The University of Zambia
School of Natural Sciences
2006/7 Second Semester Examinations

1.	BS 212	Plant and animal physiology (theory paper)
2.	BS 319	Biostatistics
3.	BS 222	Function, form and diversity of animals (theory paper)
4.	BS 322	Ecology (theory paper)
5.	BS 332	Animal physiology (practical paper)
6.	BS 349	General microbiology (practical Paper)
7.	BS 349	General microbiology (theory paper)
8.	BS 352	Parasitology (practical paper)
9.	BS 362	Genetics (1) (theory paper)
10.	BS 412	Applied entomology (practical paper II)
11.	BS 432	Advanced parasitology (theory paper)
12.	BS 435	Medical microbiology (theory paper)
13.	BS 442	Advanced molecular biology II (theory paper)
14.	BS 445	Ecophysiology of plants
15.	BS 455	Wildlife ecology paper two (practical)
16.	BS 455	Wildlife ecology paper one (theory)
17.	BS 482	Food microbiology (theory paper)
18.	BS 925	Terrestrial vertebrate biology (deferred exam) paper two (practical)
19.	C 102	Introductory chemistry II
20.	C 212	Introductory biochemistry
21.	C 225	Analytical chemistry I
22.	C 252	Organic chemistry II
23.	C 265	Physical chemistry
24.	C 312	Biochemistry II
25.	C 342	Inorganic chemistry III
26.	C 362	Colloids and electrochemistry
27.	C 412	Advanced biochemistry II
28.	C 422	Applied analytical chemistry
29.	CS 252	Electronics for computer science
30.	CS 4012	Advanced operating systems and distributed systems
31.	CST 2012	Programming II using java
32.	CST 2042	Introduction to database and file systems
33.	CST 3022	Programming language paradigms
34.	CST 3032	Introduction to artificial intelligence
35.	CST 4122	Fundamentals of compilers
36.	CST 4132	Computer graphics fundamentals
37.	CST 4252	Electronics for computing IV
38.	GEO 111	Introduction to human geography I
39.	GEO 112	Introduction to human geography II

40.	GEO 155	Introduction to physical geography
41.	GEO 212	The geography of Zambia
42.	GEO 272	Quantitative techniques in geography II
43.	GEO 482	Environment and natural resource management II
44.	GEO 495	Enviromental hazards and disasters
45.	GEO 912	Geography of migration and refugees
46.	GEO 922	Geography of regional planning and development
47.	GEO 952	Geographical hydrology
48.	GEO 926	Biogeography
49.	GEO 971	Aerial photography (paper I)
50.	GEO 972	Satellite remote sensing and gis
51.	GEO 975	Cartography
52.	GEO 995	Environment and natural resource management I
53.	M 111	Mathematical methods I (distance education)
54.	M 112	Mathematical methods IIA
55.	M 114	Mathematical methods IIB
56.	M 162	Introduction to mathematics, probability and statistics II
57.	M 212	Mathematical methods IV
58.	M 232	Real analysis
59.	M 292	Introduction to probability
60.	M 325	Group and ring theory
61.	M 332	Real analysis IV
62.	M 362	Linear models
63.	M 412	Theory of functions of a complex variable II
64.	M 422	Field and module theory
65.	M 462	Bayesian inference and discrete analysis
66.	M 912	Mathematical methods VI
67.	M 962	Time series analysis
68.	M 982	Numerical analysis II
69.	P 198	Introduction physics II (option B)
70.	P 252	Introduction to classical mechanics II
71.	P 272	Optics
72.	P 332	Statistical physics and thermodynamics
73.	P 342	Introductory electronics
74.	P 412	Nuclear physics
75.	P 442	Digital electronics II
76.	P 455	Quantum mechanics II
77.	P 485	Environment

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF BIOLOGICAL SCIENCES

SECOND SEMESTER UNIVERSITY EXAMINATIONS
FEBRUARY, 2007

BS 212
PLANT AND ANIMAL PHYSIOLOGY

THEORY PAPER

TIME: Three Hours
Instructions: Answer **FIVE** questions: Two chosen from each section, the last question chosen from any section.

SECTION A
PLANT PHYSIOLOGY

1. (a). Explain how light energy is absorbed by chlorophyll and transferred to the reaction centers of chloroplasts leading to primary charge separation.
   (b). Explain how ATP is formed in chloroplasts

2. Discuss the effects of humidity and light on cellular water relations and diffusion conductance of leaves of land plants.

3. Compare and contrast the mechanisms of Gibberellin action and Auxin action in promoting stem growth.

4. Discuss the pathways and processes of water movement in roots.

SECTION B
ANIMAL PHYSIOLOGY

5. (a). Define energy balance.
   (b). Describe the various the feeding mechanisms found in animals.

6. (a). Explain the various ways in which CO_2 is transported in blood.
   (b). What is "Bohr Shift"?

7. Discuss the three mechanisms which control bleeding when a blood vessel raptures.

8. Write short notes on the following:
   (a). Extra-embryonic membranes.
   (b). Primary germ layers of chick embryo
   (c). Chloride shift
   (d). Icterus

END OF EXAMINATION!

THE UNIVERSITY OF ZAMBIA

THE UNIVERSITY SECOND SEMESTER EXAMINATIONS FEBRUARY 2007

BS 222 FUNCTION, FORM AND DIVERSITY OF ANIMALS

THEORY PAPER

TIME: Three (3) Hours

Special Instructions

Answer a total **of four (4)** questions, **two** from **section A** and **two** from **section B**. All questions carry the equal marks

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

SECTION A

Q1. Draw the suggested phylogenetic tree of the invertebrate group indicating major evolutionary departure points from the main line of evolution.

Q2. (a) Define the following terms or phrases

i. Holozonic nutrition
ii. Conjugation reproduction
iii. Complete metamorphosis
iv. Binary fission
v. Dioecious
vi. Homologous characters
vii. Monophyletic origin
viii. Polyphyletic origin
ix. Hemaphroditision

(b) Describe the life cycle of the Trematoda – *Schistosoma mansoni*

Q3. Describe the various feeding and excretion mechanisms found in the phylla – Protozoa, Porifera, Ctenophora and Cnidaria.

Q4. With the aid of a diagram, describe the distinguishing features of the following invertebrate classes: -

i. Arachnida
ii. Cestoidae
iii. Tentaculata
iv. Hydrozoa
v. Insecta
vi. Mastigophora
vii. Diplopoda
viii. Ciliphora (Ciliata)

SECTION B

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

i) Actinopterygii
ii) Anura
iii) Archosauria
iv) Ornithischia
v) Artiodactyla
vi) Cetacea
vii) Chiroptera
viii) Metametrical segmentation
ix) Acrania
x) Ratite

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

i) Pharynx in Cephalochordata
ii) Gill slits in Chondrichthyes
iii) Swim-bladder in Osteichthyes
iv) Lungs in Amphibia; and
v) Cudal fin in Chondrichthyes.

Q7 The Class Amphibia provides a vital link in the evolution and classification 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
FEBRUARY 2007
BS 319: BIOSTATISTICS

TIME: THREE HOURS.

ANSWER: FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

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1. a. Distinguish between "a priori" and "a posteriori" probability measures.
   b. What does the normal distribution look like, and why is it important?
   c. Under what circumstances are the binomial and poison distributions useful in biological sciences?
   d. In comparing more than two sample means what is meant by "Type 1 Statistical Error" and how can its occurrence be minimized?
   e. What are the differences between Randomized Block Design (RBD) and Latin Square Design (LSD)?
   f. What are the two major principles of experimental design?

2. Mean soil temperature and germination interval (i.e. time between sowing and appearance above ground) for winter wheat 1981-86 for 12 places are shown below:

Mean soil temperature (X):	50	30	38	42	45	42	41	40	36	44	43	40
No. of days (Y):	10	26	41	29	27	27	19	18	19	31	29	33

   a. Obtain the regression equation for number of days on mean soil temperature.
   b. Test the N.H. that $\rho = 0$

3. In a report of a randomized complete block design, the following results were given. Treatment means A = 50, B = 47, C = 62, D = 52, E = 54. The experimental error was 96 based on 32 degrees of freedom. The total sum of squared deviations from the overall mean was 5824. Reconstruct the analysis of variance table below and test the Null hypothesis that there are no significant differences among the treatment means.

Source	d.f.	ss	ms	F
Treatments				
Blocks				
Experimental Error				
Total				

4. The following measurements of length of the antennae of 10 males and 10 females of the 6th developmental stage of the Armoured ground cricket, *Acanthoplus speiseri* Brancsik, collected in bushes, west of Kaunda Square Stage I, in Lusaka, were recorded by a researcher in the Department of Biological Sciences at UNZA:

Sex	Armoured Ground Cricket Number									
	1	2	3	4	5	6	7	8	9	10
Male	76.1	67.0	61.0	63.5	53.0	52.0	66.4	60.0	59.0	73.6
Female	77.6	57.4	66.0	65.0	65.6	69.3	66.0	58.0	65.0	63.0

a. Calculate the Standard Error of the mean antennal length of each sex.
b. Test the Null Hypothesis (H_o) that the two sexes have antennae of the same length, assuming variances are unequal.

5. For a family with 10 children:

a. What is the expected number of girls?
b. What is the probability of having at least one child of each sex?
c. What is the number of different types of family that can be formed?
d. Suppose you were told that 8 of the children were girls and only 2 were boys, test the Null Hypothesis (H_o) of equal number of girls and boys.

6. The following data describe the state of grief of 66 mothers who have suffered a neonatal death. The table relates this to the amount of support given to them by hospitals and relatives:

Grief State	Type of Support		
	Good	Adequate	Poor
I	17	9	8
II	6	5	1
III	3	5	4
IV	1	2	5

Test the Null hypothesis that there is no association between the state of grief of the mothers and the support they receive from hospitals and relatives.

7. Four fertilizer treatments, each replicated three times, were applied to a crop in a randomized block design setup. At the end of the experiment two (2) of the replications (a & b) had for some reason missing yield data as indicated in the table below:

Treatment (kg fertilizer per acre)	**Replications**		
	1	**2**	**3**
1	7.62	6.00	7.93
2	8.14	7.33	**b**
3	7.76	7.73	7.87
4	**a**	6.89	7.52

a. Estimate the missing values a & b.
b. Are there any significant differences among the treatment means?

8. In an automobile exhaust emission study, four cars and four drivers were used to test the possible differences among four petrol additives (A, B, C & D) in reducing the amount of oxides of nitrogen emitted in exhaust gases. A Latin Square Design (LSD) was employed in the experimental setup and the table below gives the results of this study:

Driver	**CAR**			
	1	**2**	**3**	**4**
I	A = 21	B = 26	D = 20	C = 25
II	D = 23	C = 26	A = 20	B = 27
III	B = 15	D = 13	C = 16	A = 16
IV	C = 17	A = 15	B = 20	D = 20

a. Conduct an ANOVA to test the N.H. that there were no significant differences in the emission levels of nitrous oxides among the additives.
b. If the N.H. is rejected, test the differences among the means using LSR.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – FEBRUARY 2007

BS322

ECOLOGY

(THEORY PAPER)

TIME: THREE (3) HOURS

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

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1. *Nelsonia canescens* is a stoloniferous herbaceous plant that reproduces vegetatively through annual ramet production. A census of a population of *Nelsonia canescens* was conducted at Lusaka from 2000 to 2005 that yielded the following demographic data.

Year	2000	2001	2002	2003	2004	2005
Population size (N)	12	31	48	73	157	161

Analyze and discuss the population dynamics of *Nelsonia canescens*.

2. Explain the differences between the biological, morphological and phylogenetic definitions of a species.

3. Discuss plant adaptations in a savanna ecosystem.

4. What is species diversity and how is it measured.

5. Explain possible pathways in the succession and retrogression of dry evergreen forest in Zambia.

6. What is primary production and how can it be measured.

7. How do pyramids of numbers differ from biomass pyramids.

8. Discuss the Competitive Exclusion Principle.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

Second
~~FIRST~~ SEMESTER UNIVERSITY EXAMINATIONS
FEBRUARY, 2007

BS 332
ANIMAL PHYSIOLOGY
PRACTICAL PAPER

Time: Two Hours

Instructions: Answer **ALL** questions.

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1. Enzymes are proteins which catalyse biological reactions. The amylase experiment is suitable to demonstrate these principles in respect of amylase kinetics. Discuss the determinants
of the activity of salivary amylase.

2. Explain, using the Winkler method, how oxygen consumption and body size can be estimated in aquatic animals.

3. (a). What is Hering-Breuer reflex?
   (b). What is the importance of Hering-Breuer reflex?

4. Discuss the effects of the following on the activity of the heart:
   (a). Temperature changes
   (b). Nicotine
   (c). Acetylcholine

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

Second Semester University Examination
March 2007
BS 349 General Microbiology
Practical Paper

DURATION: 3 HOURS

INSTRUCTIONS:
ANSWER ALL QUESTIONS.
USE SPECIFIC EXAMPLES AND ILLUSTRATIONS WHERE POSSIBLE.

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1. (a) Identify the microorganisms labeled **A, B** and **C.** Record your observations. **(30 marks)**

   (b) Explain the difference between the gram positive and gram negative microorganisms. **(5 marks)**

   (c) State what is involved in the interpretation of gram stain smears. **(5 marks)**

2. What is haemolysis? Explain the difference between the three types of haemolysis: α, β and γ. **(20 marks)**

3. Examine specimens **D** and **E** and comment on their motility. **(10 marks)**

4. Inoculate specimen labeled **F** by streaking method.

   (Label the Petri dish with your computer number and incubate) **(20 marks)**

5. The following results were obtained from a BS 349 class practical on dilution plating.

Dilution	Number of colonies	
10^{-2}	542	624
10^{-4}	193	267
10^{-5}	24	19

Estimate the number of viable microorganisms present in the sample which was used for this practical. **(10 marks)**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

Second Semester University Examination
February 2007
BS 349 General Microbiology
Theory Paper

DURATION: 3 HOURS

INSTRUCTIONS:
ANSWER QUESTION 1 FROM SECTION A AND ANY TW0 QUESTIONS FROM EACH OF THE SECTIONS A AND B. ANSWER EACH SECTION IN A SEPARATE ANSWER BOOK.
USE SPECIFIC EXAMPLES AND ILLUSTRATIONS WHERE POSSIBLE.

SECTION A

1. Write an essay on the four phases of the microbial growth curve. **(20 marks)**

2. (a) Discuss the criteria on which nutritional classification of microorganisms is based. **(10 marks)**

   (b) What are the major nutritional types of microorganisms? **(10 marks)**

3. What are bacterial endospores? Describe the process of sporogenesis. **(20 marks)**

4. Write brief notes on each of the following. **(20 marks)**

   (a) Batch culture

   (b) Bacterial S-layer

   (c) Synthetic media

   (d) Co metabolism

   (e) Pasteurization

5. Describe the conditions which influence the effectiveness of an antimicrobial agent activity. **(20marks)**

SECTION B

1. The second edition of Bergey's Manual places the low G + C gram positive organisms in the phylum *Firmicutes* which contains three classes: *Clostridia, Mollicutes* and *Bacilli.*

   (i) List major properties of each class (morphology, metabolism, oxygen requirement and growth characteristics and requirements) **(12 marks)**

   (ii) What is distinctive about the morphology of *Mycoplasma*? **(2 marks)**

   (iii) What practical impact do the following genera have on society and give a representative species. **(6 marks)**

   (a) Bacillus

   (b) Clostridium

   (c) Mycoplasma

2. Describe in detail each stage of animal virus reproduction. **(20 marks)**

3. (i) What important characteristics are used in identifying animal viruses? **(10 marks)**

   (ii) What is meant by cytopathic effects (CPEs) in viral infections? Describe five possible mechanisms of host cell damage. **(10 marks)**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

SECOND SEMESTER UNIVERSITY EXAMINATIONS
FEBRUARY 2007

BS 352
PARASITOLOGY
PRACTICAL PAPER

Time: Three Hours

Instructions:

1. Answer **ALL** questions

2. For each specimen provided, labelled specimen 1 (**S1**) to specimen 11 (**S11**) and provide the following information:

   (a). Species name

   (b). Developmental stage

   (c). Sex (where applicable)

   (d). Vector (where applicable)

   (e). Intermediate host (where applicable)

   (f). Definitive host

   (g). The role it plays in either transmission or pathogenesis

   (h). Type of life-cycle for each species

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS –FEBRUARY, 2007

BS 362 GENETICS (I)

THEORY PAPER

TIME ALLOWED: THREE HOURS

INSTRUCTIONS: Answer **All questions in Section A** and **any three questions from Section B.** Inclusion of relevant diagrams and illustrations will enhance your answer.

SECTION A: Answer all questions. Each question carries a maximum of 10 marks.

1. (a) Briefly explain how geneticists can use nullisomics to identify the chromosomes that carry loci of recessive traits of interest.
   (b) The Duffy blood-group allele Fy^a is absent in Africa but has a frequency of 0.42 in whites and 0.046 among blacks from the state of Georgia. Estimate the rate of migration of genes from the white into the black population in Georgia.

2. 28% of a human population cannot taste the chemical PTC and the rest can. The ability to taste is determined by the dominant allele T and the inability to taste is determined by the recessive allele t. If the population is assumed to be in Hardy-Weinberg,
   (a) What are the allele frequencies?
   (b) What are the genotypic frequencies in this population?
   (c) Estimate the fixation index if the size of the population is 300 individuals.

3. Briefly differentiate between:
   (a) A disomic and a diploid
   (b) An Inbred line and a pedigree line
   (c) Paracentric and pericentric inversions
   (d) Natural and artificial selection

4. Write brief notes on each of the following:
   (a) Competence in bacterial cells
   (b) Life cycle of retroviruses
   (c) Lysogenic cycle of λ phage
   (d) Mechanisms of inbreeding

5. (b) Briefly explain the various methods used in artificial selection
(a) A phenotypic character was analysed in a population of *Drosophila*. The results are summarised as: current population mean = 28.4; variance = 4.3; narrow sense heritability = 0.453; q = 0.1; $z = 0.1758$. Estimate the following:
(i) The intensity of selection, i
(ii) Mean of the selected individuals.
(iii) Mean of the offspring of selected individuals.

6 (a) The total genetic variance of a sample of 180-day-old pigs is 250 kg^2. The variance due to dominance effects is 50 kg^2. The variance due to epistatic effects is 20 kg^2. The environmental variance is 300 kg^2. Calculate:
(i) The broad sense heritability of this trait.
(ii) The narrow sense heritability of this trait.

SECTION B: Answer any two questions. Each question carries 20 marks.

7. The Hardy-Weinberg Law is used by most geneticists in the study of different populations.
(a) What are the assumptions made in the formulation of the hardy-Weinberg Law?
(b) Briefly discuss the consequences due to the failure of the assumptions made in (a) above.
(c) Briefly outline the applications of Hardy-Weinberg Law.

8. (a) Briefly discuss chromosome mutations.
(b) What are the health and agricultural implications of these mutations?

9. *Neurospora* is a fungus used by geneticists to study segregation patterns. Second division segregation in *Neurospora* is used as strong evidence that meiotic crossing-over occurred after chromosome duplication.
(a) What is the logic of this argument?
(b) Why are the parental ditype (PD) and non-parental ditype (NPD) tetrads formed in equal numbers for independently assorting genes in fungi?
(c) Why are NPD tetrads rare for linked genes?
(d) Compare linear (ordered) and unordered tetrads in ascomycete fungi.
(e) (i) Express mean chiasma frequency in terms of the frequencies of the various tetrads in unordered tetrad analysis.
(ii) Estimate the map distance in centimorgans (cM) using the tetrad frequencies.

END OF EXAMINATION – GOOD LUCK

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
BIOLOGICAL SCIENCES DEPARTMENT

Second Semester Examinations 2007

BS 412 -APPLIED ENTOMOLOGY
PRACTICAL PAPER (II)

Time: Three (3) Hours

Instructions: Answer all questions

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1. You are provided with specimens **A, B** & **C.** Identify the specimens naming their use in Pest management. Briefly outline the main advantage of **A** over **B.**

2. Identify the type of damage caused to the plants **P1, P2** and **P3**. Name the pests that cause the damage. What type of insecticide would you recommend for each of the three cases?

3. Specimen **CH-b** and **CH-c** are pesticide formulations. Identify the type of formulations. What are the main differences in their mode of action?

4. You are provided with specimen **D.** Using the key to soldiers, identify this type of specimen. Make a drawing of this specimen and label it using diagnostic characters you used in identifying it. What is the pest status (if any) of this specimen and what kind of control measures would you recommend for this specimen?

5. You are provided with specimen **E.** Using the key to soldiers, identify this type of specimen. Make a drawing of this specimen and label it using diagnostic characters you used in identifying it. What is the pest status (if any) of this specimen and what kind of control measures would you recommend for this specimen?

6. Identify specimen labelled **F**. Write brief notes about diagnostic characters of this specimen. To which category does it belong and what types of crops does it attack?

7. Identify specimen labelled **G**. Write brief notes about its life cycle. What kind of crops does this insect attack?

8. Identify specimen labelled **H**. Write brief notes about the damaging stages, life cycle and typical damage.

9. Identify specimen labelled **I**. Categorise this specimen. Write brief notes about its host (s) and the typical damage it causes to its host(s).

10. Identify specimen labelled **J**. Categorise this specimen. Write brief notes about its damaging stages, hosts and damage.

END OF PRACTICAL EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
BIOLOGICAL SCIENCES DEPARTMENT

Second Semester Examinations 2007

BS 412 -APPLIED ENTOMOLOGY
PRACTICAL PAPER (II)

Time: Three (3) Hours

Instructions: Answer all questions

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1. You are provided with specimens **A, B & C.** Identify the specimens naming their use in Pest management. Briefly outline the main advantage of **A** over **B.**

2. Identify the type of damage caused to the plants **P1**, **P2** and **P3**. Name the pests that cause the damage. What type of insecticide would you recommend for each of the three cases?

3. Specimen **CH-b** and **CH-c** are pesticide formulations. Identify the type of formulations. What are the main differences in their mode of action?

4. You are provided with specimen **D**. Using the key to soldiers, identify this type of specimen. Make a drawing of this specimen and label it using diagnostic characters you used in identifying it. What is the pest status (if any) of this specimen and what kind of control measures would you recommend for this specimen?

5. You are provided with specimen **E**. Using the key to soldiers, identify this type of specimen. Make a drawing of this specimen and label it using diagnostic characters you used in identifying it. What is the pest status (if any) of this specimen and what kind of control measures would you recommend for this specimen?

6. Identify specimen labelled **F**. Write brief notes about diagnostic characters of this specimen. To which category does it belong and what types of crops does it attack?

7. Identify specimen labelled **G**. Write brief notes about its life cycle. What kind of crops does this insect attack?

8. Identify specimen labelled **H**. Write brief notes about the damaging stages, life cycle and typical damage.

9. Identify specimen labelled **I**. Categorise this specimen. Write brief notes about its host (s) and the typical damage it causes to its host(s).

10. Identify specimen labelled **J**. Categorise this specimen. Write brief notes about its damaging stages, hosts and damage.

END OF PRACTICAL EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

SECOND SEMESTER UNIVERSITY EXAMINATIONS
FEBRUARY 2007

BS 432
ADVANCED PARASITOLOGY
THEORY PAPER

Time: Three Hours

Instructions: Answer **FIVE** **(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 answers.

SECTION A

Q.1. **(A).** The erythrocytic stages of malaria parasite lack energy stores and consequently use blood glucose as primary nutrient.

(i). What mechanism of energy generation could be used by malaria parasite to satisfy its energy requirement for its growth in the host's red blood cell?

(ii). Indicate the pathways of glucose degradation by this parasite.

(iii). Where in the parasitic cell does energy metabolism occur?

(iv). What is the major end product of glucose metabolism.

(B). (i). Explain the mode of action of chloroquine on malaria parasite. Support your answer by drawing a diagrammatic representation of its action against malaria parasite.

(ii). Write the chemical structure of chloroquine and state its side-effect.

Q2. (A). (i). Define the cell. Describe a protozoan parasitic cell and give its functions.

(ii). Why must cell membrane be partially permeable?

(B). (i). Differentiate between cilia and flagella.

(ii). Draw and describe the structure of a parasitic flagellum.

(iii). What does the term "9+2" structure refer to?

(C). (i). Mention one available drug for the treatment of early cases of Trypanosomiasis and another drug for the late stage cases.

(ii). State the mode of action of each drug and its side effect.

SECTION B

Q3. (A). (i). Define the term aerobic respiration.

(ii). Discuss and give an example of a parasite which posses aerobic pathway of glucose metabolism for its growth.

(iii). Draw a diagram showing the major pathways of carbohydrates degradation and their end products.

(iv). Where in the parasitic cell does aerobic metabolism occur?

(B). (i). Differences in Folate metabolism in man and protozoa have led to the development of anti malaria drugs. Discuss the mechanism of action, therapentic uses and adverse effects. Support your answer by drawing the tree diagram of folate inhibitors.

Q4. (A). (i). Draw a diagram of the trophozoite of **Trichomonas vaginalis** and label its components.

(ii). To which order and family does this parasite belong?

(iii). Name the enzymes that are involved in the oxidation of pyruvate in this parasite.

(iv). Outline the role of each enzyme you have named.

(v). Where in the cell of **Trichomonas vaginalis** does the oxidation of pyruvate occur?

(B). (i). Mention the names of two (2) drugs that could be used in the treatment of Trichomoniasis, Giardiasis and Amoebiasis.

(ii). Discuss their mode of action and their relative toxicity.

Q5. **(A).** (i). Compare the terms cuticle and tegument.

(ii). Draw and describe a diagramatic representation of the basic tagumental pattern in parasitic platyhelminthes. State its primary functions.

(B). Write short notes on:

(i). Ontogenetic migration

(ii). Hemozoin

(C). (i). Distiguish between control and eradication of parasitic diseases.

(ii). Define the term chemotherapy.

(iii). Explain why the **kinetoplastidae** are insensitive to sulfonamides while **malaria** parasites are not.

SECTION C

Q6. **(A).** (i). Draw a simple diagram to show the structure of the infective metacercaria of **Fasciola hepatica** parasite for the final host.

(ii). Explain briefly why further development of **Fásciola hepatica** metacercaria (the process of excystation and activation) only takes place in the gut of the final host and neither within the tissues of its intermediate host or attached to vegetation.

(B). (i). Discuss the role of molecular parasitology in the control of parasitic diseases.

(ii). What is the drug of choice for Faciola infection? Write its chemical structure.

Q7. **(A).** List the barriers that confront the invasion and establishment of a parasite during its infection of a single host. Indicate in your answer which barriers affect the invasion and which affect the establishment and growth of a parasite.

(B). (i). Explain how the parasite paralysis is achieved by neuromuscular blockers (NMP). Give an example of a drug acts as a neuromuscular blocker. State its use and its side effect.

(ii). Calculate the dose of praziquantel (in terms of tablets) that should be given to treat a patient whose body weight is 80 kg. (Each tablet contains 600 mg Praziquatel).

Q8. (A). Once a parasite has invaded a host's body, it migrates to the chosen target. Migration of a parasite 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.

(B). (i). What is the drug of choice for lymphatic filariasis. Write its chemical structure.

(ii). What is the drug of choice for tape worm infections? State its side effect and its mode of action.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
SECOND SEMESTER UNIVERSITY EXAMINATIONS
FEBRUARY, 2007

BS 435 – MEDICAL MICROBIOLOGY

THEORY PAPER

DURATION: 3 HOURS

INSTRUCTIONS: ANSWER QUESTION 1 AND ANY FOUR

---

1. Peptidoglycan is a vital component of the bacterial cell wall. It is a compound unique to bacteria and provides an optimum target for selective toxicity. Show how the synthetic pathway of the peptidoglycan can be inhibited at a variety of points by beta-lactams, bacitracin, glycoproteins and cycloserine.

[20 marks]

2. a. What are the virulence factors for the major pathogens in bacterial meningitis caused by :
   i. *Neisseria meningitidis* (5 factors)
   ii. *Haemophilus influenzae* (5 factors)
   iii. *Streptococcus pneumoniae* (2 factors)

   b. How are these pathogens recognised and distinguished in the laboratory?

[20 marks]

3. *Escherichia coli*, the major bacterial cause of diarrhoea and of traveller's diarrhoea has distinct groups within the species; enterotoxigenic *E. coli* (ETEC), entropathogenic *E. coli* (EPEC); entroinvasive *E. coli* (EIEC) and enterohemorrhagic *E. coli* (EHEC). Describe the pathogenic mechanism of each group.

[20 marks]

4. Discuss the mode of action and consequences of the following exotoxins
   i. *Corynebacterium diphtheriae* cytotoxin
   ii. *Staphylococcus aureus* erythrotoxin
   iii. *Clostridium tetani* neurotoxin

[20 marks]

5. a. Discuss four ways pathogens are transmitted to humans

   b. Briefly discuss three factors that influence transmission

[20 marks]

6. a. What are prions?

   b. Describe their characteristics and mode of transmission

   c. Give an example of a human and cattle disease caused by them.

   d. What medical problems are posed by prion diseases?

[20 marks]

7. Mycoses are infections caused by fungi. They can be mild or life threatening
   i. categorise the three main types of mycoses
   ii. indicate the anatomical location(s) for each
   iii. give a representative disease
   iv. Name the causative organism of the disease, growth form (yeast or filamentous) and its treatment.

[20 marks]

8. a. Briefly discuss why selective toxicity is an issue in the development of effective antiviral and anti fungal compounds

   b. Comment on the aims of vaccination and on at least three requirements for a good vaccine.

END

THE UNIVERSITY OF ZAMBIA
SECOND SEMESTER EXAMINATIONS

FEBRUARY 2007

BS 442 ADVANCED MOLECULAR BIOLOGY II

THEORY PAPER

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: Answer **all questions from Section A** and **any two questions from Section B**. Inclusion of relevant diagrams, and illustrations will enhance your answer.

SECTION A. Answer ALL questions. Each question carries a maximum of 10 marks.

1. (a) Briefly explain the use of antisense mRNA to transfect tomato.
   (b) What are two of the benefits of this modification?
   (c) Give an example of another crop that can be modified and mention one method that could be used.

2. You have a purified DNA molecule and you wish to map restriction-enzyme sites along its length. After digesting with *Eco*RI, you obtain four fragments: A, B, C and D. After digestion of each of these fragments with *Hin*dII, you find that fragment C yields two sub fragments (C_1 and C_2) and that fragment B yields three sub fragments (B_1, B_2 and B_3). After digestion of the entire DNA molecule with HindII, you recover four pieces: W, X, Y and Z. When these pieces are treated with *Eco*RI, piece Z yields fragments A and C, W yields C_2 and B_1 and X yields B_3 and D. The Y piece is identical with B_2.
   Draw a restriction map of this DNA.

3. Sickle cell anaemia arises from a mutation in the genome for the beta chain of human haemoglobin. The changes from GAG to GTG in the mutant eliminate a cleavage site for the restriction enzyme *Mst* II which recognises the target sequence CCTGAGG.
   These findings form the basis of a valuable diagnostic test for the presence of the sickle cell gene.
   Propose a rapid diagnostic procedure for distinguishing between normal and the mutant gene.

4. Write short notes on any three of the following:
   (a) Test for viable bacteria in food
   (b) *In vitro* oligonucleotide synthesis
   (c) DEAE – dextran method of introducing foreign DNA
   (d) Use of the HSV *tk* gene as a selectable marker

5. (a) An autoradiography of gel containing four lanes of DNA fragments produced by chemical cleavage is shown in the Figure 1 below. The DNA contained a ^{32}P label at its 5' end.

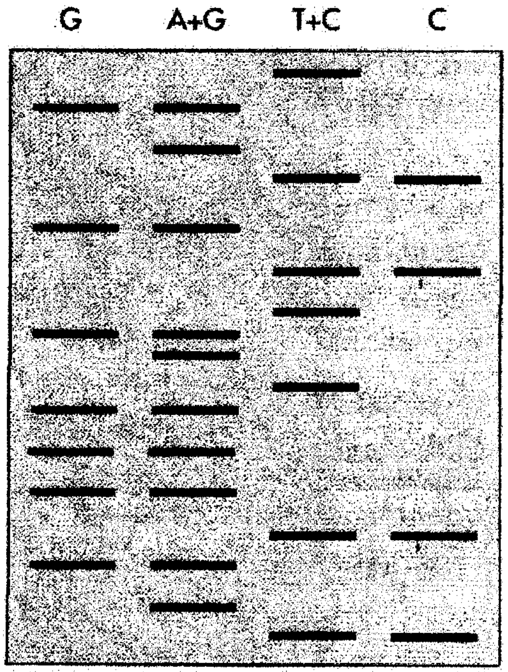

Figure 1. Result of gel electrophoresis of the products of a DNA sequencing reaction.

(i) Work out the sequence of the DNA being analysed.
(ii) What is the complementary sequence of this DNA?

(b) Suppose that you determine the DNA sequence of 5'-TGCCATTGCAC-3' by the Sanger dideoxy method, sketch the gel pattern that revealed the sequence of this oligonucleotide.

6. (a) *Bt* crops are transgenic plants which are resistant to a number of insects.
(i) Briefly explain how these plants are generated.
(ii) What mechanism do they use against insects?

(b) In July 1974, a letter appeared in *Science* urging that scientists considering recombinant DNA experiments should observe a moratorium.
(i) What does the word moratorium mean in this context?
(ii) Why was it necessary for scientists to observe this moratorium?

SECTION B. Answer any TWO questions. Each question carries 20 marks.

7. (a) Write an essay on the phenomenon of somoclonal variation in plant tissue culture.
   (b) Plant breeders make use of interspecfic sexual hybrids to transfer genes between species, but sexual incompatibility severely limits this possibility. Explain how the technology of somatic cell hybridization through protoplast fusion is now used to overcome this problem.

8. Discuss the safety and non safety concerns in the application of recombinant DNA technology. What measures have been taken to address these concerns?

9. Discuss the applications of recombinant DNA technology.

END OF EXAMINATION – GOOD LUCK

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – FEBRUARY 2007

BS445

ECOPHYSIOLOGY OF PLANTS

(PAPER)

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER AT LEAST TWO QUESTIONS FROM EACH SECTION AND USE ILLUSTRATIONS WHEREVER POSSIBLE.

SECTION A

1. Discuss the effects of internal carbon dioxide and nitrogen and their interactions on light-saturated rate of photosynthesis of leaves.

2. What are the unifying characteristics in the three subtypes of CAM? Discuss the ecological importance of CAM.

3. Explain water use efficiency. Contrast the water use efficiency of C_3 and C_4 plants.

4. Discuss the factors limiting soil fertility with respect to mineralization of nitrogen in dry savannahs.

SECTION B

5. Discuss phenological plasticity in some Zambian plants

6. Discuss the adaptive significance of leaf functional traits

7. What climate factors determine tree radial growth in Zambia.

8. Contrast between acute and chronic damage to plants by pollutants.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

FEBRUARY 2007

BS 455.
WILDLIFE ECOLOGY

PAPER TWO (PRACTICAL)

TIME: THREE HOURS

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

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

Specimen A:

(i) Class

(ii) Order

(iii) Family

(iv) Species

Specimen B:

(i) Describe appropriate census methods

(ii) Sexual dimorphism

(iii) Habitat preference

(iv) Describe Food habits

Specimen C:

(i) Give Species Name

(ii) Describe Breeding habits

(iii) Describe Distribution in Zambia

(iv) Describe capturing methods

Specimen D:

(i) Order

(ii) Describe Breeding habits

(iii) Dental formula

(iv) Conservation status

Specimen E:

(i) Scientific Name

(ii) Field impression

(iii) Distribution in Zambia

(iv) Habitat preference

2. You are required to use the map (**Figure 1)** provided to answer this question. Study the map carefully, and then answer the following questions:

(A) Describe in detail each habitat type as indicated by the vegetation types.

(B) List and rank habitats according to the preference of the following species:

(a) Tragelaphus spekei
(b) Equus burchelli
(c) Syncerus caffer
(d) Allopochen aegyptiacus
(e) Oreotragus oreotragus

3. Zambezi - Samaki Farms Ltd is considering establishing a Game Ranch in the Choma District along the Munyeki stream. Initial investigations show that the range is suitable for Impala, Zebra, Wildebeest, Kudu and Buffalo. The range is relatively flat, well watered and nearly all the range is within 3.5km from water. Based on the information from the Ministry of Agriculture, Food and Fisheries (MAFF) in Choma, the soils are generally excellent for the game ranch. Also results from your preliminary estimates indicate that the production of key forage species averages about 200kg/ha of dry matter per year. The proposed Sanctuary is 10,000 ha in size. Assuming that allowable use is 25% and daily dry matter intake is 2% of the animal body weight (a) how many 230 kg Sable antelopes can you stock as your base herd in the area and (b) Discuss the procedure for establishing a Game Ranch in Zambia, and discuss limitations associated with game farming in the country.

4. State the main advantages and disadvantages of using mechanical animal capture method, and discuss difficulties associated with the translocation and restocking operations in wildlife management.

End of Examination

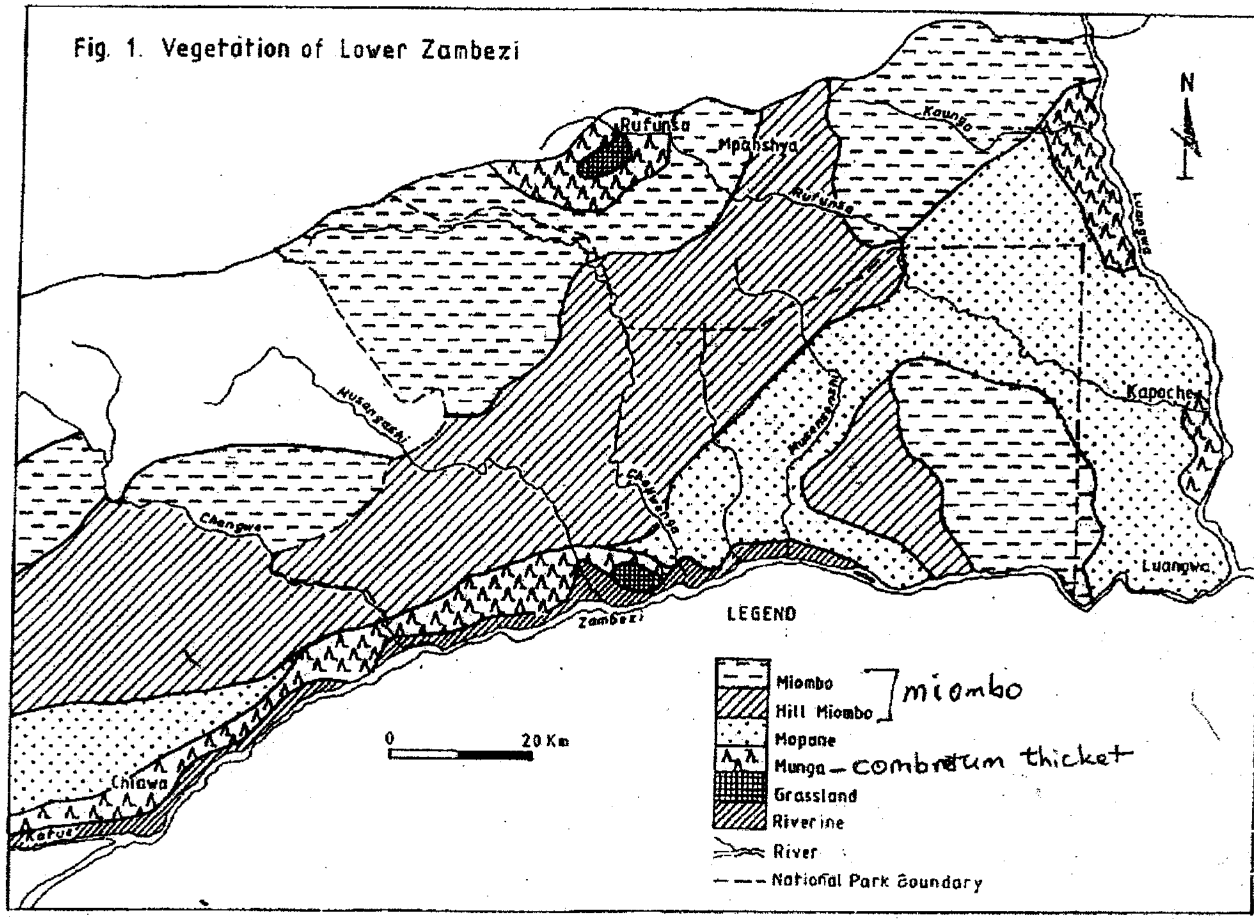

Figure 1: Map of Lower Zambezi for Question 2

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

FEBRUARY, 2007

BS 455
WILDLIFE ECOLOGY

PAPER ONE (THEORY)

TIME: THREE HOURS

INSTRUCTIONS: QUESTION **ONE(1)** IS COMPULSORY. ANSWER QUESTION **ONE (1)** AND **FOUR(4)** OTHERS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY.

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1. Carefully study **Figure 1** provided and answer the following questions:

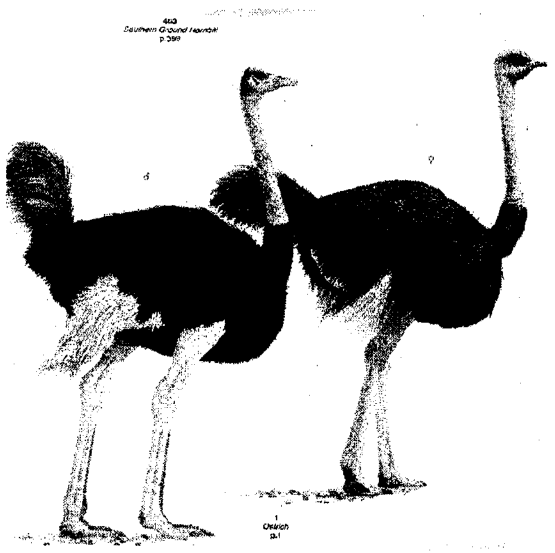

Figure 1 for question 1

a) Name the Order to which the species belongs
b) Give Scientific Name
c) Describe its habitat
d) Describe its feeding habits
e) Describe its breeding habits

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

(i) $1 - \mathbf{e}^{-H}$
(ii) Gross Energy
(iii) *Panthera pardus*
(iv) *Numida meleagris*
(v) Animal Unit

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

4. 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 in the exploitation of wildlife species.

5. Two hundred (200) skulls of Kafue Lechwe (*Kobus leche kafuensis*) were collected and aged as follows:

Age	0	01	02	03	04	05	06	07	08	09	10	10+
Skulls	97	13	15	11	13	4	5	11	14	9	6	2

From this information, **(i)** Construct a life table of the population and **(ii)** Assuming that $\mathbf{m_x}$ for the species is known to be 0.5 for all age classes except for ages 0 and 1. Determine $\mathbf{r_m}$ for the species population.

6. A rodent survey in the Nampundwe area used a capture-recapture method to determine the population of the Cane Rat (*Thryonomys swinderianus).* Twenty (20) traps were set at different points along each transect in the area for 2 occasions, and each captured rat was marked and released. The following data were obtained. (i) Using the Lincoln – Petersen method, calculate the populations of the rat in the area, and (ii) Discuss the differences between this method and the Schnabel method in assessing wildlife populations.

TRAPS	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Initial Capture	6	9	23	14	18	7	3
Second Capture	12	13	11	9	15	10	12
Recaptures	3	8	3	5	7	4	2

End of Examination

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
SECOND SEMESTER UNIVERSITY EXAMINATIONS
FEBRUARY, 2007

BS 482 – FOOD MICROBIOLOGY

THEORY PAPER

DURATION: 3 HOURS

INSTRUCTIONS: ANSWER ANY 5 QUESTIONS
ALL QUESTIONS CARRY EQUAL MARKS

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1. a. Explain how the following factors: temperature, relative humidity and physical structure of a food affect (i) the growth of microorganisms (ii) the course and extent of spoilage of food

   b. When does spoilage occur in a food commodity?

   c. What are the results of fungi growing on grains (e.g. maize)?

   d. Define food safety

2. A small number of chemicals are widely used in food protection to prevent or delay the spoilage of foods and are generally recognised as safe (GRAS). Provide the following information:(i) chemical composition (ii) permissible levels in foods (iii) organisms affected and mode of inhibition and (iv) the type of food in which they are used, on the following chemicals that are usually used
   a. Benzonic acid/benzoates
   b. Propionic acid/propionates
   c. Sorbic acid/sorbates
   d. Sodium nitrate

3. Write short notes on
   i. infections of grain by the ascomycete *Claviceps purpura*
   ii. Blanching of foods, how it is achieved and its primary function
   iii. The three groups of lactobacilli and give examples of species
   iv. Commercial cultured buttermilk (indicate starter cultures)
   v. Probiotics

4. Suggest reason(s) why foods are pasteurized a single time and why it is recommended that frozen food once thawed not be frozen again. What would be the consequence of repeated pasteurization and of refreezing?

5. a. Match the following procedures of food preservation with the factors influencing growth or survival

Procedure	Factor influencing growth or survival
1. Pasteurization and appertization	**a.** Low temperature to retard growth
2. Lactic fermentation	**b.** Low temperature and reduction of water to prevent growth
3. Addition of preservatives	**c.** Reduction in water activity sufficient to delay or prevent growth
4. Drying, curing and conserving	**d.** Inhibition of specific groups of microorganisms
5. Cooling chill distribution and storage	**e.** Reduction of pH value in situ by microbial action and sometimes additional inhibition by the lactic and acetic acids formed and by other microbial products e.g. ethanol, bacteriocins
6. Frozen distribution and storage	**f.** Delivery of heat sufficient to inactivate target microorganisms to the desired extent
	g. Delivery of ionizing radiation at a dose sufficient to inactivate target microorganisms to the desired extent

b. what is the objective of the following heat process[es] applied to foods?

1. Cooking (including baking, boiling, frying and grilling)
2. Drying

6. a. Discuss the importance of mesophilic and psychrotrophic organisms in food microbiology

   b. What problems do thermophiles pose in relation to food protection and what are some characteristics of thermophiles

7. Discuss the organism *Clostridium botulinum* its characteristics, pathogenesis and clinical features of the disease caused, isolation and identification and association with foods

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THE END

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGICAL SCIENCES

Second Semester Examinations **February 2007**

BS 492 Fisheries Biology **Theory Paper**

Maximum Time allowed **Three Hours**

Instructions

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

SECTION A

Q1 Define the following symbols as used in fish population assessments and explain how each of the parameters indicated by each symbol could be estimated:

i) B
ii) E
iii) CPUE
iv) Z
v) t_c

Q2 Briefly describe the following fishery management measures or systems and indicate advantages and disadvantages for each fishery management system.

i) Adaptive Fishery Management
ii) Centralized fishery management System
iii) Closed fishing season
iv) TAC
v) Limiting number of fishing units

SECTION B

Q3 List and describe methods that can be used to estimate absolute abundance of fish stocks. Indicate advantages and disadvantages if any for each method described.

Q4 Describe various types of fish stock migrations. Explain how fish stock migrations are related to survival strategies of fish stocks

Q5 Fishing methods are usually grouped into two categories. Name the methods that are found in each category and indicate the types of fish that are caught by each of the methods described.

END OF THE EXAMINATION

ID#

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER EXAMINATIONS

DEFERRED EXAMINATIONS

March, 2007

BS 925
TERRESTRIAL VERTEBRATE BIOLOGY

PAPER TWO (PRACTICAL)

TIME: **THREE HOURS**

INSTRUCTIONS: ANSWER ALL QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY.

EXAMINATION ANSWER BOOK
For Question One(1)

CANDIDATE'S COMPUTER EXAMINATION

NUMBER..

1. Full-time or Part –time..

2. Qualifications for which registered......................................

3. Course number......................

4. Date of Examination.........................

ID #

QUESTION S 1- 25

Complete each statement by answering the question for each specimen examined from **1 to 25,** and use the answer sheet provided.

SPECIMEN 1:

a) Class ______________________________

b) Family ______________________________

SPECIMEN 2:

a) Species ______________________________

b) Reproductive habits

SPECIMEN 3: Give the main differences between specimen (a) and Specimen (b)

:

SPECIMEN 4:

a) Genus ______________________________

b) Species ______________________________

ID #

SPECIMEN 5:

a) Order ______________________________

b) Family ______________________________

SPECIMEN 6:

a) Class ______________________________

b) Species ______________________________

SPECIMEN 7:

Dental formula ______________________________

____

SPECIMEN 8:

a) Class ______________________________

b) Feeding habits: ______________________________

SPECIMEN 9: Respiratory mechanism:

ID #

SPECIMEN 10:
Dental characteristics:

SPECIMEN 11:
a) Order ____

b) Species ____

SPECIMEN 12: Give the main differences between specimen (i) and specimen (ii)

ID #

SPECIMEN 13: Give the main characteristics that distinguish specimen (a) from Specimen (b)

SPECIMEN 14: Give the main characteristics that distinguish specimen (a) from Specimen (b)

SPECIMEN 15:)

Order ____

Species ____

ID #

SPECIMEN 16:

Order____

Species____

SPECIMEN 17: Draw and label dorsal view of this specimen

SPECIMEN 18:

Class____

Family____

ID #

SPECIMEN 19:

a) Class ____

b) Order ____

SPECIMEN 20; Construct a key for identifying this specimen

ID #

SPECIMEN 21;

Species____

Economic importance:

SPECIMEN 22; Method of collection and preservation

ID #

SPECIMEN 23;

Scientific Name:____

Habitat____

SPECIMEN 24: Draw and label the dorsal head region of the specimen

SPECIMEN 25: Uro-Genital System

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
UNIVERSITY EXAMINATIONS – SEMESTER II-2006

INTRODUCTORY CHEMISTRY II – C102

15 FEBRUARY, 2007

DURATION: Three (3) Hours

INSTRUCTIONS TO THE CANDIDATES

1. Indicate your **STUDENT ID NUMBER (ONLY) and TG number** on ALL your answer booklets.

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

3. Section **A** has ten **(10)** short answer questions (Total marks = **40)**

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

5. **ANSWER ALL QUESTIONS IN SECTION A; AND ANSWER <u>B1</u> AND ANY OTHER THREE (03) QUESTIONS IN SECTION B.**

6. **ANSWER SECTION A QUESTIONS IN ONE BOOKLET AND SECTION B QUESTIONS EACH IN A SEPARATE ANSWER BOOKLET.**

7. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY**

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

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

Department of Chemistry-UNZA

SECTION A ANSWER ALL QUESTIONS

A1 Sketch graphs of the rate against concentration to indicate the order with respect to reactant A for:

(i) Zero order reaction

(ii)Second order reaction

[4 Marks]

A2 The rate of combustion of hexane according to the following reaction was found to be 1.20 $M^{-1}s^{-1}$.

$$2C_6H_{14} + 19\,O_2 \longrightarrow 12CO_2 + 14H_2O$$

Calculate the rate of formation of CO_2.

[4 Marks]

A3. Solid sodium iodide is slowly added to a solution containing 0.01 M Ag^+ ion and 0.01 M Cu^+ ion.

(a) Which compound will begin to precipitate first?

(b) Calculate the $[Ag^+]$ when CuI just begins to precipitate.

K_{SP} of AgI = 8.3×10^{-17} and K_{SP} of CuI = 5.1×10^{-12}.

[4 Marks]

A4 Calculate the concentration and pH of all species in a 0.10 M solution of hypochlorous acid (HOCl) whose $K_a = 3.5 \times 10^{-8}$.

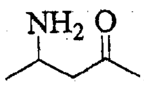
[4 Marks]

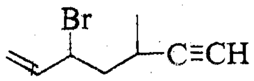
A5. What explanation can you give for the differences in properties of diethyl ether (CH_3OCH_3) and ethanol (CH_3CH_2OH) which have the same molecular formular?

[4 Marks]

A6. One of the various manganese oxides crystallizes with a cubic unit cell that contains manganese ions at the corners and in the centre. Oxide ions are located at the centre of each of each edge of the unit cell. What is the formula of the compound? **[4 Marks]**

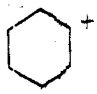
A7. Provide IUPAC names for the following compounds:

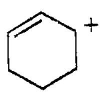
(a) 

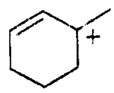
(b) 

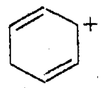
[4 Marks]

A8. (a) Arrange the following molecular species in order of increasing stability.


(i)


(ii)


(iii)


(iv)

(b) Draw the geometric representation of the carbocationic carbon in the reactive species, $^{+}CH_2CH = CH_2$

[4 Marks]

A9. Ketenes are highly reactive. Highly reactive species, are frequently used for synthesis of a class of biologically active compounds called beta-lactams. Describe the types of bonds present in the ketene A, structure shown below.

Ketene A: $CH_3HC = C = O$

[4 Marks]

A10. Give the structures of five constitutional isomers represented by the molecular formula C_3H_6O. **[4 Marks]**

SECTION B **ANSWER B1 AND ANY OTHER THREE(3) QUESTIONS**

B1. In the measurement of equilibrium constant (Laboratory Experiment 3) the equilibrium reaction between SCN^- and Fe^{3+} ions proceeds as:

$$Fe^{3+} + SCN^- \rightleftharpoons FeSCN^{2+}$$

(a) (i). Explain why large excess of Fe^{3+} ions were added to a relatively low concentration of SCN^- ions in preparation tube 1?

(ii). Describe a simple colorimetric method used in the above indicated experiment.

(iii). What are the principal sources of error in this experiment?

(b) The Laboratory test-experiment involved investigation of kinetics of reaction below:

$$H_2O_{2\,(aq)} + 2I^-_{(aq)} + 2\,H^+_{(aq)} \longrightarrow 2\,H_2O_{(l)} + I_{2\,(aq)}$$

(i). Explain why small fixed amount of the sodium thiosulphate solution is added to the reaction mixture?

(ii). Why is the volume of water used in each experiment varied?

(iii). What is an oxidation number of oxygen in H_2O_2 and in H_2O?

[15 Marks]

B2. Tetrafluoroethene, C_2F_4, is obtained from chlorodifluoromethane, $CHClF_2$, according to the equation:

$$2CHClF_2(g) \rightleftharpoons C_2F_4(g) + 2HCl(g) \qquad \Delta H = +128\ kJ\ mol^{-1}$$

(a) A 1.0 mol sample of $CHClF_2$ is placed in a container of volume 18.5 dm^3 and heated. When equilibrium is reached, the mixture contains 0.20 mol of $CHClF_2$.

(i) Calculate the number of moles of C_2F_4 and the number of moles of HCl present at equilibrium.

(ii) Write an expression for K_c for the equilibrium.

(iii) Calculate a value for K_c.

(iv) Calculate K_c for the following reaction:

$$CHClF_2(g) \rightleftharpoons \tfrac{1}{2}C_2F_4(g) + HCl(g)$$

(b) (i) State and explain, how the temperature should be changed at constant pressure to increase the equilibrium yield of C_2F_4

(ii) State and explain how the total pressure should be changed at constant temperature to increase the equilibrium yield of C_2F_4

[15 Marks]

B3 (a) Using the experimental rate constant data below, calculate the activation energy, E_a.

Rate constant, k ($M^{-1}s^{-1}$)	11.590	1.670
T, (K)	1125	1053

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

(b) What are the mole fractions of HNO_3 and water in a concentrated nitric acid solution (68.0 % HNO_3 by mass)?

(c) When 0.400 g of an unknown covalent compound is dissolved in 40.0 g of water, the resulting solution freezes at -0.465 °C. What is the molecular mass of the compound? K_f (H_2O) = 1.86 °C/molal and the freezing point of pure water is 0.00 °C.

(d) Calculate the osmotic pressure of 50.0 g of an enzyme of molecular mass of 98,000 g mol^{-1} dissolved in 2.600 dm^3 of benzene at 30.0 °C.

[15Marks]

B4. (a) Calculate the pH of 0.0010 M solution of C_5H_5NHI. K_b for $C_5H_5N = 1.7 \times 10^{-9}$.

(b) Calculate the concentrations of all species in a solution of 0.010 M phthalic acid using H_2A to represent the acid. $K_{a1} = 1.1 \times 10^{-3}$ and $K_{a2} = 3.9 \times 10^{-6}$.

(c) 0.010 mole of solid NaOH is added to 1 liter of a buffer that is 0.10 M in CH_3COOH and 0.10 M in CH_3COO^-. What will be the pH change as a result? Assume no volume change as a result of addition of soild NaOH. K_a (CH_3COOH) = 1.8×10^{-5}.

[15Marks]

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURALSCIENCES
UNIVERSITY EXAMINATIONS –SEMESTER II-2006

INTRODUCTORY CHEMISTRY II – C102

15 FEBRUARY, 2007

DURATION: Three (3) Hours

INSTRUCTIONS TO THE CANDIDATES

1. Indicate your **STUDENT ID NUMBER (ONLY) and TG number** on ALL your answer booklets.

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

3. Section **A** has ten **(10)** short answer questions (Total marks = **40)**

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

5. **ANSWER ALL QUESTIONS IN SECTION A; AND ANSWER <u>B1</u> AND ANY OTHER THREE (03) QUESTIONS IN SECTION B.**

6. **ANSWER SECTION A QUESTIONS IN ONE BOOKLET AND SECTION B QUESTIONS EACH IN A SEPARATE ANSWER BOOKLET.**

7. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY**

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

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

SECTION A

ANSWER ALL QUESTIONS

A1 Sketch graphs of the rate against concentration to indicate the order with respect to reactant A for:

(i) Zero order reaction

(ii) Second order reaction

[4 Marks]

A2 The rate of combustion of hexane according to the following reaction was found to be 1.20 $M^{-1}s^{-1}$.

$$2C_6H_{14} + 19\,O_2 \longrightarrow 12CO_2 + 14H_2O$$

Calculate the rate of formation of CO_2.

[4 Marks]

A3. Solid sodium iodide is slowly added to a solution containing 0.01 M Ag^+ ion and 0.01 M Cu^+ ion.

(a) Which compound will begin to precipitate first?

(b) Calculate the $[Ag^+]$ when CuI just begins to precipitate.

K_{SP} of AgI = 8.3×10^{-17} and K_{SP} of CuI = 5.1×10^{-12}.

[4 Marks]

A4. Calculate the concentration and pH of all species in a 0.10 M solution of hypochlorous acid (HOCl) whose $K_a = 3.5 \times 10^{-8}$.

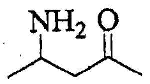
[4 Marks]

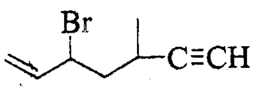
A5. What explanation can you give for the differences in properties of diethyl ether (CH_3OCH_3) and ethanol (CH_3CH_2OH) which have the same molecular formular?

[4 Marks]

A6. One of the various manganese oxides crystallizes with a cubic unit cell that contains manganese ions at the corners and in the centre. Oxide ions are located at the centre of each of each edge of the unit cell. What is the formula of the compound? **[4 Marks]**

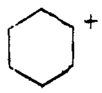
A7. Provide IUPAC names for the following compounds:

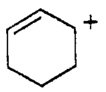
(a) 

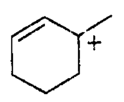
(b) 

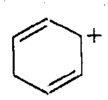
[4 Marks]

A8. (a) Arrange the following molecular species in order of increasing stability.


(i)


(ii)


(iii)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(b) Draw the geometric representation of the carbocationic carbon in the reactive species, $^{+}CH_2CH = CH_2$

[4 Marks]

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A10. Give the structures of five constitutional isomers represented by the molecular formula C_3H_6O. **[4 Marks]**

SECTION B **ANSWER B1 AND ANY OTHER THREE(3) QUESTIONS**

B1. In the measurement of equilibrium constant (Laboratory Experiment 3) the equilibrium reaction between SCN^- and Fe^{3+} ions proceeds as:

$$Fe^{3+} + SCN^- \rightleftharpoons FeSCN^{2+}$$

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(ii). Describe a simple colorimetric method used in the above indicated experiment.

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(ii). Why is the volume of water used in each experiment varied?

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[15 Marks]

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(iii) Calculate a value for K_c.

(iv) Calculate K_c for the following reaction:

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(b) (i) State and explain, how the temperature should be changed at constant pressure to increase the equilibrium yield of C_2F_4

(ii) State and explain how the total pressure should be changed at constant temperature to increase the equilibrium yield of C_2F_4

[15 Marks]

B3 (a) Using the experimental rate constant data below, calculate the activation energy, E_a.

Rate constant, k ($M^{-1}s^{-1}$)	11.590	1.670
T, (K)	1125	1053

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

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(c) When 0.400 g of an unknown covalent compound is dissolved in 40.0 g of water, the resulting solution freezes at -0.465 °C. What is the molecular mass of the compound? K_f (H_2O) = 1.86 °C/molal and the freezing point of pure water is 0.00 °C.

(d) Calculate the osmotic pressure of 50.0 g of an enzyme of molecular mass of 98,000 g mol^{-1} dissolved in 2.600 dm^3 of benzene at 30.0 °C.

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B4. (a) Calculate the pH of 0.0010 M solution of C_5H_5NHI. K_b for $C_5H_5N = 1.7 \times 10^{-9}$.

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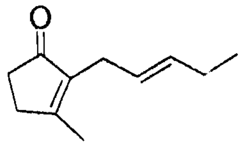
(c) 0.010 mole of solid NaOH is added to 1 liter of a buffer that is 0.10 M in CH_3COOH and 0.10 M in CH_3COO^-. What will be the pH change as a result? Assume no volume change as a result of addition of soild NaOH. $K_a (CH_3COOH) = 1.8 \times 10^{-5}$.

[15Marks]

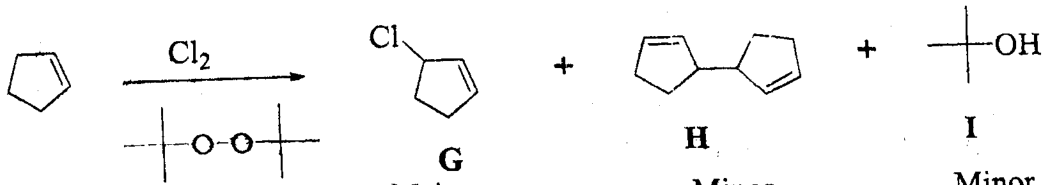
B5. (a) *cis*-Jasmone, an important constituent of perfumes, was treated with excess bromine in carbon tetrachloride (CCl_4) at 25 ^0C. Predict the major organic product and give mechanism of this reaction.

***cis*-Jasmone:**



(b) Loss of a proton from cyanic acid (H – O – C ≡ N) yields the same anion as that obtained by loss of a proton from isocyanic acid (H – N = C = O). Provide an explanation for this observation.

(c) Treatment of cyclopentene with chlorine in presence of tertiary-butyl peroxide [$(CH_3)_3$ C –O-O – C $(CH_3)_3$], gave three products shown below.



Based on your understanding of radical mechanism for halogenation, suggest mechanisms of the reactions involved in the formation of the minor products **H** and **I** in the above reaction.

[15Marks]

END OF EXAMINATION

The University of Zambia

University Examinations

Semester II 2006 Academic year

Introductory Biochemistry C212

Instructions to Candidates:

Write your computer number on ALL answer booklets

There are two (2) sections in this examination paper; Section A and Section B.

Read the instructions for each section carefully.

Time: THREE (3) Hours

You are required to present your work neatly and in logical order.

IMPORTANT DATA

pKa Values of Amino acids

Amino acid	α-pKa1	α-pKa2	R group pKa
Lysine	2.2	9.0	10.5
Phenylanine	1.8	9.1	
Glutamate	2.2	9.7	4.3
Serine	2.2	9.2	
Histidine	1.8	9.2	6.0
Proline	2.0	9.2	
Glycine	2.3	9.6	

pKa of tris =8.08

1Å=10^{-10}m or 10^{-8}cm

Amino acid ($Mwt_{average}$ =110 Daltons)

P.T.O

Section A **Answer All Questions (10 Marks Each)**

A1 a) Many biochemical experiments are conducted in buffered solutions. Explain how you will prepare 500ml of a tris buffer starting with 0.075 moles of tris and 50ml of 1.0M HCl What is its pH? [5]

b) Calculate the degree of deprotonation of the side chain of His at pH 7.0. [5]

A2 Rank the following amino acids based on how strongly they bind to an anion exchanger at pH 7.0 and pH 11.0
Lys, Glu and Ser [10]

A3 a) State the second Law of thermodynamics in six different ways. What eventually does it say about natural processes? [6]

b) Define any two of the following
  i. A reversible process
  ii. A cyclic process
  iii. Gibbs free energy
  iv. An erg [4]

A4 a) List any three properties of the element carbon that make it best suited to support life? [3]

b) Draw full structures of the fatty acids $18:2^{\Delta 9,12}$ and $18:3^{\Delta 9,12,15}$. What is the common name of a fatty acid with two double bonds? [7]

Section B **Answer Any Three Questions (20 Marks Each)**

B1 a) Within a single paragraph (up to 80 words), design a simple experiment that a C212 student can use to estimate the amount and purity of DNA. [10]

b) Given that the average molecular weight of complementary deoxyribonucleotide pairs is 618 Daltons and that the rise per nucleotide base pair is 3.4Å, calculate

i. The length of double stranded DNA of molecular weight 3×10^7 Daltons

ii. The volume occupied by this DNA molecule if it external diameter is 20×10^{-8} cm. [10]

B2 a) What is the significance of periodate oxidation in carbohydrate chemistry? An α-methyl hexose derivative consumes 2 moles of periodate and releases 1 mole of formate. Draw the Haworth structure of the original hexose sugar giving its systematic name. [8]

b) A trisaccharide was found to contain galactose and glucose in a 2:1 ratio. The original trisaccharide was reduced by $NaBH_4$ followed by exhaustive methylation with CH_3I. Acid hydrolysis and another reduction by $NaBH_4$ then followed. Acetylation with acetic anhydride gave the following products: 2,3,4,6-tetramethyl-1,5-diacetylgalactitol, 2,3,4-trimethyl-1,5,6-triacetylgalactitol and 1,2,3,5,6-pentamethyl-4-acetylsorbitol. Deduce the structure of the trisaccharide from this information [12]

B3 a) Write short notes on

i. Salting out.
ii. Triple collagen helix.
iii. Pro and Gly

[6]

b) A 70 kilo Dalton protein was found to contain 80% α-helix and 20% β-pleated sheet. If four amino acids are used in the β turn to give an equal number of amino acid residues in the β sheet, estimate the total length of this protein assuming it's completely stretched. [4]

c) Discuss the classical experiment of Christian Anfinsen. Using your C212 laboratory experience, what technique can be used to separate urea and β-mercaptoethanol from the denatured protein? What is the basis of the technique? [10]

B4 a) Distinguish with separate equations and diagrams between the three types of reversible inhibition. By using a single diagram, show how the three types of reversible inhibition can be identified. [10]

d) How would you determine the quantity of the following substances in biologic fluids?

i. Blood Urea Nitrogen
ii. Alcohol
iii. Glucose

[6]

e) Using a table, show four (4) ways in which enzymes may be used as therapeutic agents. [4]

END OF C212 FINAL EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY
2006 ACADEMIC YEAR, SECOND SEMESTER
FINAL EXAMINATIONS
C 225: ANALYTICAL CHEMISTRY 1
FEBRUARY 2007.

TIME: 3 HOURS.

ANSWER QUESTION 1 AND ANY 3 OTHERS IN THIS PAPER.

1. a). Vitamin B_2 is determined in a cereal samples by measuring its fluorescence intensity in 5% acetic acid solution. A calibration curve was constructed using fluorescence intensities of a series of standards of increasing concentration. The data is:

Fluorescence Intensity (I):	0.00	5.80	12.20	22.30	43.30
Riboflavin (mg/ml):	0.000	0.100	0.200	0.400	0.800

Use the method of lest squares to determine:

i). the best straight line for the calibration curve

ii). calculate the concentration of riboflavin for fluorescence intensity of 28.4

b). Calcium in blood is determined by two methods (AAS; and, a new Colorimetric method). The data is as follows:

AAS (mg/dL) : 10.9, 10.1, 10.6, 11.2, 9.7, 10.0

Colorimetry (mg/dL): 9.2, 10.5, 9.7, 11.5, 11.6, 9.3, 9.3, 10.1, 11.2

Determine whether there is significant difference in the precision of the two methods at 95% confidence level.

c). A batch of cough mixture bottles was weighed to determine if they fell within acceptable standard control guidelines. The individual weights were: 127.2; 128.4; 127.1; 129.0 and 131.1 g.

i). Calculate the mean ii). Determine whether the last weight is an outlier datum at 99% CL

2. a). A standard solution of hydrochloric acid (0.100 N) was used to standardise sodium hydroxide solution. Exactly 25 mL of the base was transferred to a beaker, some phenolphthalein indicator was added, and titration was performed. To reach end-point, 26.03 mL of the acid was used. What is the normality of the sodium hydroxide?

b). A solution contains 75.0 ppm of dissolved $NaNO_3$. Calculate the concentration of nitrate in ppb.

c). If 6.28 g of $KHC_2O_4.H_2C_2O_4$ (three ionisable protons) having 15% inert impurities, and 8.02 g of $KHC_8H_4O_4$ (one ionisable proton) are dissolved in water and diluted to 250 cm^3, calculate the normality of the solution assuming complete ionisation.

d). A solution contains 2.50×10^{-4} M $Cu(NO_3)_2$. What is the concentration of NO_3^- in this solution (in ppm) given that $Cu(NO_3)_2$ is a strong electrolyte.

3. a). The first and second acidity constants of H_2S are 10^{-7} and 10^{-15} respectively. Calculate:

   i. the equilibrium constant (K_a) for the reaction $H_2S + 2H_2O \rightarrow 2H_3O^+ + S^{2-}$

   ii. the concentration of S^{2-} ion in a 0.1 M H_2S solution at pH 2.

   iii. What is meant by the term 'triprotic'?

   iv. Write appropriate equations for the first two dissociation constants of H_3AsO_4

   b). Determine the pH values for the titration curve pertaining to the titration of 30 mL of 0.050 M NH_3 with 0.050 M HCl after 45 mL has been added.

   c). What is the pH and degree of hydrolysis of a 0.10 M solution of sodium acetate, (Na $C_2H_3O_2$)? for acetic acid, $K_a = 1.75 \times 10^{-5}$

   d). If 0.05 mole of NH_4Cl is added per litre of solution to a 0.01M aqueous ammonia solution (for NH_3, $K_b = 1.75 \times 10^{-5}$). Calculate the concentration of hydronium ion in the resulting solution

4. a). Write balanced equations, and decide which of the following may be regarded as redox reactions, stating your reasons:

   i. $2Ag + Cl_2 \rightarrow 2AgCl$

   ii. $FeCl_3 + SnCl_2 \rightarrow FeCl_2 + SnCl_4$

   b). Name two differences between iodimetric and iodometric titrations

   c). When sodium hypochlorite (NaOCl) and lead nitrate ($Pb(NO_3)_2$) solutions are boiled together in water, two of the three products formed are common salt and nitric acid.

   i. write a balanced ionic equation for the reaction

   ii. identify the oxidant and reductant

   iii. if 0.00513 mol of sodium hypochlorite was used, how many milligram of salt will be produced?

5. a). i). Distinguish between the solubility and solubility product of silver chloride.

   ii). Barium iodate, $Ba(IO_3)_2$, is a sparingly soluble salt with solubility product of 1.3×10^{-10}. Calculate the concentration of $Ba(IO_3)_2$ in:

   1) Water
   2) 0.05M $BaCl_2$
   3) 0.05M KIO_3

   b). Determine whether a precipitate will form if: 0.01M

   i). 20 mL of 0.01M $AgNO_3$ is added to 80 mL of K_2CrO_4 (K_{sp} for $Ag_2CrO_4 = 1.7 \times 10^{-12}$)

   ii). 0.05 mg $AgNO_3$ is added to 2 dm^3 of 0.0001 M NaCl (K_{sp} for AgCl $= 1.0 \times 10^{-10}$)

   c). What is the Mohr titration?

   i). Why is pH control vital during the procedure?

   ii). What type of indicator is used for end-point detection, and what substance is used to control pH?

   d). i) What is the overall complex formation equilibrium constant (K_f) for the reactions: $Fe^{3+} + SCN^- \rightarrow Fe(SCN)^{2+}$ ($K_{f1} = 890$) and $Fe(SCN)_2^+ + SCN^- \rightarrow Fe(SCN)_2^+$ ($K_{f2} = 2.6$)

   ii). Calculate the value of K_d for the above equilibrium

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY SEMESTER II EXAMINATIONS- FEBRUARY 2007

C252: ORGANIC CHEMISTRY II

TIME ALLOWED: THREE (3) HOURS

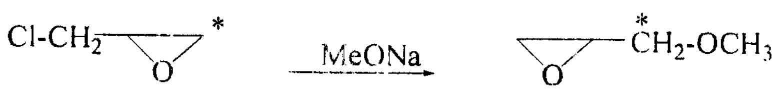
MAX. MARKS: 120

INSTRUCTIONS:

1. **ANSWER ANY FOUR (4) QUESTIONS. EACH QUESTION CARRIES THIRTY MARKS (30).**
2. **PRESENT YOUR ANSWERS IN A LOGICAL MANNER.**

Question 1

(a). Treatment of epichlorohydrin **A**, labeled with ^{14}C as shown by asterisk, with sodium methoxide gave an epoxide **B** bearing the carbon label (^{14}C) as shown below:

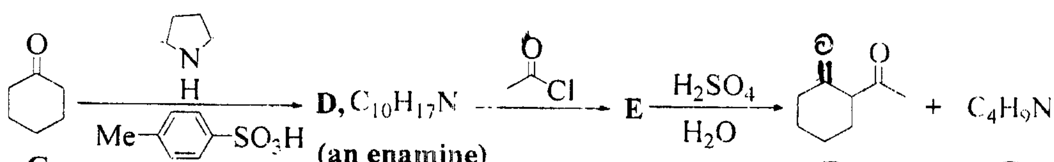


A (Epichlorohydrin) **B (an epoxide)**

(i) Propose a mechanistic explanation for this experimental result.

(ii) Give a synthesis of epichlorohydrin **A** from labeled propene, $^{*}CH_2 = CHCH_3$. State the reagents, including the solvents, and reaction conditions for each step of your synthesis. **[12 Marks]**

(b). Enamines are important reactive intermediates in organic synthesis. A synthetic route to 1,3-diketones via enamines is illustrated below:



C **F** **G**

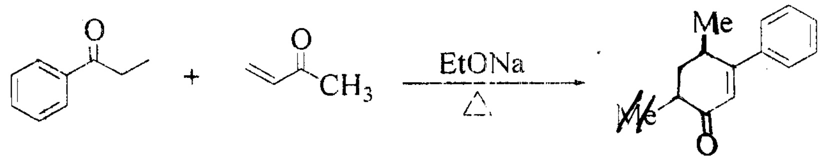
(i) Identify the intermediates **D** and **E**.

(ii) Give mechanisms of all steps involved in the formation of the intermediates **D** and **E** in the above synthesis.

(iii) Based on your understanding of the reactions of carbonyl compounds with nitrogenous nucleophiles, predict the major organic product you would expect to be formed, if compound **F** was refluxed with 1,2-diaminoethane in ethanol in presence of traces of concentrated sulfuric acid. *Reaction mechanisms are not required to be shown.* **[18 Marks]**

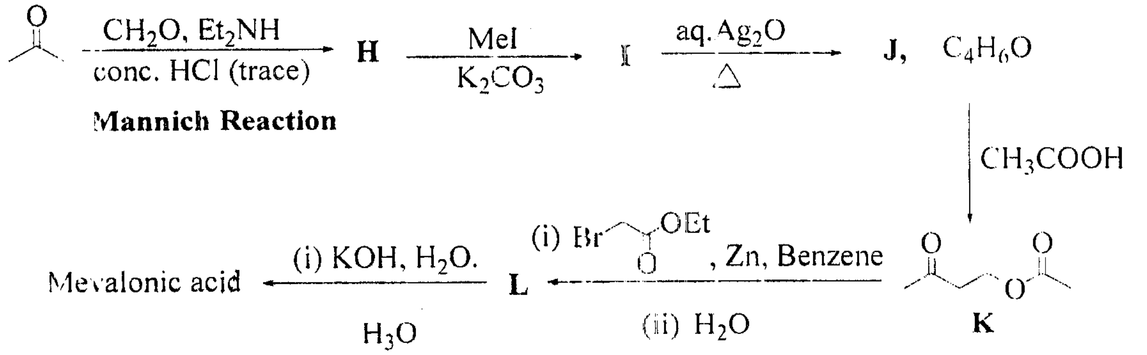
Question 2

(a). Suggest mechanisms for all steps involved in the following Robinson annulation reaction:



[14 Marks]

(b) (i) Deduce the structure of mevalonic acid, an important intermediate in the biosynthesis of terpenes in plants, from the following synthesis:



(ii) Give the structures of the intermediate **H**, **I**, **J** and **L**

(iii) Give mechanism for the formation of **L** from **K** in the above synthesis.

[16 Marks]

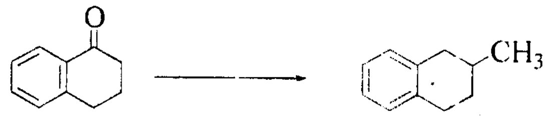
Question 3

(a). Cycloheptatriene readily loses a hydride ion to form cycloheptatrienyl cation, $C_7H_7^+$. Provide an explanation for this reaction. What geometry would you expect for the cycloheptatrienyl cation?

[10Marks]

(b) Propose synthetic routes for each of the following transformations. Show the reagents, including the solvents, and the reaction conditions for each step of your proposal. *Reaction mechanisms are* ***NOT*** *required to be shown.*

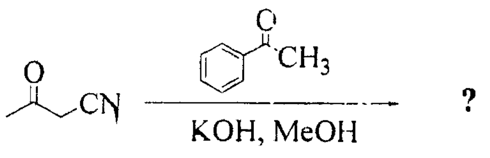
(i) 

(ii) 

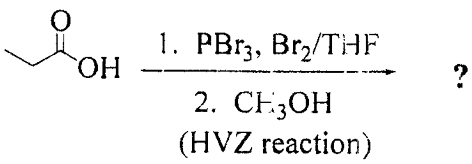
[20 Marks]

Question 4

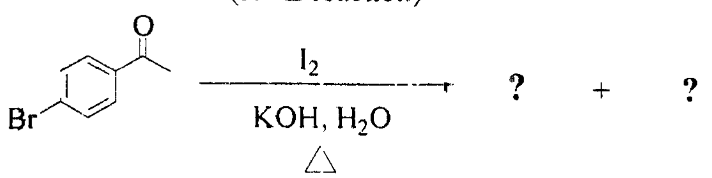
(a). Predict the major organic products and give mechanisms of the following reactions:

(i) 

[4 Marks]

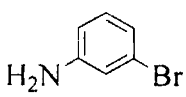
(ii) 

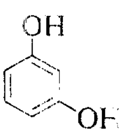
[5 Marks]

(iii) 

[5 Marks]

(b). How would you synthesise each of the following compounds from benzene? Show the reagents and the reaction conditions for each step of your proposal. *Reaction mechanisms* are **NOT** required to be shown.

(i) 

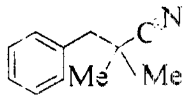
(ii) 

[16 Marks]

Question 5

Many organic compounds are prepared following specific routes of synthesis. The following questions are based on a specific route of an appetite suppressing drug called phentermine. Follow the questions carefully.

(i) When 2,2-dimethyl-3-phenylpropanenitrile, structure shown below, is subjected to basic hydrolysis a compound **M** is obtained. Write the molecular structure of compound **M**.



2,2-Dimethyl-3-phenylpropanenitrile

[4 Marks]

(ii) When compound **M** obtained in Q5 (i) above is treated with diazomethane, CH_2N_2, a compound **N** is obtained. Write a mechanism of this reaction and give the molecular structure of compound **N**.

[10 Marks]

(iii) Ammonolysis (treatment with ammonia) of compound **N** gives compound **O** and methanol. Write the molecular structure of compound **O**.

[4Marks]

(iv) Upon treatment of compound **O** with an aqueous mixture of sodium hydroxide and bromine, an intramolecular rearrangement occurs that leads to the formation of the appetite suppressing drug phentermine. Propose a reasonable mechanism for this reaction and write the molecular structure of phentermine.

[12 Marks]

END OF EXAMINATION

UNIVERSITY SEMESTER EXAMINATION
SEMESTER II, 2007

C265 PHYSICAL CHEMISTRY

Duration: Three (3) Hour

Instructions:

This question paper is divided in two sections: **A (40)** & **B (60)**
Answer **all questions** in section **A**
Answer **4 questions in** Section B
Answer Section A and B in **separate answer booklets**.

You are reminded to answer questions in a clear and logical manner

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Useful Information and 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.
Molar volume of gas at STP = 22.4 dm^3 mol^{-1}, STP = 273 K and 1 atm
Avogadro's constant = 6.02 x 102^3 mol^{-1}
Atomic masses: Ca 40, C 12, O 16

SECTION A: Answer all questions

A1. Cement is a vital material in the construction industry. An important chemical reaction in the manufacture of Portland cement is the high temperature decomposition of calcium carbonate to give calcium oxide and carbon dioxide.

$$CaCO_3(s) \rightarrow CO_2(g) + CaO(s)$$

Suppose that 1.25 g $CaCO_3$ is decomposed by heating, what volume of CO_2 is evolved if it is measured at 740 torr and 25 °C?

A2. The concentration of a drug in the body is often expressed in units of milligram per kilogram of body weight. The initial dose in an animal was 25 mg/kg body weight. After 2 hours, this concentration dropped to 15 mg/kg body weight. If the drug is eliminated metabolically by a first order process, what is the rate constant for the process min^{-1}?

A3. (a) Define bond dissociation enthalpy.

(b) The entropies of $Br_2(g)$ and $Br(g)$ are 245.4 and 174.9 J mol^{-1} K^{-1} respectively at 298 K. Using the data given below calculate the bond energy of Br_2.

$$Br_2(g) \rightarrow 2Br(g) \qquad \Delta G^\circ = 161.7 \text{ kJ}$$

A4. A hydrocarbon is burned in a container with a movable piston with a cross-section area of 0.5 m^2. If the piston moved a distance of 30 cm against a pressure of 1 atm, how much work is done in the expansion?

A5. (a) Copper metal can be obtained by heating copper oxide in the presence of carbon monoxide according to the equation

$$CuO(s) + CO(g) \rightarrow Cu(s) + CO_2(g)$$

Calculate ΔH° in kJ given the following thermochemical equations.

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g) \qquad \Delta H^\circ = -566.1 \text{ kJ}$$
$$2Cu(s) + O_2(g) \rightarrow 2CuO(s) \qquad \Delta H^\circ = -310.5 \text{ kJ}$$

(b) Construct an enthalpy diagram for the reaction between CuO(s) and CO(g) consistent with the result in A5(a) above.

A6. The equilibrium for the production methanol from CO and H_2 is

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

The value of K_P at 500 K is 6.23 x 10^{-3}. Calculate $\Delta_r G^\circ$.

A7. By how much in degree centigrade will the normal freezing point of benzene ($T_f^* =$ 5.53 °C, K_f =5.12 K Kg mol^{-1}) be reduced by addition of 10 g of hexane (M = 84.16 g/mol) to 100 g of benzene (M = 78.11g/mol).

A8. Calculate the activity coefficient of H^+ and CH_3COO^- in a solution which is 0.0078 M CH_3COOH. The degree of dissociation at this concentration is 4.8 percent.

SECTION B: Answer any four (4) questions

B1. (a) (i) State the first law of thermodynamics in words.

(ii) What equation defines the change in internal energy in terms of heat and work? Define the meaning of the symbols, including the significance of their algebraic signs.

(b) The decomposition of calcium carbonate in limestone is used to make carbon dioxide

$$CaCO_3\,(g) \rightarrow CaO\,(s) + CO_2\,(g)$$

The reaction is endothermic and has $\Delta H° = +572$ kJ.

(i) What is the value of $\Delta E°$ for this reaction?

(ii) Determine the percent difference between $\Delta E°$ and $\Delta H°$.

(iii) Under what conditions is $\Delta H° \cong \Delta E°$?

B2. (a) A 1.00 mol sample of propane a gas used for cooking in some rural households was placed in a bomb calorimeter with excess oxygen and ignited. The reaction was

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2\,(g) + 4H_2O(g)$$

The initial temperature of the calorimeter was 25.000 °C and its total heat capacity was 97.1 kJ °C^{-1}. The reaction raised the temperature of the calorimeter to 27.282 °C.

(i) What is the heat of reaction of propane with oxygen expressed in kJ per mole of C_3H_8 burned?

(ii) What is the internal energy change for the combustion reaction involving propane as described above?

(b) For ionisation of acetic acid in aqueous solution

$$\underset{-\,399\ \text{kJ}}{CH_3COOH(aq)} \rightleftharpoons \underset{-\,372}{CH_3COO^-(aq)} + \underset{-\,0.00}{H^+(aq)}$$

The standard free energy of formation ΔG_f° at 25 °C are immediately under each species in kJ mol^{-1}.

(i) Calculate the standard free energy change and the equilibrium constant for the reaction.

(ii) What additional information is required to determine the equilibrium constant at a different temperature?

B3. (a) For the reaction

$$2HCrO_4^- + 3HSO_3^- + 5H^+ \rightarrow 2Cr^{3+} + 3SO_4^{2-} + 5H_2O$$

the rate law is = $k[HCrO_4^-][HSO_3^-]^2[H^+]$

(i) What is the order of reaction with respect to each of the reactants?

(ii) What is the overall order of reaction?

(b) The initial stage of decomposition for a new drug just discovered by an UNZA research student according to a consecutive reaction was found to be first order. The initial concentration C_0 of the solution was 0.050 mole/litre and after 10 hrs at 40 °C, the drug concentration **C** was 0.015 mole/litre.

(i) What is the drug concentration after 2 hours?
(ii) If the *k* value for this reaction at 20 °C is 0.0020 hr^{-1}, what is the activation energy and the Arrhenius factor *A* for the reaction?

(c) Explain the concept of activation energy within the context of the collision theory.

B4. The following is the schematic for a cell:

$$Ag \mid AgBr \mid Br^- \parallel Ag^+ \mid Ag$$

The standard electrode potential for the half-cell Ag | Ag^+ electrode is 0.7992 V and that for Ag | AgBr | Br is 0.0732 V.

(a) Write the cell reaction.
(b) Calculate E°_{cell}.
(c) Calculate the equilibrium constant for the reaction
(d) What is the solubility product K_{SP} of AgBr?

B5. The reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ takes place at 298 K and1 bar and K_P = 0.141. The extent of reaction of the above reaction is

$$\xi = \frac{1}{[1+(\frac{4}{K_P})(\frac{P}{P^o})]^{1/2}}$$

(a) Calculate ξ at 1 bar and mole fractions of $N_2O_4(g)$ and $NO_2(g)$.
(b) Calculate ξ at 10 bars and mole fractions of $N_2O_4(g)$ and $NO_2(g)$.
(c) In what direction is the equilibrium shift when the total pressure of the gases is increased from 1 bar to 10 bars?
(d) Calculate K_p using the mole fractions calculated in (b) using the relationship.

$$K_P = K_y(\frac{P}{P^o})^v$$

END OF EXAMINATION

The University of Zambia
School of Natural Sciences
Department of Chemistry
2007 Academic year second semester
Final Examinations

C342 Inorganic Chemistry 111

Time : 3 Hours

Instructions: Attempt any four questions.
All questions carry equal marks.

1.(a) The structure of $CO_2(CO)_8$ shows that in the solid state there are two bridging carbonyl groups. Studies of $CO_2(CO)_8$ in solution have shown that the compound also exists in an unbridged form in which 18 electron rule is obeyed Give the strctures. Is anywhere a M-M bond required?

cotton.

(b) Complete the following

$$2Fe(CO)_5 \xrightarrow{\Delta/h\nu}$$

$$Mn_2(CO)_{10} + H_2 \xrightarrow[200oC]{200\ atmos}$$

Explain the above reactions in one sentence.

(c) How do the rates of insertion reation vary in $[Mn(CH_3)(CO)_5]$ and $[Mn(CH_2NO_2)(CO)_5]$ with any ligand XY?

2.(a) ΔG for an outer sphere electron transfer process is zero but activation energy is not zero. why?

(b) Predict the products of the following reaction. (One mole of each reactant). A mini trans effect series is given.

$CO > CH_3^- \sim SC(NH_2)_2 \sim PR_3 > Br^- > Cl > Py > NH_3 > H_2O$

(1) $[Pt(CO)Cl_3]^- + NH_3 \rightarrow$
(2) $[Pt(NH_3)Br_3]^- + NH_3 \rightarrow$
(3) $[SC(NH_2)_2PtCl_3]^- + NH_3 \rightarrow$

(c) Six co-ordinate octahedral complex undergo substitution Reaction generally via Dissociative mechanism (D) whereas the square planar complexes react via Associative mechanism (A). Briefly account for this observation.

3.(a) 1. Most of the lanthanide complexes are with oxygen containing ligands. (eg. acetylacetone, citric acid, EDTA). Comment.

2. A number of lanthanide minerals (eg. Monozite) are usually deficient in Europium, which is found among Calcium minerals. Comment.

3. Many of the oxides of actinides eg. U_3O_8, AmO_2 are non stoichiometric but this is true of few lanthanide oxides. Why

(b) Compare and contrast the electronic spectra of Lanthanide ions with those of transition metal.

(c) Extraction of Uranium involves both chemical and physical separation techniques. Briefly outline the steps involved in the separation of nuclear fuel grade uranium from its ore.

4. (a) What are the three important effects of interaction of radiation with matter. What is the working principle behind Geiger Muller counter. How is it used?.

(b) Write short note on (1) orbital electron capture
(2) neutron activation analysis.

(c) Explain the major reactions involved in a breeder reactor How is it more useful than an ordinary nuclear reactor.

5 .(a) Describe the properties of liquid ammonia as a non-aqueous solvent explaining behaviour of dissolved ammonium salts [such as NH_4Cl and $(NH_4)_2SO_4$].

(b) Write down the reactions production of non-aqueous solvents: NH_3, SO_2 and H_2SO_4.

(c) Write down the reactions between AgCl and KNO_3 in liquid ammonia and explain why the result is considerable different if KCl and $AgNO_3$ react in water.

6.(a) Describe the physical and chemical properties of liquid H_2SO_4 and SO_2.

(b) How do they obtain sulfites of sodium and barium using liquid SO_2? Write down the reactions between liquid SO_2 and H_2S at room temperature and at –70°C.

(c) Write down the reactions between liquid H_2SO_4 and oxides of nitrogen and SO_3.

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

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 Einsteinium	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
UNIVERSITY SEMESTER II EXAMINATIONS
FEBRUARY 2007

C 362: COLLOIDS AND ELECTROCHEMISTRY

TIME: THREE(3) HOURS
INSTRUCTIONS: 1. ANSWER *ANY* FIVE (5) OF SIX QUESTIONS
2. USE *SEPARATE* ANSWER BOOKS FOR SECTION A AND SECTION B

DATA

R = 8.314 J $K^{-1}mol^{-1}$; *F* = 96485 C mol^{-1} ; Charge of one electron = 1.602 x 10^{-19} C ; J = m^2 kg s^{-2}

SECTION A

1. a) Identify each of the following equations and explain all the symbols:

$$\frac{Hc}{\tau} = \frac{1}{M} + 2Bc \qquad (1)$$

$$\pi = RT\left(\frac{c}{M} + Bc^2\right) \qquad (2)$$

What are the differences between the equations?

b) What is Donnan equilibrium?

c) What is the Gibbs Adsorption Isotherm? Draw a labelled sketch diagram to show the behaviour of the surface tension γ as a function of concentration for two component aqueous solutions of the following surfactants: simple non-ionized organic compounds, amphipathic compounds, and small electrolytes. On your diagram indicate the onset of critical micelle concentration. For each type of surfactant comment on the surface excess.

2. a) The title of the C 362 Laboratory Experiment 7 that you performed in the laboratory was "The Determination of Adsorption Isotherms". In this experiment, you investigated the Freundlich isotherm. What is the Freundlich isotherm? *Briefly outline* the experiment indicating (i) the theoretical basis of the experiment, (ii) the experimental procedures followed, (iii) what parameters were measured and determined?, (iv) what was your conclusion?, and (v) how the experiment could be improved upon?

2. b) The following data were obtained for the adsorption of acetone on charcoal from an aqueous solution at 291 K:

y (*m*mol.g^{-1})	0.208	0.618	1.075	1.50	2.08	2.88
c (*m*mol.dm^{-3})	2.34	14.65	41.03	88.62	177.69	268.97

Evaluate the constants k and n in the Freundlich equation.

3. a) The sedimentation and diffusion coefficients for the protein haemoglobin, corrected to 20 °C in water are 4.41 *svedbergs* and 6.3 x 10^{-11} m^2 s^{-1} respectively. If the partial specific volume of haemoglobin is v = 0.749 cm^3 g^{-1} and the density of water is 0.998 g cm^{-3} at this temperature, calculate the molar mass of haemoglobin. If there is one mole of iron per 17000 g of protein, how many atoms of iron are there per haemoglobin molecule?

* b) The tobacco mosaic virus (TMV) (density ρ) exists as uniform cylindrical particles of radius R_c and length L. Derive an expression for the specific surface area A_{sp} for TMV and discuss the limiting forms of A_{sp} when either the radius R_c or the length L is very small.

SECTION B

4. a) Explain why
   (i) Li^+ has a lower ionic conductivity than Na^+?
   (ii) the ionic conductivity of H^+ is higher than that of both ions?

   b) To investigate the mobility of proton in liquid ammonia, the moving boundary method was used to determine the transport number of the NH_4^+ ion in liquid ammonia at - 40 °C . A steady current of 5.000 *m*A was passed for 2500 s, during which the boundary formed between mercury(II) iodide and ammonium iodide solutions in ammonia moved 286.9 mm in a 0.01365 mol.kg^{-1} solution. Calculate the transport number of the ammonium ion.
   The bore of the tube = 4.146 mm and the density of ammonia = 0.682 g cm^{-3}.

5. a) What are the conditions that allow a metal to be deposited from aqueous acidic solution before hydrogen evolution occurs significantly at 293 K? Why may silver be deposited from aqueous silver nitrate solution?

5. b) How many electrons are transported through the double layer in each second, when the $Pt,H_2|H^+$ and $Pb,H_2|H^+$ electrodes are at equilibrium at 25 °C? The area of the electrodes is 1.0 cm^2. Estimate the number of times each second a single atom on the surface takes part in an electron transfer event, assuming an electrode atom occupies $(280\ pm)^2$ of the surface.

Electrode.	**Electrode current density ($A\ cm^{-2}$)**
$Pt,H_2\|H^+$	7.9×10^{-4}
$Pb,H_2\|H^+$	5.0×10^{-12}

6. a) Estimate the limiting current density at an electrode in which the concentration of Mg^{2+} ion is 1.5 *m*mol dm^{-3} at 25 °C. The thickness of the Nerst diffusion layer is 0.32 mm. The ionic conductivity of the Mg^{2+} ion at infinite dilution is 10.60 *m*S $m^2\ mol^{-1}$ at 25 °C.

b) V. V. Cosev and A. P. Pchel'nikov (*Soviet Electrochem.*, **6**, 34 (1970)) obtained the following current voltage for an indium anode relative to a standard hydrogen electrode at 293 K :

- E / V	0.388	0.365	0.350	0.335
$j / A\ m^{-2}$	0	0.590	1.438	3.507

Use these data to calculate the transfer coefficient and the exchange current density. Calculate the cathodic current density when the potential is 0.365 V.

THE UNIVERSITY OF ZAMBIA
CHEMISTRY DEPARTMENT
C 482 - INORGANIC INDUSTRIAL CHEMISTRY
SEMESTER II EXAMINATION
February 14, 2007

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

1.Describe the properties, manufacture and use of:
a). Complex fertilizers,
b). Micro fertilizers.
c). Give examples of synergism and antagonism of the mixed fertilizers.

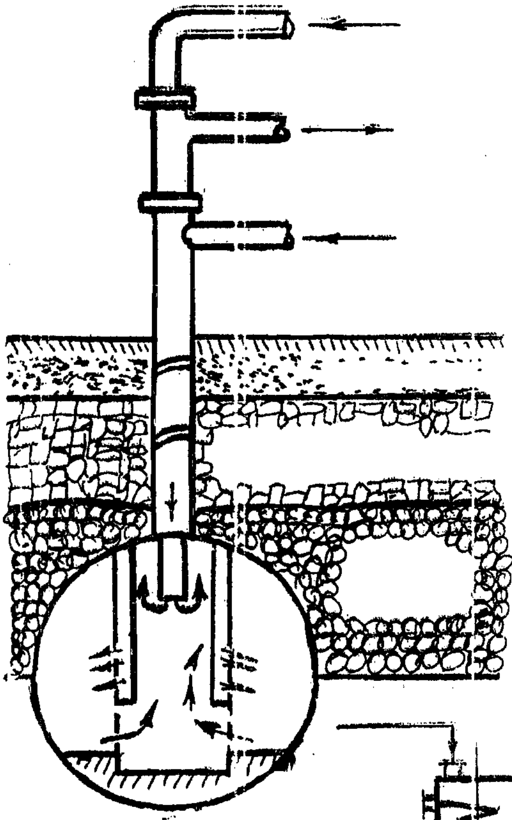
2. Sulphuric acid is mainly produced from sulphur or iron pyrite.
a). What are the advantages and disadvantages associated with the use of these raw-materials?
b).Why 98.3 % H_2SO_4 is used for absorption of SO_3 containing gas and how do they purify the flew-gas?
c). Describe the main properties of sulphuric acid.

3. State the mining and manufacture of liquid Sulphur (Flow-sheets are attached):
a). By Frasch method,
b). By floatation method.
c). Describe the main properties of sulphur.

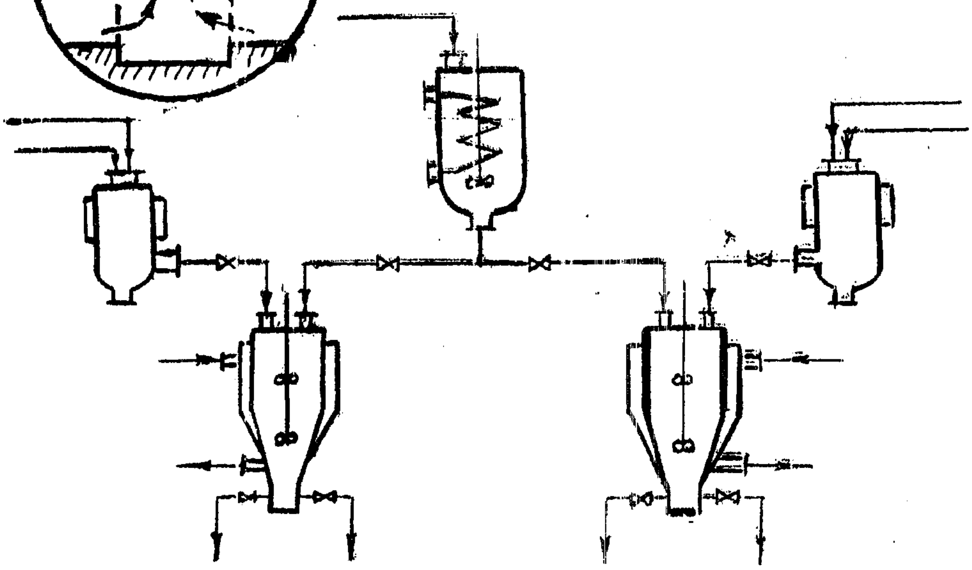
4. Potassium and its compounds are widely used in industry, agriculture, refreshment of air in submarines, space crafts, etc. Outline the properties and reactions of manufacture of:
a). Melallic potassium,
b). Potassium oxide, potassium peroxide, potassium superoxide and ozonide.
c). Potassium hydroxide.

5.Describe the methods production of (a &b):
a). Potassium chloride from sylvinite (draw-up the simplified Flow-sheet),
b). Potassium sulphate.
Indicate the temperatures of the processes.
c). What raw-materials (ores), containing potassium, you know?

6. The dilute and concentrated nitric acids are produced in industry.
a). Describe the physicochemical foundation manufacturing dilute nitric acid from ammonia,
b). State the manufacturing process of concentrated nitric acid by means of dehydrating agents.
c). Suggest the method to minimize impurities in the off-gas (in the processes indicated in 6 (b) above).



Flow-sheet manufacturing sulphur
by Frasch method



Floatation method manufacturing liquid sulphur

END OF EXAMINATIONS

THE UNIVERSITY OF ZAMBIA
CHEMISTRY DEPARTMENT
C 482 - INORGANIC INDUSTRIAL CHEMISTRY
SEMESTER II EXAMINATION
February 14, 2007

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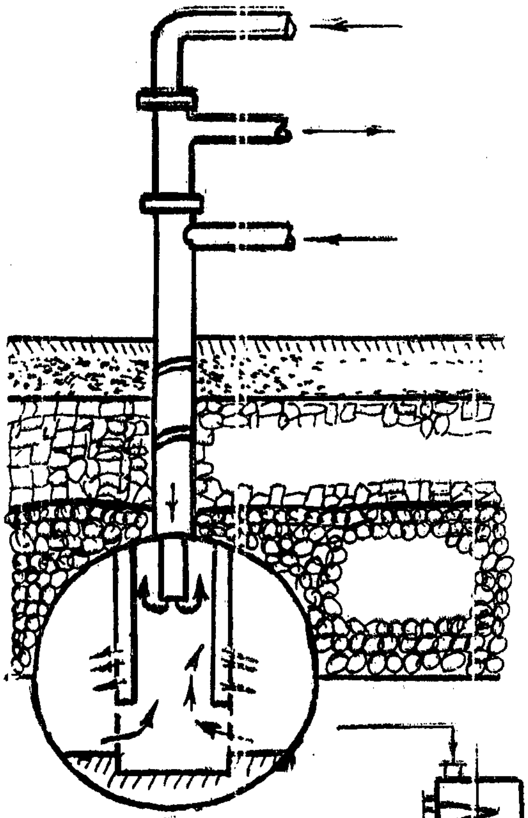
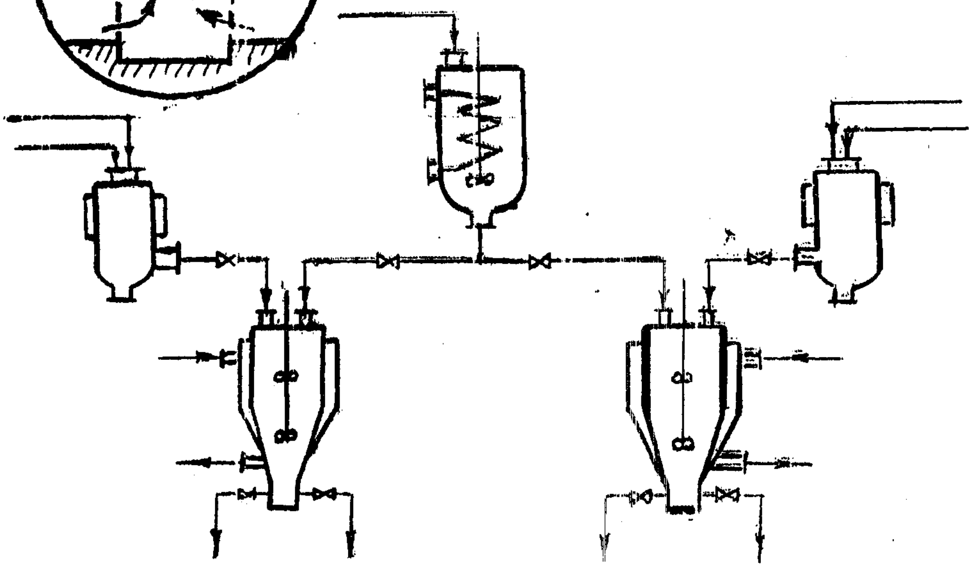


Flow-sheet manufacturing sulphur by Frasch method



Floatation method manufacturing liquid sulphur

END OF EXAMINATIONS

The University of Zambia

University Examinations

Semester II – 2006 Academic Year

C312 Biochemistry II

INSTRUCTIONS

1. **WRITE** your Computer number on **ALL** your answer books
2. There are **TWO** sections in this examination paper: **Section A** and **Section B**
3. **READ** the instructions for each section carefully
4. Time: **THREE (3) HOURS**

Section A (20 marks)

Answer **ALL** questions in this section

1. Draw the structure of a purine ring system. What is the source of all the atoms in the in the structure you have drawn? ***Do not write down the pathway.***
   [6 marks]

2. If a photosynthesizing system is exposed briefly to radioactive CO_2, the first compound to be labeled is 3-phosphoglycerate and not a hexose sugar. Give a brief explanation for this observation.
   [3 marks]

*For questions 3 to 5, answer **TRUE** or **FALSE**. If false, explain why.*

3. Considering the fact that ATP hydrolysis yields -7.3 kcal/mol energy, the transfer of an electron in cyclic photophosphorylation from the primary acceptor of photosystem I (E'_0 = -0.50V) to cytochrome b_6 (E'_0 = -0.05V) does not generate enough energy that can lead to synthesis of ATP (Faraday constant = 2.304×10^4 cal/volt/eq).
   [4 marks]

4. Defective metabolism of purine nucleotides leads to development of gout.
   [3 marks]

5. The amino acid sequence of the following DNA sequence, AGGCATTGAATTGAT, is arg-his-cys-ile-asp
   (*Genetic code is given on page 4*).
   [4 marks]

Please turnover the page for Section B

Section B (80 marks)

Answer any **FOUR** questions in this section

6. a) Highlight similarities and differences between synthesis and breakdown of a fatty acid.
   [5 marks]

   b) Write down a detailed account on the biosynthesis of palmitic acid (16:0) in a cell. How many ATP and NADPH molecules are required for this process?
   [15 marks]

7. **Either**

Discuss in detail DNA repair mechanisms with special emphasis on *E. coli*. What is xeroderma pigmatosum and how does it arise?
[20 marks]

Or:

Discuss in detail DNA replication in prokaryotes highlighting the roles of all proteins and enzymes
[20 marks]

8. Write short notes on
   a) C4 plants
   b) Photorespiration including a statement on appropriateness (or otherwise) of the name of this biological process
   c) Photosystem I
   d) Generation of ATP in photosynthesis

[20 marks]

9. Briefly;

   a) Outline the reactions of the Urea cycle and the consequences of defect(s) in the cycle.

   b) Describe the reaction and role of nitrogenase in plants and glutamine synthetase in animals.

[20 marks]

10. Discuss in detail control of gene expression in *E. coli* using the *lac operon.*
[20 marks]

Genetic code

	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

End of C312 examination.

The University of Zambia

University Examinations

Semester II 2006 Academic year

Advanced Biochemistry II C412

Instructions to Candidates:

Write your computer number on ALL answer booklets

Read Instructions carefully

Time: THREE (3) Hours

You are required to present your work neatly and in logical order.

Answer Any Four (4) Questions

1 a) Define the following terms

i. LTLT

ii. HTST [5]

b) Its normally advisable to consume milk immediately the container is opened. Other w se one can use a refrigerator. If milk goes bad in a day on a warm summer day (24^{O}C), how long will it last in a fridge operating at 4^{O}C? [6]

c) Write a short note on the production of cheese. What species of bacteria causes flavoring and ripening in Cheddar cheese? [8]

d) Enlist any three of the methods for preservation of food. In each case give a brief note on how the method helps reduce food spoilage. [6]

---

2 a) Discuss and explain gene control in prokaryotes and give one classical example. [10]

b) How would you employ gene manipulation to produce large, juicy tomatoes from small, non-juicy tomatoes? Explain and cite all the tools you would need and how they would be used. [15]

---

3 Write a paper to be presented to an anti-AIDS club on "HIV/AIDS and a crippled immune system". Your paper should include definitions of all the technical terms you will use, nature and structure of the human immunodeficiency virus (HIV). Also include the type of antigen-antibody reactions and how the HIV/AIDS cripples the immune system. [25]

---

4 a) "The mammalian liver performs functions such as rendering harmless many drugs and toxicants by changing them chemically". Discuss this statement with the help of appropriate equations where necessary. [15]

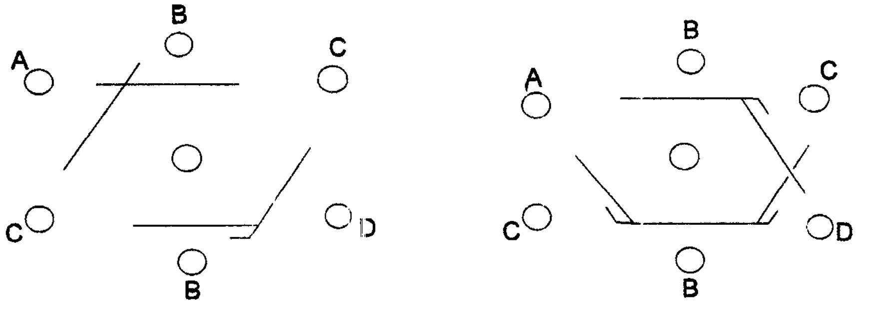
b) The bark and roots of the cinchona tree contain quinine. Some people tend to be sensitive to this drug such that instead of the hydroxylated product, this drug is excreted Explain the probable molecular basis for this problem. Is there need for caution in administering other drugs to these patients? Explain. [10]

---

5 The labels on four bottles came off but you know that each bottle contains either hapten 1- carrier 1(H1-C1), hapten 1-carrier 2(H1-C2), hapten 2-carrier 1(H2-C1) or hapten 2-carrier 2 (H2-C2). You carry out double immunodiffusion assays with either ant H1-C2 or anti H2-C2 and observe the following precipitin patterns in the figure below.

a) Determine the conjugate in each bottle. [16]

b) What can you conclude about
   i. A and B (in experiment 1)
   ii. B and C (in experiment 2) [4]



Anti -H1-C2 in central well   Anti -H2-C2 in central well

c) Write a short note on ELISA [5]

END OF C412 FINAL EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2006 ACADEMIC YEAR SECOND SEMESTER EXAMINATIONS
FEBRUARY/MARCH -2007

C422 - APPLIED ANALYTICAL CHEMISTRY

TIME: 3 HOURS

ANSWER ANY 4 FROM THE 5 QUESTIONS IN THIS PAPER

QUESTION 1

(a) 0.3g feed sample is analysed for its protein content by the modified well-known distillation method. If 25ml of a 0.1N HCl is used in the titration, what is the % protein in the sample?(3)
(b) Describe the following terms used in chromatography by giving an equation, labeled diagram or description: resolution, retention time, stationary phase, theoretical plate and Kovats index. (4)
(c) How would you determine 2 fat-soluble vitamins in food.(4)
(d) Discuss how to evaluate the effectiveness of the following processes used in dairy industry: pasteurization and sterilization.(4)

QUESTION 2

(a) The purity of hydrazine N_2H_4 sample was determined by titration with iodine. a sample weighing 1.42g was dissolved in one litre of water, a 50ml aliquot was titrated with iodine solution requiring 42.41ml. The iodine solution was standardized against 0.41g As_2O_3, a primary standard which was dissolved in NaOH, adjusted to pH 8 and titrated requiring 40.38ml iodine solution. What is the purity of hydrazine? What type of titration is it (iodometric or iodimetric, explain). (5)
(b) Describe how to determine drugs of abuse using HPLC and include the descriptions of useful components of this instrument. (3)
(c) Describe 2 methods you would use in crude protein analysis. (3)
(d) How would you differentiate soap from non-soap detergent and how would you test for detergency of these products? (4)

QUESTION 3

(a) Name two antioxidants allowed in Zambian foods and describe how to detect them in such foods and include their uses in food (4)

(b) Kachasu is not a legal drink in Zambia, what makes it unfit for human consumption and what tests would you carry out to test for quality of this famous drink?(4)

(c). A storekeeper at the Mazabuka farm discovers that a careless farm worker mixed-in a herbicide with the routine insecticides in use. Suggest an appropriate analytical technique, together with at least three (3) solvents you would use to determine whether there actually is a herbicide in a recently sprayed plot.(3)

(d) How would you differentiate between thiols and disulfides in organic compounds? (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? (2) How many plates would be required to achieve a resolution of 1.8 if the retention times remain unchanged? (5).

(b) PCBs or polychlorinated biphenyls, belong to a larger family of POPs or Persistent Organic Pollutants, which are extensively used in power generation and transmission equipment. The compounds persist and bio-accumulate, thus posing a risk causing adverse effects to both human health and the environment. Suggest an appropriate confirmatory technique to test for PCBs in soil collected near a transformer unit. (3)

(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 components. (4)

QUESTION 5

(a) The great variety of chemical compounds used as pesticides, as well as the complexity of the compounds and their metabolite chemistry call for a large battery of analytical methods. Describe, in detail, the basic stages in pesticides analysis.(3)

(b) A Mazabuka fruit and vegetables farmer is anxious to know the levels of pesticides residue in his produce. Suggest and describe the elements of two (2) analytical techniques to help identify and estimate amounts of DDT and malathion on the produce .(3)

(c) How would you test for freshness of fish or meat product bought from Soweto market?(3)

(d) Describe two reactions associated with organic alcohols and organic acids.(3)

(e) In food analysis, 2 methods are normally used in the preparation of samples for evaluation of metallic contaminants, describe them and include any precautions needed to be observed during the process.(3)

K= 39.1; Fe= 55.8; Mn = 54.9; O= 16.0; C= 12.0; Cr = 52.0; I = 126.9; As =74.9; S =32.1; N = 14.0)

($N_2H_4 + 2I_2 \rightarrow N_2 + 4H^+ + I^-$; $H_2AsO_3^- + I_2 + H_2O) \rightarrow 2I^- + 3H^+ + H_3AsO_4$)

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2006 ACADEMIC YEAR SECOND SEMESTER EXAMINATIONS
FEBRUARY/MARCH -2007

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THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF COMPUTER STUDIES

CST2012

PROGRAMMING II USING JAVA

SEMESTER TWO

2006/2007

EXAMINATION

DATE: 22nd FEBRUARY, 2007

DURATION: THREE (3) HOURS

INSTRUCTIONS:

SECTION A

There are **20 multiple** choose questions in this section. Answer ALL. Wrong choices will cost you -0.5 marks. **[Total 20 Marks]**

SECTION B

There are **nine (9)** open ended questions in this section.Answer ALL questions. **[Total 30 Marks].**

SECTION C

There are three programming questions in this section. Answer any **TWO** questions. **[Total 50 Marks]**

SECTION A: ANSWER ALL QUESTIONS: (Wrong answers cost (-0.5))

1. True of false, JFrame is a lightweight component.
2. True or false. A JPanel cannot be added to another JPanel.
3. What's wrong with the following code?

```
class Test3 {
   public static void main(String args[]) {
     MouseListener listener = new MouseAdapter() {
       static int count;
       public void mouseEntered(MouseEvent e) {
         processIt(e);
       }
       private void processIt(MouseEvent f) {
         System.out.println("Got: " + f);
         System.out.println("Count: " + ++count);
       }
     };
   }
}
```

   a.) Anonymous inner classes can only implement interfaces.
   b.) Inner classes can't have support methods.
   c.) All the methods of MouseListener aren't implemented.
   d.) Inner classes can't have static declarations.
   e.) Nothing is wrong. The code compiles fine.

4. In the following class definition, which variables are inaccessible within the method of the inner class?

```
class Testing {
   public static int a = 1;
   private static int b = 2;
   public int c = 3;
   private int d = 4;
   public void aMethod(int e) {
     int f = 5;
     class Inner {
       int g = 6;
       public void anotherMethod(int h) {
       // What can?t be accessed here?
       }
     }
   }
}
```

   a.) c, d
   b.) e, f
   c.) c, d, e, f
   d.) e, f, g
   e.) None of them.

5. You have been given a design document for a veterinary registration system for implementation in Java Technology. It states: "A pet has an owner, registration date, and a vaccination-due date. A cat is a pet that has a flag indicating if it has been neutered and a textual description for its markings".

Given that the Pet class already been defined, which of the following fields would be appropriate for inclusion in the Cat class as members?

a.) Pet thePet;
b.) Date registered;
c.) Date vaccinationDue;
d.) Cat theCat;
e.) Boolean neutered;
f.) String markings;

6. What will happen when you attempt to compile and run the following code

```
import java.io.*;
class Base{
    public void amethod()throws FileNotFoundException{}
}
public class ExcepDemo extends Base{
    public static void main(String argv[]){
       ExcepDemo e = new ExcepDemo();
    }
    public void amethod() throws IOException{}
    protected ExcepDemo(){
       try{
           DataInputStream din = new
DataInputStream(System.in);
           System.out.println("Pausing");
           din.readByte();
           System.out.println("Continuing");
           this.amethod();
       }catch(IOException ioe) {}
    }
}
```

a.) Compile time error caused by protected constructor
b.) Compile time error caused by amethod declaring new Exception
c.) Runtime error caused by amethod declaring new Exception
d.) Compile and run with output of "Pausing" and "Continuing" after a key is hit

7. Consider the following source file:

```
interface Animal {
void saySomething();
}
class farm {
void setName(String name){};
}
// insert code here
public class Cow implements Pasture {
public void graze() { }
void saySomething(){}
}
```

Which of the following code lines inserted independently at line 7 will make this source file compile?

a.) interface Pasture {void graze();}

b.) interface Pasture {void graze(){}}

c.) interface Pasture extends Animal{void graze();}

d.) interface Pasture extends Animal{void saySomething(){}}

e.) interface Pasture implements Animal{void graze();}

8. Consider the following code:

```
class AllMyExceptions {
    public static void main(String [] args) {
          try {
               System.out.println(Double.valueOf("420.00"));
          } catch (Throwable e) {
                 System.out.println("Some exception!");
           }catch (Exception ne) {
                 System.out.println("Number format exception!");
           }
          System.out.println("All My Exceptions!");
    }
}
```

What is the result?

a. 420.0
   All My Exceptions!

b. Some exception!
   All my exceptions

c. Number format exception!
   All my exceptions

d. Compilation fails.

e. An exception is thrown at runtime.

9. Consider the following code:

```
public class MyThread {
    public static void main(String[] args) {
            Counter ct = new Counter();
            ct.run();
            ct.start();
            ct.start();
    }
}
class Counter extends Thread {
    public void run() {
            System.out.print("Running");
    }
}
```

What is the output? (choose two);

a. Running

b. Running Running

c. Running Running Running

d. Compilation fails.

e. An exception is thrown at runtime.

10. Which of the following statements are true? (Choose all that apply.)

a. Readers and writers are used for I/O on 16-bit Unicode characters.

b. FileInputStream and FileOutputStream can be used to handle I/O on 16-bit Unicode characters.

c. FileInputStream and FileOutputStream can be used to read image files.

d. FileInputStream and FileOutputStream can be used to read text files.

11. Consider the following code:

```
import java.io.*;
class Animal implements Serializable {}
class Cow extends Animal{
Milk m = new Milk();
}
class Milk implements Serializable {
SaturatedFat sf1 = new SaturatedFat();
SaturatedFat sf2 = new SaturatedFat();
SaturatedFat sf3 = new SaturatedFat();
}
class SaturatedFat implements Serializable { }
```

When you serialize an instance of Cow, how many objects will be serialized?

a. 0

b. 2

c. 3

d. 4

e. 5

f. 6

12. Consider the following code:

```
public class MyThreads {
public static void main(String[] args) {
Thread t1 = new Counter();
Thread t2 = new Thread(t1);
t1.start();
t2.start();
}
}
class Counter extends Thread implements Runnable {
public void run() {
System.out.println("Running");
}
}
```

What is the output?

a. Running

b. Running

c. Running

d. No output.

e. Compilation fails.

f. An exception is thrown at runtime.

13. Consider the following code:

```
int i = aReader.read();
```

What is true of the type of variable aReader?

a. It has to be a BufferedReader.

b. It has to be a FileReader.

c. It can either be a FileReader or a BufferedReader.

d. It can be neither a FileReader nor a BufferedReader.

14. Which one of the following class definitions is a valid definition of a class that cannot be instantiated?

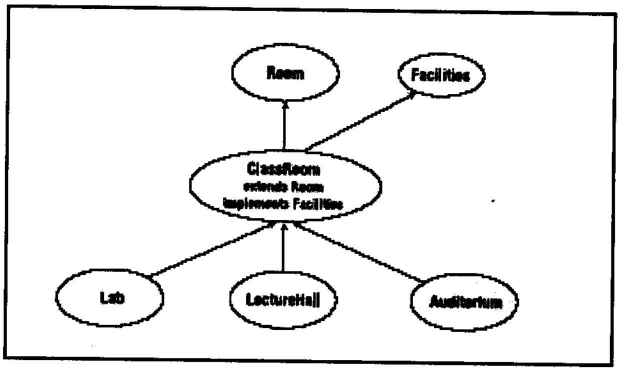
    Select the one correct answer.

    a. class Ghost {
    ```
    abstract void haunt();  }
    ```
    b. abstract class Ghost {
    ```
    void haunt();
    }
    ```
    c. abstract class Ghost {
    ```
    void haunt() {};
    }
    ```
    d. abstract Ghost {
    ```
    abstract void haunt();
    }
    ```
    e. static class Ghost {
    ```
    abstract haunt();
    }
    ```

15. Without time slicing, each thread in a set of equal-priority threads runs to completion before other threads of equal priority get a chance to execute.

    a. false
    b. true

For questions 16 and 17, consider the class hierarchy shown in the Figure:



16. Consider the following code fragment:

```
1. LectureHall lh = new LectureHall();
2. Auditorium a1;
3. Facilities f1;
4.
5. f1 = lh;
6. a1 = f1;
```

What of the following is the true statement about this code?

   a. The code will compile and execute without any error.
   b. Line 5 will generate a compiler error because an explicit conversion (cast) is required.
   c. Line 6 will generate a compiler error because an explicit conversion (cast) is required to convert Facilities to Auditorium.

17. Consider the following code fragment:

```
1. LectureHall lh = new LectureHall();
2. Auditorium a1;
3. Facilities f1;
5. f1 = lh;
6. a1 = (Auditorium) f1;
```

What of the following is the true statement about this code?

   a. The code will compile and execute without any error.
   b. Line 5 will generate a compiler error because an explicit conversion (cast) is required.
   c. Line 6 will generate a compiler error because an interface cannot be converted to the class that implements the interface.
   d. Line 6 will compile fine, but an exception will be thrown during the execution time.

18. Which of these field declarations are legal within the body of an interface?
Select the three correct answers.
   a. `public static int answer = 42;`
   b. `int answer;`
   c. `final static int answer = 42;`
   d. `public int answer = 42;`
   e. `private final static int answer = 42;`

19. Which of the following has FlowLayout has it's default layout manager
   a. JFrame
   b. JDialog
   c. JPanel
   d. JApplet
   e. Applet

20. When the following program is run, it will print all the letters I, J, C, and D. Is this statement true or false?

```
public class MyClass {
    public static void main(String[] args) {
        I x = new D();
        if (x instanceof I) System.out.println("I");
        if (x instanceof J) System.out.println("J");
        if (x instanceof C) System.out.println("C");
        if (x instanceof D) System.out.println("D");
    }
}
interface I{}
interface J{}
class C implements I {}
class D extends C implements J {}
```

Select the one correct answer.

a. True.

b. False.

Section B :Answer ALL questions (30 Marks)

1. What exception types can be caught by the following handler?

```
catch (Exception e) {
    ...
}
```

What is wrong with using this type of exception handler? **[2 Marks]**

2. What exceptions can be caught by the following handler?

```
...
} catch (Exception e) {
    ...
} catch (RuntimeException a) {
    ...
}
```

Is there anything wrong with this exception handler as written? Will this code compile? **[3]**

3. Match each situation in the first column with an item in the second column

a. `int[] A;` `A[0] = 0;`	1. error
b. The Java VM starts running your program, but the VM can't find the Java platform classes. (The Java platform classes reside in `classes.zip` or `rt.jar`.)	2. checked exception
c. A program is reading a stream and reaches the end of stream marker.	3 runtime exception
d. Before closing the stream and after reaching the end of stream marker, a program tries to read the stream again.	4. No exception

[4 Marks]

4. How would you append data to the end of a file? Show the constructor for the class you would use and explain your answer. **[3 Marks]**

5. What is wrong with the following interface?

```
public interface MyInterface  {
    public void aMethod(int aValue){
        System.out.println("Hi Mom");}
 }
```

Fix problem in the interface . **[3 Marks]**

6. The program below doesn't compile. What do you need to do to make it compile? Why?

```
import java.util.*;
public class MyClass {
    public static void main(String[] args) {
        Timer timer = new Timer();
        timer.schedule(new TimerTask() {
                public void run() {
                    System.out.println("Exiting.");
                    timer.cancel();}
            },
            5000);
System.out.println("In 5 seconds this application will exit.
");
    }}
```

[4 Marks]

Section B Questions continue on the next page

7. What is the point of the following statement?

```
out = new PrintWriter( new FileWriter("data.dat") );
```

Why would you need a statement that involves two different stream classes, `PrintWriter` and `FileWriter`?

[4 Marks].

8. In Java, input/output is done using streams. Streams are an abstraction. Explain what this means and why it is important. **[4 Marks]**

9. What does it mean to use a `null` layout manager, and why would you want to do so? **[3]**

Section C: Any Two Questions (50 Marks)

Question One

(a) The following code is supplied for you to analyze.

```
public class MyClass1 {
    protected MyInnerClass1 ic;
    public MyClass1() {
     ic = new MyInnerClass1();
    }
    public void displayStrings() {
     System.out.println(ic.getString() + ".");
     System.out.println(ic.getAnotherString() + ".");
    }
    static public void main(String[] args) {
        MyClass1 c1 = new MyClass1();
     c1.displayStrings();
    }
    protected class MyInnerClass1 {
     public String getString() {
         return "MyInnerClass1: getString invoked";
     }
    public String getAnotherString() {
         return "MyInnerClass1: getAnotherString invoked";
     }
    }
}
```

(i) What is the output of the program when it's compiled and executed? **[2 Marks]**

(ii) Create a Java class called `MyClass2.java` that defines subclasses of both `MyClass1` and its inner class, `MyInnerClass1`. (Call the subclasses `MyClass2` and `MyInnerClass2`, respectively.) `MyInnerClass2` should override the `getAnotherString` method to return `"MyInnerClass2 version of getAnotherString invoked"`. `MyClass2` should define one constructor and one method:

- A no-argument constructor that initializes the inherited `ic` instance variable to be an instance of `MYInnerClass2`
- A main method that creates an instance of `MyClass2` and invokes `displayStrings` on that instance

[6 Marks]

(iii) What is the output when you run `MyClass2`? **[2 Marks]**

(b) Create a class **Rectangle**. The class has attributes length and width, each of which defaults to 1. It has methods that calculate the perimeter and the area of the rectangle. It has set and get methods for both length and width. The set methods should verify that length and width are each floating-point numbers larger than 0.0 and less than 20.0; otherwise they should throw your **own defined exception** with appropriate messages. Write a program to test class Rectangle. **[10 Marks]**

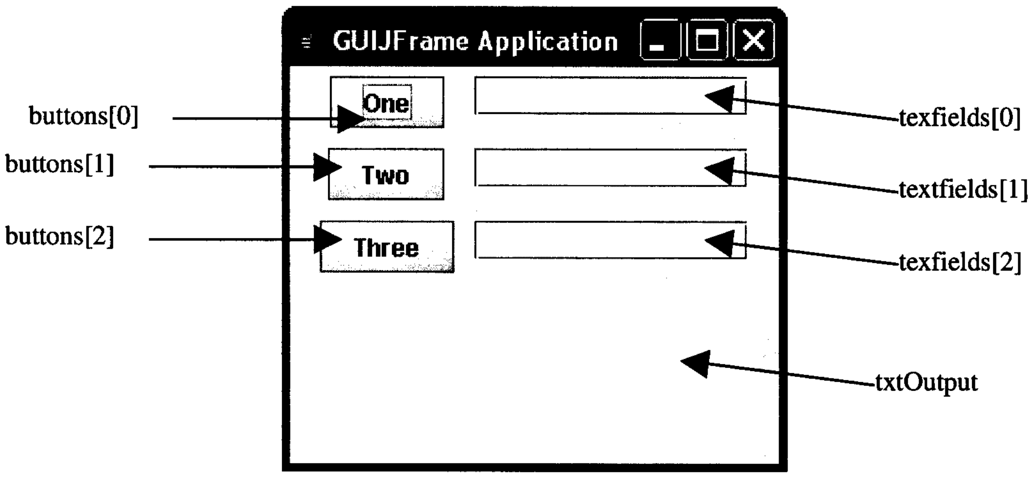
(c) Question Two

(a) Study the Java JFrame Application given below. Line numbers have been included so that you can refer to them in your answer if you wish.

```
1. import javax.swing.*;
2. import java.awt.*;
3. public class GUIJFrame extends JFrame {
4.        JButton [] buttons;
5.        JTextField [] textfields;
6.        JPanel [] pans;
7.        JTextArea txtOutput;
8.        public GUIJFrame(){
9.         super("GUIJFrame Application");
10.        Container cp =getContentPane();
11.        buttons=new JButton[]{new JButton("One"),new JButton("Two"), new
   JButton("Three")};
12.       textfields=new JTextField(new JTextField("",12),new
   JTextField("",12),JTextField("",12) };
13.     pans=new JPanel[6];
14.     txtOutput=new JTextArea(5,20);
15.// your code to create the GUI goes here.
16.}//end constructor
17.}//end class
```

(i) The JFrame Application given above is a skeleton which creates a number of GUI components (three Buttons, three JTextField, six JPanels and one JTextArea) but doesn't use them to set up a GUI. When the JFrame Application is executed it will show a blank screen.

What needs to be added to the create the following GUI?



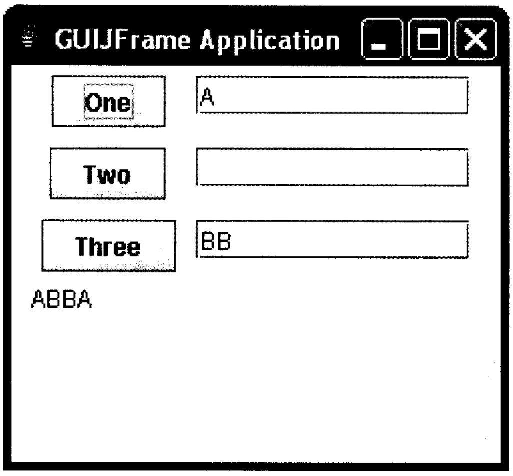
You may need to create additional panels and use appropriate layout managers to archive the desired effect. Please state any assumptions that you make.(Write the full Java code)

[10 Marks]

Question continues on the next page

(ii) Give the code that needs to be added to your JFrame Application above to make the program behave as follows:
When the user clicks on any of the three buttons any text they have entered into the corresponding textfield is output in the JTextArea. The text is appended to any other text that is already displayed.

For instances if the user entered "A" into textfields[0] and "BB" into textfields[2] and then clicked buttons[0], then buttons[2] and then buttons[0] again; the resulting display would be as shown below.



[5 Marks]

(b) Write a temperature conversion application that converts from Fahrenheit to Celsius. The Fahrenheit temperature should be entered from the keyboard (via a JTextField). A JLabel should be used to display the converted temperature. Use the following formula for the conversion. Your program should be able to handle errors such as users entering strings instead of numbers.

$$Celsius = \frac{5}{9} \times (Fahrenheit - 32)$$

[10 Marks]

QUESTION THREE

(a) A Junior programmer as given the following code below.

```
int i;
URL url = new URL("http://java.sun.com/");
URLConnection javaSite = url.openConnection();
InputStream input = javaSite.getInputStream();
InputStreamReader reader = new InputStreamReader(input);
while ((i = reader.read()) != -1) {
    System.out.print(i);
}
```

How can you improve the performance of the given above? Explain your answer and show the new line(s) of code. (**Note:** Class URL represents a Uniform Resource Locator, a pointer to a "resource" on the World Wide Web. A resource can be something as simple as a file or a directory, or it can be a reference to a more complicated object, such as a query to a database or to a search engine).

[8 Marks]

(b) Assume that you have written some classes. Belatedly, you decide that they should be split into three packages, as listed in the table below. Furthermore, assume that the classes are currently in the default package (they have no package statements). The Server and Client class uses the Utilities class.

Package Name	Class Name
zm.unza.cs.server	Server
zm.unza.cs.shared	Utilities
zm.unza.cs.client	Client

(i) What line of code will you need to add to each source file to put each class in the right package? **[3 Marks]**

(ii) To adhere to the directory structure, you will need to create some subdirectories in your development directory, and put source files in the correct subdirectories. What subdirectories must you create? Which subdirectory does each source file go in? **[3 Marks]**

(iii) Do you think you'll need to make any other changes to the source files to make them compile correctly? If so, what? **[3 Marks]**

(c) Has-a relationship is a form of composition/aggregation where a class has reference types has member variables and is-a relationship refers to inheritance. Given the following statements below write Java code describing the statements given.

(i) A city has a community center. A community center is a building.**[4]**

(ii) A classroom has a whiteboard. The classroom is a room **[4]**

END EXAMINATION

GOOD LUCK

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF COMPUTER STUDIES
CST 2042 INTRODUCTION TO DATABASE AND FILE SYSTEMS

SEMESTER TWO (2) EXAMINATION 2006

INSTRUCTIONS	:	Section 1 Answer all Questions Section 2 Answer Any Two (2) Questions.
TIME ALLOWED	:	Three (3) Hours.

SECTION 1

QUESTION 1

(A). Describe the relationship between a relation, and the relation schema. [4]

(B). What is the relational database schema? [3]

(C). Discuss the properties of a relation. [3]

(D). Explain the difference between a primary key, and the foreign key? [5]

QUESTION 2

(A). Using the SQL syntax CREATE a table structure for the base relation for the Property for Rent, using the following: [4]

1. Property Number	NOT NULL;
2. Street	NOT NULL;
3. City	NOT NULL;
4. Property Type	NOT NULL DEFAULT 'F';
5. Rooms	NOT NULL DEFAULT 4;
6. Owner Number	NOT NULL;
7. Staff Number;	
8. Rent Amount	NOT NULL;
9. Property Rented (y/n)?	NOT NULL;

(B). Using the SQL syntax CREATE VIEW for the Property for Rent so that users can view available properties for rent. All columns in the Property for rent table (created above in 2 A) should be used. [4]

(C). Using the SQL syntax, give the user with the authorization identifier Manager full privileges to the Property for rent table (created above in 2 A). [4]

(D). Using the SQL syntax, revoke all privileges granted to Manager on the Properties for Rent table. [4]

(E). Using the SQL syntax, remove Properties for Rent view from the database (which you created in 2. B above). [4]

QUESTION 3

From the information provided in the Properties for Rent (see Question 2 above), write the SQL syntax simple queries, aggregate functions, sub-queries and joins to:

3.1 List full details of all properties. [2]

3.2 List all properties located in Kitwe. [2]

3.3 How many properties are they in Kitwe? [2]

3.4 What's the average rent? [2]

3.5 List the monthly rentals, the type of properties in Kitwe. [2]

3.6 List properties, which are currently un-rented. [2]

3.7 What is the average number of rooms for all properties? [2]

3.8 What is the lost income from unoccupied properties? [2]

3.9 Insert rows into each table. [2]

3.10 Update the rental for all properties by 5%. [2]

SECTION 2

QUESTION 4

(A) Define two (2) integrity rules for a relational model. [5]

(B). Discuss why it's desirable to enforce these rules. [5]

(C). Describe and define a view? [5]

(D). Discuss the difference between a view and a base relation. [5]

QUESTION 5

(A). What are the two (2) major components of SQL? [5]

(B). What functions do they serve? [5]

(C). Describe at least five (5) advantages of SQL. [5]

(D). Describe at least five (5) disadvantages of SQL. [5]

QUESTION 6

(A). Describe the five (5) components of the of the DBMS environment. [5]

(B). Discuss how they relate to each other. [5]

(C). Describe at least four (4) advantages of the DBMS; [5]

(D). Describe at least four (4) disadvantages of the DBMS; [5]

QUESTION 7

(A). Discuss the functionality and importance of the Integrity Enhancement Feature (IEF). [5]

(B). Discuss several advantages and disadvantages of views. [5]

(C). What restrictions are necessary to ensure that a view is updateable? [5]

(D). Describe how the access controls mechanism of SQL work. [5]

OOOOOOOOOOOOOOOOOOOOOOOOO

End of Examination

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF COMPUTER STUDIES

2006/2007 SECOND SEMESTER EXAMINATION

TITLE OF PAPER: PROGRAMMING LANGUAGES PARADIGMS

COURSE CODE: CST3022

LEVEL: THIRD (3) YEAR

DATE: 14th FEBRUARY, 2007

DURATION: THREE (3) HOURS

INSTRUCTIONS:

- **There are FIVE questions in this paper. ANSWER ALL**

Question One

(a) Describe 4 programming languages paradigms covered in this course. **[4]**
(b) Given the following languages below classify them according to the paradigms described above: Eiffel, C#, Prolog, Scheme, VisiCalc, Basic ,Pascal, Algol, Cobol, Haskell **[5]**
(c) There about eight (8) reasons covered in this course on why there are so many programming languages. State at least five (5) of them **[5].**
(d) Explain how the Assembly language differs from Machine language **[2]**
(e) "It is said that it is a waste of time to write something in Assembly language that can be written acceptably fast in a high-level language". Based on the statement above describe four ways where it makes sense to program in Assembly language. **[4]**

Question Two

(a) List the principal phases of compilation in order, and describe the work performed by each. **[6]**
(b) Describe the form in which a program is passed from the scanner to the parser; from the parser to the semantic Analyzer; from semantic analyzer to the intermediate code generator.**[5]**
(c) Write JFlex rules to match the following tokens, and where appropriate return a value, or perform some appropriate action.
  (i) A decimal integer, with ","s to separate the digits into groups of three, as is normally done when writing numbers in English. For example 12,345,678 but not 12345678 or 123,456,78. **[5]**
  (ii) A string composed of a double quote ("), zero or more component characters, then another double quote ("). A component character can be: any character except a control character (\0 to \037, \177) or backslash (\) or double quote ("); or can be a pair of double quotes ("", representing a single "). For example "He said ""hello""", but not "He said \"hello\"" or "he said "hello"". **[3]**
  (iii) A binary integer, composed of the binary indicator "0b", followed by one or more binary digits. For example 0b101011, but not 0b1234 or 0B101011 or 101011. **[1]**

Question Three

(a) Outline the three basic operations that can be used to build complex regular expressions from simpler regular expressions, explaining what each operation is. **[3].**
(Note: use these operations to answer part b and c. use BNF format)
(b) Write regular expressions to capture a digit. Using the digit expression write regular expressions to capture integers and real numbers. For real numbers, take the expression of strings of integers separated by a dot. **[3].**
(c) Write regular expressions to capture comments in Pascal. They are delimited by (* and *). Between these delimiters there can be an empty string, a single term or many terms. Terms are basically identifiers. **[3]**
(d) Show (as "circle-and-arrows" diagram) the finite automata for the part (b) and (c). **[6].**

(e) List all valid sentences with one, two or three characters that can be derived from the EBNF grammar.
Sequence -> 'A' {'B'|'C'} ['D']
Represent the EBNF grammar as a syntax diagram and give an equivalent grammar in BNF. **[5]**

Question Four

(a) Consider the following grammar:

<S> ::= a <S> c <B> | <A> | b
<A> ::= c <A> | c
<B> ::=d | <A>

Which of the following sentences are in the language generated by this grammar? Show your work.
(a). abcd (b). acccbd (c). bacccbc (d) accd (e) bacccd **[5]**

(b) Consider the following grammar

```
G ::= S $$
S ::= A M
M ::=S | ∈
A ::=a E | b A A
E ::= a B| b A | ∈
B ::= b E| a B B
```

The $$ is the end-marker while ∈ is an empty string.

i. Describe in English the language that the grammar generates. **[2]**
ii. Generate and show the parse tree for the string **a b a a.** **[3]**
iii. Is the grammar LL? If not identify a prediction conflict. **[4]**

(c) Summarize the differences between LL and LR parsing. Which one of them is also called "bottom-up"? "Top-down"? Which one is also called "predicate"? "Shift-reduce"? What do LL and LALR stand for. **[6]**

Question Five

(a) Describe three ways in which Prolog programs can depart from a pure logic programming model? **[3]**

(b) For the Prolog code given below identify all syntax errors and Singleton variable warnings.Line numbers have been included to assist in answering.

```
1.%% Harrison is a wizard.
2.wizard(Harrison).

3.%% Hagrid scares dudley.
4.Scare(hagrid,dudley).

5.%% All wizards are magical.
6.magical(X) :- wizard(X).

7.%% Uncle Vernon hates everything that is magical.
8.hate(uncle dudley,X) :- magical(X).

9.%% Aunt Petunia hates everything that is magical.
10.hate(aunt_petunia,X :- magical(X).

11.%% Aunt Petunia hates anything that scares dudley.
12.hate(aunt_petunia,X) :- scare(X,dudley)
```

[4]

(c) This is lunch menu at some eating place in Lusaka.

Starters

green salad
melon
tomato salad
rabbit pate

Main dishes

rock salmon with mayonnaise and capers
roast beef with girolle mushroom sauce
pasta, courgette and cheese bake

Desert

cheese
yoghurt
Paris Brest pastry

You are allowed to take one starter, one main dish, and one desert.

Use the predicates `starter/1`, `main/1`, and `desert/1` to represent lunch menu options in Prolog. **[5]**

(d) If you are very hungry, you can have one starter, one main dish, and one desert. If you are not so hungry (or have a course right after lunch), you might want to only have a starter and a main dish or a desert and a main dish. If you are currently on a diet, it's probably wisest to only take a starter.

Define a predicate `menu/4` which finds menus for you depending on whether you are hungry, not so hungry or on a diet. So, `menu(Status,X,Y,Z)` should be true if `Status` is `hungry` and `X`, `Y`, `Z` are a starter, a main dish, and a desert, respectively. It should also be true if `Status` is `not_so_hungry`, and either `X` is a starter, `Y` a main dish, and `Z` is `nothing`, or `X` is `nothing`, `Y` is a main dish, and `Z` is a desert. Finally, `menu(Status,X,Y,Z)` should be true if `Status` is `on_diet`, `X` is a starter and `Y` and `Z` are `nothing`. **[8]**

THE UNIVERSITY OF ZAMBIA
2nd SEMESTER EXAMINATIONS 2006

February 2007

CST3032 – Introduction to Artificial Intelligence

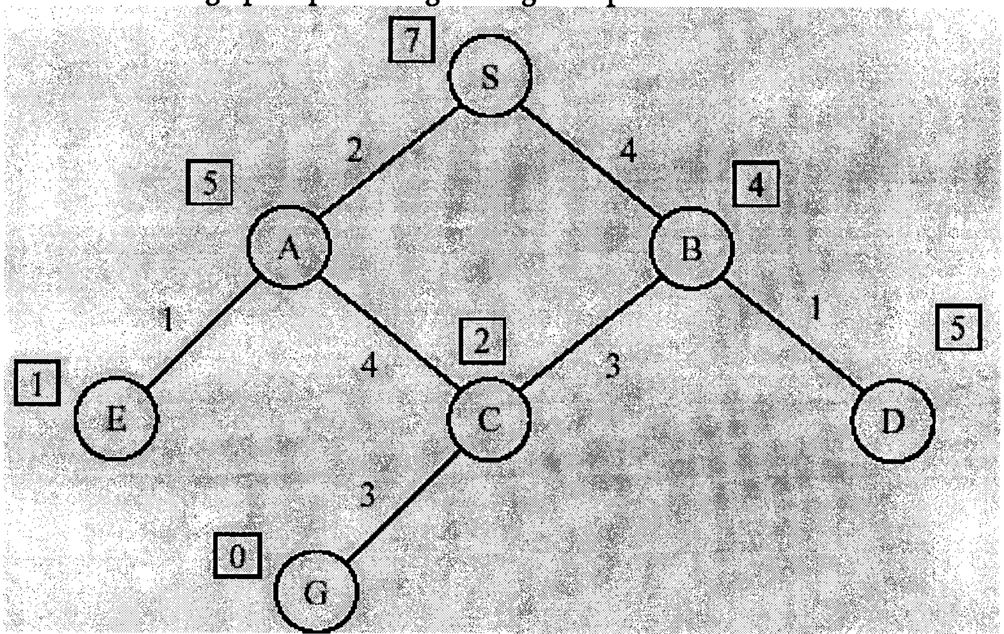
INSTRUCTIONS : There are Six (6) Questions in this paper and you are required to answer only five (5) of them

DURATION : 3Hours

1.

a. Explain what each of the term below means with respect to search algorithms
   i. Completeness
   ii. Optimality
   iii. Space requirements
   iv. Time

b. Shown below is a graph representing a navigation problem



The path cost is shown by the number on the links; the heuristic evaluation is shown by the number in the box. Assume that during search

- S is the start state and G is the goal state
- When placing nodes on the queue use alphabetical ordering to break ties
- Assume that we never generate child nodes that appear as ancestors of the current node in the search tree

   i. What is the order that breadth first search will expand the nodes?
   ii. What is the order that iterative deepening search will expand the nodes?
   iii. What is the order that hill climbing search will expand the nodes?

iv. What is the order that A* search will expand the nodes?

2.

a. Define the following
   i. A sound inference rule
   ii. A complete inference rule
b. Prove the modus ponens is sound using the truth table
c. Consider the following knowledge base
   If it is raining out then Ann puts the top up on her convertible. If it is raining and Ann does not put the top up her convertible then Ann gets soaked. Ann did not put the top up on her convertible. It is raining
   i. Describe a set of propositional letters which can be used to represent the knowledge base.
   ii. Translate the KB into propositional logic using your propositional letters from part a.
   iii. Convert the KB into disjunction of conjunction and
   iv. Hence prove the Ann got soaked (show the derivation by naming the inference rules)

3.

a. Write a function in Scheme called sum-list, which given a list of numbers the function returns the sum of all the numbers in the list
b. Write a function called rec-power, which given two integers m and n, the function returns m^n by repeatedly multiplying m by itself n times
c. Write the pseudocode for the A* search algorithm

4. Consider the following situation. There are four variables P, R, S, and T and the set of values 2, 3, and 4. Values are to be assigned to these variables such that no two adjacent variables have the same number. (Adjacency is defined by positions in the alphabet). Further P and S can not be assigned an even number with T not odd.
   a. Define what a constraint satisfaction problem
   b. Describe the following scenario as a CSP by outlining the constraints and hence
   c. Draw the constraint graph for this scenario
   d. Draw a tree that leads to the solution for this problem, if one exists, using backtracking

5.

a. Define the following
   i. Admissible heuristic function
   ii. An evaluation function
b. Show that the search algorithm that uses an admissible heuristic is optimal
c. Consider the game tree below

iv. What is the order that A* search will expand the nodes?

2.

a. Define the following
   i. A sound inference rule
   ii. A complete inference rule
b. Prove the modus ponens is sound using the truth table

c. Consider the following knowledge base
   If it is raining out then Ann puts the top up on her convertible. If it is raining and Ann does not put the top up her convertible then Ann gets soaked. Ann did not put the top up on her convertible. It is raining
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   ii. Translate the KB into propositional logic using your propositional letters from part a.
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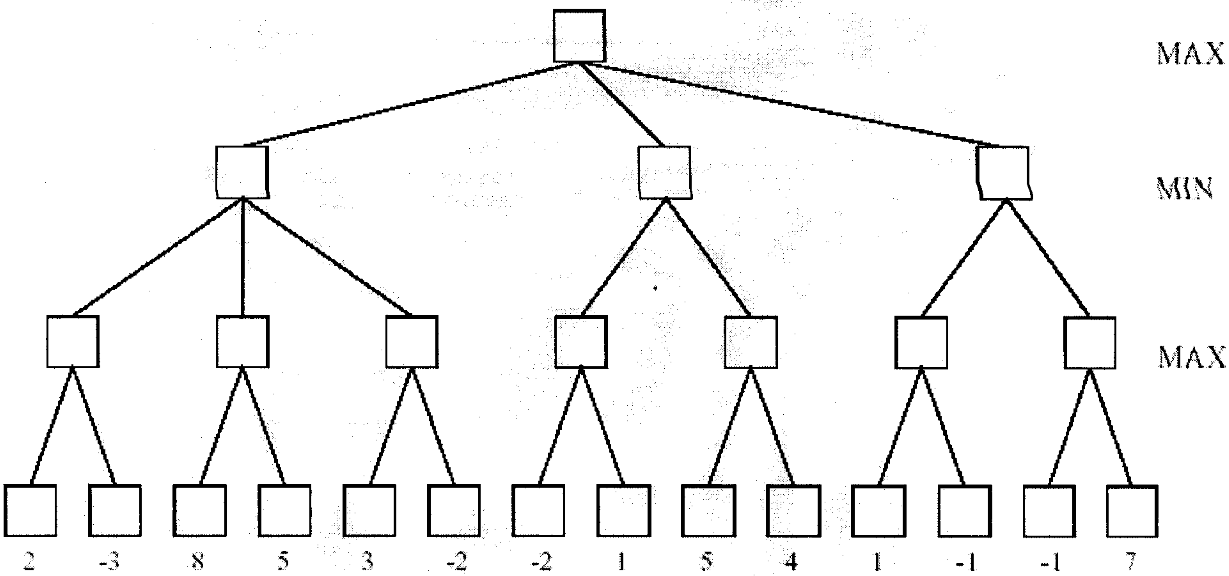
b. Write a function called rec-power, which given two integers m and n, the function returns m^n by repeatedly multiplying m by itself n times
c. Write the pseudocode for the A* search algorithm

4. Consider the following situation. There are four variables P, R, S, and T and the set of values 2, 3, and 4. Values are to be assigned to these variables such that no two adjacent variables have the same number. (Adjacency is defined by positions in the alphabet). Further P and S can not be assigned an even number with T not odd.
   a. Define what a constraint satisfaction problem
   b. Describe the following scenario as a CSP by outlining the constraints and hence
   c. Draw the constraint graph for this scenario
   d. Draw a tree that leads to the solution for this problem, if one exists, using backtracking

5.

a. Define the following
   i. Admissible heuristic function
   ii. An evaluation function
b. Show that the search algorithm that uses an admissible heuristic is optimal
c. Consider the game tree below



i. Propagate the numbers using alpha-beta pruning
ii. Hence indicate the move taken by MAX

6.

a. Describe the four components necessary to formally define a problem as a search.
b. Given the following scenario: You have the three jugs measuring 12litres, 8litres and 3litres and an infinite capacity of a water faucet from which water can be drawn. You can fill the jugs up from the faucet or from any other jug or empty them to the ground. You only need one litre.
   i. Formulate this problem as a search
   ii. Draw the search tree that leads to a solution.
   iii. List the operators leading to the solution

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

THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF COMPUTER STUDIES
SECOND SEMESTER EXAMINATION 2007

CS3252: ELECTRONICS FOR COMPUTER SCIENCE

TIME:	3 HOURS
INSTRUCTIONS:	ANSWER ANY FOUR QUESTIONS
	TOTAL MARKS 100
	ALL QUESTIONS CARRY EQUAL MARKS

Q.1. a) Convert the following decimal numbers to BCD and then to binary. **[8]**

i. 58

ii. 21

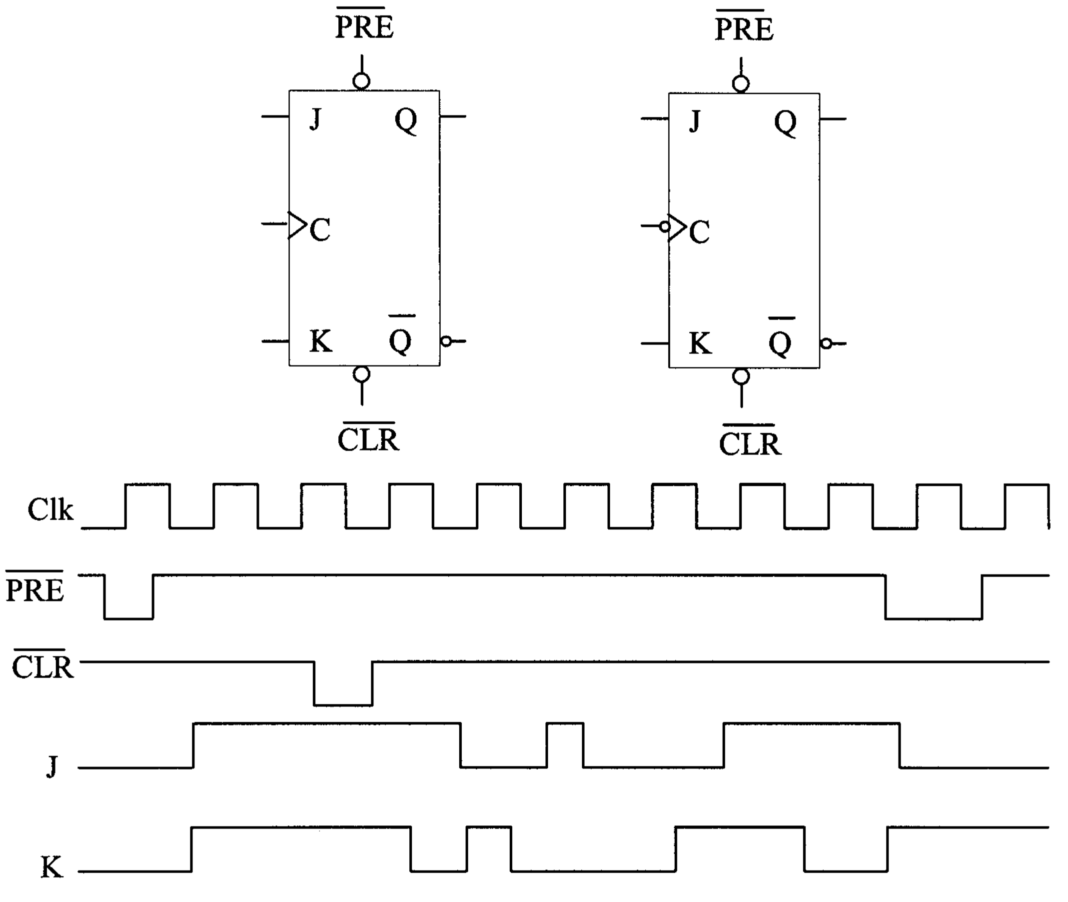
b) Show the logic required to convert the binary numbers in part a) into gray code. Convert the numbers in part a) to gray code. **[6]**

c) Draw the circuit diagram for an Analog to Digital converter using the Ramp technique. Explain how the converter performs the conversion. **[11]**

Q.2. a) Design a 4 bit counter that counts multiples of three (0,3,6,9,12,15,0,.....). **[18]**

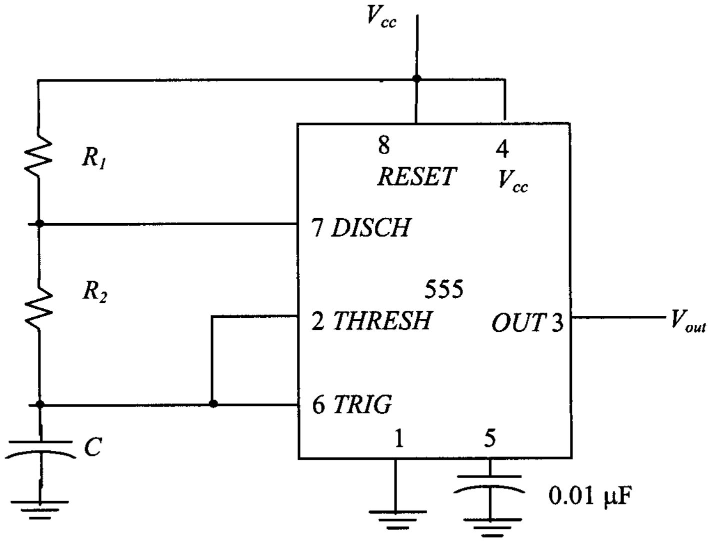
b) Use J-K Flip-Flops to create a 3 bit Johnson counter. Draw the output waveforms. **[8]**

Q. 3. a) For the circuits below draw the output waveform for each flip-flop. **[16]**

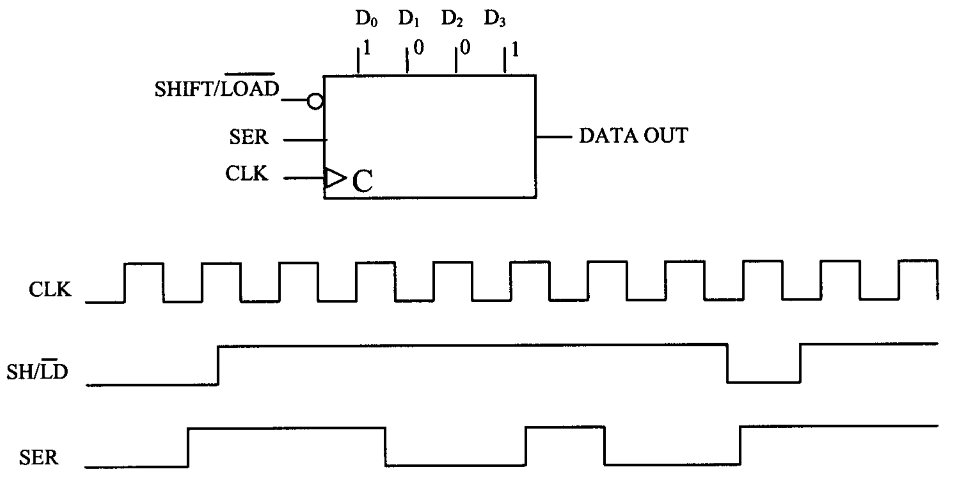


b) The circuit below uses the 555 IC timer in astable mode to achieve a 100 kHz square wave . Given that $C = 1$ nF, $R_1 = 10$K. Calculate R_2 and the duty cycle.

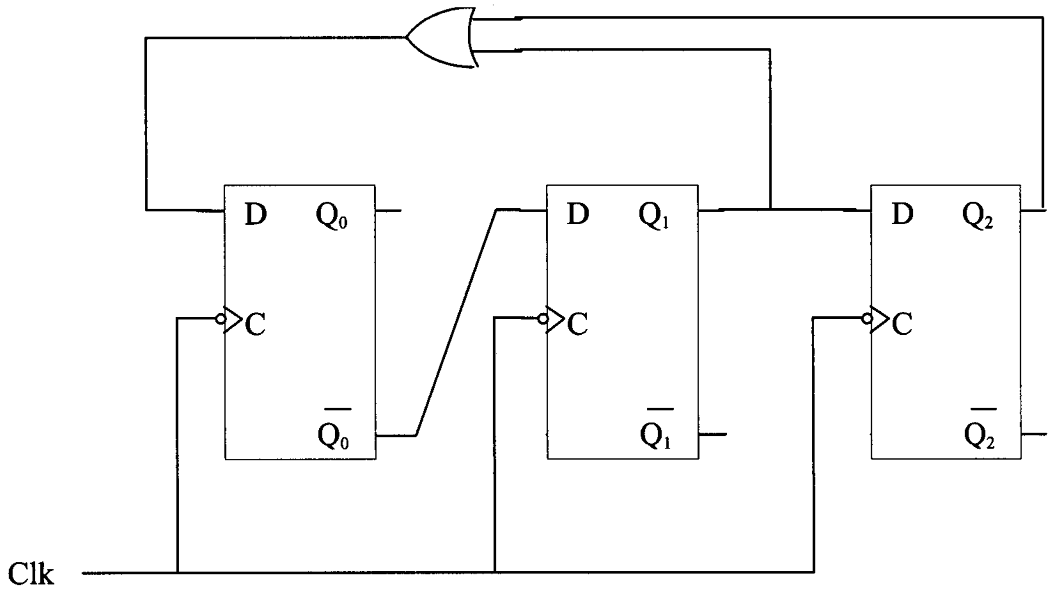
[9]



Q.4. a) Draw the output waveform for the shift register below. **[13]**



b) Draw the output waveforms (Q_0, Q_1, Q_2) for the circuit below. Start with all Flip-Flops in reset state. Draw the waveform until it repeats. **[12]**



Q.5. a) Draw the circuit diagram of a DRAM cell, include all the necessary support circuitry. Explain how a 1 is written and read into and from the cell. **[8]**

b) Use 16K x 2 EPROMs to build a 32K x 8 EPROM memory system. Draw the diagram. **[13]**

c) Make a memory map of the system in hexadecimal starting at the address 0000H. **[4]**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF COMPUTER STUDIES

2006 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATION

CS 4012 – Advanced Operating Systems and Distributed Systems

Instructions:

- Time allowed: Three (3) hours
- Answer **ALL** questions
- Each question carries 20 marks
- The exam is closed book

Question 1

(a) What are client and server stubs and how are they used in remote procedure calls?

(b) When passing data values between different machines with different operating systems what problems have to be solved?

(c) Besides network transmission times, name and explain four (4) main components that affect RPC performance (RPC delay).

(d) Name three (3) types of Interprocess communication methods. Briefly explain how one of them works.

Question 2

(a) Name two advantages and two disadvantages of distributed systems over centralized ones

(b) The term *loosely coupled system* and *tightly coupled system* are often used to describe distributed computer systems. What is the difference between them?

(c) Distributed systems have to be designed carefully, since there are many pitfalls for the unwary. Some key issues are transparency, reliability, performance, scalability and flexibility. A design should be made with the idea of making future changes easy. In this respect microkernels are superior to monolithic kernels.

(i) Describe *parallelism, location* and *migration* transparency in a distributed system

(ii) Name two advantages of a microkernel over a monolithic kernel

(iii) Explain how microkernels can be used to organize an operating system in a client-server fashion.

Question 3

(a) Consider a procedure `incr` with two integer parameters. The procedure adds one to each parameter. Now suppose that it is called with the same variable twice, for example, as `incr(i,i)`. If `i` is initially 0, what value will it have afterward if call-by-reference is used? How about if copy/restore is used?

(b) The SPARC chip uses a 32-bit word in big endian format. If a SPARC sends the integer 2 to an Intel 486, which is little endian, what numerical value does the Intel 486 see?

(c) Network transmission time accounts for 20% of a null RPC, and 80% of an RPC that transmits 1024 user bytes (less that the size of a network packet). By what percentage will the times for these two operations improve if the network is upgraded from 10 megabits per second to 100 megabits per second?

Question 4

On the Internet, the domain name system (DNS) stores and associates many types of information with domain names; most importantly, it translates domain names (computer hostnames) to IP addresses. It also lists mail exchange servers accepting e-mail for each domain. In providing a worldwide keyword-based redirection service, DNS is an essential component of contemporary Internet use.

(a) With examples explain the difference between iterative name resolution and recursive name resolution

(b) Why might a DNS client choose recursive navigation rather that iterative navigation? What is the relevance of recursive navigation option to concurrency within a server?

(c) When might a DNS server provide multiple answers to a single name lookup, and why?

(d) You are browsing the internet from a computer with a host name `cs4012.cs.unza.zm`. You would like to access `www.yahoo.co.uk` website. Describe the steps involved in resolving the IP address of www.yahoo.co.uk (Clearly state your assumptions).

Question 5

(a) In many layered protocols, each layer has its own header. Surely it would be more efficient to have a single header at the front of each message with all the control in it than all these separate headers. Why is this not done?

(b) Why are transport-level communication services often inappropriate for Building distributed applications?

(c) Discuss the three main features of a distributed system

(d) With examples describe what middleware is and its role in a distributed system

END OF EXAM

University of Zambia

School of Natural Sciences

Department of Computer Studies

EXAM:	**FEBRUARY FINAL EXAM - SEMESTER TWO**
COURSE:	**CST4122 – FUNDAMENTALS OF COMPILERS**
DURATION:	**3 HOURS**

INSTRUCTIONS

- ***Attempt ANY FIVE (5) questions out of the given SEVEN.***
- *All questions carry equal marks*
- *Clearly number your solutions*
- *Use the marks as a guide to the detail required in your answers while keeping your answers concise and relevant.*

GOOD LUCK!!

QUESTION ONE

(a) **CST41222006 Identifiers** must begin with an uppercase or lowercase **letter**, followed (optionally) by any number of uppercase letters, lowercase letters, **digits**, or **underscores** ('_'). An identifier may not end with an underscore, nor may it contain two or more consecutive underscores. A **CST41222006** integer literal is a sequence of digits, optionally preceded by a '-' character (indicating a negative number). Write regular definitions for;

i. CST41222006 Identifiers **[5 marks]**

ii. CST41222006 Integer Literals **[2 mark]**

(b) Design deterministic finite automaton's to recognize;

i. Valid CST41222006 identifiers **[5 marks]**

ii. Valid CST41222006 integer Literals **[3 marks]**

(c) For each of the CST41222006 identifiers below state whether it is **valid** or **invalid**. **[5 marks]**

i. a

ii. AA__k7

iii. _GT_9y

iv. mName390_a

v. your_name_

QUESTION TWO

(a) Outline three roles of the parser in a compiler **[3 marks]**

(b) What are the components in a grammar? **[2 marks]**

(c) What is an ambiguous grammar? **[2 marks]**

(d) Consider the following grammar:

$E \rightarrow$ id |! E | E && E | (E)

Where id, !, &&, (,) are terminals.

i. Prove that the grammar is ambiguous. **[8 marks]**

ii. Eliminate left-recursion from the grammar. **[5 marks]**

QUESTION THREE

(a) Every construct that can be described by a regular expression can also be described by a grammar. Why use regular expressions and not grammar to define the lexical forms of a language?" Outline four (4) reasons. **[8 marks]**

(b) Given the following grammar;

$$A_0 \rightarrow aA_0 \mid bA_0 \mid aA_1$$

$$A_1 \rightarrow bA_2$$

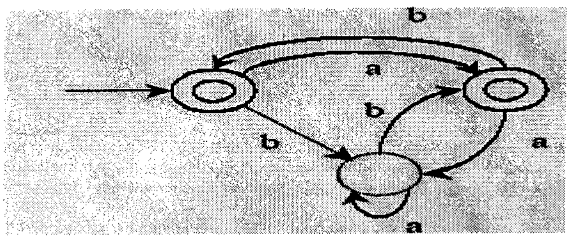
$$A_2 \rightarrow bA_3$$

$$A_3 \rightarrow \varepsilon$$

i. What language is described by this grammar? **[4 marks]**

ii. Write a regular expression for the language. **[3 marks]**

(c)



Which of the following strings are in the language specified by this finite state machine? **[5 marks]**

i. abab

ii. bbb

iii. aaab

iv. aaa

v. ε

QUESTION FOUR

(a) A compiler operates in phases, each of which transforms the source program from one representation to another. With the aid of a diagram, discuss what role each phase plays in a compiler. **[10 marks]**

(b) In addition to a complier, several other programs may be required to create an executable target program. With the aid of a diagram, discuss the context of a compiler. **[10 marks]**

QUESTION FIVE

(a) Distinguish between the ``front-end" and ``back-end" of a compiler. **[6 marks]**

(b) A grammar that can be parsed top-down is said to be LL (*1*). What do the two L's and "1" in LL (1) stand for. **[2 marks]**

(c) A grammar that can be parsed bottom-up is said to be LR (*1*). What do the L, R and "1" in LR (1) stand for. **[2 marks]**

(d) Eliminate left-recursion from the following grammars. **[10 marks]**

i. E → aa | abba | E b | E E

ii. E → E + T | T

T → T * F | F

F → (E) | id

QUESTION SIX

Consider the following grammar;

(0) S → (L)

(1) S → a

(2) L → L , S

(3) L → S

i. Eliminate left recursion from this grammar. **[5 marks]**

ii. Construct a non-recursive predictive parser for the grammar in (i). **[10 marks]**

iii. Show the behaviour of the parser on sentence (a, a) **[5 marks]**

QUESTION SEVEN

(a) Consider the following augmented CFG for prefix expressions.

(0) $E' \rightarrow E\ \$$

(1) $E \rightarrow +\ E\ E$

(2) $E \rightarrow -\ E\ E$

(3) $E \rightarrow id$

i. Construct an SLR parsing table for the grammar **[15 marks]**

ii. Show behaviour of parser on input + id id. **[5 marks]**

THE END

THE UNIVERSITY OF ZAMBIA
2nd SEMESTER EXAMINATIONS 2006

February 2007
CST4132 - Computer Graphics Fundamentals

INSTRUCTIONS: You have 6 questions in this paper and you are required to answer only 5 of them with question 1 being compulsory
DURATION: 3Hours

1.
   a. List four applications of computer graphics
   b. Distinguish between application computer graphics and general programming computer graphics software.
   c. List four devices used in computer graphics for input
   d. Distinguish between the operation characteristics the following display techniques
      i. Raster scan displays and Vector scan displays
      ii. Emissive and non-emissive display
      iii. Plasma displays and LCD

2. Given the set of parabolas expressed in the form of $y = ax^2 - b$, with input of a, b and the range of values of x.
   a. What is the range of x in terms of a and/or, b in which the gradient of the parabola is less or equal to 1.
   b. Set up a midpoint algorithm for these parabolas taking symmetry into consideration.

3. Suppose you have an 8 inch by 10 inch video monitor that can display 100 pixels per inch. If memory is organised in one-byte per word, each pixel is assigned one-byte of storage and the starting frame buffer address is 0.
   a. What size frame buffer (in bytes) is needed for this system?
   b. How many different colours does this system provide?
   c. What is the frame buffer address of the pixel with screen coordinates (x, y)

4.
   a. Outline the steps in the Bressenham line generation algorithm for $|m| < 1$
   b. Use the algorithm above to display the points selected for a line that connects (20, 10) and (30, 18)

5.
   a. Describe the operating characteristics of a raster scan display for Non-interlaced and Interlaced Systems
   b. What is the purpose of interlacing, when is it required and when is it not required?
   c. Given that t_h is the horizontal retrace and t_v is the vertical retrace of an m by n system. Express in terms of t_v, t_h, m, and/or n the total amount of time spent on retrace during a single refresh for interlaced system

6.
   a. Describe the two mechanisms that are used to achieved colour CRT monitors (use diagrams)
   b. Give the comparative advantages and disadvantages of the two approaches

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

THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF COMPUTER STUDIES
SECOND SEMESTER EXAMINATION
February 2007

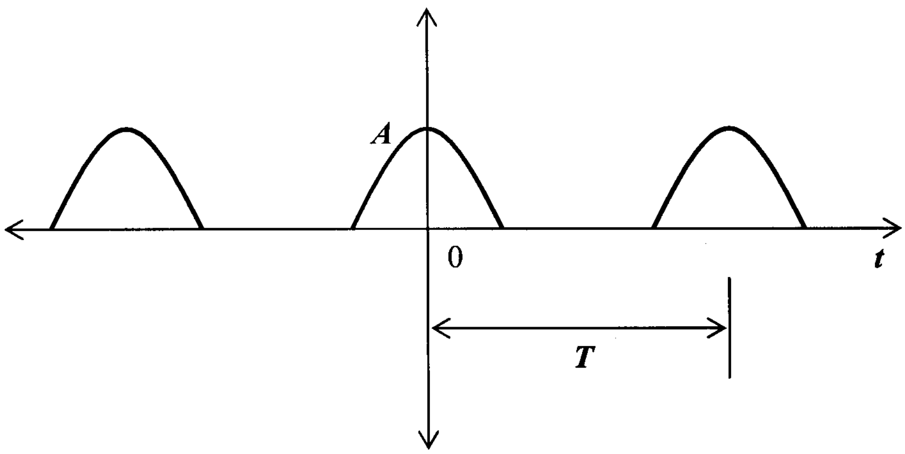
CST 4252: ELECTRONICS FOR COMPUTING IV

TIME: 3 HOURS
INSTRUCTIONS: Follow instructions for each section.

SECTION I Answer all questions (20,10,10)

Q.1

A half wave rectifier circuit is used to produce the waveform below. Find the Fourier series expansion for the waveform.



Q.2

a) What is meant by the following terms

i) Gain distortion
ii) Group delay distortion
iii) Doppler shift
iv) Thermal noise

b) Give a brief explanation of Multipath fading and the methods used to cope with this phenomena.

c) A satellite dish is limited in performance by thermal noise. It is designed to provide S/N ratio of 20 dB to the demodulator input. If the average thermal power is -130 dBm and the temperature is 300° K what is bandwidth of the channel?

Q.3

a) A wireless internet link has a Baud rate of 50,000 baud operating on a bandwidth of 50 kHz. Given that the bandwidth efficiency of the link is 1.5 bits/second/Hz find

i) The bit rate
ii) The no of levels per symbol.

b) What is the maximum S/N ratio in dB that can be tolerated if the link in part (a) is to provide error free communication.

c) What is the E_b/N_o ratio for the link.

SECTION II Answer all questions (40)

1. What is the difference between symmetric and asymmetric communication? Give an example of each.
2. Why is it important of using standardized protocols in data communication systems?
3. How many addressing schemes are their in the TCP/IP protocol and what are the layers associated with them?
4. Why is it important to fragment data blocks.
5. What is the maximum size of an Ethernet frame?
6. What are the main differences between TCP and UDP and in what instance is one used over the other?
7. Identify two applications that use UDP and give the reason why UDP is preferred in the instance.
8. Briefly outline how the TCP/IP protocol handles errors in data transfer? In your answer make reference to the appropriate protocol layers.
9. What method is used to insure that packets in a packet switched network are assembled correctly in the TCP/IP suite?
10. What is meant by a virtual circuit at the transport layer and how is a virtual circuit established?
11. What is the difference between Unicast, Broadcast and Multicast with regards to addressing?
12. What is the main advantage of using multiplexing on a communication line?
13. The physical layer of the OSI model describes the interface of acommuncation technology. What are the four aspects that a standard must describe in order to implement a particular physical layer?
14. Briefly describe the function of the following protocols;
    a. ICMP
    b. FTP
    c. OSPF
    d. SMTP
15. Give three advantages of digital communication over analog communication.
16. What factors affect attenuation in a communication channel?
17. Name two different types of noise sources in a communication channel and how they can be reduced?
18. Give a reason why one would use the following encoding systems?
    a. Digital data to digital signal
    b. Digital data to analog signal
19. When evaluating an encoding scheme briefly explain how the following affect performance;
    a. Signal spectrum
    b. Clocking

20. What are differences between the following modulation methods? Give the merits or disadvantages for each.

a. ASK
b. FSK
c. PSK

SECTION III Answer 1. (20) (At least two pages long)

1. Write a short essay on the TCP/IP model. The essay must include the following.
    a. The overall advantages of using TCP/IP
    b. The function of each layer and how it achieves this.
    c. The data type for each layer.
    d. The associated hardware for each layer if any.

2. Write a short essay on the following encoding techniques outlining their advantages and disadvantages. Give an example of how a bit pattern would be encoded in each of these schemes.
    a. NRZ
    b. Manchester
    c. Bipolar AMI

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR DISTANCE EDUCATION FINAL EXAMINATIONS

GEO 111: INTRODUCTION TO HUMAN GEOGRAPHY I

TIME: Three hours

INSTRUCTIONS: Answer Question 1 (40%) and any other three. Credit will be given for the use of relevant illustrations. Use of a certified electronic calculator and a Philip's University Atlas is allowed.

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1. Table 1 shows population sizes of ten largest towns in Zambia. Critically examine the population figures and answer the question that follows below.

Table 1: Ten largest Town's Population in Zambia

Name of Town	Population
Lusaka	1, 084,703
Kitwe	376,124
Ndola	374,757
Chipata	367,539
Chibombo	241,612
Lundazi	236,833
Petauke	235,879
Solwezi	203,797
Choma	204,898
Mazabuka	203,219

Source: Census of Population & Housing 2000.

Use the graph method to determine whether the above data set conforms to the Rank-Size rule or not.

2. Keeping in view the exemplars in Geography, explain the current trends in the development of human geography.

3. Write a detailed account of the distribution of rural settlements in Zambia.

4. 'Zambia's rapid urbanization is problematic'. Discuss.

5. Outline the contributions of T. Hagerstrand on the Diffusion process.

6. Write short explanatory notes on each of the following:

   (a) Multiple-nuclei model of Urban Land Use

   (b) Von Thünen's Model

   (c) Weber's Industrial Location Theory

   (d) Man and Environment

   (e) Jacob's Model of cultural development.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 112: INTRODUCTION TO HUMAN GEOGRAPHY II

TIME: Three hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks and candidates are advised to make use of illustrations and examples wherever appropriate. Use of a Philip's University Atlas is allowed.

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1. Explain the causes and effects of the industrial Revolution in England and show the extent to which industrialization has diffused to Africa.

2. Comment on Zimmermann's (1964:12) statement that "knowledge is truly the mother of all other resources", with respect to the role of both material and non-material resources in socio-economic development.

3. Define land tenure and state the arguments for reforming land tenure in sub-Saharan Africa with respect to the tenure debate.

4. How do the Functional and Conflict models explain social change in society?

5. Define modernization and state the elements in the Modern-Traditional Dichotomy.

6. Explain the Theory of Demographic Transformation and comment on its applicability to the experience of African countries.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR DISTANCE EDUCATION FINAL EXAMINATIONS

GEO 212: THE GEOGRAPHY OF ZAMBIA

TIME: Three hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks. Use of a Philip's University Atlas is allowed. Candidates are advised to make use of illustrations and examples wherever appropriate.

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1. Explain the distribution of Zambia's population.

2. Discuss the economic policies adopted by the Zambian government after 1991 and their impact on Zambia's socio-economic welfare.

3. 'Zambia is geographically a 'cockpit'. Examine this statement in reference to the geo-political and economic situation in the country.

4. 'Zambia's vegetation is a function of relief, climate and soil'. Discuss.

5 Explain the main factors that affect the distribution of rainfall and temperature in Zambia.

6. Examine Zambia's membership of the regional economic groupings, pointing out the advantages and disadvantages.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 272: QUANTITATIVE TECHNIQUES IN GEOGRAPHY II

TIME: Three hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks. Use of a certified scientific calculator is allowed.

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1. A large manufacturing firm wants to determine whether a relationship exists between the number of work-hours an employee misses per year and his/her annual wages. A sample of produced data which were assumed to have equal mean, median and mode is given in Table1. Do these data provide evidence that the work-hours missed are related to annual wages? Use the 0.05 level of significance.

Table 1: Work-hours Missed and Corresponding Wages

Work-hours Missed (per year)	Annual Wages ('000 US $/Year)
49	15.8
36	17.5
127	11.3
90	12.2
33	12.0
154	13.5
10	10.8
190	19.2
5	9.8
62	17.8
78	12.7
42	24.2

2. Weevils cause millions of Dollars worth of damage each year to cotton crops. Three chemicals A, B, and C designed to control weevil populations were applied, one to each of three sample-fields of cotton. After three months, nine plots of equal size were randomly selected from the three sample fields with equal areas and the percentage of cotton plants with weevil damage was recorded. Do the data in Table 2 provide sufficient evidence to indicate a significant difference in location among the distributions of damage rates corresponding to the three treatments? Aim at a 99 percent accuracy in your analysis.

Table 2: Percentage of Cotton Plants with Weevil Damage after the Application of Chemicals A, B, and C.

Percentage of Cotton Plants with Weevil Damage per Sample		
A	B	C
10.8	22.3	9.8
15.6	19.5	12.3
19.2	18.6	16.2
17.9	24.3	14.1
18.3	19.9	15.3
9.0	20.4	10.8
19.0	23.6	12.2
20.3	21.2	17.3
19.4	22.6	11.3

3. A University of Zambia researcher randomly sampled quantities of caterpillars that were harvested by women in Makumbi and Ching'ombe areas on the same days of the month. Assuming that both the respective quantities of caterpillars that were harvested were skewed, would it be in order to conclude that more caterpillars were harvested in Makumbi than in Ching'ombe? Use the 95 percent accuracy level.

Table 3: Quantities of Caterpillars Harvested in Makumbi and Ching'ombe Areas during a specific Period of the Month

Area	Quantities of Caterpillars in Kilograms											
Makumbi	58	74	48	88	69	45	68	78	55	16	98	54
Ching'ombe	25	15	24	45	16	60	20	09	12	18	24	19

4. Shown in Table 4 are small-scale farmers classified according to age cohorts, who adopted use of organic manure with different zeal namely; Fairly, Highly and very highly after a one-year training programme. Determine whether the zeal of acceptance of the use of organic manure measured by the number of adopters was significantly different if a 95 percent level of accuracy were used in the analysis.

Table 4: Association between ages of small-scale farmers and the adoption of use of organic manure

	Adoption of use of organic manure		
Age cohort (Years)	**Fairly**	**Highly**	**Very Highly**
15 – 20	20	35	70
30 – 40	45	55	80
50 – 60	65	15	50

5. Study the data provided in Table 5 and then answer the questions that follow:

(a) Plot the data

(b) Determine a simple regression equation

(c) Define your linear regression equation

(d) Estimate the number of 90 Kg bags of groundnuts that would have been harvested if:

(i) 36 Kg of fertilizer were applied to the groundnuts per hectare
(ii) 53 Kg of fertilizer were applied to the groundnuts per hectare
(iii) 76 Kg of fertilizer were applied to the groundnuts per hectare

Table 5: Fertilizer applied to each hectare of groundnuts and the Associated 90Kg bags of groundnuts harvested.

Amount of Fertilizer (Kilograms)	90 Kg bags of groundnuts harvested
70	5.0
24	13.0
46	12.0
3	15.0
40	10.0
55	14.0
90	8.0
12	22.0
30	20.0
66	13.0
18	24.0
46	12.0
80	3.0

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

(a) Three meanings of statistics

(b) How quartiles are used

(c) The difference between positive and negative skewness

(d) Problems of multimodal distribution

(e) Four types of parametric tests

(f) Distinguish between dependent and independent variables

(g) A symmetrical curve

(h) The difference between two-tailed and one-tailed test.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 482: ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT II

TIME: Three Hours

INSTRUCTIONS: Answer any **four** questions. All questions carry equal marks. Use of a Philip's University Atlas is allowed. Candidates are advised to make use of illustrations and examples wherever appropriate.

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1. What is Mechanical Biological Treatment (MBT) in waste management and what does the mechanical and biological element refer to?

2. What is a wetland and why are wetlands referred to as "Kidneys of the landscape" as well as "biological supermarkets"?

3. Pyrolysis and Gasification are two related forms of thermal treatment where materials are heated at high temperatures and limited oxygen. Explain.

4. What is Trade-Off in environmental planning? Use Aswan High Dam of Egypt as a case example.

5. What causes stratospheric Ozone depletion and what are the environmental effects?

6. Why does EIA and SEA often fail to supply reproducible results in developing countries? Use Zambia as a case example.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 495: ENVIRONMENTAL HAZARDS AND DISASTERS

TIME: Three Hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks. Use of a Philip's University Atlas is allowed. Candidates are advised to make use of illustrations and examples wherever appropriate.

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

   (a) Human reactions to irregular natural hazards between events

   (b) The relationship between hazard and its probability

   (c) Distinct stages in risk assessment

   (d) Dissonant perception

   (e) An event tree technique.

2. With the help of a diagram, explain the process of marginalisation typical of LDCs in relation to disaster.

3. Explain how the people of Luangwa District react to irregular natural hazards like flooding during the event.

4. Discuss the J – curve with respect to human's dominance in the ecosystem and its impact on food supply for humans.

5. Discuss the depletion of natural resources and environmental degradation in view of the Gaia hypothesis on environmental response to human interference of the ecosystem.

6. Table 1 shows the incidence of tropical cyclones and the number of people killed in selected Asian countries during the period 1980 – 1988. Examine Table 1 and then answer the questions that follow.

Table 1: Income, Disaster events and Disaster related Deaths in Selected Countries Asian countries 1980 - 1988

Country	Economy (Income)	No. of Cyclone Events	Deaths	No. of Deaths/Event
Japan	High	11	254	23
Philippines	Medium	22	4,322	196
Bangladesh	Low	08	10,733	1,341

(a) What relationship does the data in Table 1 validate concerning national wealth and disaster related deaths?

(b) What could be the logical explanation for the observed relationship?

(c) According to Funaro-Curtis (1982), what explanation did he provide for the observed relationship and why?

(d) How did Funaro-Curtis link his explanation to the 1972 earthquake in Nicaragua?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 912: GEOGRAPHY OF MIGRATION AND REFUGEES

TIME: Three hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks and candidates are advised to make use of illustrations and examples wherever appropriate. Use a Philip's University Atlas is allowed.

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1. Discuss the negative control sub-systems that exist in both rural and urban areas of Zambia with regards to migration since independence.

2. 'Refugees cannot be effectively protected and assisted without the tripartite approach in any country of asylum.' Discuss.

3. Discuss the strengths of Petersen's (1958) typology of migration as compared to Lee's (1966) model of migration.

4. Use Zambia as an example to ascertain differences between refugee camps and settlements.

5. Use examples from Sudan and Zambia to explain how refugees can attain self-sufficiency in urban areas.

6. Ascertain the argument that 'any country in the world can handle the refugee situation without involving the United Nations High Commissioner for Refugees (UNHCR).'

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 922: GEOGRAPHY OF REGIONAL PLANNING AND DEVELOPMENT

TIME: Three hours

INSTRUCTIONS: Answer any **four** questions. All questions carry equal marks. Use of a Philips' Atlas is allowed. Candidates are encouraged to use Illustrations wherever appropriate.

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1. Explain the major shifts in the perception of the development process.

2. What are the merits and demerits of the conservative model of economic development?

3. Evaluate Wilber's (1973) criticism of traditional economists for using the Gross National Product (GNP) as a measuring rod for economic development.

4. Discuss the position of either the United Nations Economic Commission for Africa (UNECA) or the World Bank (WB) on Structural Adjustment Progammes (SAPs).

5. 'Agglomeration in some regions produces deglomeration in others'. Discuss this assertion in relation to the way in which space provides inequality of economic opportunity.

6. 'Railway corridors are potential areas for economic development'. Examine this statement in relation to Zambia's railway system.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 952: GEOGRAPHICAL HYDROLOGY

TIME: Three hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks and candidates are advised to make use of illustrations and examples wherever appropriate.

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

   (a) Hydrometric measurement
   (b) Hydrologic modeling
   (c) Soil moisture
   (d) Effective rainfall
   (e) Cross-grading and micro-piracy.

2. With the aid of a well labeled diagram, describe and distinguish between confined and unconfined aquifer.

3. 'The notion of integrated management of land and water resources is not new.' Discuss this assertion and its application to Zambia.

4. State the three climatic balance equations and discuss the ways in which they help in maintaining the current global atmospheric and hydrological conditions.

5. Discuss the developments and theoretical bases of the Penman equation.

6. Define flood and maximum probable flood and explain the value of magnitude frequency analysis to the investigation of hydrological problems.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 962: BIOGEOGRAPHY

TIME: Three Hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks. Use of a Philip's University Atlas is allowed. Candidates are advised to make use of illustrations and examples wherever appropriate.

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

   (a) Historical biogeography

   (b) Biotic processes

   (c) Species range with reference to physical factors

   (d) Kinds of fires

   (e) Practical value of burning vegetation.

2. The Linnean system of classification is described as being generic, hierarchical, comprehensive and binomial. Explain the terminology in relation to this classification.

3. 'The theory of Continental Drift is nothing more than a scientist's dream based on imagination rather than facts'. Discuss.

4. Why do geographers study plants more than they study animals?

5. Distinguish between the three types of animal adaptations to the environment.

6. Identify and explain the three groups of processes that comprise the biogeographic system.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SECOND SEMESTER EXAMINATIONS
FEBRUARY, 2007

GEO 971 AERIAL PHOTOGRAPHY (PAPER I)

TIME: 3 HOURS **MARKS**: 80

INSTRUCTIONS: ANSWER ALL QUESTIONS

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1. In applying remote sensing techniques in vegetation studies a number of approaches may be adopted to classify the vegetation cover. Using suitable examples and illustrations suggest and explain what these approaches may be. **(10 marks)**

2. Explain the following remote sensing terms: **(10 marks)**

   a. Film speed
   b. Orthocromatic film
   c. Multiband photography
   d. Airphoto ground distance
   e. Parallax

3. How does the leaf structure of a plant influence in-coming radiation? **(10 marks)**

4. a. The distance between UNZA bus stop and Lusaka International Airport road junction measures about 500mm on a map with a scale of 1:50 000. The distance between these two points measures 600mm on an airphoto. What would be the scale on the airphoto, assuming Lusaka is about 1000m above mean sea level?
(5 marks)

   b. A tree appears on two stereo airphoto pairs. On airphoto 'A' the difference between the top and the base of the tree is 10mm while on airphoto 'B' the difference is 4mm. Assuming the distance between the principle points on the two airphotos is 10cm determine how high, above the ground, the plane was flying when it took the photographs.
(5 marks)

5. Give the main types of commonly used airphotos (not films), explaining their characteristics, advantages and any disadvantages.
(5 marks)

6. Discuss the main types of displacements commonly found in airphotos? **(10 marks)**

7. a. Why is blue light often not used in aerial photography? **(5 marks)**

   b. How may the use of wavelength in 'a' above affect the appearance of objects on aerial photographs? **(5 marks)**

8. a. Explain how aerial photos may be used in the study of land cover and land use change. **(5 marks)**

   b. Why is the information generated during land use and land cover studies important? **(5 marks)**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 972: SATELLITE REMOTE SENSING AND GIS

TIME : THREE HOURS

INSTRUCTIONS : ANSWER QUESTION ONE AND ANY OTHER THREE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS. USE OF A PHILIP'S UNIVERSITY ATLAS IS ALLOWED

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1. Using the digital image below, illustrate and explain how a parallel piped classifier can be applied. Assume that there are three (3) features in the image.

126	128	124	120	123	124	121	117	119	120
116	120	117	112	114	124	117	116	110	109
113	118	116	124	106	129	107	113	119	116
109	118	118	111	146	155	138	123	122	136
132	123	119	135	134	131	136	146	137	142
136	163	159	150	136	168	130	142	143	139
159	161	147	148	142	172	163	176	157	124
138	141	156	171	147	178	170	174	167	123
255	255	138	158	168	169	175	176	175	170
255	255	255	155	163	173	176	170	167	171
255	255	255	142	162	163	166	165	167	164
255	255	255	161	164	172	161	165	169	167
255	255	146	154	167	170	166	163	167	162
255	255	140	143	165	160	167	168	171	172
255	255	151	167	171	164	165	160	170	174

Figure: A digital image

2. Write short explanatory notes on **ALL** of the following:

   (a) Image understanding.
   (b) Resolution and extent.
   (c) Spectral signature.
   (d) Pure pixel and mixed pixel.
   (e) Rayleigh and mie scattering.

3. 'Remote sensing is simply pattern recognition'. Discuss.

4. Discuss the assertion that the objective of any image data analysis is to distinguish effects and events in the data.

5. 'Adjusting contrast on a TV set does not change the image'. Discuss.

6. Outline the four basic components of a remote sensing system and show how they interact to produce an image.

END OF EXAMINTAION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 975: CARTOGRAPHY

TIME: Three Hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks. Use of a Philip's University Atlas is allowed. Candidates are advised to make use of illustrations and examples wherever appropriate.

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

    (a) Classes of maps
    (b) Map projections
    (c) Universal Transverse Mercator (UTM) grid
    (d) Graphic elements of symbolization
    (e) Disadvantages of a globe

2. With the help of examples, describe the three classes of symbols and explain how they can be used to portray nominal, ordinal and interval data.

3. 'Type size is an element of typographic design whose subject is said to be complex'. Discuss.

4. Compare and contrast the development of cartography before and after the 1950s.

5. 'There is a general claim that names on a map are a necessary evil'. Discuss.

6. Write an essay on the different methods of lettering a map.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 995: ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT I

TIME: Three hours

INSTRUCTIONS: Answer questions one (compulsory) and any other three. All questions carry equal marks and candidates are advised to make use of illustrations and examples wherever appropriate. Use of a Philip's University Atlas is allowed.

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

   (a) Ecofeminism
   (b) Energy futures
   (c) Poison and natural balance paradigm
   (d) Global climate change
   (e) Precautionary principle.

2. Elucidate the assertion that rural communities and peoples must be the central actors in the process of restoring ecocentric sustainability in Africa.

3. 'The ivory ban reflects the power dynamics of North/South relationships of dependency that have been perpetuated throughout the colonial and postcolonial periods'. Discuss.

4. At the beginning of the new demographic era (1800), world population stood at about 250 million and was growing at 0.4% per annum. The world population now stands at more than 6 billion and growing at an annual rate of 1.5% per annum. What are the ecological implications of this growth?

5. Outline the five potential values of natural resources, and show how they can influence natural resource conservation.

6. Elucidate the assertion that as a result of the global population size, consumption patterns, and technology choices, humans have surpassed the planet's carrying capacity.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 995: ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT I

TIME: Three hours

INSTRUCTIONS: Answer questions one (compulsory) and any other three. All questions carry equal marks and candidates are advised to make use of illustrations and examples wherever appropriate. Use of a Philip's University Atlas is allowed.

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

   (a) Ecofeminism
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END OF EXAMINATION

2006 ACADEMIC YEAR FINAL EXAMINATIONS

M111 MATHEMATICAL METHODS I

DISTANCE EDUCATION

Time Allowed: **Three (3) hours**

Instructions:
- **(i) Answer any Five (5) questions**
- **(ii) Calculators and Tables are not allowed in this paper**
- **(iii) Full credit will only be given when all the necessary working is shown**

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1. (a) Let $U = R$, the set of real numbers, be the universal set, $A = [-20,\ 20]$ $\quad B = (-\infty,\ 3)$ $\quad$ *and* $\quad C =$ all non negative integers. Find

   (i) $B \cap C$ $\qquad$ (ii) $A - B$ $\qquad$ (iii) B'

   (b) The quadratic function $f(x) = ax^2 + bx + c$ is symmetric about the line $x = \frac{1}{2}$ and has miminum value -4. If its graph passes through the point $\left(-\frac{1}{2},\ 0\right)$

   (i) Find the values of $a,\ b$ *and* c
   (ii) Sketch the graph of $f(x)$
   (iii) Find the solution set of x for which $f(x) < -3$.

   (c) Solve the inequalities

   (i) $\left|\frac{3x+2}{x-1}\right| \le \frac{3}{4}$ $\qquad$ (ii) $6x^2 + 13x > 5$

2. (a) (i) Let $1.1\overline{6}\overline{6}$ *and* $y = 0.3\overline{3}$. Express $x - y$ in the form $\frac{a}{b}$ where a *and* b are integers.

   (ii) If p *and* q are rational numbers, prove that $p + q$ is also a rational number.

   (b) Let $f(x) = x^2 + 3$.
   (i) If $f(a) = 28$ find possible values of a.

(ii) What is the domain and the range of $f(x)$?

(iii) Determine giving reasons for your answer, if $f(x) = x^2 + 3$ has an inverse.

(c) Given that $L: x + 2y - 3$ is a straight line. Find the equation of a straight line

(i) Parallel to L passing through the point $\left(\frac{1}{2}, -\frac{1}{2}\right)$

(ii) Perpendicular to L passing through the point $\left(\frac{1}{2}, -\frac{1}{2}\right)$.

3. (a) Differentiate from the first principle

(i) $f(x) = \sqrt{x}$ (ii) $f(x) = x^2$

(b) (i) If $z = 3 - 2i$ *and* $w = 8 + 5i$, find the value of $2z + (1 + i)w$ *and* $\left|\frac{w}{z}\right|$

(ii) Express in the form $a + b\sqrt{2}$ where a *and* b are rationals.

(.) $\dfrac{1}{7 + 3\sqrt{2}}$

(. .) $\dfrac{2 + 3\sqrt{2}}{1 - 5\sqrt{2}}$

(c) The roots of the equation $9x^2 + 6x + 1 = 4kx$ where k is a real number are α *and* β.

(i) Show that the equation whose roots are $\frac{1}{\alpha}$ *and* $\frac{1}{\beta}$ is $x^2 + 6x + 9 = 4kx$.

(ii) Find the set of values of k for which α *and* β are real.

4. (a) Let $p(x) = 2x^3 + ax^2 + bx - 3$ be a polynomial. Given that $x - 1$ *and* $2x + 1$ are factors of $p(x)$, find the values of a *and* b. Hence factorise $p(x)$ completely.

(b) (i) Let $A = \{3p : p = -1, 0, 1, 2, 3\}$ *and* B another set such that $B - A = \{2, 5\}$ *and* $A - B = \{0, 6, 9\}$. List set B and find $n(A \cup B)$

(ii) Express $3i/_{5+2i}$ in the form $a + bi$ where a *and* b are rational numbers.

(c) Prove the following identifies

(i) $\dfrac{1 - Cos\,2x + Sin\,2x}{1 + Cos\,2x + Sin\,2x} = \tan x$

(ii) $\tan x + Cot\,x = 2\,Co\sec\,2x$

5. (a) Let $f(x) = \dfrac{1}{x}$ *and* $g(x) = 3 - 2x$.

(i) Find $f \circ g(5)$

(ii) Find also $g^{-1}(x)$ *and* $f \circ f(x)$

(iii) Find $(g \circ f)'(x)$

(b) Given that $f(x) = \dfrac{x-1}{x+2}$

(i) Show that $f(x)$ is a one-to-one function

(ii) Find the inverse of $f(x)$

(iii) Find also $(f^{-1}(x))'$ if it exists.

(c) Find $\dfrac{dy}{dx}$ for the following functions

(i) $y = x^3\,Sin\,x$

(ii) $y = (x^2 + 2x)^{\frac{1}{2}}$

(iii) $x^2 + 4y^2 = 4$

6. (a) (i) Find the values of x in the range $0 \le x \le 2\pi$ for the equation $2\,Sin\,x\;Cos\,x = \dfrac{1}{2}$.

(ii) Find the general solution to the equation
$2\ Sin x\ \ Cos x = Sin\ x$

(b) Find $\lim_{x \to \infty} f(x)$ if

(i) $f(x) = \dfrac{x^2+1}{2x^2-1}$ (ii) $f(x) = \dfrac{x^3-2x}{4x^4-1}$

(iii) $f(x) = \dfrac{x^5+6x^4-3}{7x^4+2x^2}$

(c) Let $f(x) = 2 Sin\ \pi\ (x-1)$.

(i) Find the amplitude, the period and the phase shift of $f(x)$.

(ii) Find also $f\left(-\dfrac{1}{2}\right)$, $f\left(\dfrac{1}{2}\right)$ *and* $f(1)$.

(iii) Hence sketch the curve of $f(x) = 2\ Sin\ \pi(x-1)$ for values of x in the range $-1 \leq x \leq 2$.

7. (a) Solve each of the following equations

(i) $\dfrac{5}{x+6} = \dfrac{7}{x-5}$ (ii) $\dfrac{x}{7} = \dfrac{4}{x+3}$

(iii) $\left| x - \dfrac{2}{3} \right| = \dfrac{3}{4}$

(b) (i) Find the following limits

$\lim_{x \to 2} \dfrac{3x^2-6x}{x^2+x-6}$ *and* $\lim_{x \to -2} x^3 - 3x + 4$

(ii) Given that θ is an angle such that $0 \leq \theta \leq \dfrac{\pi}{2}$ and that $Cos\ \theta = \dfrac{3}{5}$, find a value of $\tan 2\theta$.

(c) Given that $y = \dfrac{3}{4}x + 5$ is an equation of a straight line.

(i) Find the point on the line $y = \dfrac{3}{4}x + 5$ which has minimum distance from the origin

(ii) Calculate how far this point is from the origin

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR

SECOND SEMISTER EXAMINATIONS

M112 : MATHEMATICAL METHODS IIA

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS:
(i) Answer any **Five** (5) questions.
(ii) Calculators and Tables are not allowed in this paper.
(iii) Full credit will only be given when all necessary working is shown.
(iv) Write your computer number and Tutorial group. (No Names).

---

1. (a) (i) Sketch the graph of $f(x) = e^x$ and of $g(x) = 2 + 3e^{-x}$ on the same diagram.

(ii) State the equation of the asymptote for each function.

(iii) By solving the appropriate equation find the co-ordinates of the point of intersection of the two graphs.

(b) (i) Prove by mathematical induction that $n^3 + 2n$ is divisible by 3 for $n \geq 1$.

(ii) Find the value of n if the coefficient of x^2 in the expansion of $(1 + 2x)^n$ is 264.

(c) (i) If A is the point $(-1, 3)$ and B is the point $(-1, -1)$, find the equation of the locus of points P such that $2AP = 3BP$.

(ii) Find the distance between the parallel lines $3x - 4y + 5 = 0$ and $3x - 4y + 7 = 0$.

2. (a) Given that $z = -1 - i\sqrt{3}$

(i) Express z in polar form.

(ii) Find the square roots of z.

(b) (i) Find the term independent of x in the expansion of $\left(2x^2 - \frac{1}{2x}\right)^6$.

(ii) The equation of a circle is $4x^2 + 4y^2 + 16x - 12y = 0$, find the center and radius of the circle.

(iii) Prove by mathematical induction that $x - y$ is a factor of $x^{2n-1} - y^{2n-1}$ for any $n \geq 1$ where $x \neq y$.

(c) Evaluate the following integrals

(i) $\int_1^4 \frac{1-x}{\sqrt{x}}\, dx$ (ii) $\int_0^a x^3\sqrt{a^4 - x^4}\, dx$

3. (a) Let $f(x) = x^3 + ax^2 + bx + c$. If the stationary points of $f(x)$ are $(3, f(3))$ and $(-1, f(-1))$.

(i) Find the values of a and b.
(ii) If the maximum value of f(x) is 7, find the value of c.
(iii) Determine the minimum point of f(x).

(b) Given the points P (1, 2, 3), Q (2, –1, 1) and R (1, 2, – 4), find the following;

(i) $\overrightarrow{PQ} \cdot \overrightarrow{RQ}$ (ii) $\overrightarrow{PQ} \times \overrightarrow{PR}$ (iii) Area of the triangle PQR.

(c) The equation $x^2 + 2x + 4y - 7 = 0$ represents a conic.

(i) Identify the conic.
(ii) Find its vertex or vertices, focus or foci and directrix or directrices.
(iii) Sketch its graph.

4. (a) (i) Express $\frac{8x-14}{x^2-x-6}$ into partial fractions.

(ii) Evaluate the integral $\int \frac{8x-14}{x^2-x-6}\, dx$.

(b) Given that an ellipse has foci at (–3,3) and (–3 –1) and has eccentricity $\frac{1}{3}$.

(i) Find the equation of the ellipse.
(ii) Find the center and vertices of the ellipse.
(iii) Find the equations of its directrices.
(iv) Sketch its graph.

(c) Given the function $f(x) = x^2 - x - 2$.

(i) Sketch its graph.
(ii) Find the area bound by the function $f(x)$ and the x – axis Between $x = -2$ and $x = 3$.

5. (a) Given the matrix $B = \begin{pmatrix} 2 & 1 & 1 \\ -3 & 0 & 1 \\ -2 & 1 & -1 \end{pmatrix}$

(i) Find the inverse of B.

(ii) Solve the following systems of linear equations using inverse method.

$$\begin{aligned} 2x + y + z &= 1 \\ -3x + z &= 3 \\ -2x + y - z &= 3 \end{aligned}$$

(b) (i) Find the derivative of $y = \sin\left(\ell n(x^2 + 1)\right)$.

(ii) Calculate the distance of the point $(-3, 4)$ to the line $4y + 3x + 4 = 0$.

(c) Evaluate the following integrals.

(i) $\int (x+2)\sqrt{x-2}\,dx$

(ii) $\int \sqrt{x}\,\ell n x\,dx$

6. (a) Let $A = \begin{pmatrix} 2 & 4 \\ 3 & -1 \\ 0 & 2 \end{pmatrix}$, $B = \begin{pmatrix} 1 & 3 & -2 \\ 0 & 2 & 1 \end{pmatrix}$ and $C = \begin{pmatrix} 3 & 0 & 1 \\ 2 & -1 & 1 \end{pmatrix}$

Find the following

(i) $2BA - 3CA$ (ii) $(B^t C)$ (iii) $\det(C^t B)$

(b) If $z_1 = \cos\frac{3\pi}{4} + i\sin\frac{3\pi}{4}$ and $z_2 = \cos\frac{\pi}{3} + i\sin\frac{\pi}{3}$. Find the following and express your answer in form $a + ib$.

(i) $w_1 = z_1^2 z_2$ (ii) $w_2 = \frac{z_1^2}{z_2}$

(c) Given the equation of the hyperbola as $9x^2 - 4y^2 - 54x - 32y - 19 = 0$

(i) Find the center and vertices.
(ii) Find the foci and eccentricity.
(iii) Find the equations of asymptotes.
(iv) Sketch its graph.

7. (a) Given a matrix $A = \begin{pmatrix} 1 & 2 & 3 \\ -2 & 1 & 2 \\ 1 & -1 & 4 \end{pmatrix}$

(i) Find the determinant of A.

(ii) Use Cramer's rule to solve the given systems of linear equations

$$\begin{aligned} x + 2y + 3z &= -4 \\ -2x + y + 2z &= 0 \\ x - y + 4z &= 3 \end{aligned}$$

(b) (i) Write down the expansion of $(8 - x)^{\frac{1}{3}}$ in ascending powers of x up to and including x^3.

(ii) State the range of values for which the expansion is valid.

(iii) Using the expansion in (i) approximate the cube root of 10, do not simplify.

(c) The rate at which anti-bodies are produced t hours after an injection of serum is given by $f(t) = \dfrac{10t}{t^2 + 9}$.

(i) Find the value of t at which f(t) is maximum.
(ii) Find the rate at which the anti-bodies are produced when f(t) is maximum.

End of Examination !

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2006 ACADEMIC YEAR

SECOND SEMESTER EXAMINATIONS

M 114 – MATHEMATICAL METHODS IIB

INSTRUCTIONS:
- i) Answer any **five** (5) questions
- ii) Show all the essential working to earn full marks.
- iii) Write down the questions attempted on the front page of the main booklet.
- iv) Use of tables or calculators is **not** allowed

TIME ALLOWED: Three (3) hours.

1 (a) Given the matrix

$$A = \begin{pmatrix} 3 & 1 & -2 \\ 1 & 2 & 3 \\ 2 & 3 & 4 \end{pmatrix},$$

find (i) $|A|$ (ii) A^{-1}

Hence, solve the following systems of equations by inverse method

$$3x + y - 2z = 7$$
$$x + 2y + 3z = 1$$
$$2x + 3y + 4z = 3$$

(b) The ellipse $\frac{x^2}{16} + \frac{y^2}{4} = 1$ cuts the y-axis at A and C and the negative x-axis at B. Show that the circle passing through A, B and C has the equation

$$x^2 + y^2 + 3x - 4 = 0$$

(c) Given the equation $px^2 + qxy + ry^2 = 0$,
(i) find the condition that the equation represents a pair of straight lines.
(ii) determine what the equation represents if $2p = 2q = r$.

(d) (i) Evaluate the numerical value of $\tan\left[\tan^{-1}\left(\frac{1}{3}\right) + \sin^{-1}\left(\frac{1}{\sqrt{5}}\right)\right]$

(ii) Given $f(x)=\sin x+\sqrt{3}\cos x$,

r) express $f(x)$ in the form $R\sin(x+\alpha)$ where $R>0$ and α is acute.

s) solve the equation $f(x)=\sqrt{3}$ for $0^0 \le x \le 360^0$.

t) find the greatest value of $\dfrac{1}{12+f(x)}$

2. (a) Prove by mathematical induction that for all positive integers n,

$$(1x4)+(2x5)+(3x6)+\dots\dots\dots\dots+n(n+3)=\frac{n\,(n+1)(n+5)}{3}$$

(b) Given the vectors

$$u=2i-j+2k,$$
$$v=ai+bk \qquad \text{and}$$
$$uxv=i+ck$$

(i) find the values of the scalar constants a, b and c.
(ii) find in surd form, the cosine of the angle between u and v.
(iii) find the magnitude of the vector perpendicular to both u and v.

(c) The magnitude and direction of a constant force $\vec{F}$ are given by $a=5i+2j+6k$. Find the work done if the point of application of the force $\vec{F}$ moves from $P(1,-1,2)$ to $R(4,3,-1)$

(d) Find the four fourth roots of -1. Display the roots in the argand diagram

3 (a) Discuss and sketch the conic section $9x^2-4y^2-54x-16y+29=0$.

(b) Find $\dfrac{dy}{dx}$ of each of the following:

(i) $xy+xy^2+y+4=0$ (ii) $y=\ln\tan x$ (iii) $y=(x^2+1)^{10} \quad +10^{x^2+1}$

(c) Given $f(x)=\dfrac{4x^2+13x-9}{x^3+2x^2-3x}$,

(i) Express $f(x)$ in partial fractions.
(ii) Find $f'(x)$

(d) (i) If $x^2+3y^2+2y=0$, and $\dfrac{dx}{dt}=2$ when $x=3$ and $y=-1$, find $\dfrac{dy}{dt}$.

(ii) A stone is dropped into a lake causing waves whose radii increase at a rate of $0.5m/\text{sec}$. At what rate is the circumference of a wave changing when its radius is 4 *metres* .

4 (a) For the curve $f(x) = x^3 - 4x^2 + 4x$,

(i) find the x and y intercepts.

(ii) find the maximum, minimum and inflection points.

(iii) sketch the graph of $f(x)$

(b) Evaluate the following:

(i) $\int_0^1 x\sqrt{1+x^2}\,dx$ (ii) $\int_3^4 \frac{1}{x^2 - 3x + 2}\,dx$

(c) Given that $y = (x+1)\ln(x+1) - x$,

(i) find $\frac{dy}{dx}$

(ii) Using (i) above, evaluate $\int \ln(x+1)\,dx$

(d) Farmer A owns a plot of land bounded by the x-axis, the line $x = 9$ and the line $y = \frac{4}{3}x$.

Farmer B owns a neighbouring plot bounded by the y-axis, the line $y = 12$ and $y = \frac{4}{3}x$

Relation between the two men is strained.

One night, farmer A moves the fence separating the farms from $y = \frac{4}{3}x$ to $y = 4\sqrt{x}$.

(i) Find the area he gains.

The next night, farmer B moves the fence to $y = \frac{4}{27}x^2$.

(ii) What is the area of farm B now?

5 (a) (i) Express $\cosh^2 2x$ in terms of e^x, and hence find $\int \cosh^2 2x\, dx$

(ii) Given that $y = x^2 \ln x$, prove that $x = \dfrac{y'}{-2 + y''}$.

(b) (i) Solve the differential equation

$f''(x) = 5\cos x + 2\sin x$

subject to the initial conditions $f(0) = 3$ and $f'\left(\dfrac{\pi}{2}\right) = 4$

(ii) Show that $e^{\ln x} = x$

(c) Given that $x + y = 2$ and $3^x = 4^y$,

Show that $x = \dfrac{\ln 16}{\ln 12}$.

(d) In the binomial expansion of $(1 + kx)^n$, where k is a constant and n is a positive integer, the coefficients of x and x^2 are equal.

(i) Show that $k(n-1) = t$, where t is a positive integer.

(ii) Given that $nk = 2\frac{1}{3}$, find the value of k and n

6) a) (i) Find an equation of the tangent line to the graph $y = x^2 + \ln(2x-5)$ at the point $P(3,9)$

(ii) Solve the differential equation $\dfrac{dy}{dx} = 3e^{2x} + 6e^{-3x}$,

subject to the initial condition $y = 4$ if $x = 0$

(b) (i) On the same diagram, sketch the graphs of the curves,

$y = e^x$ and $y = \sqrt{x}$ for $x \geq 0$.

(ii) shade area A, the area bounded by the two curves and the lines $x = 0$ and $x = 1$.

(iii) Hence, find the area A.

(c) The circle T has equation

$x^2 + y^2 - 6x - 8y = 0$

(i) show that the point $A(7,2)$ lies inside the circle.

(ii) show that the chord of T which is bisected at A has equation $y = 2x - 12$

(d) (i) If $\tan x = \dfrac{4}{3}$, find $\tan \dfrac{x}{2}$.

(ii) Prove that if n is a positive integer, then

$(1+i)^n + (1-i)^n = 2^{\frac{n}{2}+1}$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR

SECOND SEMESTER EXAMINATIONS

M162: INTRODUCTION TO MATHEMATICS, PROBABILITY AND STATISTICS II

TIME ALLOWED: Three (3) Hours

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 booklet.
(c) There are <u>six</u> questions in this paper. Candidates must answer any <u>five</u> **(5)** questions only. All questions carry equal marks.
(d) Calculators may be used.

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1. (a) Differentiate the following from first principles

 (i) $y = \sqrt{2x+1}$ (ii) $y = \dfrac{1}{x-1}$

 (b) If $z \sim N(0,1)$, find,

 (i) $P(z > -1.86)$
 (ii) $P(z < -2.34)$
 (iii) $P(1.09 < z < 2.18)$

2. (a) Let A and B be events with $P(A) = \dfrac{1}{4}$, $P(A \cup B) = \dfrac{1}{3}$ and $P(B) = p$. Find p if,

 (i) A and B are mutually exclusive events.
 (ii) A and B are independent events.
 (iii) A is a subset of B.

 (b) Find,

 (i) $\int x e^{2x}\, dx$ (ii) $\int \sin^6 x \cos x\, dx$ (iii) $\int \dfrac{x^2 - 4x}{x^2}\, dx$

 (c) Find the median and mode of the following:

 2, 3, 3, 4, 4, 4, 6, 9, 11, 13, 13, 13 .

3. (a) The curve C has equation $y = x^3 - 5x + \frac{2}{x}$, $x \neq 0$. The points A and B both lies on C and have coordinates $(1, -2)$ and $(-1, 2)$ respectively.

(i) Show that the gradient of C at A is equal to the gradient of C at B.

(ii) Show that an equation for the normal to C at A is $4y = x - 9$. The normal to C at A meets the y-axis at the point P. The normal to C at B meets the y-axis at Q.

(iii) Find the length PQ.

(b) (i) Calculate the (i) mean deviation and (ii) standard deviation of the values given below:

Class Interval	f
0 – 5	1
5 – 10	3
10 – 15	5
15 – 20	2
20 – 25	1

(c) (i) Define conditional probability of A given B.

(ii) Let A and B be events with $P(A) = \frac{1}{2}$, $P(B) = \frac{1}{3}$ and $P(A \cap B) = \frac{1}{4}$, find $P(A'/B')$.

4. (a) For a normal population with mean 10, and standard deviation 5, find the probability that a member chosen at random gives a value of the variate which is

(i) greater than 11.
(ii) less than 5.
(iii) Between 5 and 11.

(b) Write $\frac{3x}{(x-2)(x+1)}$ into partial fractions, Hence, $\int \frac{3x}{(x-2)(x+1)}$.

(c) T is the tangent to the curve $y = x^2 + 6x - 4$ at $(1, 3)$ and N is the normal to the curve, $y = x^2 - 6x + 18$ at $(4, 10)$. Find the coordinates of the point of intersection of T and N.

5. (a) (i) Show that $\int_0^1 \frac{x}{\sqrt{1+x}}\,dx = \frac{2}{3}\left(2-\sqrt{2}\right)$, Use the substitution $u^2 = x+1$.

(ii) Find $\frac{dy}{dx}$ of : $x^2 - y^2 = 3xy + x$.

(b) For the set of values given below:

(i) Construct a frequency table.
(ii) Construct a frequency polygon.

10	5	11	2	15	9	5	12	14	17
7	19	11	8	4	7	3	19	20	13
8	16	12	17	7	11	1	10	15	19
3	19	12	14	9	7	2	15	19	12
14	8	6	16	9	18	7	6	14	13

(c) A sample of 3 items is drawn from a box containing 12 items of which 3 are defective. Let X be a random variable of defective items.

(i) Write the probability distribution of X.
(ii) Find the probability of drawing at most 2 defective items.
(iii) Find E (X).

6. (a) Given the curve $y = x^3 - 3x^2 - 9x + 11$,

(i) Find the stationary points of the curve.
(ii) Determine the nature of the stationary points.
(iii) Sketch the curve.
(iv) Determine the range(s) where the function is increasing and decreasing.

(b) Toss a pair of fair dice.

(i) Write the sample space S.
(ii) If the sum is 6 , what is the probability that one of the dice is a 2 .
(iii) Find the probability that the sum of the two numbers appearing is 5

(c) The values in the table below show the mean and standard deviation of the marks obtained by two classes in a test. Calculate

(i) the mean for the two classes combined.
(ii) the standard deviation for the two classes combined.

	Mean	Standard deviation	Class size
Class A	67	5	15
Class B	58	8	18

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SECOND SEMESTER EXAMINATIONS
FEBRUARY/MARCH 2007

M212 MATHEMATICAL METHODS IV

INSTRUCTIONS:
1. Write down your **computer number** on all answer booklets used.
2. Answer any **five (5)** questions only.
3. Indicate the **question number** answered on the main answer booklet.

TIME ALLOWED: **Three (3) hours.**

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1. (a) Find the

   (i) vector equation
   (ii) parametric equations and,
   (iii) symmetric equations

   of the line which passes through the point $(2,-1,-1)$ and is orthogonal to both lines L_1 through the points $A(1,1,0)$ and $B(-2,3,1)$, and L_2 through the points $C(1,-1,3)$ and $D(0,0,0)$.

   (b) Find the equation of the plane which passes through the points $P(3,-1,6)$, $Q(1,5,5)$ and $R(4,-6,4)$.

   Hence, find its distance from the point $S(1,2,-1)$.

2. (a) (i) If $\overline{R}(t) = (t^2 - 4t)\hat{i} + (t^3 - 3t^2)\hat{j} + 5t\hat{k}$ is the position vector of a moving particle, and t denotes time, find the time and where the particle is when the velocity vector is parallel to the yz – plane.

   (ii) Find the distance between the line L_1 through the points $A(1,2,1)$, $B(2,7,3)$ and the line L_2 through the points $C(2,3,5)$, $D(0,6,6)$.

   (b) A space curve has equation $\overline{R}(t) = \cos t\,\hat{i} + \sin t\,\hat{j} + t\,\hat{k}$. Find at the point $t = \dfrac{\pi}{4}$,

   (i) the unit tangent vector $\overline{T}$
   (ii) the curvature κ of the space curve.

3. (a) (i) If $f(x,y,z) = w = xz + ze^{2y} + \sqrt{xy^2 - z^2}$, find $\frac{\partial w}{\partial x}$ and $\frac{\partial w}{\partial y}$.

(ii) Use the Chain Rule to find $\frac{\partial f}{\partial u}$ and $\frac{\partial f}{\partial v}$ for the function

$$f(x,y) = x^2 + xy + y^2;\ x = 2u + v,\ y = u - 2v.$$

(b) Use the total differential to estimate the number

$$\sigma = \frac{14.99}{5.02}.$$

4. (a) Prove that if $z = f(u,v)$ when $u = x + \lambda y$ and $v = x - \lambda y$, then

$$\left(\frac{\partial z}{\partial u}\right)^2 - \left(\frac{\partial z}{\partial v}\right)^2 = \frac{1}{\lambda}\frac{\partial z}{\partial x}\frac{\partial z}{\partial y}.$$

(b) Find the relative extrema of

$$f(x,y) = x^3 + 3xy^2 + 3y^2 - 15x + 2.$$

5. (a) Solve the differential equations:

(i) $\frac{dy}{dx} + 2xy = 4x$

(ii) $(3y - x\cos\frac{y}{x})dx - 3xdy = 0$

(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.

6. (a) Solve the differential equations:

(i) $(1+y^2)dx+(1+x^2)dy=0$

(ii) $\dfrac{dy}{dx}+y=xy^2, \quad y(0)=1$

(b) Solve the differential equation

$$\frac{d^2y}{dx^2}-4\frac{dy}{dx}+13=10\sin x.$$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR

SECOND SEMESTER EXAMINATIONS

M232 REAL ANALYSIS II

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: Answer any **Five (5)** questions.

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1. (a) Let $\{a_n\}_{n=0}^{\infty}$ be a sequence of positive terms. If p is any positive integer, prove that the two series $\sum_{n=0}^{\infty} a_n$ and $\sum_{n=p}^{\infty} a_n$ either converge to a real number or diverge to $+\infty$ together.

   (b) (i) If $0 < a < 1$, show that the geometric series $\sum_{n=0}^{\infty} a^n$ converges.

   (ii) If $a \geq 1$, show that the geometric series $\sum_{n=0}^{\infty} a^n$ diverges.

2. (a) If the series $\sum_{n=0}^{\infty} a_n$ of positive monotone decreasing terms converges prove the following;

   (i) $\lim_{n \to \infty} a_n = 0$ (ii) $\lim_{n \to \infty} n a_n = 0$

   (b) Let $\sum_{n=0}^{\infty} a_n$ be a convergent series. Prove that the remainders

   $r_n = \sum_{k=n+1}^{\infty} a_k$ always converge to zero.

3. (a) (i) Let $x \in \mathbf{R}, \varepsilon > 0$. Define an ε - neighbourhood of x.

(ii) Let $U = \{x \in \mathbf{R} : -1 < x < 1\}$. Show that U is a neighbourhood of $-\frac{3}{4}$.

(b) Let c be a limit point of $A \subset \mathbf{R}$ and let $f: A \to \mathbf{R}$ be any function. Prove that $\lim_{x \to c} f(x) = L$ if and only if $\lim_{x \to c} |f(x) - L| = 0$.

4. (a) Let $a \in \mathbf{R}$, $A \subset \mathbf{R}$, $(a, \infty) \subset A$ and $f : A \to \mathbf{R}$.

(i) If for some $L \in \mathbf{R}$, $\lim_{x \to \infty} f(x) = L$, what does it mean?

(ii) Suppose for every sequence $\{x_n\}_{n=1}^{\infty}$ in $A \cap (a, \infty)$ such that $\lim_{n \to \infty} x_n = \infty$ then the sequence $\{f(x_n)\}_{n=1}^{\infty}$ converges to L. Show that $\lim_{x \to \infty} f(x) = L$.

(b) Let f be defined on (a, ∞) to $\mathbf{R}$. Prove that $\lim_{x \to \infty} f(x) = L$ if $\lim_{x \to 0} f\left(\frac{1}{x}\right) = L$.

(c) Show that $\lim_{x \to c} x^2 = c^2$.

5. (a) Let $A \subset \mathbf{R}$ and $c \in A$

(i) Give the definition of a function $f: A \to \mathbf{R}$ being continuous at c.

(ii) Give the definition of $f: A \to \mathbf{R}$ being bounded on A.

(b) Let $I = [a, b]$ be a closed bounded interval and let $f : I \to \mathbf{R}$ be continuous on I. Prove that f is bounded on I.

(c) Show that the function $f(x) = \sin x$ is continuous on $\mathbf{R}$.

6. (a) Let $\{a_n\}_{n=1}^{\infty}$ be a decreasing sequence of positive real numbers such that $\lim_{n \to \infty} a_n = 0$. Prove that the series $\sum_{n=1}^{\infty} (-1)^{n+1} a_n$ converges.

(b) Let $\sum_{n=1}^{\infty} a_n$ and $\sum_{n=1}^{\infty} b_n$ be series of positive real numbers such that $\left\{\frac{a_n}{b_n}\right\}_{n=1}^{\infty}$ converges to a finite non-zero number. Show then $\sum_{n=1}^{\infty} a_n$ and $\sum_{n=1}^{\infty} b_n$ either both converge or both diverge.

7. Let $I = [a, b]$ be a closed bounded interval and $f : I \to \mathbf{R}$ be continuous on I. Prove the following;

(a) f has an absolute maximum on I.

(b) f has an absolute minimum on I.

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR

SECOND SEMISTER EXAMINATIONS

M 292 : INTRODUCTION TO PROBABILITY

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: (i) Answer any **Five** (5) questions.
(ii) Show all essential working.

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1. (a) Define the following:

   (i) mutually exclusive events.
   (ii) independent events.

   (b) Events A and B are such that $P(A) = P(B) = \frac{1}{2}$ and $P(A \cup B) = \frac{2}{3}$.

   (i) Are A and B mutually exclusive?
   (ii) Are A and B independent?
   (iii) Find $P(A' \cap B)$.
   (iv) Find $P(A' \cap B')$.

   (c) In a sample space, events A and B are independent, events B and C are mutually exclusive, and events A and C are independent.
   If $P(A \cup B \cup C) = 0.9$, $P(B) = 0.5$ and $P(C) = 0.3$, find

   (i) $P(A)$ (ii) $P(B \cup C')$.

2. (a) An experiment consists of choosing 2 numbers without replacement from the set $\{1, 2, 3, 4, 5, 6\}$ with the restriction that the second number chosen must be greater than the first.

   (i) Find the sample space for this experiment.
   (ii) What is the probability that the second number is even?
   (iii) What is the probability that the sum of the two numbers is at least 5?

(b) A car dealer has found that X, the number of cars customers buy each week, follows the probability function

$$P(X = x) = \begin{cases} \dfrac{kx^2}{x!}, & x = 1, 2, 3, 4 \\ 0, & \text{otherwise} \end{cases}$$

(i) Show that $k = \dfrac{6}{31}$.

(ii) Find the probability that the dealer sells at least 2 cars in a week.

(iii) Find the cumulative distribution function of X and sketch its graph.

(c) A man travels to work by either route A or route B. The probability that he uses route A is $\frac{1}{4}$. The probability that he is late for work if he uses route A is $\frac{2}{3}$ and the corresponding probability if he uses route B is $\frac{1}{3}$.

(i) Find the probability that he is late for work.

(ii) Given that he is late for work, what is the probability that he used route B?

3. (a) Let X be a continuous random variable with probability density function

$$f(x) = \begin{cases} \dfrac{1}{b-a}, & a < x < b \\ 0, & \text{otherwise} \end{cases}$$

(i) Show that f(x) is a probability density function.

(ii) Find E(X).

(b) A box contains 6 good and 8 defective light bulbs. If 4 bulbs are selected at random without replacement, find the probability that

(i) exactly 3 are good.

(ii) at most 2 are good.

(c) Let X be a poisson random variable with probability function

$$P(X = x) = \frac{e^{-\lambda}\lambda^x}{x!}, \quad x = 0, 1, 2, \ldots$$

(i) Show that the moment generating function of X is given by $M_X(t) = e^{\lambda(e^t - 1)}$, $t \in \mathbf{R}$.

(ii) Use the moment generating function to find E(X) and Var (X).

4. (a) (i) Define the covariance of X and Y.

(ii) Show that
$\text{Var}[aX + bY] = a^2\,\text{Var}(X) + b^2\,\text{Var}(Y) + 2ab\,\text{Cov}(X, Y)$.

(b) Suppose X and Y have joint probability function $f(x, y) = k(x + y)$, $x = 1, 2, 3;\ y = 1, 2$.

(i) Show that $k = \frac{1}{21}$

(ii) Find $\text{Cov}(X, Y)$.

(iii) Find the marginal probability functions of X and Y.

5. (a) (i) Define the conditional variance of Y given $X = x$.

(ii) Show that $E[E(X \mid Y = y)] = E(X)$.

(b) Suppose X and Y have joint probability density function
$f(x, y) = k(x + y^2),\ 0 < x < 2;\ 0 < y < 1.$

(i) Show that $k = \frac{3}{8}$.

(ii) $P(X > 1,\ Y < \frac{1}{2})$

(iii) $E(Y \mid x)$

6. (a) Suppose X has a beta distribution with probability density function
$$f(x) = \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\,\Gamma(\beta)}\, x^{\alpha-1}(1-x)^{\beta-1},\quad 0 < x < 1,\ \alpha > 0,\ \beta > 0.$$
Find

(i) $E(X)$ (ii) $\text{Var}(X)$

(b) A manufacturer of components for electric motors has found that 10% of the components are defective. Find the approximate probability that in a lot of 1200 components,

(i) exactly 130 are defective.

(ii) at least 100 are defective.

End of Examination.

Standard normal cumulative distribution function $\Phi(z)$ and $100 \times \gamma$th percentiles z_γ

$$\Phi(z) = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} e^{-t^2/2}\, dt$$

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8314	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998

γ	0.90	0.95	0.975	0.99	0.995	0.999	0.9995	0.99995	0.999995
z_γ	1.282	1.645	1.960	2.326	2.576	3.090	3.291	3.891	4.417

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
FEBRUARY/MARCH 2007

M332 REAL ANALYSIS IV

INSTRUCTIONS:
1. Write down your **computer number** on all answer booklets used.
2. Answer any **five (5)** questions only.
3. Indicate the **question number** answered on the main answer booklet.

TIME ALLOWED: **Three (3) hours**

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1. (a) Let $f:[a,b]\to\Re$ be a real valued function and let $c\in\Re$. Define

   (i) continuity of f at c
   (ii) differentiability of f at c.

   (b) Prove that if $f:[a,b]\to\Re$ is differentiable at $c\in[a,b]$, then f is continuous at c.

   (c) Prove that the function $f(x)=|x|$ is continuous on $\Re$ but not differentiable at $x=0$.

2. (a) State and prove Rolle's theorem.

   (b) Let the function f be defined by

$$f(x)=\begin{cases}1 & for \quad 0\le x<\dfrac{1}{2} \\ 2 & for \quad \dfrac{1}{2}\le x\le 1\end{cases},$$

   show that $f(x)$ satisfies none of the conditions of Rolle's theorem.

3. (a) State and prove the Taylor's theorem with the remainder.

(b) Use Taylor's theorem to show that if $x > 0$, then

$$1+\frac{x}{2}-\frac{x^2}{8} \le \sqrt{1+x} \le 1+\frac{x}{2}.$$

4. (a) Let $f:[a,b] \to \Re$ be a bounded real valued function and P a partition of $[a,b]$. Define

(i) a refinement of a partition P of an interval $[a,b]$

(ii) a lower Riemann sum $L(P;f)$ and an upper Riemann sum $U(P;f)$ of f on $[a,b]$.

(b) Let $f:[a,b] \to \Re$ be a bounded real valued function.

If Q is a refinement of a partition P, show that

(i) $L(P;f) \le L(Q;f)$

(ii) $U(Q;f) \le U(P;f)$.

5. (a) Let $f:[a,b] \to \Re$ be a bounded real valued function. Define

(i) the lower integral and upper integral of f on $[a,b]$

(ii) integrability of f on $[a,b]$

(b) Let $f:[a,b] \to \Re$ is a bounded real valued function. Prove that f is integrable on $[a,b]$ if and only if for each $\varepsilon > 0$ there is a partition P_ε of $[a,b]$ such that

$$U(P_\varepsilon;f) - L(P_\varepsilon;f) < \varepsilon.$$

(c) Let a function be defined by

$$f(x) = \begin{cases} 1, & if\ x \ne 1 \\ 0 & if\ x = 1 \end{cases} \text{ for } 0 \le x \le 1.$$

Taking a partition $P_n = \left\{0, \frac{1}{n}, \frac{2}{n}, \cdots, \frac{n-1}{n}, \frac{n}{n} = 1\right\}$, find

(i) the lower sum, $L(P_n;f)$ of f

(ii) the upper sum $U(P_n;f)$ of f.

Hence, determine whether f is integrable or not.

6. (a) Let $f:[a,b]\rightarrow \Re$ be a continuous function on $[a,b]$. Prove that f is Riemann integrable on $[a,b]$.

(b) Let $f:[a,b]\rightarrow \Re$ be integrable on $[a,b]$. Prove that the function $F_a:[a,b]\rightarrow \Re$ be defined by

$$F_a(x)=\int_a^x f,\quad x\in[a,b]\ ,$$

is uniformly continuous on $[a,b]$.

(c) Let $f:[a,b]\rightarrow \Re$ be integrable on $[a,b]$ and let $F_a(x)=\int_a^x f$ for $x\in[a,b]$.

Prove that F_a is differentiable at any point $c\in[a,b]$ at which f is continuous, and $F_a'(c)=f(c)$.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR

SECOND SEMISTER EXAMINATIONS

M362 : LINEAR MODELS

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: (i) Answer any **Four** (4) questions.
(ii) Full credit will only be given when all working / logic is correct.

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1. (a) Define the following terms

(i) Randomization.
(ii) Random matrix
(iii) Variance – covariance matrix of a random vector Y.

(b) Let $Y_i = \mu + e_i$, $i = 1, 2, \ldots, n$, $e_i \overset{iid}{\sim} (0, \sigma^2)$.

(i) Write $\overline{Y}\cdot = \frac{1}{n}\sum_{i=1}^{n} Y_i$ as a linear form.

(ii) Write $S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(Y_i - \overline{y}.)^2$ as a quadratic form.

(Hint : In (i) and (ii) use the vector $Y = (y_1 \; y_2 \; y_3 \ldots y_n)^t$)

(iii) Find the expectation of S^2 using the quadratic form of S^2.

(c) An experiment was run to determine whether two specific firing temperatures affect the density of a certain type of Pan brick. The following data was obtained;

Temperature	Density of the Pan Brick				
75 °C	21.8	21.9	21.7	21.7	21.6
150 °C	21.9	21.7	21.8	21.4	

Assume the analysis of variance model is applicable, using the linear model with $Cov(\varepsilon) = \sigma^2 I$, and normal distribution of the errors.

(i) Write Y, X, β and ε where X is full column rank.
(ii) Compute X^tX, $(X^tX)^{-1}$, X^tY and H
(iii) Evaluate $\hat{\beta}$ and SSE.
(iv) Test $H_0 : \beta = 0$ is $H_a : \beta \neq 0$ at 0.01 level of significance.

2. (a) The yield of a chemical process was measured using five batches of raw materials, five acid concentrations and five catalyst concentrations (A, B, C, D and E). A Latin square given below was used.

	Acid Concentration						
Batch	1	2	3	4	5	Sum	Sum of Squares
1	10(E)	24(A)	17(B)	17(C)	14(D)	82	1718
2	20(C)	12(D)	16(E)	25(A)	13(B)	86	1594
3	15(D)	15(E)	22(A)	14(B)	17(C)	83	1419
4	26(A)	16(B)	19(C)	16(D)	13(E)	90	1718
5	18(B)	21(C)	18(D)	11(E)	21(A)	89	1651
Sum	89	88	92	83	78	430	
Sum of Squares	1725	1642	1714	1487	1264		7832

(i) Write the appropriate model give meaning only to the y components.
(ii) Give the ANOVA Table.
(iii) Test for differences for all the three factors and draw conclusions.

(b) A student commented in a discussion group "Random permutations are used to assign treatments to experimental units in a Randomized Block Design as is the case in a Completely Randomized design. Hence there is no basic difference between these two designs." What is your comment?

(c) (i) Let X and Y be random vectors and A be a matrix such that $Y = AX$. Prove that the variance-covariance matrix of Y is given by $\Sigma_Y = A\Sigma_X A^t$, where Σ_X is variance-covariance matrix of X.

(ii) Prove that if B is symmetric idempotent matrix, then P^tBP is also symmetric idempotent matrix if P is a square orthogonal matrix.

3. (a) It is suspected that higher-priced cars are assembled with greater care than low-priced cars. To investigate this, a large Luxury car (Model A), a medium size Sedan (Model B), and a Sub-compact Hatch-Back (Model C) were compared for defects when they arrived at Toyota Zambia show room. The number of defects for randomly selected 4 cars of Model A, 6 cars of Model B, and 5 cars of Model C were recorded. The mean number of defects were 3.5, 5.75 and 7.20 for models A, B and C respectively. The MSE in the ANOVA table was 2.254.

(i) Write the appropriate model in matrix form with the design matrix full column rank.

(ii) Find the 95% confidence interval for the true mean number of defects of each of the three models.

(iii) Find the 95% simultaneous confidence intervals for μ_A , μ_B , μ_C , μ_B , μ_A , and $\mu_C - \mu_A$, using both the Bonferroni – method and the S – method.

(b) If $\hat{\beta}$ is the least-squares estimator of β in the linear model $Y = X\beta + \varepsilon$, where X is full column rank matrix. If MSE is the mean error sum of squares, prove that $Q(\hat{\beta}) = \dfrac{(\hat{\beta}-\beta)^t (x^t x)(\hat{\beta}-\beta)}{K\,MSE}$ has an f-distribution with k and $N-k$ degrees of freedom where N = total number of observations and k is the number of components of β .

(c) An agricultural engineer is studying the effect of cutting speed on the rate of metal removal in a machining operation. However, the rate of metal removal is also related to the hardness of the test specimen. Five observations are taken at each of three cutting speeds. The amount of metal removed and the hardness of the specimen were recorded.

Let w = hardness of the specimen and z = amount of metal removed.

Treatment	$\sum_{i=1} w_{ij}$	$\sum w_{ij}^2$	$\sum z_{ij}$	$\sum z_{ij}^2$	$\sum_{i=1}^{5} w_{ij} z_{ij}$
1	421	36,001	671	90,621	57,053
2	430	38,306	683	94,539	59,995
3	445	40,841	702	100,206	63,898
Totals	1,296	115,148	2,056	285,366	180,946

(i) Write the appropriate model, giving meaning to each term in the model.

(ii) Test for treatment differences at 0.01 level of significance.

(iii) Test for significance of the slope at 0.01 level of significance.

4. (a) To determine if extra personnel are needed for the day, the owners of Adventure City in Ibex would like to find a model that would allow them to predict the day's attendance each morning before opening based on the day of the week and weather conditions. The model is of the form
$E(Y/x_1, x_2, x_3) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3$ where
Y = Daily admissions, x_1 = predicted daily high temperature (^{o}F)

$$x_2 = \begin{cases} 1 & \text{if week-end} \\ 0 & \text{otherwise} \end{cases} \qquad x_3 = \begin{cases} 1 & \text{if it is suny day} \\ 0 & \text{otherwise} \end{cases}$$

The data were recorded for a random sample of 30 days and a least squares estimates for the parameters. $\hat{Y} = 105 + 10x_1 + 25x_2 + 100x_3$

(i) Interpret the model coefficiencies.

(ii) Use the fitted model to predict the admissions (attendances), on a sunny, week-day with predicted high temperature of 95 ^{o}F.

(iii) If the standard errors of $\hat{\beta}_1$, $\hat{\beta}_2$, and $\hat{\beta}_3$ are 4, 10 and 30 respectively. Is there sufficient evidence at 0.05 level of significance to conclude that

: Mean attendance increases on week-ends ?

: Mean attendance increases on sunny days ?

(b) (i) Find the least squares estimators for the parameters in the model

$$Y_{ij} = \mu_j + \frac{\gamma}{x_{ij}} + e_{ij} \;, \quad i = 1,2,\ldots,n_j \text{ and } j = 1,2,3,\ldots,k$$

(ii) Derive the fundamental analysis of variance identity of a randomized block design with replication (n).

(c) During the course of its work on medication of common burns a pharmaceutical company came up with new compound MM-77, which it felt would offer substantial relief. MM-77 was compared in performance against five competing medications in the presence of various external conditions (causes of burn). Sixty individuals with burns were selected in such a way that each of the five types of burns there were twelve individuals with that type. The twelve individuals with the same type of burn two were randomly assigned to one of the medications (MM-77 and five others). The number of hours until occurrence of noticeable relief was recorded for each individual.

(i) What type of design was used?

(ii) Write the appropriate model and give meaning to the terms in the model.

(iii) Complete the ANOVA table given below.

(iv) Test for difference among medications, type of burns, and interactions.

Source	Sum of squares	df	Mean sum of squares
Medication	1322.5		
Type of burn	264.8		
Interaction			
Error	350.4		
Total	2753.6		

5. (a) A collector of antiques knows that the price of the antique increases linearly with age of the item. In addition, the collector suspects that the auction price of the antique increases linearly as the number of bidders increases, hence the following model was assumed.

$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + e$ where Y = Auction price
x_1 = age of antique in years , and x_2 = number of bidders.

The model was fitted for thirty-five auction prices of antiques, along with their age and number of bidders. However, upon examining the residuals, the following model was suggested to remove the interaction effect of age with number of bidders $Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + e$, where $x_3 = x_1 x_2$ and the fitted model to the same data set is
$\hat{Y} = 322.754 + 0.873x_1 - 93.41x_2 + 1.297x_3$.

(i) Comment on the antique collector's view that price increases with the increase in number of bidders.

(ii) Complete the ANOVA table below.

Source	Sum of squares	df	Ms
Regression			
Error	218,646.232		
Total	4,791,194.219		

(iii) Test the significance of the model at 0.05 level of significance.

(b) For the linear model $Y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \varepsilon_i$ $i = 1, 2, 3, \ldots, n$, $e_i \sim N(0, w_i\sigma^2)$, the e_i's are independent and w_i's are known constants.

(i) Write the model in matrix form, specifying Y, X, β and ε.

(ii) Derive the normal equations.

(iii) Show that the estimator $\hat{\beta}$ of β from normal equations in (ii) is unbiased estimator of β.

(iv) Derive the variance-covariance matrix of $\hat{\beta}$.

(c) (i) Prove that if Y is a random vector with k- components, a mean vector μ and variance-covariance matrix Σ which is non-singular then $Q(Y) = (Y - \mu)^t \, \Sigma^{-1} (Y - \mu)$ has a chi-square distribution with k- degrees of freedom if Y has normal distribution.

(ii) Derive the fundamental analysis of variance identity of unbalanced completely randomize design.

End of Examination !

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR

SECOND SEMISTER EXAMINATIONS

M 325 : GROUP AND RING THEORY

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: Answer any **Five (5)** questions.

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1. (a) (i) Find the g c d (328 ,168) and express it in the form $328u + 168w$ where u and w are integers.

   (ii) Prove that if a and b are relatively prime such that ' a divides n ' and ' b divides n ' then their product ' ab also divides n ' where a, b, and n are integers.

   (b) Let X be a set. Define an equivalence relation $x \equiv y$ on X.

   (c) Let x be an integer such that $1 < x \leq 12$. Solve the congruence $x^2 \equiv 1 \mod 15$ for x.

2. (a) (i) List all the elements of S_3. Hence show that S_3 is a group under the composition of maps.

   (ii) Let $K = <(1\,2\,3)>$ be the cyclic subgroup of S_3 generated by $(1\,2\,3)$. Show that K is a normal subgroup of S_3.

   (b) Let $\alpha, \beta \in S_4$ where $\alpha = (2\,1\,3)$ and $\beta = (1\,4)$.

   (i) Compute $\alpha\beta$.
   (ii) Determine the order and the inverse of $\alpha\beta$.
   (iii) Find the number of permutations in S_4 with the same cycle structure as $\beta\alpha\beta^{-1}$.

(c) (i) Let $\alpha, \beta \in S_n$. Prove that if α and β have the same parity then $\alpha\beta$ is even and if α and β have distincty parity then $\alpha\beta$ is odd.

(ii) Shaow that A_n, the set of all even permutations in S_n, is a normal subgroup of S_n.

3. (a) (i) Define a subgroup H of a group G.

(ii) Let H be a non empty subset of a group G with the property that whenever $x, y \in H$ then $xy^{-1} \in H$. Show that H is a subgroup of G.

(b) Let G be a group of order 4. Show that G is an abelian group.

(c) (i) Let a group contain elements a and b such that order of a is 4 and order of b is 2 and also $a^3 b = ba$. Find the order of ab.

(ii) Prove that $G = \{x, 1-x\}$ is a group under the composition of functions where x and $1-x$ are real valued functions.

4. (a) (i) State the Second Isomorphism Theorem.
(ii) Define a homomorphism $f: G \rightarrow H$ of groups.

(b) Let G be the multiplicative group of all non zero complex numbers. Define a transformation φ by $\varphi(a+ib) = \sqrt{a^2 + b^2}$.

(i) Show that φ is a homomorphism.
(ii) Find the kernel and the image of φ.

(c) Let G be a group and $g \in G$. Define a mapping $\gamma_g(a) = gag^{-1}$ for all $a \in G$. Prove that $\gamma_g : G \rightarrow G$ is an isomorphism. (In particular, you need to show that γ_g is a bijection and a homomorphism).

5. (a) Define

(i) a unit in a commutative ring R.
(ii) an integral domain D.
(iii) a field F.

(b) (i) Let D be an integral domain, $a, b \in D$ be non zero elements. Show that ' a divides b ' and ' b divides a' if and only if there is a unit $u \in D$ such that $b = u a$.

(ii) Let $F(\mathbf{R})$ be the commutative ring of all functions $f : \mathbf{R} \to \mathbf{R}$ with pointwise addition and pointwise multiplication, that is $f + g : a \to f(a) + g(a)$ and $fg : a \to f(a) g(a)$ for all $f, g \in F(\mathbf{R})$. Show that $F(\mathbf{R})$ is not an integral domain.

(c) (i) Prove that Z_3 is a field.

(ii) Let $f(x)$ and $g(x)$ be elements of $Z_3[x]$ where $f(x) = x^4 + x$ and $g(x) = x^2 + x$. Show that $f(x)$ and $g(x)$ define the same function from Z_3 to Z_3.

6. (a) Define or state;

(i) Unique Factorization Domain (UFD)
(ii) Ring homomorphism.
(iii) Eisenstein Criterion for Irreducibility.

(b) Given that $f : A \to R$ is a ring homomorphism, prove that kernel of f (ker f) is a <u>proper</u> ideal in A.

(c) Consider the polynomial $\phi_5(x) = \dfrac{x^5 - 1}{x - 1} = x^4 + x^3 + x^2 + x + 1$.

Show that $f(x) = \phi_5(x + 1)$ is irreducible in $Q[x]$.

7. (a) Define

(i) a simple group.
(ii) the center of a group G.
(iii) the centralizer of $x \in G$.
(iv) a sylow p – subgroup.

(b) Prove that the centralizer of $x \in G$, $C_G(x)$, is a subgroup of G.

(c) Let G be a p – group for some prime p. Show that the center of G is not trivial, i.e. $Z(G) \neq \{1\}$.

END OF EXAMINATION !

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR

SECOND SEMISTER EXAMINATIONS

M 412 : Theory of Functions of a Complex Variable II

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: (i) Answer any Four (4) questions.
(ii) Full credit will only be given when working is shown.

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1. (a) (i) State the Taylor's Theorem for a function f.

   (ii) Define a zero of an analytic function f of multiplicity $m \geq 1$.

   (b) Find the Taylor series about the given point and state the radius of convergence.

   (i) $\log z$ about $z = i$.

   (ii) $z^{\frac{i}{2}}$ about $z = 1$

   (c) Let f be analytic in a domain D. If there are distinct points $z_1, z_2, \ldots$ in D with $f(z_n) = 0$ $n = 1, 2, 3, \ldots$ and if the sequence $\{z_n\}$ converges to a point z_0 in D, show that $f(z) = 0$ for all z in D.

2. (a) (i) Find the zeros and the poles of the function

$$f(z) = \frac{z^2 - 2z}{(z+1)^2(z+4)}$$

   (ii) Find the residue of the function $f(z) = \dfrac{e^{zt}}{z^2(z^2 + 2z + 2)}$, at $z = 0$ and at $z = -1 + i$.

   (b) (i) Let f be a function analytic at a point z_0. Define a function $g(z) = \dfrac{f(z)}{z - z_0}$. Show that if $f(z_0) = 0$ then z_0 is a removable singularity for $g(z)$ and if $f(z_0) \neq 0$ then z_0 is a simple pole for $g(z)$.

   (ii) Find the Laurent series on the annulus $1 < |z| < 4$ for the function

$$g(z) = \frac{z+2}{z^2 - 5z + 4}.$$

(c) Let $D = \{z : |z| < 1\}$ and suppose that f is analytic on D with $|f(z)| \leq 1$ for all z in D and $f(o) = 0$. Show that $|f'(o)| \leq 1$ and $|f(z)| \leq |z|$ for all z in D.

3. (a) Let $f(z) = \dfrac{H(z)}{(z - z_0)^m}$ where $H(z)$ is analytic on the disc $\{z : |z - z_0| < r\}$ and $H(z_0) \neq 0$.

(i) Determine the nature of the singularity of f at z_0.
(ii) Express $f(z)$ in series about $z = z_0$.

(b) Let f be analytic on a domain D except at a finite number of poles, γ a piecewise smooth simple closed curve in D passing through no zero or pole of f. If $z_1, z_2, \ldots, z_N$ are distinct zeros of f inside γ and $w_1, w_2, \ldots w_m$ are distinct poles of f inside γ, let n_j be the other order of the zero of f at z_j $j = 1, 2, \ldots N$ and m_k be the order of the pole of f at w_k $k = 1, 2, \ldots m$. Use the Residue Theorem to the function $\dfrac{f'}{f}$ to find $\displaystyle\int_\gamma \frac{f'(z)}{f(z)}\, dz$.

(c) Evaluate the following integrals;

(i) $\displaystyle\int_0^\infty \frac{(\log x)^2}{1 + x^2}\, dx$, $\left(\text{Note } \displaystyle\int_0^\infty \frac{\log x}{1 + x^2}\, dx = 0\right)$

(ii) $\displaystyle\int_0^{2\pi} \frac{d\theta}{(2 - \sin\theta)^2}$

4. (a) State

(i) The Argument Principle.
(ii) Rouche's Theorem.

(b) (i) Show that all the zeroes of $P(z) = 3z^3 - 2z^2 + 2iz - 8$ lie in the annulus $1 < |z| < 2$.

(ii) Determine the number of solutions of the equation $z^4 - 5z^2 + 3 = 0$ in the half-plane $\operatorname{Re} z > 0$.

(c) Let $P(z) = z^n + a_{n-1} z^{n-1} + \ldots + a_1 z + a_0$ be a polynomial of degree n. Use Rouche's Theorem to prove that $P(z)$ has exactly n zeros counting their multiplicities.

5. (a) State

(i) The Open Mapping Theorem.
(ii) The Maximum Modulus Theorem.

(b) Let f be a non constant analytic function on a domain D.

(i) Show that if w_o is in D then $f(w_o) = \frac{1}{2\pi}\int_0^{2\pi} f\left(w_o + re^{it}\right)dt$.

(ii) Show that if $u = \text{Re}f$ then u has no local maxima and no local minima in D.

(c) Let f be analytic in the disc $D = \{z : |z| < 1\}$ with $f(o) = 0$ and $|f(z)| \leq 1$ for all z in D. If $|f(z_o)| = |z_o|$ for some $z_o \neq 0$ in D, or if $|f'(o)| = 1$, show that $f(z) = \lambda z$ for some constant λ with $|\lambda| = 1$.

6. (a) Define the following

(i) Analytic continuation of f.
(ii) The elements f_1 and f_2 of a function F.
(iii) γ is homotopic to zero.

(b) Let D_1 be the half-plane $\text{Re}z > 0$ and $D_2 = \{z : |z + i| < 1\}$. Define

$$f(z) = \int_0^{\infty} e^{-zt}\,dt \quad \text{Re}z > 0 \quad \text{and} \quad g(z) = i\sum_{n=0}^{\infty}\left(\frac{z+i}{i}\right)^n \quad |z+i| < 1.$$

(i) Show that $f(z) = g(z)$ on the domain $D_1 \cap D_2$.

(ii) Find a function $F(z)$ an analytic continuation of $f(z)$ into the complex plane minus the origin and show that $f(z)$ and $g(z)$ are elements of $F(z)$.

(c) Let $\gamma : [0, 1] \to \mathbb{C}$ be a closed rectifiable curve. If $w \notin \gamma$ show that $\frac{1}{2\pi i}\int_{\gamma} \frac{dz}{z - w}$ is an integer.

End of Examination.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR

SECOND SEMESTER EXAMINATIONS

M422 FIELD AND MODULE THEORY

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: Answer any **Four** (4) questions in all and at least two questions from Section A plus at least one question from Section B.

SECTION A – FIELD THEORY
(Answer at least two (2) questions from this section).

1. (a) Give the meaning of each of the following terms

   (i) The field L <u>is a splitting field</u> for a polynomial $f(x) \in k[x]$.

   (ii) The field extension L : K is <u>normal</u>.

   (b) Prove that if L : K is a normal finite extension, then L is a splitting field for some polynomial over K .

   (c) Construct the splitting field for the polynomial $x^4 - 3x^2 + 4$ over ,

   (i) Q , the field of rational numbers.

   (ii) the finite field $\mathbf{Z}_7$.

2. (a) Define each of the following terms.

   (i) The <u>Galois Group</u> of a field extension L : K .

   (ii) <u>Intermediate fields</u> of the field extension L : K .

   (b) Show that the Galois Group of a polynomial f(x) over the field K is a subgroup of the symmetric group S_n of degree n , where n is the degree of f(x).

   (c) Determine the Galois group of $f(x) = x^4 - 2$ over Q , the field of rational numbers, and determine its subgroups and the corresponding intermediate fields.

3. (a) What is meant by each of the following terms;

(i) The Galois Group of a polynomial f(x) over a field K ?

(ii) The field extension L : K is radical ?

(b) Given that the Galois group G_f of a polynomial f(x) is solvable, show that the extension L : K is a radical extension, where L is the splitting field for $f(x) \in K[x]$.

(c) Show that if α is a root of $f(x) = x^6 + 3$, then $\frac{1}{2}(1+\alpha^3)$ is a 6^{th} root of unity. Hence deduce that the roots of f(x) are of the form $\varepsilon^i\alpha$, where $\varepsilon = \frac{1}{2}(1+\alpha^3)$, $(i = 1,2,\ldots,5)$. Hence by calculating the Galois Group of f(x) over Q or otherwise, deduce that f(x) is solvable by radicals.

SECTION B – MODULE THEORY

(Answer at least one (1) question from this section).

4. (a) Define each of the following terms as applied to left R – modules.

(i) the map $\phi : M \to N$ from an R – module M to an R – module N is an R – homomorphism.

(ii) the order ideal o(m) of an element $m \in M$.

(b) Show each of the following :

(i) if $\phi : M \to N$ is an R – homomorphism then the kernel ker ϕ is a submodule of M and M / Ker ϕ is isomorphic to a submodule of N.

(ii) If m is a torsion element of M then it has a non-zero order ideal.

(c) Let $\mathbf{Z}_n$ denote the set of integers module n, where n is a positive integer. Then determine a condition on $m \in \mathbf{Z}$ in order that m lies in 0 (x) the order ideal of x in $\mathbf{Z}_n$. Hence deduce that $\mathbf{Z}_n$ is not torsion-free.

5. (a) What is the meaning of each of the following terms?

(i) M is <u>a finitely generated</u> R – module .

(ii) the element m of an R – module M is a <u>torsion element</u> .

(b) (i) Show that if each element m of an R – module M has a unique expression of the form $m = \sum_{i=1}^{t} r_i\, m_i$, then each m_i is a torsion-free element.

(ii) Prove that if N is an R – submodule of M such that N and M/N are finitely generated then M is also finitely generated.

(c) Show that the subset T of an R – module M defined by
T = { m ∈ M : m is a torsion element } is an R – submodule of M and that the quotient module M / T is torsion-free.

6. (a) What is the meaning of each of the following terms:

(i) an R – module M is an <u>internal direct sum</u> of $M_1, M_2, \ldots, M_r$?

(ii) module M is <u>R – free</u> .

(b) (i) Let M be an R – module, and let M_i (i = 1, 2, …, n) be submodules such that $M = \sum M_i$ and $M_i \cap \sum_{i \neq j} M_j = \{0\}$.

Then prove that $M = \oplus \sum M_i$.

(ii) Let M be freely generated by the set $X = \{ m_1, m_2, \ldots, m_s)$ and N be freely generated by $\{ e_1, e_2, \ldots, e_s \}$, where
$e_1 = (1, 0, 0, \ldots, 0)$; $e_2 = (0, 1, 0, \ldots, 0)$; $e_s = (0, 0, \ldots, 1)$. Then prove that $M \cong N$.

(c) Show that the **Z** – module **Z** is **Z** – free and determine whether $\mathbf{Z}_n$ is **Z** – free .

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR

SECOND SEMESTER EXAMINATIONS

M462 BAYESIAN INFERENCE AND DISCRETE ANALYSIS

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: (i) Answer any **Four** (4) questions.
(ii) Show all essential working.

---

1. (a) Define the following:

   (i) posterior density of a parameter θ.
   (ii) Bayes estimator for θ.
   (iii) Bayes risk of an estimator $\delta(X_1, \ldots, X_n)$.

   (b) If Y has p.d.f. $f(y) = 4y^2 e^{-2y}$, $y > 0$. Show that

   (i) $E(Y) = \frac{3}{2}$ (ii) $E(Y^2) = 3$

   (c) Let $X_1, X_2, \ldots, X_n$ be a random sample from a Poisson distribution

$$f(x;\theta) = \frac{e^{-\theta}\theta^x}{x!}, x = 0, 1, 2, \ldots$$

   and let the prior distribution of θ be $\pi(\theta) = 4\theta^2 e^{-2\theta}$, $\theta > 0$. Assuming a squared error loss function,

   (i) show that the posterior density function of θ is given by

$$\pi(\theta|x) = \frac{(n+2)^{3+\sum_{i=1}^{n} x_i}}{\Gamma\left(3+\sum_{i=1}^{n} x_i\right)} \theta^{2+\sum_{i=1}^{n} x_i} e^{-(n+2)\theta}, \theta > 0$$

   (ii) find the Bayes estimator of θ.

   (ii) find the Bayes risk of the estimator

$$\delta(X_1, \ldots, X_n) = \frac{3+\sum_{i=1}^{n} X_i}{n+2} \text{ of } \theta$$

2. (a) Define the following:

(i) right censoring.
(ii) interval censoring.
(iii) mean residual life.

(b) Let T be a continuous random variable with probability density function f(t) and survival function S(t). Prove that

(i) $$S(t) = \exp\left\{-\int_0^t h(x)\,dx\right\} = \exp\{-H(t)\}$$

(ii) $$\text{Var}(T) = 2\int_0^\infty t\,S(t)\,dt - \left[\int_0^\infty S(t)\,dt\right]^2$$

(c) The time to death (in months) for a mouse exposed to a high dose of radiation follows a Gompertz distribution with probability density function

$$f(t) = \theta e^{\alpha t} \exp\left\{\frac{\theta}{\alpha}(1-e^{\alpha t})\right\}, \quad t>0,\ \theta>0,\ \alpha>0.$$

(i) Show that $S(t) = \exp\left\{\frac{\theta}{\alpha}(1-e^{\alpha t})\right\}$

(ii) Find the hazard function $h(t)$.

(iii) Find the probability that a randomly chosen mouse will live at least one year given that $\theta = 0.01$ and $\alpha = 0.25$.

(iv) Find the probability that a randomly chosen mouse will die within the first six months given that $\theta = 0.01$ and $\alpha = 0.25$.

(v) Find the median time to death given that $\theta = 0.01$ and $\alpha = 0.25$.

3. (a) Define the following:

(i) minimax estimator.
(ii) a $100(1-\alpha)\,\%$ Bayesian interval for θ.
(iii) Kaplan – Meier estimator.

(b) Let $X_1, X_2, \ldots, X_n$ be a random sample from the exponential distribution with probability density function $f(x;\theta) = \theta e^{-\theta x}$, $x > 0, \theta > 0$. Assume that the prior density of θ is also exponential with probability density function $\pi(\theta) = \mu e^{-\mu\theta}, \theta > 0$.

(i) Show that the posterior density function of θ is

$$\theta|x \sim GAM\left(n+1, \frac{1}{\mu + \sum_{i=1}^{n} x_i} \right)$$

(ii) Find the Bayes estimator of θ using the absolute error loss function.

(iii) Find a 95% Bayesian interval for θ given that $\mu = 3$ and

$$\sum_{i=1}^{10} x_i = 3.4$$

$$\left[\text{Hint: If } Y \sim GAM(\alpha,\beta) \text{ with p.d.f. } f(y) = \frac{1}{\Gamma(\alpha)\beta^{\alpha}} y^{\alpha-1} e^{-y/\beta}, \; y > 0 \text{ then } \frac{2Y}{\beta} \sim \chi^2(2\alpha) \right]$$

(c) The death times of 10 heart transplant patients (in months) following surgery are given below:

4, 10, 10, 15, 19, 22, 25*, 26, 38*, 39*
* denotes censored observations.

Find the Kaplan – Meier estimate of the survival function and sketch its graph. (no standard errors are required).

4. (a) Let $Y_1 \sim B(n_1, p_1)$ and $Y_2 \sim B(n_2, p_2)$ be independent binomial distributions. Find

(i) $\mathrm{Var}\left(\frac{\hat{p}_1}{1-\hat{p}_1} \right)$

(ii) $\mathrm{Var}\left(\log(\widehat{OR})\right)$
where $\hat{p}_1$ and $\hat{p}_2$ are maximum likelihood estimators of p_1 and p_2, and $\widehat{OR}$ is the estimated odds ratio.

(b) The data in the following table describes the relationship between the degree of alcohol consumption and occurrence of a heart attack.

	Heart Attack		
	Yes	No	Total
Heavy consumer	71	52	123
Light consumer	29	48	77

(i) Compute and interpret the observed risk difference, relative risk and odds ratio.

(ii) Compute a 95% confidence interval for the odds ratio. What is your conclusion?

(iii) What are the estimates of β_o and β_1 for the logistic regression model

$$\text{logit}\left[P(Y = 1|x) \right] = \beta_o + \beta_1 x$$

where Y denotes the occurrence of a heart attack.

$$Y = \begin{cases} 1 \ , & \text{heart attack occurs} \\ 0 \ , & \text{no heart attack} \end{cases}$$

and x denotes the level of alcohol consumption

$$x = \begin{cases} 1 \ , & \text{heavy consumer} \\ 0 \ , & \text{light consumer} \end{cases}$$

(c) The death times of 10 AIDS patients (in years) following infection are given below:

3, 4*, 10*, 11, 15, 16*, 28, 33, 36*, 37

* denotes censored observations.

Find the Nelson – Aalen estimate of the survival function and sketch its graph. (no standard errors are required).

5. (a) The failure times (in weeks) of 50 light bulbs are given below:

3	8	10	14	15	16	19	19	23	24*
26	27*	35*	37*	37	38	41*	46	46	49*
50	52*	53*	55	61*	61	61	64	69*	69
72	72	77	79*	83	86	87*	88*	88*	90*
93	100	103	106	107	109	110	110	116	117

* denotes censored failure times.

Prepare a life table for the above data using the intervals $[0, 20), [20, 40), \ldots, [100, \infty)$.

(b) (i) State and define the three components of a generalized linear model.

(ii) State the form of the natural exponential family of distributions.

(iii) Show that the poisson distribution with probability density function $f(y;\lambda) = \dfrac{e^{-\lambda}\lambda^{y}}{y!}$, $y = 0,1,2,...$ belongs to the exponential family, and hence find the functions $a(\cdot)$, $b(\cdot)$, and $c(\cdot)$. State the canonical link function $\eta = g(\lambda)$.

(c) A study was conducted to investigate the effect of aspirin use, smoking status and alcohol consumption on the probability of developing a heart attack. Consider fitting the logistic regression model
$\text{logit}\left[P(Y=1|x)\right] = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3$ where

$$Y = \begin{cases} 1 \text{ , heart attack occurs} \\ 0 \text{ , no heart attack} \end{cases}$$

$$x_1 = \begin{cases} 1 \text{ , subject smokes} \\ 0 \text{ , subject doesn't smoke} \end{cases}$$

$$x_2 = \begin{cases} 1 \text{ , subject takes alcohol} \\ 0 \text{ , subject doesn't take alcohol} \end{cases}$$

$$x_3 = \begin{cases} 1 \text{ , subject on aspirin} \\ 0 \text{ , subject on placebo} \end{cases}$$

(i) Does smoking increase the probability of a heart attack?

(ii) Does aspirin use affect the probability of a heart attack?

(iii) Test the hypothesis $H_o: \beta_1 = \beta_2 = 0$.

(iv) What are the odds of a heart attack for a smoker on aspirin versus a non smoker on placebo ? Calculate a 95% confidence interval for the estimated odds ratio. What is your conclusion ?

(A computer output is attached.
Use $\alpha = 0\cdot05$ for the above questions.)

END OF EXAMINATION.

```
> model1<-glm(y~x1+x2+x3,family=binomial)
> summary(model1)

Call:
glm(formula = y ~ x1 + x2 + x3, family = binomial)

Deviance Residuals:
[1]  -0.55313   0.06879   0.54048   0.83315  -0.08070  -0.57664

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.0410     0.5275  -1.973   0.0484 *
x1            1.1569     0.6670   1.734   0.0828 .
x2            1.3589     0.7151   1.900   0.0574 .
x3           -1.2670     0.5630  -2.251   0.0244 *
---
Signif. codes:  0 `***' 0.001 `**' 0.01 `*' 0.05 `.' 0.1 ` ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 10.9278  on 5  degrees of freedom
Residual deviance:  1.6360  on 2  degrees of freedom
AIC: 25.615

Number of Fisher Scoring iterations: 4

> one$cov.unscaled
            (Intercept)          x1          x2          x3
(Intercept)   0.2782337 -0.24413302 -0.23965816 -0.08064461
x1           -0.2441330  0.44488098  0.26966097 -0.05336785
x2           -0.2396582  0.26966097  0.51135453 -0.07095363
x3           -0.0806446 -0.05336785 -0.07095363  0.31692593

> model2<-glm(y~x3,family=binomial)
> summary(model2)

Call:
glm(formula = y ~ x3, family = binomial)

Deviance Residuals:
[1]  -1.900e+00   7.672e-01   1.415e+00  -2.952e-01   2.724e-01  -
5.576e-08

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -0.2719     0.3318  -0.819   0.4125
x3           -1.1144     0.5373  -2.074   0.0381 *
---
Signif. codes:  0 `***' 0.001 `**' 0.01 `*' 0.05 `.' 0.1 ` ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 10.9278  on 5  degrees of freedom
Residual deviance:  6.3623  on 4  degrees of freedom
AIC: 26.341

Number of Fisher Scoring iterations: 4
```

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR

SECOND SEMESTER EXAMINATIONS

M912: IMATHEMATICAL METHODS VI

TIME ALLOWED: Three (3) Hours

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 booklet.
(c) There are **six** questions in this paper. Candidates must answer any **five (5)** questions only. All questions carry equal marks.
(d) No Calculators to be used.

---

1. (a) Show that the function $y_1 = e^{-x}$, $y_2 = e^{x}$ and $y_3 = e^{2x}$ are solutions of the differential equation $y''' - 2y'' - y' + 2y = 0$. Hence, write the General solution.

   (b) State and prove Green's Theorem.

2. (a) Find the General solution of the differential equation.

   $$D^2y - Dy = 4x + 3 \qquad (\text{where } D = \frac{d}{dt})$$

   (b) (i) Evaluate $\int_1^2 \int_0^{\log x} (x-1)\sqrt{1+e^{2y}}\, dy\, dx$

   (ii) Write the Fourier expansion of the periodic function whose definition in one period is $f(t) = \begin{cases} 0 & -\pi < t < 0 \\ \sin t & 0 < t < \pi \end{cases}$

3. (a) (i) Find $\int_D (x^3 y + \cos x)\, dA$ where D is the triangle consisting of all points (x, y) such that $0 \le x \le \frac{\pi}{2}$, $0 \le y \le x$. Sketch D.

(ii) Find the Fourier integral representation of the function

$$f(x) = \begin{cases} 1, & |x| < 1 \\ 0, & |x| > 1 \end{cases}.$$

Hence, or otherwise, show that

$$\int_0^\infty \frac{\cos wx \sin w}{w}\, dw = \begin{cases} \frac{\pi}{2} & 0 \le x < 1 \\ \frac{\pi}{4} & x = 1 \\ 0 & x > 1 \end{cases}$$

(b) Using power series method, solve the differential equation $D^2 y = xy$.

4. (a) Find the Fourier series of the function $f(t) = \begin{cases} 0 & -2 < t < -1 \\ 3 & -1 < t < 1 \\ 0 & 1 < t < 2 \end{cases}$

Sketch f(t).

(b) Let w be the region bounded by the planes $x = 0$, $y = 0$, $z = 2$ and the surface $z = x^2 + y^2$, $x \ge 0$, $y \ge 0$. Compute $\int_w x\, dx\, dy\, dz$.

Sketch the region w.

5. (a) (i) Evaluate $\int_\sigma \cos z\, dx + e^x dy + e^y dz$, where

$\sigma(t) = (1, t, e^t)$ and $\in t[0, 1]$.

(ii) Verify the Stokes' Theorem for $F(x, y, z) = -y^2 i + zj + xk$, where C is the oriented triangle lying in the plane $2x + 2y + z = 6$.

(b) A cone shaped surface lamina S given by $z = 4 - 2\sqrt{x^2 + y^2}$, $0 \leq z \leq 4$ at each point on S, the density is proportional to the distance between the point and the z – axis. Find the mass of the lamina. (given that a density of $\rho(x, y, z) = k\sqrt{x^2 + y^2}$.

6. (a) (i) State and prove the Parseval Theroem.

(ii) Consider C, the perimeter of the unit square in the first quadrant in $\mathbf{R}^2$, oriented in the counter clockwise sense.

Evaluate the line integral $\int_c x^2\,dx + xy\,dy$.

(b) While subject to the force $F(x, y) = y^3 i + (x^3 + 3xy^2)j$ a particle travels once around the circle of radius 3 in a counter clockwise direction. Use Greens' Theorem to find the work done by F.

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR

SECOND SEMESTER EXAMINATIONS

M962: TIME SERIES ANALYSIS

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: Answer any five (5) questions.

Specific Instruction: In all the following questions , $\{ a_t \}$ is a discrete , purely random process such that $E(a_t) = 0$, $V(a_t) = \sigma_a^2$, $Cov(a_t, a_{t+k}) = 0$, $k \neq 0$.

1. (a) Define the following:

   (i) A Stochastic Process.

   (ii) A Weakly Stationary Stochastic Process.

   (iii) A Time Series.

   (iv) Find $V(Z_t)$ and $Cov(Z_t, Z_{t+1})$ for the process $\{Z_t\}$ defined by $Z_t = \mu + a_t + \theta_1 a_{t-1}$.

   (b) Discuss which of the following processes are weakly stationary

   (i) $X_t = \sum_{j=1}^{t} a_j$ (ii) $X_t = a_t a_{t-1}$

   (c) The first ten autocorrelations of a time series of 100 observations were as follows:

1	2	3	4	5	6	7	8	9	10
0.889	0.765	0.631	0.509	0.400	0.313	0.238	0.188	0.149	0.108

   Discuss if the time series was generated from

   (i) a random process.

   (ii) a stationary process.

   (iii) a non stationary process.

2. (a) Given the process $X_t = a_t - \theta a_{t-1}$.

(i) Find $V(X_t)$

(ii) Find the autocorrelation function of X_t.

(iii) Find variance of the first differenced series and compare with $V(X_t)$.

(b) Find an invertible process which has the following autocorrelation function : $\rho_0 = 1$, $\rho_1 = \cdot 25$ and $\rho_k = 0$ for $k \geq 2$.

(c) Given the process $Z_t = (1 - 1{\cdot}2B + \cdot 5B^2)\, a_t$

(i) Show that it is invertible.

(ii) Find the autocorrelation function of the process.

(iii) Discuss the pattern of the partial autocorrelation of the process.

3. (a) Show that the autoregressive process $Z_t = Z_{t-1} - \frac{13}{16} Z_{t-2} + a_t$ is stationary.

(b) Given the stochastic process $Z_t - \frac{2}{3} Z_{t-1} + \frac{1}{12} Z_{t-2} = a_t$

(i) Show that $\rho_k = \left(\frac{35}{26}\right)\left(\frac{1}{2}\right)^k - \frac{9}{26}\left(\frac{1}{6}\right)^k$

$k = 0, 1, 2, \ldots$

(ii) By evaluating the first five autocorrelations using part (i), show that the autocorrelations are decaying exponentially.

(c) Assuming that 100 observations from an AR(2) model $Z_t = \varphi_1 Z_{t-1} + \varphi_2 Z_{t-2} + a_t$ gave the following sample autocorrelations : $\hat{\rho}_1 = 0{\cdot}7$, $\hat{\rho}_2 = 0{\cdot}5$, $\hat{\rho}_3 = 0{\cdot}4$. Find initial estimates of φ_1 and φ_2.

4. (a) Define a zero mean ARIMA (0, 1, 1) process and state the characteristics of the autocorrelations of this process and the first differenced process.

(b) Given the model $\left(\frac{1-B}{1-\theta B}\right) Z_t = a_t$,

Using the expansion $\frac{1}{1-\theta B} = 1 + \theta B + \theta^2 B^2 + \cdots$,

Show that the autoregressive representation of the model is

$$Z_t = (1-\theta)\sum_{j=1}^{\infty} \theta^{j-1} Z_{t-j} + a_t .$$

(c) (i) Using the result of part (b), show that $\hat{Z}_{t+1} = (1-\theta)Z_t + \theta \hat{Z}_t$ where $\hat{Z}_{t+1}$ is the optimal forecast of Z_{t+1}.

(ii) The quarterly sales of electric fans at GAME store in 2006 were

Q1	Q2	Q3	Q4
28	20	57	90

By taking the sum of the sale of quarters one and two as a forecast for quarter three and $\theta = 0.4$, find the optimal forecast for the first quarter of 2007.

5. A stationary process $\{W_t\}$ is defined by the model $W_t = \lambda W_{t-1} + a_t + \beta a_{t-1}$.

0

(a) Discuss the stationarity and invertibility of the process. σ_a^2 1

(b) Show that

$\sigma_a^2 = \lambda \sigma_a^2 + \beta \sigma_a^2$

(i) $\rho_1 = \frac{(\lambda+\beta)(1+\lambda\beta)}{1+2\lambda\beta+\beta^2}$

(ii) $\rho_k = \lambda \rho_{k-1}$, $k \geq 2$

(c) The autocorrelations and partial autocorrelations of a time series of 100 values are

K	1	2	3	4	5	6	7
$\hat{\rho}_k$	·57	·5	·47	·35	·31	·25	·21
$\hat{Q}_{kk}$	·57	·26	·18	–·03	·01	–·01	·01

(i) Construct correlograms of the autocorrelations and partial autocorrelations.

(ii) Discuss why the given model appears appropriate for the time series.

(ii) Find initial Estimates of λ and β.

6. A quarterly sales time series was fitted by the model

$$(1 - \cdot 8B + \cdot 4B^2)(Z_t - 610) = a_t$$

where $\sigma_a^2 = 8400$ and the last four observations are

$Z_1 = 580$, $Z_2 = 640$, $Z_3 = 770$ and $Z_4 = 800$.

(a) Forecast sales for the next four quarters.

(b) Find the 90% forecast limits.

(c) The observation at $t = 5$ turns out to be $Z_5 = 621$. Find the updated forecast for Z_6, Z_7, Z_8.

The updating equation in the usual parameters is

$$\hat{Z}_{n+1}(\ell) = \hat{Z}_n(\ell+1) + \psi_\ell\left[Z_{n+1} - \hat{Z}_n(1)\right]$$

END OF EXAMINATION.

TABLE III

The Normal Distribution

$$\Pr(X \leq x) = \Phi(x) = \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}} e^{-w^2/2}\, dw$$

$$[\Phi(-x) = 1 - \Phi(x)]$$

x	$\Phi(x)$	x	$\Phi(x)$	x	$\Phi(x)$
0.00	0.500	1.10	0.864	2.05	0.980
0.05	0.520	1.15	0.875	2.10	0.982
0.10	0.540	1.20	0.885	2.15	0.984
0.15	0.560	1.25	0.894	2.20	0.986
0.20	0.579	1.282	0.900	2.25	0.988
0.25	0.599	1.30	0.903	2.30	0.989
0.30	0.618	1.35	0.911	2.326	0.990
0.35	0.637	1.40	0.919	2.35	0.991
0.40	0.655	1.45	0.926	2.40	0.992
0.45	0.674	1.50	0.933	2.45	0.993
0.50	0.691	1.55	0.939	2.50	0.994
0.55	0.709	1.60	0.945	2.55	0.995
0.60	0.726	1.645	0.950	2.576	0.995
0.65	0.742	1.65	0.951	2.60	0.995
0.70	0.758	1.70	0.955	2.65	0.996
0.75	0.773	1.75	0.960	2.70	0.997
0.80	0.788	1.80	0.964	2.75	0.997
0.85	0.802	1.85	0.968	2.80	0.997
0.90	0.816	1.90	0.971	2.85	0.998
0.95	0.829	1.95	0.974	2.90	0.998
1.00	0.841	1.960	0.975	2.95	0.998
1.05	0.853	2.00	0.977	3.00	0.999

UNIVERSITY OF ZAMBIA
DEPARTMENT OF COMPUTER STUDIES
UNIVERSITY EXAMINATIONS
SECOND SEMESTER 2006
M982
NUMERICAL ANALYSIS II

TIME: THREE HOURS
ANSWER ANY FOUR QUESTIONS FROM THE SIX GIVEN
ALL QUESTIONS CARRY EQUAL MARKS
TOTAL MARKS: 100

Useful formulas:

$$\text{Inverse of a matrix} : A^{-1} = \frac{1}{\det A} B^T,$$

Condition number of a matrix:

$$\kappa(A) = \|A\| \left\|A^{-1}\right\|$$

Norms of a matrix:

$$\|A\| = \sqrt{\sum_{j=1}^{n} \sum_{k=1}^{n} a_{jk}^2}$$

$$\|A\| = \max_k \sum_{j=1}^{n} |a_{jk}|$$

$$\|A\| = \max_j \sum_{k=1}^{n} |a_{jk}|$$

Question 1. **(a)** Explain the importance of pivoting when solving a linear system by Gauss elimination. [2 marks]

(b) Explain the essence of Doolittle's method. [5 marks]

(c) Showing the LU factorization, solve the following system using Cholesky's method.

$$
\begin{aligned}
4x_1 + 2x_2 + 4x_3 \qquad &= 10 \\
2x_1 + 2x_2 + 3x_3 + 2x_4 &= 18 \\
4x_1 + 3x_2 + 6x_3 + 3x_4 &= 30 \\
2x_2 + 3x_3 + 9x_4 &= 61
\end{aligned}
$$

[18 marks]

Question 2 **(a)** Explain when it might be preferable to solve a linear system using Gauss-Seidel iteration as opposed to Gauss elimination. [2 marks]

(b) A sufficient condition for convergence of Gauss-Seidel iteration for any choice of the starting vector $\mathbf{x}_0$ is that the norm of the iteration matrix

$$C = -(I+L)^{-1}U$$

should be less than unity:

$$\|C\| < 1.$$

(i) Prove that the system

$$
\begin{aligned}
x_1 + 9x_2 - 2x_3 &= 36 \\
2x_1 - x_2 + 8x_3 &= 121 \\
6x_1 \; + x_1 + x_3 &= 107
\end{aligned}
$$

can be solved by Gauss-Seidel iteration. [20 marks]

(ii) Perform one Gauss-Seidel iteration on this system using $\mathbf{x}_0 = (10 \;\; 10 \;\; 10)^T$. [3 marks]

Question 3 **(a)** The matrix

$$S = \begin{pmatrix} \frac{1}{\sqrt{2}} & -\frac{i}{2} & 0 \\ \frac{i}{2} & 0 & -\frac{i}{2} \\ 0 & \frac{i}{2} & -\frac{1}{\sqrt{2}} \end{pmatrix}$$

occurs in the theory of angular momentum in physics.

(i) Explain why it is Hermitian [2 marks]

(ii) Show that it has the eigenvalues $\lambda = 0, \pm 1$ [5 marks]

(iii) Obtain the respective normalized eigenvectors. [15 marks]

(iv) Show that the values of the eigenvalues are in accordance with Gerschgorin's theorem. [3 marks]

Question 4. **(a)** **(i)** Derive the second-order Runge-Kutta method

$$\begin{aligned} y_{i+1} &= y_i + h(a_1 k_1 + a_2 k_2) \\ k_1 &= f(x_i, y_i),\ k_2 = f(x_i + p_1 h, y_i + q_{11} k_1 h) \end{aligned}$$

and hence show that

$$\begin{aligned} a_1 + a_2 &= 1 \\ a_2 p_1 &= \frac{1}{2} \\ a_2 q_{11} &= \frac{1}{2} \end{aligned}$$

[13 marks]

(ii) Show that if $a_2 = \frac{1}{2}$ the resulting formula is Heun's method

$$y_{i+1} = y_i + \frac{h}{2}[f(x_i, y_i) + f(x_i + h, y_i + hf(x_i, y_i))]$$

[2 marks]

(b) Use Euler's method with $h = 0.2$ to obtain the value of y at $x = 1$ if

$$y' = (x + y - 4)^2,\ y(0) = 4.$$

[10 marks]

Question 5. **(a)** Show that Laplace's equation

$$u_{xx} + u_{yy} = 0$$

can be replaced by the difference equation

$$u(x+h, y) + u(x, y+h) + u(x-h, y) + u(x, y-h) - 4u(x, y) = 0$$

[7 marks]

(b) Using $h = 0.5$, solve Laplace's equation in the rectangular region $0 \leq x \leq 1.5$ and $0 \leq y \leq 1.0$. The boundary conditions are $u = 0$ on the horizontal edges, $u = 50$ on the left vertical edge and $u_x = 3y^2$ on the right vertical edge. It is enough for you to set up the linear system whose solution gives the values at the grid points without solving it. [18 marks]

Question 6. **(a)** **(i)** Define a similarity transformation and show that the eigenvalues of a matrix are invariant under such a transformation [5 marks]

(ii) Prove that the elements of a diagonal matrix are its eigenvalues. [3 marks]

(iii) Explain the logic underlying the QR algorithm. [3 marks]

(c) Prove that the system

$$\begin{aligned} 1.0001x_1 + 0.9999x_2 &= 2.9999 \\ 0.9998x_1 + 1.0002x_2 &= 3.0002 \end{aligned}$$

is ill-conditioned. [14 marks]

****END OF EXAMINATION****

The University of Zambia
Physics Department
University Examinations 2006
Second Semester
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 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 :

$g = 9.8 \text{m/s}^2$

$P_A = 1.01 \times 10^5 \text{ N/m}^2$

1 cal. = 4.186 joules

$\varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$

$c = 3 \times 10^8 \text{ m/s}$

$h = 6.63 \times 10^{-34}$ J-s

1 pascal =1 N/m^2

$1\text{eV} = 1.6 \times 10^{-19}$ J

$e = 1.6 \times 10^{-19}$ C

$m_e = 9.11 \times 10^{-31}$ kg

$k = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$

$\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$

$\rho_{water} = 1000 \text{ kg/m}^3$

$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

Efficiency of a Carnot engine,
$e = 1 - T_2/T_1 = \frac{\text{work done}}{\text{input heat}} = \frac{W}{Q_h}$

Question 1 : Sample answers : F(a), G(d).... etc. 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. **It is worth trying !!** [10 × 2 = 20]

(A) Which of the following is not correct about the internal energy of the system ?

(a) It is a state variable
(b) It is a process
(c) It is a thermodynamic variable
(d) It measures the total energy of the system.

(B) 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

(C) Between layers of liquid in relative motion, viscosity introduces :

(a) radial forces (b) tangential forces
(c) cohesive forces (d) intermolecular forces.

(D) An electric charge at rest produces :

(a) localized electric and magnetic fields both
(b) magnetic field only
(c) electric field only
(d) electric and magnetic fields that are radiated.

(E) A parallel plate capacitor has capacitance C. If the air between the plates is pumped out completely, the new capacitance would become :

(a) zero (b) zero
(c) slightly more than C (d) slightly less than C.

(F) A wire of resistance 12Ω is bent in the form of a closed circle. The resistance between the ends of the diameter is :

(a) 3Ω (b) 6Ω
(c) 9Ω (d) 12V

(G) Magnetism in substances is caused by :

(a) orbital motion of electrons only
(b) spin motion of electrons only
(c) both orbital motion and spin of electrons
(d) hidden magnets.

(H) When a magnet is moved towards a coil with its north pole nearer to the coil, the nearer end of the coil acts as :

(a) north pole (b) south pole
(c) positive charge (d) negative charge.

(I) The reactance of a capacitance at 50Hz is 5Ω. If the frequency is doubled, the new reactance would be :

(a) 5Ω (b) 10Ω
(c) 2.5Ω (d) 125Ω

(J) The voltage of a certain a.c. supply is represented by $v = v_0 \sin 120\pi t$ where t is in seconds. The frequency of this a.c. supply is :

(a) 100Hz (b) 100π Hz
(c) 50π Hz (d) 60 Hz

Attempt any four questions from the following :

Q2(a) A certain e.m. wave has the electric field $E = 1.2 \times 10^{-2} \sin (5 \times 10^{8}t)$ N/C.

Find (i) the frequency of the wave and
(ii) the time period τ of the wave.
(iii) By how much does the value of E change as *t* goes from zero to $\frac{\tau}{4}$, where τ is the time period calculated in part (ii) ? [8]

(b) If the amplitude of the electric field is 10V/m at a distance of 2m from the source, calculate the average power radiated uniformly in all directions by a source.

[Given $I = P/A = \frac{c E_0^2 \varepsilon_0}{2} = \frac{c B_0^2}{2\mu_0}$] [6]

(c) A cooler box used to keep drinks cold has total wall area (including the lid) of $0.8m^2$ and wall thickness of 1cm. It is filled with ice and cans of orange soda at 0^0C.

(i) what is the rate of heat flow into the box if the outside temperature is 30^0C ?
(ii) how much ice melts in one day ?
Given, k for cooler box = 0.01J/s.m.^{0}C, $H_f = 335000$J/kg. [6]

Q3(a) An unknown inductor L is connected in series with an 800Ω resistor and a 90V, 2000Hz power source. The voltage drop measured across the resistor is found to be 40 volts.

Find

(i) the current in the circuit, and (ii) the value of the inductance. [9]

(b) A certain volume of gas at 27°C is expanded adiabatically until its temperature becomes −15°C. How many times was the expansion of the gas relative to its original volume ? Given, $\gamma = 1.4$ for the gas. [9]

(c) Arrange from lower to higher frequency : gamma rays, visible light, infrared, ultraviolet. [2]

Q4(a) A series circuit consists of a 9.0V battery, a $4 \times 10^6\ \Omega$ resistor, a 5.0μF capacitor and an open switch. The capacitor is initially uncharged. The switch is now closed.

(i) what is the time constant of the circuit ?
(ii) about how long does it take for the capacitor to become two-thirds charged ?
(iii) how much charge will flow into the capacitor in the time calculated in part (b) ?
(iv) about what is the average current into the capacitor during this time interval ?
[8]

(b) A reversible engine takes in heat from a high temperature reservoir at 527^0C and gives out heat to a sink at 127^0C.

How many joules per second must it take from the hot reservoir to produce useful mechanical work at the rate of 750 watts ? [6]

(c) The input of a certain transformer is 5000V, while the output is 240V. The transformer is rated at a maximum power of 10,000 watts.

(i) what is the ratio of turns in the windings of the transformer ?
(ii) what are the maximum currents in the primary and secondary circuits ? [6]

Q5. (a) A particle executes linear simple harmonic motion with a frequency of 0.25 Hz about the point x =0. At time t = 0, it has displacement x = 0.37 cm and zero velocity.
For the motion, determine
(i) the period, (ii) the angular frequency ω, (iii) the amplitude, (iv) the displacement at time t, (v) the velocity at time t, (vi) the maximum speed, (vii) the maximum acceleration, (viii) the displacement at t = 3.0 s, and (ix) the speed at t = 3.0 s.
[Given $x = x_0 \cos \omega t$]. [10]

(b) A long straight wire carries a 5.0A current along the positive x-axis; a second wire carries a 6.0A current along the positive y-axis.

Find the magnitude and direction of their combined magnetic field at the point x = 6cm, and y = 9cm. [8]

(c) Explain the phenomenon of resonance. [2]

Q6(a) A rod of length 1m is clamped at its centre. The distance between the first node and the 10^{th} node when the rod is vibrating longitudinally is 45cm.

If the velocity of sound in air is 330m/s,
(i) calculate the frequency of the note emitted;
(ii) hence calculate the velocity of sound in the rod. [9]

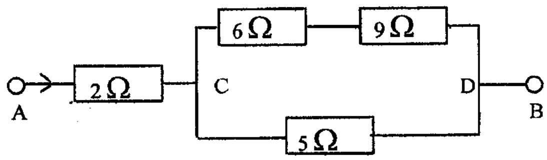
(b) A proton and a deuteron move perpendicular to a uniform magnetic field. The two particles have equal values of kinetic energy. The deuteron is observed to move in a circular path of radius 20cm. The mass of the deuteron is twice that of the proton. Given $m_p = 1.67 \times 10^{-27}$ kg and $m_d = 2 \times 1.67 \times 10^{-27}$ kg.

What is the radius of the proton orbit ?

[9]

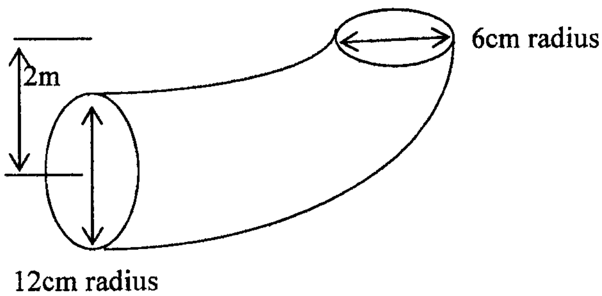
(c) Define the unit of current *ampere* in terms of the force between two long parallel current-carrying wires. [2]

Q7(a) In the circuit given, the 5Ω resistor develops 45 joules of heat per second due to a current flowing in it.



Calculate (i) the heat developed per second in the 2Ω resistor, and
(ii) the potential difference across the 6Ω resistor. [9]

(b) Water flows upward through the pipe shown in the figure at 50 litres/second. If the pressure at the lower end is 80-kPa, find (i) the water speed at both ends, and (ii) the pressure at the upper end. [9]

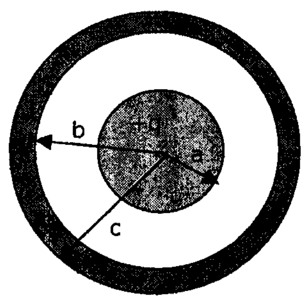


(c) Differentiate between *e.m.f.* and *terminal potential difference* of a battery. [2]

Q8(a) A parallel-plate capacitor C of capacitance 13.5pF is charged to a potential difference V = 12.5V between its plates. The charging battery is now disconnected and a porcelain slab (dielectric constant K = 6.50) is slipped between the plates.

What is the potential energy of the device, both before and after the slab is introduced ? Explain any difference between the two values. [6]

(b) A sphere of radius a has a charge $+q$ uniformly distributed throughout its volume. The sphere is concentric with a spherical conducting shell of inner radius b and outer radius c. The shell has a net charge of $-q$.



- What are the charges on the inner and outer surfaces of the shell ? [2]
- Find expressions for the electric field, as a function of the radius r,

  (i) within the sphere ($r<a$), [6]
  (ii) between the sphere and the shell ($a<r<b$), [2]
  (iii) inside the shell ($b<r<c$), and [2]
  (iv) outside the shell ($r>c$). [2]
  [Hint : Gauss' theorem may help to obtain the fields]

==End of P-198 Exams==

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 = $Fs \cos\theta$: kinetic energy = $(½)mv^2$: $Ft = \Delta p$

g. p. energy = mgh : $v_{avg.} = (½)(v_o + v_f)$: power = work/time : $t = 2u \sin\theta/g$

$\Delta PE + \Delta KE + \Delta TE = 0$: $F = ma$: $P = Fv$: $R = (2u^2 \sin\theta \cos\theta)/g$: $a_T = \alpha r$: $L = I\omega$

$v_T = \omega r$: $\omega_f = \omega_0 + \alpha t$: $\omega_f^2 = \omega_0^2 + 2\alpha\theta$: $\theta = \omega_0 t + (½)\alpha t^2$: $p = mv$: $F_C = mv^2/r$

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: $F = qvB_\perp$: volume of a right cylinder = $\pi r^2 L$

$x = x_0 \cos(\omega t)$: $\rho = (RA)/L$: $E = (½)qV$: $F = (\mu_0 I_1 I_2 L)/(2\pi b)$: area of a sphere = $4\pi r^2$

$P = IV = I^2R$: $qV = (½)mv^2$: $W = qV_{AB}$: $F = (k\, q_1\, q_2)/r^2$: $F = qE$: $F = BIL \sin\theta$

$V_{AB} = Ed$: $C = (\varepsilon_o A)/d$: $\Delta R = R_o\alpha\Delta T$: $1/p + 1/i = 1/f$: $X_L = 2\pi fL$: $X_C = 1/(2\pi fC)$

$I_o = 10^{-12}$ 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 $\sin\theta$: $\Sigma\Delta A.E = q_{encl.}/\varepsilon_o$: $W = (1/2)Li_f^2$: $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$f / f' = [1 - (v_l/v_w)] / [1 - (v_s/v_w)]$: $f' = f(v/(v \pm v_s))$: $f' = f(v \pm v_l)/(v)$

$B = \mu_o nI$: $B = (\mu_o I)/(2a)$: $B = (\mu_o I)/(2\pi r)$: $f_n = (2n - 1)f_1$: $f_b = f_2 - f_1$: $f_n = nf_1$

$v = v_o \sin(2\pi ft)$: $I = i_o/\sqrt{2}$: $V(t) = V_o e^{-t/RC}$: $\tan\varphi = (X_L - X_C)/R$: $i(t) = i_o e^{-t/RC}$

$f_o = (1/2\pi)\sqrt{(1/LC)}$: $1/f = 1/f_1 + 1/f_2$: $n\lambda = d \sin\theta_n$: e.m.f. = $L(\Delta I/\Delta t)$: $E = c.B$

$P = IV \cos\varphi$: e.m.f. = $B_\perp vd$: μ = (area)I : $\eta = (F/A)/(V/L)$: $I(t) = I_f(1 - e^{-t/(L/R)})$

$\sin(2\varphi) = 2 \sin\varphi \cos\varphi$: $\sin(90 - \theta) = \cos\theta$: $f' = f(v \pm v_L)/(v \mp v_s)$:

$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$: $B_0 = E_0/c$: $I = (½)c\,\varepsilon_0 E_0^2$: $\Sigma B_\parallel.\Delta L = \mu_o.I_{enclosed}$: $E_s/E_p = N_s/N_p$

$A_1v_1 = A_2v_2$: $F_D = 6\pi\eta rv$: $6\pi\eta a v_T = (4\pi/3)a^3(\rho - \sigma)g$: $Q = (\pi R^4/8\eta L)(P_1 - P_2)$

$P_1 + (½)\rho v_1^2 + \rho gh_1 = P_2 + (½)\rho v_2^2 + \rho gh_2$: $N_R = \rho vd/\eta$: $V = IZ$: 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. = $N(\Delta\varphi/\Delta t)$

$y = y_0 \sin(\omega t - kx)$; $k = \frac{2\pi}{\lambda}$: fundamental ⇒ first overtone ⇒ second overtone

UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS
SECOND SEMESTER 2006
P252
INTRODUCTION TO CLASSICAL MECHANICS II

TIME: THREE HOURS
ANSWER ANY FIVE QUESTIONS FROM THE SEVEN GIVEN
ALL QUESTIONS CARRY EQUAL MARKS
TOTAL MARKS: 100

Useful formulas

$$\omega^* = [\omega_0^2 - \frac{c^2}{4m^2}]^{1/2}$$

$$R = \frac{F_0}{[m^2(\omega^{*2} - \omega^2)^2 + \omega^2 c^2]^{1/2}}$$

$$p_k = \frac{\partial L}{\partial \dot{q}_k} = \frac{\partial H}{\partial \dot{q}_k}$$

$$\dot{p}_k = -\frac{\partial H}{\partial q_k}, \quad \dot{q}_k = \frac{\partial H}{\partial p_k}$$

$$\frac{d}{dt}\frac{\partial L}{\dot{q}_k} - \frac{\partial L}{\partial q_k} = 0$$

$$Q_k = \sum_i F_i \frac{\partial x_i}{\partial q_k}$$

$$x' = \gamma(x - Vt), \quad t' = \gamma(t - Vx/c^2), \quad \gamma = \frac{1}{\sqrt{1 - V^2/c^2}}$$

$$v_x' = \frac{v_x - V}{1 - v_x V/c^2}$$

Question 1. (a) (i) Show that the equation of motion

$$m\ddot{x} + c\dot{x} + kx = 0$$

for the damped harmonic oscillator has the solutions

$$\begin{aligned} x(t) &= Re^{-\alpha t}\sin(\omega^* t + \delta) \\ x(t) &= Ae^{-\alpha t} \\ x(t) &= e^{-\alpha t}(Ae^{-\beta t} + Be^{\beta t}) \end{aligned}$$

for the three cases of under-damped, critically-damped and over-damped motion respectively and deduce the expressions for α, β, ω^*, δ and R. [10 marks]

(ii) Verify that for critical damping the other solution is $Bte^{-\alpha t}$. [3 marks]

(iii) If $x(t=0) = 0$ and $\dot{x}\ (t=0) = v_0$, find $x(t)$ for each case. [7 marks]

Question 2. (a) Derive the wave equation

$$\frac{\partial^2 y(x,t)}{\partial t^2} = v^2 \frac{\partial^2 y(x,t)}{\partial x^2}$$

for transverse waves of small amplitude on a string under tension. [12 marks]

(b) If the string is clamped at both ends and is of length L, the solution of the equation above is

$$y(x,t) = \sum_{n=1}^{\infty} \sin\frac{n\pi x}{L}\left(A_n \cos\omega_n t + B_n \sin\omega_n t\right)$$

where the Fourier coefficients are

$$A_n = \frac{2}{L}\int_0^L u_0(x)\sin\frac{n\pi x}{L}dx,\ B_n = \frac{2}{n\pi v L}\int_0^L \dot{u}_0\ (x)\sin\frac{n\pi x}{L}dx$$

while $u_0(x)$ is the displacement of the string and $\dot{u}_0\ (x)$ is its velocity at $t=0$. Such a string has zero velocity at $t=0$, but has the displacement given by

$$u_0(x) = h\sin\frac{\pi x}{L}$$

where h is a constant.

(i) Determine $y(x,t)$. [6 marks]

(ii) Determine the allowed frequencies of vibration [2 marks]

You may need the formulas

$$\cos(\alpha \pm \beta) = \cos\alpha\cos\alpha \mp \sin\alpha\sin\beta$$

$$\lim_{n\to 1}\frac{\sin(n-1)\pi}{(n-1)\pi} = 1$$

Question 3. (a) An undamped harmonic oscillator of mass 100 g has an angular frequency of 2π rad/s.

(i) Obtain the frictional constant required for the angular frequency to fall by 10%. [6 marks]

(ii) Obtain the ratio of successive maxima of the displacement [4 marks]

(b) A harmonic oscillator of mass 200 g has a period of 0.5s when undamped. A frictional force which is proportional to the velocity is now introduced. When the velocity of the oscillator is 0.1 m/s, this force is 0.3 N. The oscillator is driven by a force given by

$$F(t) = 5\cos 7t \text{ Newtons}$$

(i) Obtain the maximum value of the response of the oscillator to this force and the frequency at which it occurs. [7 marks]

(ii) Obtain the response when the frequency of the driving force equals the natural frequency of the undamped oscillator. [3 marks]

Question 4. **(a)** Derive the equation

$$m^2c^4 = p^2c^2 + m_0^2c^4$$

for a relativistic particle. [6 marks]

(b) As observed in a certain reference frame, a particle has a total energy of 5 GeV and a momentum of 3 GeV/c (i.e., pc, which has dimensions of energy, equals 3 GeV).

(i) Obtain the energy of the particle in the frame in which its momentum is 4 GeV. [4 marks]

(ii) Obtain the rest mass of the particle. [4 marks]

(iii) Obtain the relative velocity of the two frames. [6 marks]

Note that 1 GeV$= 10^9$ eV, 1 eV $= 1.6 \times 10^{-19}$ J, $c = 3 \times 10^8$ m/s

Question 5. **(a)** **(i)** Explain the major advantage and the major disadvantage of the Hamiltonian formulation of mechanics over the Lagrangian. [3 marks]

(ii) Under what circumstances is the momentum associated with a generalized coordinate conserved? [2 marks]

(b) A particle of mass m moves under the action of the central force

$$F(r) = -\frac{k}{r^3}$$

The particle moves in a plane and can be described by the generalized coordinates $q_1 = r$ and $q_2 = \theta$.

(i) Obtain the equations of motion of the particle using Hamilton's equations. Interpret the equations. [13 marks]

(ii) Identify any ignorable coordinates and justify the conservation of the corresponding momentum. [2 marks]

Question 6. **(a)** Explain two major advantages of the Lagrangian formulation of mechanics over the Newtonian. [3 marks]

(b) A pendulum consists of a mass m_2 with a mass m_1 at the point of support which can move in a horizontal line lying in the plane in which the pendulum vibrates, as shown in the accompanying diagram. Let the generalized coordinates be y and θ, where y is the distance of m_1 from the point of support and θ is the angle which the rigid massless rod l supporting m_2 makes with the vertical. The coordinate system is such that the y axis is horizontal and pointing to the right, while the x axis is vertical and points downwards. The mass m_1 experiences a friction force proportional to the velocity.

(i) Write down the position vector of m_1. [1 mark]

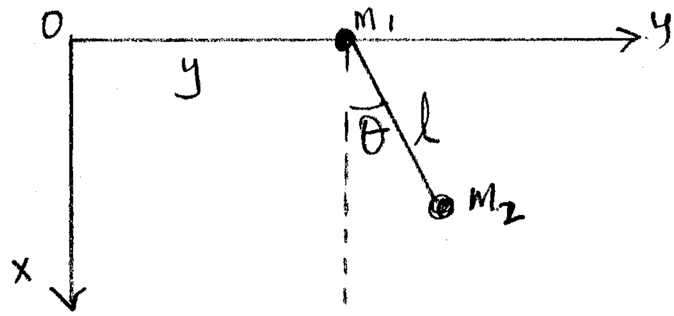
(ii) Show that the position vector of m_2 is $\mathbf{r}_2 = (l\cos\theta, y + l\sin\theta)$ [2 marks]

(iii) Show that the kinetic energy of the system is

$$T = \frac{1}{2}m_1 \dot{y}^2 + \frac{1}{2}m_2[\dot{y}^2 + l_1^2 \dot{\theta}^2 + 2l\,\dot{y}\dot{\theta}\cos\theta]$$

[3 marks]

(iv) Obtain the Lagrangian equations of motion of the system. [10 marks]



(c) In Cartesian coordinates x and y, the force acting on a particle is given by $\mathbf{F} = -\hat{\mathbf{i}}kx - \hat{\mathbf{j}}ky$ where k is a constant. Suppose the system on which the force is acting is treated using the generalized coordinates r and θ such that $x = r\cos\theta$ and $y = r\sin\theta$. Obtain the generalized forces Q_r and Q_θ associated with these coordinates and interpret your results. [4 marks]

Question 7 **(a)** **(i)** State the two postulates on which the theory of relativity is founded. [2 marks]

(ii) Outline one problem solved by special relativity which was insoluble under classical mechanics. [2 marks]

(b) Prove the following:

(i) Measuring rods are compressed in the direction of motion. [3 marks]

(ii) Travelling clocks run slow. [3 marks]

(iii) The velocity of light has the same value no matter what coordinate system it is measured from. [2 marks]

(c) An electron is accelerated from rest through a potential difference of 5 MeV.

(i) Calculate its final velocity and its final momentum. [6 marks]

(ii) Calculate these values classically and compare. [2 marks]

$m_e = 9.1 \times 10^{-31}$ kg, $e = 1.6 \times 10^{-19}$ C, $c = 3 \times 10^8$ m/s

****END OF EXAMINATION****

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

P272 OPTICS

TIME: THREE HOURS MAXIMUM MARKS=100

INSTRUCTIONS:

Answer any FIVE questions.
All questions carry equal marks.
The marks are shown in brackets.

Q1. (a) Show that the deviation produced by a thin lens is independent of the position of the object. [8]

(b) Two thin converging lenses of focal lengths 15cm and 20cm are placed coaxially 10cm apart. An object is placed at a distance of 24cm from the first lens. Find

(i) the position of the cardinal points. Indicate these positions in a diagram. [8]

(ii) the position and magnification of the image. [4]

Q2. (a) What is spherical aberration and how does it affect the definition of the image formed by a lens? [7]

(b) Mention three methods for minimizing spherical aberration. [3]

(c) A converging achromatic doublet of 40cm focal length is to be constructed out of a thin crown glass and a thin flint glass lens. The radius of curvature of the surface in contact is 25cm. Calculate the radius of curvature of the second surface of each lens, given that the dispersive power and mean refractive index are respectively 0.017 and 1.5 for crown glass and 0.034 and 1.7 for flint glass. [10]

Q3. (a) What is dichroism? Explain the phenomenon on the basis of electron theory. Give an example of crystal which exhibits this phenomenon. [12]

(b) A Fresnel's biprism of angle 1° and refractive index 1.5 forms interference fringes on a screen 80cm away from it. If the distance between the source and the biprism is 30cm, find the fringe width for light of wavelength 5000Å. [5]

(c) A biprism forms interference fringes with monochromatic light of wavelength 5450Å. On introducing a thin glass plate (μ=1.5) in the path of one of the interfering beams, the central fringe shifts to the position previously occupied by the third bright fringe. Find the thickness of the plate. [3]

Q4. (a) Describe the construction of a Nicol prism. Show how it can be used as a polarizer. [12]

(b) Find the polarizing angle and angle of refraction for light incident from [8]

(i) air to glass
(ii) glass to water.

Given μ of glass = 1.54 and μ of water = 1.33.

Q5. (a) Discuss the formation of colours in thin films in reflected light with the help of suitable diagrams. [7]

(b) Derive an equation for the path difference between the waves producing interference. [9]

(c) State the condition for producing constructive and destructive interference. [4]

Q6. (a) Explain the difference between Fresnel and Fraunhoffer diffraction. [5]

(b) Explain the meaning of half period zones in the case of a plane wavefront. Calculate the area of a half period zone and show that it is practically constant. [12]

(c) A plane wavefront of light of wavelength 5×10^{-5}cm falls on an aperture and the diffraction pattern is observed in an eye-piece at a distance of 1m from the aperture. Find the radius of the 100^{th} half period element and the area of a half period zone. [3]

Q7. (a) Explain how thin film interference can be used for estimating the quality of surface finish of a work piece. [8]

(b) In a Newton's rings experiment, the diameter of the 15^{th} ring was found to be 0.59cm and that of the 5^{th} ring wwas 0.336cm. If the radius of the plano-convex lens is 100cm, calculate the wavelength of the light used. [3]

(c) Write short notes on [9]

(i) Antireflection coatings
(ii) Fizeau fringes
(iii) Pin cushion distortion and barrel shaped distortion

END OF P272 EXAMINATION

The University of Zambia

Physics Department

University Examinations

Second Semester 2006

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 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) A certain one-dimensional lattice has lattice constant a, as shown in Figure 1. An atom transits from a site to a nearest neighbour site every τ seconds. The probabilities of transiting to the right and left are p and $q = 1 - p$ respectively.

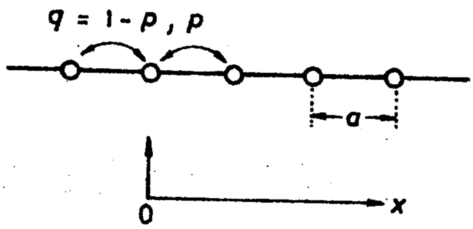


Figure 1

i. Calculate the average position of the atom at the time $t = N\tau$ where $N \gg 1$

[4 marks]

ii. Calculate the mean square value $\overline{(x - \overline{x})^2}$ at the time t

[6 marks]

(b) For small values of the probability p, the Poisson distribution provides a good approximation to the Binomial distribution

$$W(k) = \frac{N!}{k!(N-k)!} p^k (1-p)^{N-k}$$

where $0 \leq p \leq 1$ and $k = 0, 1....N$. Consider p as a function of N. Also consider the case when $p(N) \to 0$, $\ln(1 - P) \approx -p$, $N \to \infty$ and $k \ll N$ in such a way that the mean number of events $Np \to \lambda$ where $\lambda \neq 0$.

i. Show that $(1 - P)^{N-k} \approx e^{-Np}$ [3 marks]

ii. Show that $N!/(N-k)! \approx N^k$ [3 marks]

iii. Show that the Binomial expression $W(k)$ reduces to

$$W(k) = \frac{\lambda^k}{k!} e^{-\lambda}$$

The distribution above is called the "Poisson distribution".

[3 marks]

iv. Use the Poisson distribution to calculate $\overline{k}$ [3 marks]

v. Use the Poisson distribution to calculate $\overline{(\Delta k)^2} = \overline{(k - \overline{k})^2}$.

[3 marks]

2. (a) Give the definition of entropy in statistical mechanics. Advance a general argument to explain why and under what circumstances the entropy of an isolated system A will remain constant, or increase. For convenience you may assume that A can be divided into subsystems B and C which are in weak contact with each other, but themselves remain in internal thermodynamic equilibrium.

[6 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 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. [5 marks]

ii. Assuming that only the ground state and the first excited state are occupied, find the mean energy of the oscillator as a function of temperature T.

[5 marks]

iii. Assuming that this oscillator is an atom in a solid, and still assuming that only the ground and the first excited states are appreciably occupied, estimate its contribution to the heat capacity at constant volume. Obtain this heat capacity in the limit $kT/\hbar\omega \ll 1$ and comment on it.

[5 marks]

3. (a) A mole of an ideal gas undergoes a reversible isothermal expansion from V_1 to $2V_1$

i. What is the change in entropy of the gas? [6 marks]

ii. Suppose the same expansion takes place as a free expansion. Find the change in entropy of the gas under these same conditions.

[4 marks]

(b) Suppose you are given the following relation among the entropy S, volume V and internal energy E of a thermodynamic system:

$$S = A[VE]^{\frac{1}{3}}$$

where A is a constant.

i. Derive an expression for the temperature T in terms of E and V. [5 marks]

ii. Derive the equation of state of the system. [6 marks]

iii. Obtain the specific heat capacity at constant volume of the system in terms of S, T and V. [4 marks]

4. (a) Outline the essential difference between micro canonical, canonical and grand canonical ensembles.

[6 marks]

(b) Show that for a canonical ensemble, the dispersion of energy $\overline{(\Delta E)^2}$ can be calculated from the partition function as

$$\overline{E^2} - \overline{E}^2 = \frac{\partial^2 \ln Q}{\partial \beta^2}$$

[10 marks]

(c) Two systems 1 and 2 are in weak thermal interaction. The quantum energies of one system are E_r and the energies of the other system are E_s, where r and s are quantum numbers.

i. Prove that if the systems have respective partition functions Z_1 and Z_2, their combined partition function is

$$Z = Z_1 Z_2$$

[4 marks]

ii. Show that the total entropy is the sum of the entropies of the two subsystems. [6 marks]

5. (a) Use the first law of thermodynamics $dQ = dE + pdV$ to explain the difference between purely thermal and purely mechanical interactions between systems.

[4 marks]

(b) An ideal monoatomic gas is allowed to expand slowly until its pressure decreases to exactly half its original value. Calculate the extent of volume change if

i. the expansion is carried out adiabatically [3 marks]

ii. the process is isothermal [3 marks]
(Take $\gamma = \frac{5}{3}$ for this gas)

(c) What do you understand by intensive and extensive parameters of a thermodynamic system? Given the intensive parameters p and T, show that the equation which connects these parameters with the extensive variables H, V and S of a system is

$$dS = \frac{1}{T}\left(\frac{\partial H}{\partial T}\right)_p + \frac{1}{T}\left[\left(\frac{\partial H}{\partial p}\right)_T - V\right] dp$$

where $H = E + pV$ is the enthalpy

[15 marks]

6. (a) i. Give the thermodynamic definition of the Helmholtz free energy F, the classical statistical mechanical definition of the partition function and the relationship between these quantities.

[3 marks]

ii. Using the expressions in (i) and some thermodynamic arguments, show that the heat capacity at constant volume C_V is given by

$$C_V = kT\left[\frac{\partial^2}{\partial T^2}(T \ln Z)\right]_V$$

[3 marks]

iii. Consider a classical system that has two discrete total energy states E_0 and E_1. Find the partition function Z and the heat capacity (C_V) at constant volume.

[6 marks]

(b)

i. Give a definition of the partition function Z for a statistical system [2 marks]

ii. Outline the derivation of the probability distribution P_r, for the Grand Canonical Ensemble. [6 marks]

(c) The volume coefficient of expansion α of a substance is given by

$$\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_p .$$

Obtain an expression for α for a gas which obeys the van der Waals equation

$$(p + \frac{a}{V^2})(V - b) = RT$$

[5 marks]

End of P332 Examination

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
P206 ACADEMIC YEAR UNIVERSITY EXAMINATIONS

P 342 Introductory Electronics

Instructions: This paper consists of six questions. Answer **four** questions only. They are of equal marks. The marks are shown in square brackets.
Time allowed: three hours.

Q1 (a) (i) What are logic gates? [2]

(ii) The NOR and the NAND gates are known as universal logic gates. Explain what this means. [2]

(iii) Explain how the circuit in figure 1 achieves a NAND operation. The network is in a group of DTR logic gates. Explain what DTR means. [8]

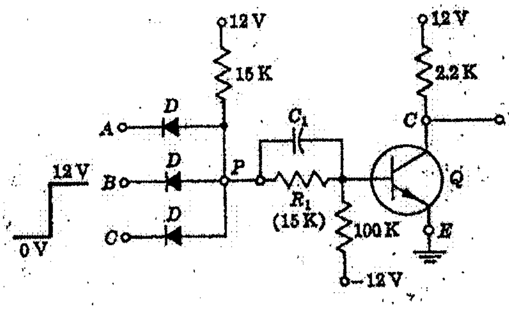


Figure 1

(b) (i) Define the following terms:

- Fan in
- Fan out
- Noise immunity

[3]

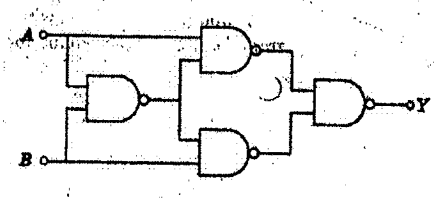
(ii) What are floating inputs and why must they be avoided in a logic circuit?

[3]

(c) By considering the output of the each of the gates in figure 2, and simplifying the final output expression, state the logic operation performed by the network.

[7]

Figure 2



Q2 (a) (i) What does it mean when we say that a binary number has been complemented? Illustrate this by way of an example. [2]

(ii) Define the "two's complement" of a binary number. [2]

(iii) Subtract 15 – 24 directly and by the two's complement. [5]

(iv) Convert decimals 0.875 and 0.65 to binary with three significant Figures. [4]

(b) (i) Show that $(A+B)(A+C) = A+BC$ [5]

(ii) The function f = A.B is to be realized using only NOR gates. Use DeMorgan's theorems to express f in terms of $\overline{C+D}$ where C and D can be expressed in terms of A and B and draw the necessary logic circuit. Check by constructing the truth table for the network. [7]

Q3 (a) (i) Differentiate between an ordinary RS flip-flop and a clocked flip flop. Why is the latter called a synchronous flip-flop and the former an asynchronous flip-flop. [4]

(ii) One of the problems encountered in an ordinary RS flip flop is the application of identical inputs to both the S and R inputs. By means of a clearly labelled diagram and a few notes, show how this problem is avoided in the data latch. [6]

(iii) The following wave forms drive a D-latch: What is the value of D placed in the latch after the 1st clock pulse, 2nd clock pulse and 3rd clock pulse? [6] Assume level triggering.

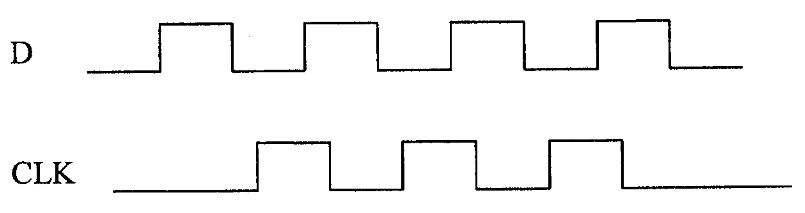


Figure 4

(b) Explain what is meant by the following:

(i) Level triggering;
(ii) Leading edge triggering or positive edge triggering;
(iii) Trailing edge triggering or negative edge triggering
(iv) Preset and clear inputs to a flip-flop

[5]

(c) The propagation time for a particular flip-flop is 10 ns; the set-up time is 15 ns and the hold time is 5 ns.

(i) How long, after the data reaches the flip-flop, will it take before it appears at the output of the flip-flop? [2]

(ii) For how long is the data required to stay at the input before the clock edge arrives? [2]

Q4 (a) (i) In the JK flip-flops, the J and K inputs are called control inputs. Explain the reason for this description. [2]

(ii) Shown below, figure 5 is a diagram of the JK flip-flop. Study it carefully and explain its action (by referring to the diagram) when

J =K= LOW;
J= LOW and K = HIGH;
J= HIGH and K = LOW;
J= K= HIGH. [8]

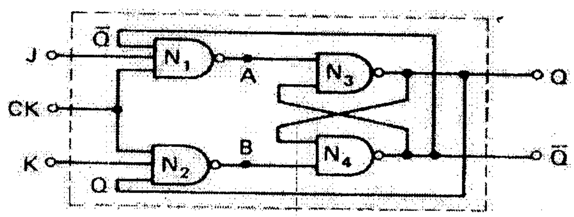


Figure 5

(b) (i) Using the JK master/slave flip-flop is another way to avoid racing. What is racing? How does this flip-flop avoid it? [3]

(ii) In the master/slave flip-flop, the master responds to its JK inputs before the slave does. What does this tell you about the triggering modes of the master and the slave? [2]

(iii) Whatever the master does the slave copies. With the help of a clearly labelled diagram, describe how this action takes place. [6]

(c) Draw a simple diagram of a serial-in-parallel-out negative-edge triggered three bit capacity shift register. How many clock pulses are required to load the three bits? Assume that all flip-flops are initially cleared. [4]

Q5 (a) (i) What are computer memories? Give two examples. [3]

(ii) A flip-flop is known as the simplest memory element. State the reason for this. [2]

(iii) In what respect does a byte differ from a bit? [2]

(b) Figure 6 is a memory cell logic diagram..

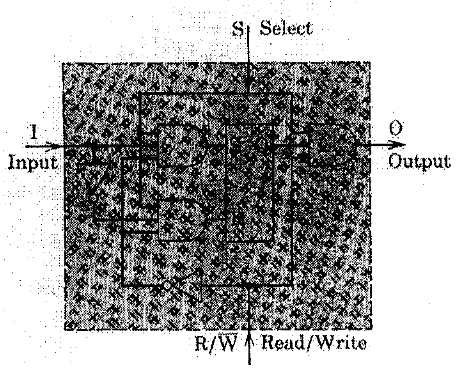


Figure 6

(i) Describe the action of the cell during the WRITE operation and during the READ operation. [10]

(ii) Organize the memory cells into an elementary RAM with a capacity of two-3 bit words clearly specifying the address lines, word select lines, data input and output lines and the READ/WRITE line. [8]

Q6 (a) (i) Explain what is meant by "data-multiplexing" [2]

(ii) Draw a well labeled diagram of a one-into-four de-multiplexing digital Circuit. Derive a truth table for it.

(iii) Draw a timing (wave form) diagram for the de-multiplexer in (ii) [14]

(b) (i) Draw a logic diagram of a mod-8 ripple counter implemented with provisions to decode the numbers 110 (decimal-6) and 111 (decimal-7). [5]

(ii) Derive a truth table for the counter. [4]

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS
2007 SECOND SEMESTER UNIVERSITY EXAMINATIONS

P455
QUANTUM MECHANICS II

DURATION: Three hours.

INSTRUCTIONS: Answer any four questions from the six given. *Each question carries 25 marks with the division of marks within each question indicated by the numbers in parenthesis next to the question.*

MAXIMUM MARKS: 100

DATE: Tuesday 13th February 2007.

Formulae that may be needed:

1. The radial Schrödinger equation is

$$\left[\frac{-\hbar^2}{2\mu}\left(\frac{d^2}{dr^2}+\frac{2}{r}\frac{d}{dr}\right)+\frac{\hbar^2 l(l+1)}{2\mu r^2}+V(r)\right]R_{El}(r)=ER_{El}(r)$$

2. Equations which give corrections to the unperturbed energy and energy eigenstates to various orders:

$$(H_0 - W^{(0)})v^{(0)} = 0, \quad (1)$$

$$(H_0 - W^{(0)})v^{(1)} + (H' - W^{(1)})v^{(0)} = 0, \quad (2)$$

$$(H_0 - W^{(0)})v^{(2)} + (H' - W^{(1)})v^{(1)} - W^{(2)}v^{(0)} = 0. \quad (3)$$

3.

$$\frac{d\delta(x-x')}{dx'} = \frac{\delta(x-x')}{(x-x')}$$

4.

$$\int u\frac{dv}{dx'}\,dx' = uv - \int \frac{dv}{dx}v\,dx'$$

5. The first order transition probability for a constant perturbation is given by

$$|a_f^{(1)}|^2 = \frac{|H'_{fi}|^2}{\hbar^2}\frac{4\sin^2(\omega_{fi}t/2)}{\omega_{fi}^2} \quad (4)$$

QUESTION 1

(i) The hydrogen atom potential is

$$V(r) = -\frac{ze^2}{4\pi\epsilon_0 r}.$$

Write down the radial Schrödinger for the hydrogen atom, and include the effective potential V_{eff} after giving its definition.

(3 marks)

(ii) By introducing the radial function

$$u_{El}(r) = rR_{El}(r),$$

show that the radial equation becomes

$$\frac{d^2u_{El}(r)}{dr^2} + \frac{2\mu}{\hbar^2}\left[E - V_{eff}(r)\right]u_{El}(r) = 0. \qquad (1)$$

(5 marks)

(iii) By substituting the following dimensionless quantities

$$\rho = \left(-\frac{8\mu E}{\hbar^2}\right)^{1/2} r, \quad \lambda = z\alpha\left(-\frac{\mu c^2}{2E}\right)^{1/2}, \quad \alpha = \frac{e^2}{4\pi\epsilon_0\hbar c},$$

where α is the fine structure constant, into eq. (1) show that it reduces to

$$\left[\frac{d^2}{d\rho^2} - \frac{1}{4} + \frac{\lambda}{\rho} - \frac{l(l+1)}{\rho^2}\right]u_{El}(r) = 0. \qquad (2)$$

(9 marks)

(iv) By first substituting $u_{El} = e^{\rho/2}f(\rho)$ into eq.(2), simplifying and then substituting $f(\rho) = \rho^{l+1}g(\rho)$, the radial Schrödinger equation reduces to the form

$$\left[\rho\frac{d^2}{d\rho^2} + (2l+2-\rho)\frac{d}{d\rho} + (n-l-1)\right]g(\rho) = 0. \qquad (3)$$

By identifying this equation, name the solutions and write them down using standard notation. Eq. (3) imposes restrictions on the allowed values of n and l. Write down these values and explain what they mean physically. Using

$$u_{nl}(\rho) = \rho R_{nl}(\rho), \quad u_{nl}(\rho) = e^{-\rho/2}f(\rho), \quad f(\rho) = \rho^{l+1}g(\rho), \quad g(\rho) \propto L_{n+l}^{2l+1}(\rho),$$

write down the normalized hydrogen atom radial function R_{nl}, using N for the normalization constant N. Write down the general form of the full hydrogen atom eigenfunction $\psi_{nlm}(r,\theta,\phi)$.

(5 marks)

(v) Find the energy eigenvalues. (3 marks)

QUESTION 2

(i) Show how the matrix representation of a wave function and its complex conjugate follow from the expansion postulate, and write down these matrices in Dirac notation. (7 marks)

(ii) What is the meaning of the term 'representation'? (3 marks)

(iii) Derive the matrix representation of the momentum operator $\hat{p}$ in the x-representation. Hint: First use the commutator $[x,p] = i\hbar$ to show that

$$\langle x|\hat{p}|x'\rangle = i\hbar\frac{d}{dx'}\delta(x-x').$$

(15 marks)

QUESTION 3

Time-independent perturbation theory leads to the following zeroeth, first and second order equations

$$
\begin{aligned}
(H_0 - W^{(0)})v^{(0)} &= 0 \\
(H_0 - W^{(0)})v^{(1)} + (H' - W^{(1)})v^{(0)} &= 0 \\
(H_0 - W^{(0)})v^{(2)} + (H' - W^{(1)})v^{(1)} - W^{(2)}v^{(0)} &= 0.
\end{aligned}
$$

Solve the zeroeth order equation, eq. (1), and then use this solution to show that the first and second order equations, eq. (2) and eq. (3), lead to the equations

$$
\begin{aligned}
(E_k - E_m)c_k^{(1)} + H'_{km} - W^{(1)}\delta_{km} &= 0, & (4)\\
(E_k - E_m)c_k^{(2)} + \sum_{n=0}^{\infty}(H'_{kn} - W^{(1)}\delta_{kn})c_n^{(1)} - W^{(2)}\delta_{km} &= 0. & (5)
\end{aligned}
$$

(These equations when solved give the first and second order corrections to the energy eigenvalues and eigenfunctions $W^{(1)}$, $c_k^{(1)}$, $c_m^{(1)}$, $W^{(2)}$, $c_k^{(2)}$, and $c_m^{(2)}$, respectively.) Assume that the eigenfunctions of the unperturbed Hamiltonian are non-degenerate.

(25 marks)

QUESTION 4

Let v be the eigenfunction and W the eigenvalue of $H = H_0 + \lambda H'$, i.e.,

$$Hv = Wv.$$

For two degenerate eigenfunctions u_{m1} and u_{m2} the zeroth and first order corrections to v can be expressed as

$$
\begin{aligned}
v^{(0)} &= a_1^{(0)}u_{m1} + a_2^{(0)}u_{m2} & (6)\\
v^{(1)} &= a_1^{(0)}u_{m1} + a_2^{(0)}u_{m2} + \sum_{n=0}^{\infty}{}' c_n^{(1)}u_n. & (7)
\end{aligned}
$$

Substituting these into eq. (2) leads to two equations:

$$
\begin{aligned}
(h_{11} - W^{(1)})a_1^{(0)} + h_{12}a_2^{(0)} &= 0, & (8)\\
h_{21}a_1^{(0)} + (h_{22} - W^{(1)})a_2^{(0)} &= 0. & (9)
\end{aligned}
$$

We apply the above to the Stark effect of the hydrogen atom for which $\lambda H' = e\xi z$.

(i) Write down the form of the solutions of eqs. (8) and (9) without calculation. Explain the physical significance of these solutions. (4 marks)

(ii) Write down the four possible degenerate eigenfunctions representing the first excited state E_2 ($n = 2$) in the form ϕ_{nlm_l}, i.e. find the allowed values of l and m_l for $n = 2$. (3 marks).

(iii) The matrix elements are given by

$$\lambda h_{2l'm_l',2lm_l'} = \lambda\langle\phi_{2l'm_l'}|z|\phi_{2lm_l}\rangle = e\xi\langle\phi_{2l'm_l'}|z|\phi_{2lm_l}\rangle$$

For $n = 2$ and the allowed values of l and m_l there are sixteen matrix elements. The selection rules $\Delta m_l = 0$ and $l' = l + 1$, $l' = l - 1$ reduce all but two of these to zero. The only non-zero matrix elements are $h_{00,10}$ and $h_{10,00}$. Identify these with λh_{12} and λh_{21} of eqs. (8) and (9), and also give the value of λh_{11} and λh_{22} of the same equation. Then solve the equations for $E^{(1)} = \lambda W^{(1)}$ to obtain $E_+^{(1)}$ and $E_-^{(1)}$. You are given that

$$\langle\phi_{200}|z|\phi_{210}\rangle = \langle\phi_{210}|z|\phi_{200}\rangle = -3a.$$

Do not calculate $a_{1+}^{(0)}$, $a_{2+}^{(0)}$, $a_{1-}^{(0)}$ or $a_{2-}^{(0)}$. (10 marks)

(vi) Given that the coefficients in eq. (6) corresponding to $E_+^{(1)}$ are

$$a_{1+}^{(0)} = \frac{1}{\sqrt{2}}, \qquad \text{and} \qquad a_{2+}^{(0)} = -\frac{1}{\sqrt{2}},$$

and those corresponding to $E_-^{(1)}$ are

$$a_{1-}^{(0)} = \frac{1}{\sqrt{2}} \qquad \text{and} \qquad a_{2-}^{(0)} = \frac{1}{\sqrt{2}},$$

write down the two energy eigenvalues $E_2 + E_+^{(1)}$ and $E_2 + E_-^{(1)}$ and the corresponding energy eigenfunctions. In doing this let $u_{m1} = \psi_{200}$ and $u_{m2} = \psi_{210}$. Draw a diagram indicating the four first excited state energy eigenfunctions before and after the perturbation. You are given that $E_2 = (-\mu e^4)/(8\hbar^2)$.

(8 marks)

QUESTION 5

(i) Time-dependent perturbation theory begins by expanding the wave function as follows:

$$\psi(x,t) = \sum_{n=0}^{\infty} a_n(t) u_n(x) e^{-iE_n t/\hbar}, \tag{10}$$

and then substituting the expansion into the time-dependent Schrödinger equation

$$i\hbar \frac{\partial \psi(\boldsymbol{r},t)}{\partial t} = (H_0 + \lambda H')\psi(\boldsymbol{r},t), \tag{11}$$

where λ is a small parameter. Derive the following differential equation for the expansion coefficients:

$$\frac{da_f}{dt} = \frac{1}{i\hbar} \sum_n \lambda a_n e^{i\omega_{fn} t} H'_{fn}, \tag{12}$$

where

$$H'_{fn} = \langle f | H' | n \rangle$$
$$\omega_{fn} = \frac{E_f - E_n}{\hbar}.$$

(10 marks)

(ii) By expanding a_f in powers of λ derive the following zeroth order, first order, second order and the r^{th}-order equations:

$$\frac{da_f^{(0)}}{dt} = 0$$
$$\frac{da_f^{(1)}}{dt} = \frac{1}{i\hbar} \sum_n a_n^{(0)} e^{i\omega_{fn} t} H'_{fn}$$
$$\frac{da_f^{(2)}}{dt} = \frac{1}{i\hbar} \sum_n a_n^{(1)} e^{i\omega_{fn} t} H'_{fn}$$
$$\frac{da_f^{(r)}}{dt} = \frac{1}{i\hbar} \sum_n a_n^{(r)} e^{i\omega_{fn} t} H'_{fn}$$

(4 marks)

(iii) Explain how the initial condition

$$a_f^{(0)}(t) = \delta_{fi}$$

is obtained.

(4 marks)

(iv) Using the initial condition of part (iii) we can show that the first and second order corrections to the coefficients are given by

$$a_f^{(1)}(t) = \frac{1}{i\hbar}\int_0^t e^{i\omega_{fn}t'} H'_{fn}(t')\, dt', \tag{13}$$

$$a_f^{(2)}(t) = \frac{1}{(i\hbar)^2}\sum_n \int_0^t e^{i\omega_{fn}t''} H'_{fn}(t'')\, dt'' \int_0^{t''} e^{i\omega_{fn}t'} H'_{fn}(t')\, dt',\ t'' > t'. \tag{14}$$

By rewriting eqs. (13) and (14) in an appropriate order, give their physical interpretation. Draw a diagram to illustrate your answer. (7 marks)

QUESTION 6

Derive the Fermi Golden Rule. State clearly the kind of energy spacing to which the rule applies. Give two types of physical calculations in which the Fermi Golden rule is extensively used.

(25 marks)

END

The University of Zambia
Physics Department
University Examinations 2006
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 :

$\varepsilon_0 = 8.85 \times 10^{-12}$ C²/Nm²	$m_{hydrogen\ atom} = 1.007825$ a.m.u.
$m_n = 1.008665$ a.m.u. = 939.551 MeV	$m_{alpha} = 4.002603$ a.m.u.
1 a.m.u. = 931.5 MeV = 1.6604×10^{-27} kg	$m_p = 1.67 \times 10^{-27}$ kg = 938.28 MeV
$c = 3 \times 10^8$ m/s	$m_e = 9.11 \times 10^{-31}$ kg = 0.511 MeV
$h = 6.63 \times 10^{-34}$ J-s	$e = 1.6 \times 10^{-19}$ C
$\hbar = 6.58 \times 10^{-22}$ MeV-s = 1.05×10^{-34} J-s	1eV = 1.6×10^{-19} J
1 fermi = 10^{-15} m	1 barn = 10^{-28} m²
Avogadro's constant = 6 x 10^{23} per mole	Velocity of light = 3 x 10^8 m.sec^{-1}.
$\frac{e^2}{4\pi\varepsilon_0}$ = 1.44 MeV-fermi	$\hbar c$ = 197.33 MeV-fermi

$(1s_{1/2})^2$, $(1p_{3/2})^4$, $(1p_{1/2})^2$, $(1d_{5/2})^6$, $(2s_{1/2})^2$, $(1d_{3/2})^4$, $(1f_{7/2})^8$, $(2p_{3/2})^4$, $(1f_{5/2})^6$, $(2p_{1/2})^2$, $(1g_{9/2})^{10}$, [50]. $E = \frac{\hbar^2}{2\Im}\left[J(J+1) - BJ^2(J+1)^2\right]$. $\Delta E_C = \frac{3}{5}\frac{e^2}{R}\left[Z^2 - (Z+1)^2\right]$

Q 1. (a) (i) Name the four basic interactions known in Nature and give a number characterizing the strength of each interaction. [6]

(ii) Discuss the range of each of these interactions and explain how each one is believed to arise. [6]

(iii) List a few important processes for which each one of these interactions is essential. [6]

(b). It is seen that at ranges less than 0.4 F, the nuclear potential is repulsive. Using the uncertainty principle estimate the mass of the virtual particle responsible for this potential. [7]

Q2. (a) Explain the origin of each term in the following expression for the average binding energy of a nucleus having Z protons, N neutrons and A nucleons :

$$B.E. = -a_1 A + a_2 A^{2/3} + a_3 \frac{Z^2}{A^{1/3}} + a_4 \frac{(A-2Z)^2}{A} + \delta \text{, where}$$

$\delta = -a_5\,\lambda(Z,A)A^{-3/4}$	for even-even nuclei, λ(Z,A)
$= 0$	for odd-even and even-odd nuclei
$= a_5\,\lambda(Z,A)A^{-3/4}$	for odd-odd nuclei. [13]

(b) Neglecting the pairing energy correction, use the above formula to obtain the Q-value of the symmetrical fission of a nucleus (A,Z) into two fragments $(\frac{A}{2},\frac{Z}{2})$ as a function of the mass and atomic numbers. Assume the following values for the various coefficients :

a_1 = 15.5 MeV	a_2 = 16.8 MeV	a_3 = 0.72 MeV
a_4 = 19 MeV	a_5 = 33.5 MeV	

What is the condition for positive energy release ? [12]

Q 3. (a) (i) Describe briefly the basic assumptions concerning the features of the forces involved in the single-particle shell model of the nucleus. [4]

(ii) Write down the rules for determination of angular momenta and parities of nuclear ground states as obtained from the shell model. [8]

(iii) Does the shell model give correct values for the angular momenta of excited states, and for the magnetic moments ? [4]

(b). For the following nuclei the spins and parities of the ground state are given. Justify the obtained values by shell-model considerations :

$${}^{19}_{10}Ne\left(\frac{1}{2}^+\right);\ {}^{27}_{13}Al\ (\frac{5}{2}^+)\text{ and }{}^{34}_{17}Cl(0^+)\quad [9]$$

Q 4. (a) Describe briefly the independent particle approximation and the collective approximation. What properties and types of nuclei are described by them. [8]

(b) The energy of rotational states of an even-even spheroidal nucleus is usually written as :

$$E = \frac{\hbar^2}{2\Im}[J(J+1) - BJ^2(J+1)^2]$$

where $\Im$ is the moment of inertia and B is a constant; the two parameters are obtained from a comparison ("fitting") of this equation with the observed excitation energies.

Explain the origin of the second term in parenthesis on the right hand side of this equation. [6]

(c) The highest rotational levels of ^{232}Th have the following excitation energies : 825 keV, 550 keV, and 332 keV. Determine the quantum number J corresponding to these levels and make an estimate of the moment of inertia corresponding to this type of rotation [11]

Q5(a) Distinguish between the Fermi and the Gamow-Teller selection rules in beta decay of nuclei. [6]

On the basis of these selection rules, deduce :

(i) the degree of forbiddenness, and
(ii) the type (Fermi, G-T, or mixed) of the following J^π beta transitions :

$$0^+ \to 1^+ \qquad \frac{5}{2}^+ \to \frac{7}{2}^+ \qquad \frac{1}{2}^+ \to \frac{1}{2}^+ \qquad 0^+ \to 0^+ \qquad [7]$$

(b) What do you understand by super-allowed transitions ? Under what circumstances is such a transition most probable ? [4]

(c) In a certain nucleus the ground and first excited states have respectively the following values of $J^\pi : \frac{1}{2}^+, \frac{11}{2}^-, \frac{5}{2}^+$ and $\frac{7}{2}^+$. Draw a notional energy level diagram and identify the multipolarities of the following gamma-transitions :

$$\frac{7}{2}^+ \to \frac{5}{2}^+, \qquad \frac{7}{2}^+ \to \frac{11}{2}^-, \qquad \frac{5}{2}^+ \to \frac{1}{2}^+, \qquad \frac{11}{2}^- \to \frac{1}{2}^+ \qquad [8]$$

Q6. (a) Estimate the probability of a slow proton to penetrate the Coulomb barrier of a hydrogen atom in a head-on collision. As an approximation, use a rectangular barrier of height 0.77MeV, extending from the distance of 1 fermi to 10 fermi.

Use the following energies of the proton : 1 keV; 0.5 MeV. [9]

Given, $P = \exp\left[-2\int_{R_1}^{R_2} k\,dr\right]$ where $k = \frac{\sqrt{2m}}{\hbar}\sqrt{V-E}$.

(b) Explain why the $0^+ \rightarrow 0^+$ transition will not allow any gamma radiation. Name the most common $0^+ \rightarrow 0^+$ transition. [8]

(c). 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. [8]

==End of P-412 Examination==

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2006 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

P442: DIGITAL ELECTRONICS II

TIME: THREE HOURS **MAXIMUM MARKS=100**

INSTRUCTIONS:

Answer any four questions.
All questions carry equal marks.
The marks are shown in brackets.

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

Q1. (a) What are microprocessor-initiated operations? [7]

(b) Explain with a figure the bus organization of the 8085 microprocessor and discuss the function of each bus. [9]

(c) Simplify the following function using the Karnaugh map technique. [9]

$Y = \Sigma\, m\,(0, 1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 13, 14, 15)$

Q2. (a) Explain the requirements of a program counter, a stack pointer and status flags in a microprocessor. [6]

(b) How is an adder/subtractor built using full adders? Draw its logic circuit network. Illustrate the performance of the circuit with a suitable example. [13]

(c) Simplify the expression

$$(X+Y)(\overline{X}+Z)(Y+Z)$$ [6]

Q3. (a) Explain primary memory, secondary memory and cache memory. What type of memory devices are used in each of these categories of memory and explain the criteria for selection? [12]

(b) Draw the memory hierarchies with and without cache memory. [5]

(c) Write a program to load the data byte **8EH** in register D and **F7H** in register E. Mask the higher order bits from first data byte (8EH) and lower order bits from second data byte (F7H). Display the answers at **PORT 00H** and **PORT 01H**. [8]

Q4. (a) A system is designed to monitor the voltage of a circuit. A set of voltage readings are stored in memory locations starting at XX60H. The end of data string is indicated by the data byte 00H. The readings are expected to be positive. Draw a flowchart and write a program to [25]

(i) Check each reading to determine whether it is positive or negative
(ii) Reject all negative readings
(iii) Add all positive readings
(iv) Store FFH in memory location XX80H when the sum exceeds 8-bits to indicate 'ERROR'; otherwise store the sum.

Use the instruction set of the 8085 microprocessor.

Q5. (a) What is the DMA scheme of data transfer? Discuss its operating principle. [6]

(b) What is the difference between a compiler and an interpreter? [4]

(c) Define memory map. Illustrate the memory map of 2K (2048) memory with a figure. Explain how the memory map can be changed by modifying the hardware of the chip select line. [15]

Q6. (a) Explain the differences between the instructions MOV R,M and LDAX Rp with an example. [8]

(b) Write a program to find the two's complement of a 16-bit number. The number to be complemented is placed in the memory location 2150H and 2151H. The result is to be stored in the memory location 2152H and 2153H. [11]

(c) Write short notes on [6]

(i) Device Polling
(ii) EPROM
(iii) Asynchronous Data Transfer Scheme

END OF P442 EXAMINATION

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS – SECOND SEMESTER 2006
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^{2}K^4
Sun's radius R_s = 6.96×10^{8}m
Mean Earth-Sun distance r_0 = 1.496×10^{11}m
Solar constant I_{sc} = 1367 Wm^{-2}
Earth's radius R_e = 6.37×10^{6}m
Planck's constant h = 6.6×10^{-34}J.s
Speed of light c = 3×10^{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

$$\lambda_{max} T = 2898 \ \mu\text{m.K}$$

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

$$R = r\left[1 + \frac{\alpha^2(1-r)^2}{1-\alpha^2 r^2}\right]$$

$$T = \frac{\alpha(1-r)^2}{1-\alpha^2 r^2}$$

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

$$\dot{Q} = \dot{m}C_f\,(T_B - T_{f,i})\left[1 - \exp\left(-\frac{\overline{U}_L L}{\dot{m}C_f}\right)\right].$$

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

$$J = J_0\left(e^{\frac{eV}{kT}} - 1\right)$$

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

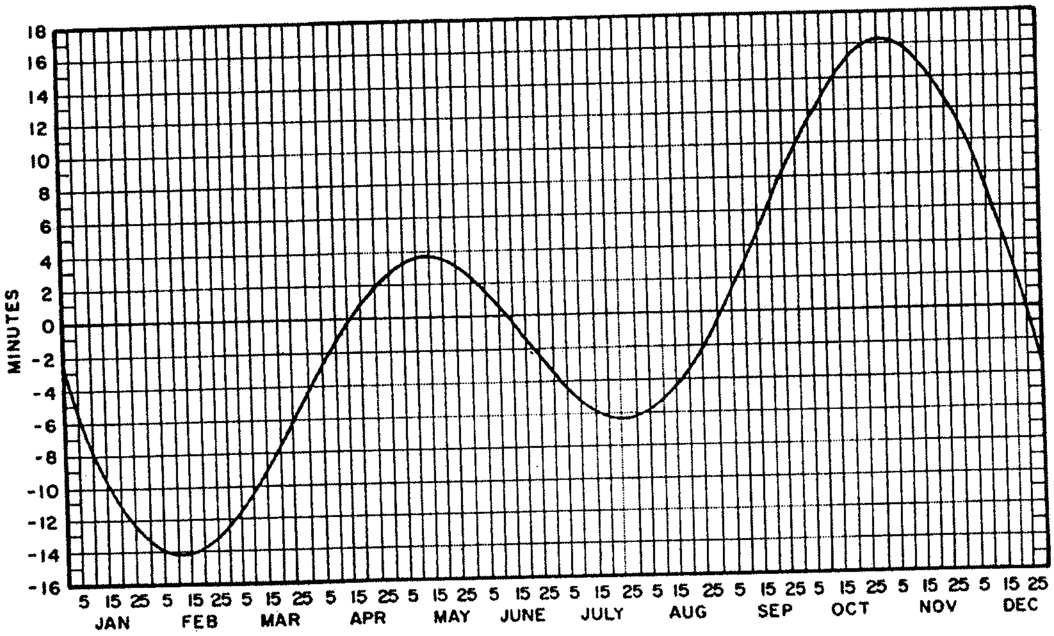


TABLE *The function f(x)*

x(μm-K)	f(x)	x(μm-K)	f(x)	x(μm-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 solar panel is situated in Lusaka. The panel is tilted at an angle of 30° from the horizontal and is facing North. The average optical thickness of the atmosphere is r = 0.2. Given the latitude of Lusaka is 15°S and the longitude is 28°E, find at 10.00 hour on 25 February:

(i) declination (3 marks)
(ii) solar time (4 marks)
(iii) hour angle (2 marks)
(iv) angle of incidence of direct radiation on the panel (6 marks)
(v) the zenith angle (5 marks)
(vi) direct flux incident on the panel (5 marks)

Q.2.

(a)

(i) Define solar constant. (2 marks)
(ii) The value of the solar constant is 1367 W/m^2. What will be its value if the mean Earth-Sun distance were increased by 5%. (4 marks)
(iii) Using the value of the solar constant and assuming the Sun to be a black body, calculate the temperature of the Sun. (4 marks)
(iv) Find the characteristic wavelength of the Sun's spectrum. (2 marks)
(v) Assuming that the human eyes can see electromagnetic radiation in the range of 0.4μm – 0.8 μm, estimate the fraction of the Sun's radiation which lies in the visible range. (5 marks)

(b)

(i) Describe the physical principles underlying the Greenhouse Effect. (2 marks)
(ii) Name two gases that contribute maximum to the Greenhouse Effect and their principal sources? (2 marks)
(iii) Name three problems that can arise as a result of the Climate Change. (2 marks)
(iv) Give two measures to mitigate climate change? (2 marks)

Q.3.

(a) A pipe carrying water passes through a tank containing fluid at a given temperature. Describing the physics involved obtain expressions for
(i) the exit temperature of the water, and (9 marks)
(ii) the rate of heat extracted. (3 marks)

(b) A large solar storage tank contains a fluid at 70°C. A coiled copper pipe is inserted in the tank and is used to warm a stream of water from 20°C to 50°C. The pipe is 5m long and has an average heat transfer coefficient of 12W/m-°C. Assuming that the tank temperature remains constant and the specific heat capacity of water is 4200 J/°C-Kg,

(i) What flow rate is being used to warm water to the desired value? (5 marks)
(ii) Calculate the heat extraction rate from the tank. (4 marks)
(iii) If the flow rate is doubled, what will the exit temperature of the water be? (4 marks)

Q.4.

(a) Describe the function and use of selective absorber coatings. What is an ideal selective coating? Explain if these coatings violate Kirchhoff's Law. (5 marks)

(b) Show that for an ideal selective coating with cut-off at λ_c

$$f(x)x^4 = x_0^4$$

where $x = \lambda_c T_P$ and $x_0 = \lambda_c T_0$. (6 marks)

(c)

(i) A grey plate (ϵ=0.6) is hung above the atmosphere facing the Sun such that solar radiation is incident normally on it. The back side of the plate is insulated. Find the steady state temperature of the plate. (5 marks)

(ii) If the insulation of the plate is removed, what will be the steady state temperature? (3 marks)

(iii) The plate in (i) (insulated on the back) is now coated on the front with an ideally selective coating with cut-off wave-length $\lambda_c = 4\mu m$. Estimate the steady state temperature of the plate. (6 marks)

5. (a) A solar heating panel under stagnant conditions is in thermal equilibrium with its surroundings when no solar radiation is incident upon it. The panel is then placed in the Sun. Write down the equation of heat balance under non-steady conditions and use it to show that

$$T_p - T_a = \frac{F_{abs}}{\overline{U}_c}\left[1 - \exp\left(-\frac{\overline{U}_c t}{C_A}\right)\right].$$

What will be the expression for T_p - T_a when steady-state stagnant condition is reached? (15 marks)

(b) An absorber plate of a collector is made of copper (C = 389 J/kg-°C) and has an area of 5 m^2 and a mass of 30 kg. The overall heat transfer coefficient to the surroundings is $\overline{U}_c$ = 8 W/m^2.

(i) Find the time constant of the collector. (3 marks)

(ii) If the insolation suddenly changes from zero to some constant value, how much time will it take for (T_p - T_a) to reach 90% of the steady state limit? (7 marks)

Q.6

(a)

(i) Why is it important to keep silicon PV cells cool while operating? (2 marks)

(ii) If you short-circuit a battery, it can be damaged. Explain what happens to a panel if it is short-circuited during operation. (2 marks)

(iii) You are provided with identical 60 PV cells each of 0.5 V and 1A current under given radiation conditions. You are asked to prepare an array which can give a minimum of 14 V and 2A. How will you arrange the PV cells into an array? (2 marks)

(iv) A major area of research worldwide is to produce silicon PV cells with increasingly higher efficiency. Can one hope to achieve an efficiency of close to 100%, say 70-80%, sometime in future? Give reasons. (2 marks)

(v) The PV panel of a Solar Home System is under the shade of a tree. Giving reasons explain if it will have any significant influence on the output voltage, current and power of the panel. (2 marks)

(b) A photovoltaic cell has constant spectral responsivity $K_\lambda = 0.2$ A/W for $0.5\mu m \le \lambda \le 2\mu m$, and $K_\lambda = 0$ otherwise. The cell is circular with a diameter of 10 cm, the incident flux is 1 Sun and the temperature of the cell is 300 K.

(i) Calculate the average responsivity and the photocurrent density. (5 marks)

(ii) Calculate the open circuit voltage and the short circuit current density if the reverse saturation current density $J_0 = 5 \times 10^{-9} A/m^2$. (5 marks)

(iii) An array of the above cells contains 72 cells. The cells are arranged in two parallel strings each of which has 36 cells in series. Obtain an I-V equation for the array. (5 marks)

----------------- END OF THE EXAM ----------------