Lusaka. [9]

Q. 4 A flat-plate solar heating panel contains two glazings. In the steady state, the plate temperature is T_p=120° C and the sky temperature T_{sky}=T_a=20° C. The coefficients for heat transfer from the plate to the inner glazing are $U_{d,1}^{(c)}$= 3 W.m^{-1}.° C^{-1} and $U_{d,1}^{(r)}$= 5 W.m^{-2}. °C^{-1}. Those for heat transfer from the inner glazing to the outer glazing are $U_{d,2}^{(c)}$= 5 W.m^{-2}. °C^{-1} and $U_{d,2}^{(r)}$= 7 W.m^{-2}.°C^{-1}. The coefficients for heat transfer from the outer glazing are $U_\infty^{(c)}$= 8 W.m^{-2}. °C^{-1} *and* $U_\infty^{(r)}$= 8 W.m^{-2}. °C^{-1}.

(a) Draw the resistor equivalent network for the system. [6]

(b) Calculate the heat transfer coefficients $\overline{U}_{d,1}$, $\overline{U}_{d,2}$ and $\overline{U}_{\infty}$. [4]

(c) Calculate the overall heat transfer coefficient $\overline{U}_c$ for the panel. [5]

(d) Find the flux loss from the absorber. [4]

(e) Find the temperature of the glazings. [6]

Q. 5 (a) Show that the optical efficiency of a single glazing absorber system is given by

$$\eta_{opt} = \frac{A_p T_g}{1-(1-A_p)R_g}$$

[8]

(b) A single glazing panel has the following specifications

thermal efficiency of the panel = 0.7
plate absorptance = 0.9
extinction coefficient k for the glazing = 0.1 cm^{-1}
thickness of the glazing = 0.5 cm
refractive index of the glazing = 1.5
surface reflectance r of the glazing = 0.04

If a direct solar beam is incident at an angle of 30° on the panel, calculate

(i) the bulk transmittivity of the glazing [5]
(ii) the overall transmittance of the glazing [3]
(iii) the overall reflectance of the glazing [3]
(iv) the optical efficiency of the glazing-absorber system [3]
(v) the overall efficiency of the heating panel [3]

Q.6 (a) A single solar heating panel uses water (C_f = 4186 $J.kg^{-1}.°C^{-1}$) as the transfer fluid. The water is flowing at a rate $\dot{m}$ = 0.005 $kg.s^{-1}$, it enters the panel at 20°C and leaves at 50°C. The fluid is carried to a storage tank by an exterior pipe 10 m long whose overall heat transfer coefficient per unit length is $\overline{U}_L$ = 0.2 $W.m^{-1}.°C^{-1}$ The ambient temperature is T_a = 15 °C. Find the temperature of the water entering the storage tank and the percentage of the heat produced by the panel that is lost by the pipe.
[10]

(b) A PV array has 200 circular cells each with a diameter of 10 cm. The array has 10 parallel strings each with 20 cells in series. Given $\overline{K}$ = 25$mA.cm^{-2}.Sun^{-1}$, J_0 = 5×10^{-10} $mA.cm^{-2}$ and T = 300 K:

(i) Using the J-V characteristic equation for a single cell, obtain the I-V characteristic equation for the array [6]
(ii) Find the open circuit voltage of the array for a radiation of 1 Sun. [7]
(iii) Find the short circuit current for a radiation of 1 Sun. [2]

——————— END OF THE EXAMINATION ———————