THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 SECOND SEMISTER EXAMINATIONS

29. CST 2012	Programming II
30. CST 3032	Introduction to artificial intelligence
31. CST 4031	Computer graphics
32. EM 312	Engineering mathematics
33. GEO 155	Introduction to physical geography
34. GEO 155	Introduction to physical geography (DDE)
35. GEO 175	Introduction to mapping techniques (practical & theory)
36. GEO 175	Introduction to mapping techniques (theory & practical for Distance education)
37. GEO 211	The geography of Africa
38. GEO 211	The geography of Africa (Distance)
39. GEO 212	Geography of Zambia
40. GEO 272	Quantitative techniques in geography II
41. GEO 495	Environmental hazards and disasters
42. GEO 912	Geography of migration and refugees
43. GEO 952	Geographical hydrology
44. GEO 975	Cartography
45. GEO 995	Environment and natural resources management I
46. M 111	Mathematical methods I
47. M 112	Mathematical methods II- A
48. M 114	Mathematical methods II- B
49. M 162	Introduction to mathematics, probability & statistics
50. M 212	mathematical methods IV
51. M 232	Real Analysis II
52. M 292	Introduction to probability
53. M 325	Group & Ring theory
54. M 332	Real Analysis IV
55. M 362	Linear models and design of experiments
56. M 422	Module and fields theory
57. M 912	Mathematical methods VI
58. M 962	Time series analysis
59. MSE 342	
60. MSE 352	
61. MSE 362	

62. MSE 942 Biology teaching methods IV
63. P 192 Introductory physics II option A
64. P 198 Introductory physics II option B
65. P 212 Atomic physics and magnetism in matter
66. P 252 Classical mechanics II and special relativity
67. P 332 Statistical physics and thermodynamics
68. P 342 Introductory digital electronics
69. P 442 Digital electronics II
70. P 452 Selected topics in theoretical physics
71. P 455 Quantum mechanics II

62. MSE 942	Biology teaching methods IV
63. P 192	Introductory physics II option A
64. P 198	Introductory physics II option B
65. P 212	Atomic physics and magnetism in matter
66. P 252	Classical mechanics II and special relativity
67. P 332	Statistical physics and thermodynamics
68. P 342	Introductory digital electronics
69. P 442	Digital electronics II
70. P 452	Selected topics in theoretical physics
71. P 455	Quantum mechanics II

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

SECOND SEMESTER UNIVERSITY EXAMINATIONS

DECEMBER, 2005

BS 212
PLANT AND ANIMAL PHYSIOLOGY
THEORY PAPER

TIME: **THREE** HOURS

INSTRUCTIONS: Answer **FIVE** questions, Two from each section and the last question from any section.

Use **SEPARATE ANSWER BOOKS** for each section

SECTION A: PLANT PHYSIOLOGY

1. Compare and contrast the mechanisms of flow of water in the xylem and flow of sap in the phloem in terrestrial plants.

2. Explain the function of light in higher plant photosynthesis

3. Write on each of the following: -
   (a) Phototropic responses of coleoptiles.
   (b) Polar transport of Auxin.

4. What do you think are the shortcomings of the cohesion-tension theory?

SECTION B: ANIMAL PHYSIOLOGY

5. (a) Describe the major events involved in cleavage and gastrulation in the chick embryo.
   (b) List the tissues and organs produced by respective germ layers.

6. (a) What is nutrition?
   (b) Describe the various feeding mechanisms found in organisms.

7. Write short notes on each of the following: -

   (a) Receptors.
   (b) Extraembryonic membranes.
   (c) Oestrogen.
   (d) Growth hormone.

8. Describe the processes and mechanism involved in blood coagulation.

END OF EXAMINATIONS

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

SECOND SEMESTER UNIVERSITY EXAMINATIONS

DECEMBER, 2005

BS 212
PLANT AND ANIMAL PHYSIOLOGY
PRACTICAL PAPER

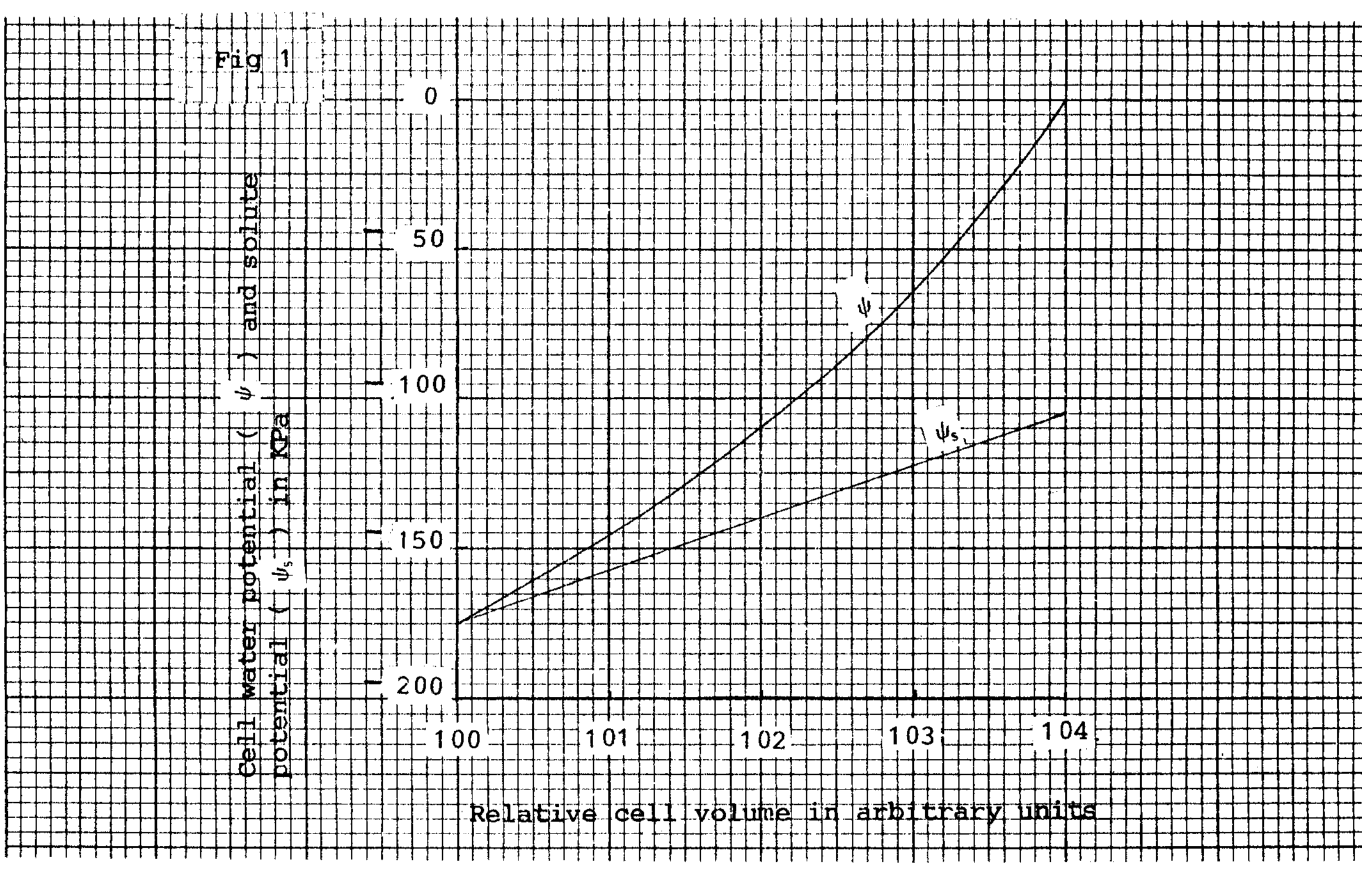
TIME: THREE HOURS

INSTRUCTIONS: Answer ALL questions

Use **SEPARATE ANSWER BOOKS** for each section

SECTION A: PLANT PHYSIOLOGY

1. Figure 1 is a modified Hofler diagram showing changes in the solute potential and water potential of a plant cell in relation to the cell volume



(a) What is the pressure potential when the cell volume had reached 102 arbitrary units?

(b) What were the pressure potential and solute potential when the cell had reached full turgor?

2. Determine the water potential of the tissue provided. Report your experiment in the following format: -

Introduction (Brief Account)
Materials and Methods
Results
Discussion
Conclusion

SECTION B: ANIMAL PHYSIOLOGY

3. (a) Describe and explain the major step undertaken in determining the hematocrit.

(b) If the packed Cell Volume (PCV) is 42 percent, what percentage of the blood is plasma?

(c) Which one of the anticogulants is preferred for studies on blood in the laboratory? Give reasons.

(d) Draw a distinction between plasma and serum.

(e) Name three principal plasma proteins.

4. (a) State the main carbohydrate sources in animal nutrition and the products of their enzymatic digestion, which are absorbable.

(b) Outline the factors which influence the distribution of digestive enzymes in the gastrointestinal tract of animals.

(c) Name the principal constituents of human, avian and frog urine.

(d) In what circumstances will glucose and albumin appear in the urine?

(e) Describe and explain diabetes mellitus.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA.

UNIVERSITY SECOND SEMSTER EXAMINATIONS - DECEMBER, 2005.

FORM, FUNCTION AND DIVERSITY OF ANIMALS- BS 222. THEORY: PAPER I

TIME: THREE (3) HOURS.
INSTRUCTIONS: Answer Four(4) Questions Only. Two Questions from Section A and Two Questions from Section B. All Questions Carry Equal Marks.
Please ensure that answers for Section A are in a separate answer book and those for Section B also in a separate one.

SECTION A

Q 1. If you were to establish a collection of invertebrates for a museum, where would you collect them from and what methods of collection and preservation would you use for various categories of invertebrates?.

Q 2. In the early classsification of animals all creatures with long slender bodies were called "worms". What structural or anatomical similarities and differences exist between the Nemathelminthes, Platyhelminthes and Annelids?.

Q 3. According to Meglitsch and Schram(1991), " Nothing more certainly symbolises the sea than the starfish, Sea urchins and sand dollars." Discuss this statement and highlight the diversity of form in the Echinodermata.

SECTION B

Q 4. Define the following words and phrases as commonly used in the study of Chordates and Vertebrates:

i). Urochordata.
ii). Agnatha
iii). Testudinata
iv). Squamata
v). Ratite
vi) Metathera.
vii) Aeluroiids
viii) Insectvora
ix) Acrania
x) Anura

Q 5 Using appropriate diagrams, describe functions of the following organs and structures in taxonomic groups indicated below:

i). Gill slits in Cyclostomata.
ii). Pharynx in Cephalochordates
iii). Gizzard in Aves
iv). Skin in Amphibia; and
v). Amniotic egg in the Class Reptilia.

Q 6. The Class Amphibia provides a link in the evolution of vertebrates. Explain how the Class Amphibia demonstrates relationships between the two groups of the Gnathostomata.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS
BS 322: ECOLOGY THEORY (PAPER 1)
TIME : THREE (3) HOURS
INSTRUCTIONS: ***Answer five (5) questions.***

1. Distinguish between the following terms:
   (i) Ecology and ecosystem;
   (ii) Circadian rhythm and tidal rhythm;
   (iii) Net primary productivity and net community productivity;
   (iv) Centres of Plant Diversity and "hot spots";
   (v) Stability and resilience of ecosystems;
   (vi) Ecosystem diversity and genetic diversity.

2. (a) Briefly describe the following population interactions:
   (i) amensalism;
   (ii) competition;
   (iii) commensalism~~s~~;
   (iv) mutualism;
   (v) parasitism;
   (vi) predation.

   (b) Why are many of these interactions of overwhelming importance in ecosystems?

3. (a). List the tropical vegetation types.
   (b). Discuss briefly:
   (i). abiotic factors responsible for the formation of;
   (ii) structure of ;
   (iii) human impact and its consequence on

   any ***three*** of the vegetation types.

4. (a) What is the importance of solar radiation received by the biosphere?
   (b) Why are the atmospheric contents of ozone, oxygen, water vapour and carbon dioxide important in determining the wavelengths of solar radiation reaching the earth's surface?
   © Which factors influence seasonality of organisms in:
   (i) arctic and temperate regions;

(ii) tropical regions?

(d) List the activities of plants and animals that are affected by seasonality in temperate and tropical regions.

5. (a) What are the processes involved in hydrologic cycle on earth?
   (b) What are the effects of excessive and deficient moisture in an environment on plants and animals?
   © Discuss the adaptations of plants and animals to cope with these moisture extremes.

6. (a) Distinguish between biogeochemical cycles and energy flow in ecosystems.
   (b) Discuss the roles of the following processes in biogeochemical cycles and flow of energy in ecosystems:
      (i) photosynthesis;
      (ii) respiration;
      (iii) herbivory and carnivory;
      (iv) decomposition.
   © Explain why ecosystems can only contain a few trophic levels.
   (d) Why is the flow of energy in an ecosystem non-cyclic and unidirectional?

7. (a) What is a population of organisms?
   (b) Discuss the population attributes you may be interested in measuring when you wish to compare different populations, or the same population at different times.
   © What factors control population growth?
   (d) Discuss the concept of carrying capacity and its effect on the stability of populations.

8. (a) Distinguish between ecological succession and evolution.
   (b) What are the important changes or progressive developments that occur in ecological communities during the course of succession?
   © Discuss the theories to explain the existence of climax vegetation.

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – DECEMBER 2005

BS 332

ANIMAL PHYSIOLOGY (PRACTICAL)

TIME: THREE HOURS
INSTRUCTIONS: ANSWER ANY ~~FIVE~~ four QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS

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1. The heart has its own internal pace-maker so that when isolated, continue to contract regularly without the external stimulation.

   a) What are the effect of the following drugs, if you drop 1ml of each drug on the heart of a frog:
      (i) *Nicotine*
      (ii) Atropine sulphate
      (iii) Acetylcholine

   b) What is the effect of intensty of electrical stimulation on the heart.

   c) What is the effect of temperature on the heart.

   d) What is the meaning of refractory period?

   e) State the Sterling's Law of the heart.

2. Describe the changes that occurs in the rat during a normal oestrous cycle in the vaginal smear.

3. The table below gives the oxygen consumption in mammals of various body size:

Animal	Body Mass (kg)	Total oxygen comsumption (litre O_2 h^{-1})
Rat	0.29	0.25
Cat	2.50	1.70
Dog	11.70	3.87
Sheep	42.70	9.59

Human	70.00	14.76
Horse	650.00	71.10
Elephant	3,833.00	268.00

(a) Calculate the oxygen consumption (litre O_2 kg^{-1} h^{-1}) for each named animal in the table above.

(b) Explain the relationship between the metabolic rate and body size of the above named mammals.

(c) Why is it useful to determine the metabolic rate of domestic animals under various conditions.

(d) Define basal metabolic rate (BMR).

4. Many reflexes participate in regulating inflation of the lungs. Explain the significance of the Herring-Breuer reflex.

- END -

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS-MAY 2005-11-25

BS 332

ANIMAL PHYSIOLOGY (THEORY)

TIME: THREE HOURS
INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS

1. Describe the mechanisms involved in regulating output of ovarian hormones and anterior pituitary gonadotropic hormones during a normal menstrual cycle. Explain their functions.

2. What thermoregulatory mechanisms are available to homeotherms at temperatures below and above thermoneutral zone?

3. (a) Discuss the mechanisms used by the mammalian kidney to achieve the final concentration of urine.
(b) Explain the physiological adaptations involved in osmoregulation in different animals.

4. Compare and contrast cardiac muscle and skeletal muscle mass regarding their respective:
(a) histologies
(b) spread of the action potential through the muscle mass
(c) excitation contaction coupling
(d) and energy sources for contraction

5. Describe the roles played by the pancreas and the liver in the physiology of digestion in a mammal.

6. (a) What is a synapse
(b) Describe the physiology of impulse conduction over the synapse

7. (a) What is reflex arc?
(b) Give an account of the physiology of reflex action
(c) Give four examples of reflexes

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS
DECEMBER 2005

BS 342: MYCOLOGY
THEORY PAPER

ANSWER FIVE QUESTIONS
ALL QUESTIONS CARRY EQUAL MARKS

1. Design an experiment that will demonstrate that certain fungi prefer to use some carbohydrates to others. Explain the choice of fungus used in the experiment and the expected results.

2. Write concisely on what septa in fungi are and explain how they arise giving examples of the different types. Briefly comment on their significance to fungi.

3. The term "non – translocator" is not as accurate as the term "non - coloniser" with regards to the nutrition of fungi. Support this view using experimental evidence of named examples.

4. What is a conidium? Distinguish between spore liberation and dispersal. Discuss active and passive spore dispersal using *Pilobolus* sp. and *Phallus impudicus* as examples.

5. Fungi are beneficial to mankind. Support this point of view giving reasons and examples.

6. Write briefly on the Oomycetes as follows:
   (a) Vegetative characteristics
   (b) Sexual reproduction
   (c) Ecology
   (d) Significance

7. Write briefly on any **three** of the following:
   (a) The extension zone in hyphae
   (b) Dimorphism as an example of differentiation
   (c) Formation of blastic conidia
   (d) Logarithmic growth in yeasts
   (e) Survival structures in fungi

8. Why are fungi considered to be extra cellular feeders? Discuss the metabolism of carbon in a named fungus.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF BIOLOGICAL SCIENCES
2005 ACADEMIC YEAR
SECOND SEMESTER FINAL EXAMINATIONS

COURSE: BS 349 (PAPER 1)

DURATION: 3 HOURS **DATE: 5TH DECEMBER, 2005**

INSTRUCTIONS: ANSWER FIVE QUESTIONS, TWO FROM EACH OF THE SECTIONS A AND B AND ONE FROM SECTION C. ANSWER SECTION B IN A SEPERARTE ANSWER BOOK.
USE SPECIFIC EXAMPLES AND ILLUSTRATIONS WHERE POSSIBLE.

SECTION A

1. a) List the general properties of the proteobacteria. **(5 marks)**

   b) Name the five classes of the proteobacteria and give the major biological features of each group. **(10 marks)**

   c) Place the following in their respective classes. **(5 marks)**

   (i) *Enterobacteriales*

   (ii) *Campylobacter*

   (iii)*Bdellevibrio*

   (iv)*Rhizobium*

   (v) *Neisseriales*

2. With the aid of a diagram(s), discuss the nature (chemical composition), structure and functions of the outer membrane of the gram negative cell wall and show how it is connected to the peptidoglycan layer. **(20 marks)**

3. Write short notes on:

   (a) Bacterial flagella patterns and distribution. Give an example of a bacterium with a particular type of flagellation. **(12 marks)**

(b) Ways in which bacterial cells cluster together. **(4 marks)**

(c) Endospore and conidiospore. **(4 marks)**

SECTION B

1. How do the environmental factors influence the growth of microorganisms? **(20 marks)**

2. a) Discuss the three types of media.
   Give at least two examples for each type. **(10 marks)**

   b) What is continuous culture of microorganisms? Give the two types of continuous culture systems in use. **(10 marks)**

3. Write short notes on any four of the following: **(20 marks)**

   (a) Growth factors

   (b) Microbial siderophores

   (c) Quaternary ammonium compounds

   (d) Nutrition of soil bacteria

   (e) Biofilm

SECTION C

1. a) Name the three ways in which viruses differ from living cells. **(4 marks)**

   b) Discuss the ways in which viruses are cultivated. **(10 marks)**

   c) Explain the terms **(6 marks)**

   (i) Plaque forming units (PFU)

   (ii) Cytopathic effects (CPEs)

   (iii) Differential centrifugation

2. a) For the following viruses

Rotavirus (human diarrhea)

Varicella-zooster (chicken pox)

Tobacco mosaic virus (TMV)

Human immunodeficiency virus (HIV)

provide the following: **(12 marks)**

(i) Virus family and genus

(ii) Capsid symmetry

(iii) Type of nucleic acid

(iv) Site of capsid assembly

(v) Nucleic acid strandedness

(vi) Envelope or no envelope

b) Describe four factors used in classifying viruses. **(8 marks)**

END OF EXAMINATION

GOOD LUCK

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – DECEMBER, 2005

BS 362 GENETICS

PRACTICAL PAPER

TIME ALLOWED: THREE HOURS

ANSWER : ALL QUESTIONS

QUESTION 1. Genetic distance is a useful tool in determining how closely or differently related two given species are. The information derived can be used in establishing phylogenetic relationships. Given the following data of ~~three~~ 4 populations at ~~a single locus~~ 3 loci with ~~four~~ 2 alleles

Locus	Allele	Pop1	Pop2	Pop3	Pop4
1	a	0.5	0.2	0.9	0.6
	b	0.5	0.8	0.1	0.4
2	a	0.6	0.6	0.4	0.5
	b	0.4	0.4	0.6	0.5
3	a	0.5	0.7	0.3	0.6
	b	0.5	0.3	0.7	0.4

(a). Calculate the genetic distances between the populations
(b) Sketch the distances in form of a dendogram.
(c). Comment on the genetic relatedness between the populations.

QUESTION 2. Below are four populations of a plant species showing variation at an isozyme locus with alleles X and Y.

Population one:

YY XX YX XX XX YX YX YX XX YX XX YX YX YX XX XX YY YY XX YX YX
XX YY YX YY XX YX XX YX YX YX YX XX YY XX YX YX YY YY YX YX YX
XX YY YX YX YX XX YX YX XX YY YY YX YY YX YX YY YX YX YX YY XX
YX YY YX XX XX YX XX YX YX YX XX YY YX YX YY YY XX XX YX YY YX

Population two:

XX XX XX XX XX XX XX XX XX XX XX YY XX YX XX XX XX XX XX XX XX
YX XX XX XX XX XX XX XX XX YX XX YX YY XX YY XX XX XX YX YY XX
XX XX XX XX XX XX YX XX XX XX XX YX XX YY XX XX XX XX XX YY YX
YX YY XX XX XX XX XX YX XX XX XX XX YX XX YY XX XX XX YY XX YX

P.T.O

Population three:

XX YY YY YY XX YY YY YY YY XX YY XX XX XX YY YY YY YY YY XX YY
YY YY XX XX YY XX YY YY YY YY YY XX YY YY YY YY YY XX YY YY YY
YY YY XX YY YY YY YY YY XX XX YY YY YY YY YY YY YY YY XX YY YY
YY YY YY XX XX YY XX YY YY YY YY YY YY YY YY YY YY YY XX YY XX

Population four:

YY YY XX YY YY YY XX YY YY XX XX XX YY YY XX XX YY YY XX YY XX
YY YY YX YY YY XX XX YY YY XX YY XX XX YY XX XX XX YY XX YY XX
XX YY XX XX YY XX YY YY XX XX XX YY YY XX YY YY XX YY XX XX XX
XX XX YY YY XX YY YY YY XX YY XX YX XX YY YX XX XX YY YY XX XX
YY XX XX YY YY YY XX YY YY YY YY XX YY YY YY YY XX XX XX YY YY

For each population work out:

(a). Allele frequencies
(b). Genotype frequencies
(c). Goodness of fit to the Hardy-Weinberg equilibrium
(d). Heterozygosity
(e). Level of out crossing
(f). Comment on the results

QUESTION 3. The isozyme survey of five populations of two different species yielded the following data:

Species	Population	AA	Aa	aa
1	A	100	240	12
	B	150	135	13
	C	200	156	22
	D	230	448	21
	E	100	219	13
2	A	100	2	327
	B	190	5	198
	C	230	3	210
	D	240	0	125
	E	180	12	330

P.T.O

Calculate:

(a). Heterozygosity for each population

(b). Gene diversity for each population

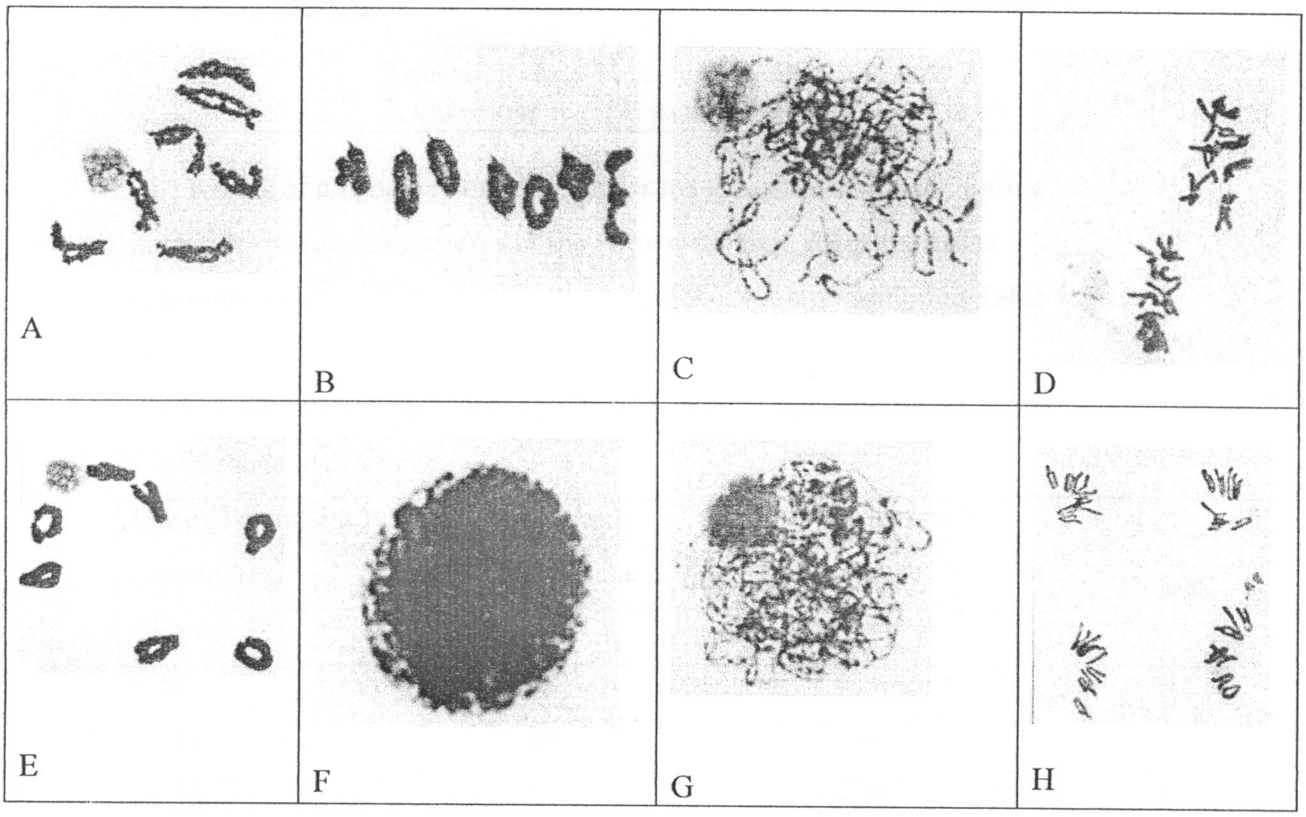
(c). Ht for each species

(d). Dst for each species

(e). Gst for each species

(f). Interpret the results as far as you can.

QUESTION 4. The figures below represent different cells undergoing cell division.



(a) Identify the stages represented by A – H as completely as you can.

(b) How many chromosomes does this species have?

(c) What is the significance of this type of cell division to the species?

END OF EXAMINATION – GOOD LUCK

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

SECOND SEMESTER EXAMINATIONS

December 2005

BS 412-APPLIED ENTOMOLOGY

PAPER 11 (Practical Paper)

TIME: **Three (3) Hours**

INSTRUCTIONS:

1. Answer **All** questions.
2. question One (1) carries twenty (20) marks.
3. Questions two (2) to ten (10) carry equal marks.

1. The results of a Bioassay experiment for toxaphene (an organochlorine acaricide) against two strains of the Brown-ear tick, ***Rhipicephalus appendiculatus*** L. from Chalimbana and Monze are presented in Table 1. below:

Table 1. Dose/Mortality Data for ***Rhipicephalus appendiculatus*** L from Chalimbana and Monze.

Dose (Toxaphene) (ug/cm^2)	% Mortality Chalimbana	% Mortality Monze
Control	0	0
6.57	9.59	0
13.14	33.69	1.96
26.28	68.66	8.18
52.56	96.60	40.12
105.12	-	96.70

(a) Using the Probit tables provided, transform the percentage mortality to probits and the dose to $\log_{10}$ and draw the dose/mortality (probits) curve on the graph paper (provided).

(b) Determine the LD 50 and LD 95 values from your curve.

2. Specimen **A** is a piece of equipment obtained from a sprayer.
   (i) Name the equipment and state its functions
   (ii) What kind of sprayer was this equipment obtained from?
   (iii) What types of nozzles does this sprayer use and in what pest control programmes can it be used?

3. You are provided with a specimen labelled **B**. Identify this specimen and assign it to any of the following categories;
   (i) Medical pest
   (ii) Veterinary pest
   (iii) Agricultural pest
   (iv) Forestry pest

   Briefly comment about the pest status and what control strategies would you Recommend for such a pest?

4. Specimen **C** is a damaged crop in storage.
   (i) What insect pest would you suspect to have caused this damage?
   (ii) If the damaged crop remained in storage for a long time and detiorated further what would happen to population of this insect? Illustrate your answer using a diagram.
   (iii) What control measures would you put in place for such a pest?

5. Identify specimen **D.** What damage does this pest cause and how would you control it?
6. Identify specimen **E.** What damage does this pest cause and how would you control it.
7. Specimen **F** is a pesticide formulation. Identify the type of formulation and what is its target use?
8. Specimen **G** is an agricultural pest commonly seen in gardens. Identify this pest and write brief notes about its life history. Is this pest an r strategist or a K strategist? How useful is the knowledge of insect life histories in designing pest management programmes.

9. Identify specimen **H**. What harm or damage does this pest cause? What recommendations would you propose to control this pest?
10. Identify specimen **I**. Write brief notes about its pest status. Is it possible to design an IPM programme for such a pest? Give reasons for your answer.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF BIOLOGICAL SCIENCES
2005 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

COURSE: BS 435 –MEDICAL MICROBIOLOGY

THEORY

DURATION: 3 HOURS **DATE 16 DECEMBER 2005**

INSTUCTIONS: ANSWER FIVE (5) QUESTIONS. TWO FROM SECTION A AND THREE FROM SECTION B, QUESTION 1 AND ANY OTHER TWO
: ANSWER SECTION B IN SEPARATE ANSWER BOOK

SECTION A

Q1. (a) What is meant by induction or artificial immunity? Describe the goals of induced immunity.

[10 marks]

(b) Write short notes on the following
- (i) Apoptosis (from assignment)
- (ii) Viral immunopathology
- (iii) Live attenuated vaccines
- (iv) To which genus does the orf virus belong and type of nucleic does it posses?
- (v) What variables must you consider when collecting specimens for viral diagnosis?

[10 marks]

Q2. Explain the principles of the ~~arrays~~ assays you would use to
- (i) Determine the varicella immune status of health personnel exposed to a patient with VZV infection.

[5 marks]

- (ii) Screen and confirm HIV infection in a community

[15 marks]

SECTION B
ANSWER QUESTION 1 AND ANY OTHER TWO.

Q1. Most human pneumonias are bacterial in origin. The commonly encountered pathogens are *Streptococcus pneumoniae*, *Mycoplasma pneumoniae* and *Klebsiella pneumoniae*. For each of the pathogens provide the following:
1. General characteristics
2. Laboratory identification
3. Transmission
4. Pathogenesis
5. Sensitivity to antibiotics or treatment

[20 marks]

Q2. (a) Describe the mode of action and consequences of the following toxins and name the microorganisms producing them:

1. Diphtheria toxin
2. Cholera toxin
3. Tetanus toxin
4. Staphylococcus pore forming toxins

[16 marks]

(b) What is the genetic control for each of the toxins?

[4 marks]

Q3. (a) Write short notes on the following

1. Opportunistic infections
2. Mantoux test
3. Therapeutic index
4. Endogenous pyrogens
5. Chemoprophylaxis

[10 marks]

(b) Explain four ways the clinical microbiology laboratory can provide preliminary or definitive identification of microorganisms from clinical specimens.

[10 marks]

Q4. (a) Discuss the factors that influence pathogen transmission.

[8 marks]

(b) Briefly discuss the four main ways by which infectious agents are transmitted

[12 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – DECEMBER 2005

BS442: ADAVANCED MOLECULAR BIOLOGY II

TIME: Three hours

ANSWER: Five (5) questions only. All questions carry equal marks. Inclusion of relevant diagrams, illustrations, labeled drawings and tabulated results will enhance your answers.

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1. Outline the two major types of experimental analysis that laid the foundation for the deduction of the structure of DNA by Watson and Crick.

2. Compare and contrast the mechanism of DNA replication in prokaryotes and eukaryotes.

3. Explain how the *E. coli* RNA polymerase recognizes the correct position within a DNA molecule at which to begin transcription, elongate the RNA transcript and terminate transcription.

4. Write short notes on any <u>four</u> of the following:
   (i) Catagena protocol on biosafety
   (ii) Polycistronic mRNA
   (iii) Gene therapy
   (iv) Transient transformation
   (v) Topoisomerase II

5. You are provided with a double stranded DNA. You are told the DNA sequence is:

   5'-ATGCTTACGACCTG-3'
   3'-TACGAATGCTGGAC-5'

   Using an appropriate cloning vehicle how would you verify that the sequence is correct. To answer the question fully, include all experimental steps.

6. Using a genetically modified organism (GMO) of your choice, explain in detail the steps you would follow to produce such an organism.

7. Recombinant DNA technology is a subject of intense debate the world over. In this course the pros and cons of this technology have been discussed. In your own understanding what are the concerns of this technology in relation to food safety and the environment.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – DECEMBER 2005

BS442: ADAVANCED MOLECULAR BIOLOGY II

TIME: Three hours

ANSWER: Five (5) questions only. All questions carry equal marks. Inclusion of relevant diagrams, illustrations, labeled drawings and tabulated results will enhance your answers.

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1. Outline the two major types of experimental analysis that laid the foundation for the deduction of the structure of DNA by Watson and Crick.

2. Compare and contrast the mechanism of DNA replication in prokaryotes and eukaryotes.

3. Explain how the *E. coli* RNA polymerase recognizes the correct position within a DNA molecule at which to begin transcription, elongate the RNA transcript and terminate transcription.

4. Write short notes on any <u>four</u> of the following:
   (i) Catagena protocol on biosafety
   (ii) Polycistronic mRNA
   (iii) Gene therapy
   (iv) Transient transformation
   (v) Topoisomerase II

5. You are provided with a double stranded DNA. You are told the DNA sequence is:

   5'-ATGCTTACGACCTG-3'
   3'-TACGAATGCTGGAC-5'

   Using an appropriate cloning vehicle how would you verify that the sequence is correct. To answer the question fully, include all experimental steps.

6. Using a genetically modified organism (GMO) of your choice, explain in detail the steps you would follow to produce such an organism.

7. Recombinant DNA technology is a subject of intense debate the world over. In this course the pros and cons of this technology have been discussed. In your own understanding what are the concerns of this technology in relation to food safety and the environment.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS – DECEMBER 2005

BS445

ECOPHYSIOLOGY OF PLANTS

(PAPER)

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS, WITH AT LEAST TWO QUESTIONS FROM EACH SECTION, AND USE ILLUSTRATIONS WHEREVER POSSIBLE

SECTION A

1. Explain how C_3 and C_4 photosynthesis might be affected by the rising level of atmospheric carbon dioxide and nitrogen supply.

2. Discuss the effects of temperature on the quantum yield of photosynthesis in the different subtypes of photosynthesis.

3. Explain how light intensity and light quality affects the growth and development of plants in a vegetation stand.

SECTION B

4. What is phenology and how are phenological studies done.

5. Discuss the significance of minimum temperature in the distribution and phenology of tropical plants.

6. How is elevated carbon dioxide likely to affect plant reproductive yield.

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

8. Discuss the classification of pollution indicators.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

DECEMBER, 2005

BS 455
WILDLIFE ECOLOGY

PAPER II (Practical)

TIME: 3 Hours

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

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

2. A rodent survey in the Kafue Flats area used a capture-recapture method to determine the distribution, habitat selection and 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.

Transect	A	B	C	D	E	E	G
Initial capture	17	13	12	14	8	15	12
Second capture	13	10	18	12	11	15	17
Recaptures	1	3	7	4	2	5	7

The technique however requires that before a large number of traps can be set, it was important to test the behavioral pattern of the rat, and therefore using the initial capture of the data provided (a) determine whether or not the capture of each rat was independent of the location of the trap, and (b) From the data of the subsequent captures, determine the population of the species.

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

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

(i) Which habitat is most important for each of the following species and why?

(a) Tragelaphis spekei
(b) Equus burchelli
(c) Damaliscus lunatus
(d) Balaeniceps rex

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

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

INFORMATION FOR QUESTION 3

THE MAP AND THE DESCRIPTION OF THE AREA:

Vegetation types:

A: Termitaria grassland

B: Munga woodland

C: Chipya woodland

D: Miombo woodland

E: Hyparrhenia grassland

F: Swamp

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

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

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..........................

Question one (1)

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

Specimen A, Indicate:

(i) Order ______________________________

(iii) Family ______________________________

Specimen B:

(i) Species ______________________________

(iii) Habitat preference

Specimen C:

(i) Species ______________________________

(ii) Breeding habits ______________________________

Specimen D:

(i) Order

(iv) Conservation status

SPECIMEN E:

i) Order ____

ii) Family ____

SPECIMEN F:

i) Species ____

ii) Reproductive habits

SPECIMEN G:

i) Species ____

ii) Habitat:

SPECIMEN H:

i) Genus ____

ii) Species ____

SPECIMEN I:

i) Order ____

ii) Family ____

SPECIMEN J:

(i) Dental formula ____

(ii) Species____

SPECIMEN K:

i) Suborder ____________________

ii) Species ____________________

SPECIMEN L:

i) Class ____________________

ii) Genus ____________________

SPECIMEN M:

i) Habitat

ii) Conservation status

SPECIMEN N:

i) Species ____________________

ii) Conservation status in Zambia: ____________________

SPECIMEN O:

i) Species ____

iii) Economic importance

____

SPECIMEN P:

i) Order ____

ii) Species ____

SPECIMEN Q:

i) Species 1.

____

ii) Species2

____

SPECIMEN R:

Field Impression ___________________________________

____

____

SPECIMEN S:

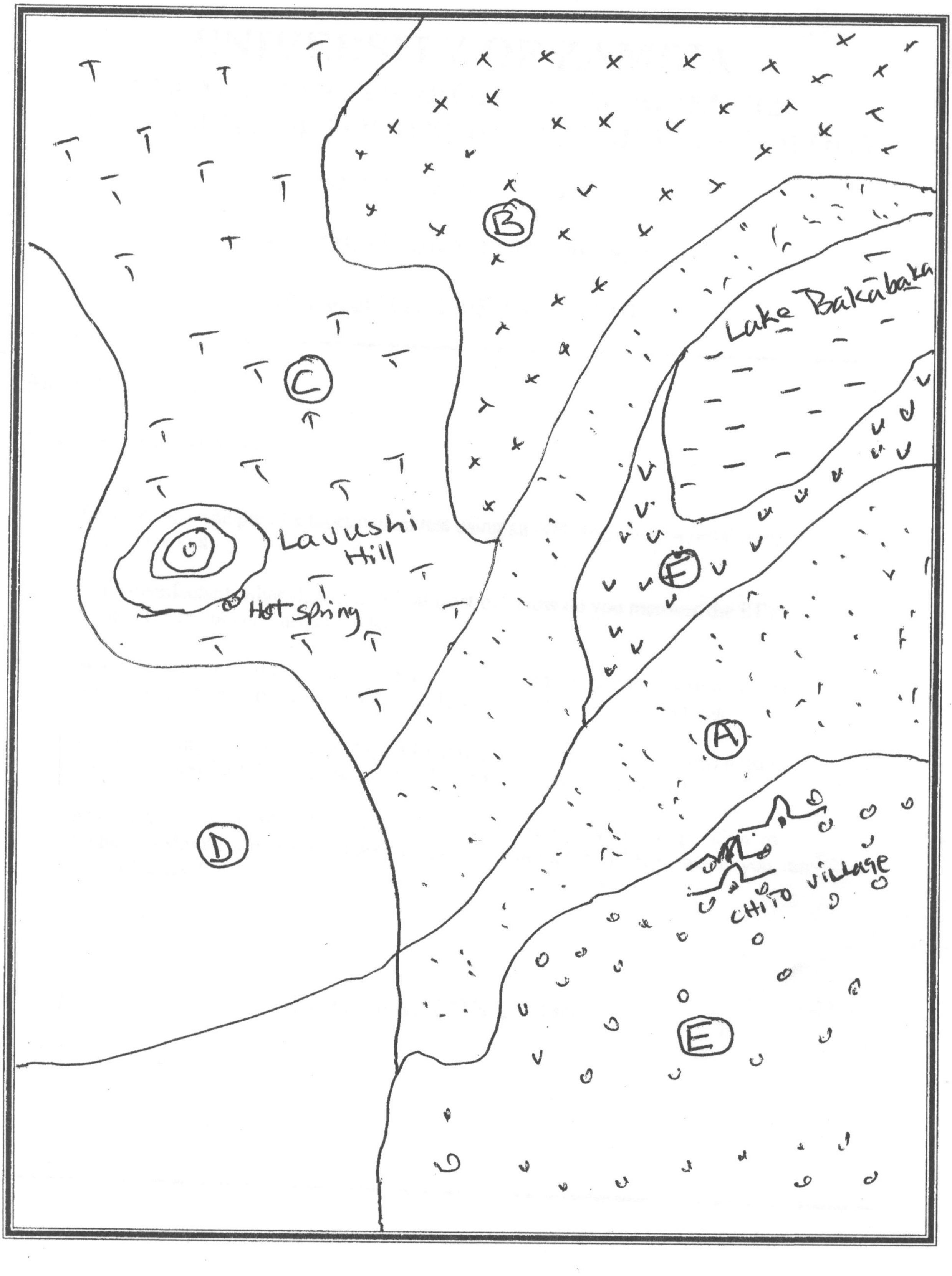
i) Order ____

ii) Family ____

SPECIMEN T;

i) Species **1**. ____

ii) Species**2**.____



MAP FOR QUESTION 3

UNIVERSITY OF ZAMBIA
DEPARTMENT OF BIOLOGICAL SCIENCES
DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

BS 482 AGF 352 Food Microbiology

Final examination, Practical paper

19 December 2005 09.00-12.00

Answer all questions

All questions carry equal marks.

1. Explain the principle of a biochemical test using an API strip. Give a full description of the protocol.

2. For a disinfectant, what should de KE at least be? How do you measure the KE? Describe 3 factors that affect the KE.

3. What factors can lead to variability in results? Describe 6, ranking these 6 factors according to their importance; include a clear justification for your ranking.

4. When studying the hygienic quality of fried rice, what groups of micro-organisms should you test for? Why? Describe a full protocol to carry out the test.

5. Name 2 factors that affect the heat sensitivity of microbes. What groups of micro-organisms should you test for in preservation by heating? Why? How would you carry out such a test?

END of EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER II EXAMINATIONS – DECEMBER 2005

INTRODUCTORY CHEMISTRY II - C102

8th December 2005

DURATION : Three (03) hours

INSTRUCTIONS TO THE CANDIDATES

1. Write your **computer number** and TG **number** on **all** your answer booklets.

2. This examination paper consists of two **(02)** sections: **A** and **B**

3. Section **A** has ten **(10)** questions. **ANSWER ALL QUESTIONS** Each question carries equal marks (Total marks = **40**).

4. Section **B** has five **(05)** questions. **ANSWER B1 AND ANY THREE (03) QUESTIONS. ANSWER EACH QUESTION IN A SEPARATE ANSWER BOOKLET**.Each question carries equal marks (total marks = **60**).

5. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORKING CLEARLY AND LOGICALLY**

DATA

Universal gas constant, R	=	$8.314\ JK^{-1}mol^{-1}$
	=	$0.0821 dm^3\ atm\ K^{-1}\ mol^{-1}$
	=	$8.314 kPa\ dm^3 K^{-1}\ mol^{-1}$
Ebullioscopic constant (K_b) for water	=	$0.512°C/m$
Cryoscopic constant (K_f) for water	=	$1.86°C/m$

Atomic masses

Zn	=	63.59
O	=	16.00
H	=	1.01
Na	=	23.00
C	=	12.01

SECTION A ANSWER ALL QUESTIONS

A1. The vapour pressure of ethanol is 15332 Pa. at 307.9K. If the heat of vaporization of ethanol is 40500J/mol, calculate the temperature in K, when the vapour pressure is 101325 Pa.

A2. Sketch two well labelled phase diagrams: one for a substance that expands when cooling and the other for the substance that contracts when cooling

---

A3. A gene fragment was isolated and a 10.0 mg portion of it was dissolved in water and the volume was made upto 30.0 mL. The osmotic pressure of this solution at 25°C was 43.33Pa. Calculate the molar mass of the gene fragment.

A4. A slightly bruised apple will rot extensively in 4 days at room temperature (20 °C). If it is kept in the refrigerator at 0 °C the same extent of rotting occur in 16 days. Calculate activation energy of rotting process.

A5. What would you see when sodium carbonate solution is added to aluminium chloride solution. Give the balanced equation(s) for the reaction taking place.

A6. The colour of black berries is due to a compound cyanidin. At low pH cyanidin (Cy) exists as CyH^+ which is red and at high pH as Cy which is purple.

(i) At pH 5 the ratio of the red to purple form is 1:5. Calculate the acid dissociation constant.

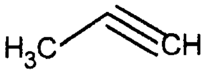
(ii) Calculate the ratio of red to purple form in a fruit juice buffered at pH 3.00 and hence predict its colour

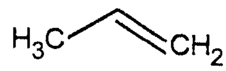
---

A7 How much of the solid sodium hydroxide must be added to 1 dm^3 of water in order to dissolve 0.10 mol of amphoteric zinc hydroxide according to following equation.

$Zn(OH)_2 + 2OH^- \rightleftharpoons Zn(OH)_4^{2-}$ K_{sp} for $Zn(OH)_2$ is 4.5×10^{-17} and K_f for the formation of $Zn(OH)_4^{2-}$ is 2.8×10^{15}

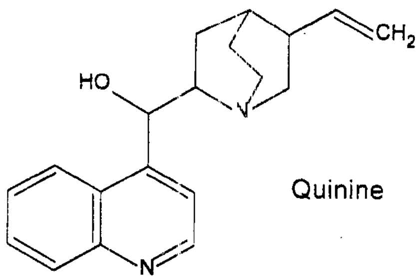
A8. Arrange the following compounds in order of increasing acidity and state briefly the reasons for your order.





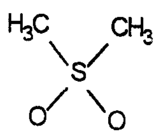
A9. (a) What is a functional group?

(b) Quinine is a powerful drug against malaria. Write any three- (03) functional groups you can identify in the quinine molecule shown below.



Quinine

A10. (a) Calculate the formal charges on the sulfur atom in the dimethyl sulfone molecule shown below.



Dimethyl sulfone

(b) Applying the concept of formal charges write the correct molecular structure of the dimethyl sulfone.

SECTION B — ANSWER B1 AND ANY THREE QUESTIONS

B1 A C102 student wants to determine the order of reaction for the reaction between potassium iodate and potassium iodide with respect to potassium iodide. He followed the same procedure as lab 3 "**The study of reaction rate I – concentration**" but varied the concentration of potassium iodide instead of potassium iodate.

A set of results obtained by this student are given in the table below. The volumes of potassium iodide solution were measured using a measuring cylinder. The times taken for the mixture to turn blue were recorded on a stop-clock graduated in seconds.

Experiment	Volume of potassium iodide	$\log_{10}$(volume of KI) solution/cm^3	time/s	$\log_{10}$(1/time)
1	5.0	0.70	68	−1.83
2	8.0	0.90	45	−1.65
3	10.0	1.00	36	−1.56
4	15.0	1.18	25	−1.40
5	20.0	1.30	22	−1.34
6	25.0	1.40	16	−1.20

Answer the following questions:

(a) Use the results given in the table to plot a graph of $\log_{10}$ (1/time) on the y axis against $\log_{10}$ (volume of KI). Draw a straight line of best fit on the graph, ignoring any anomalous points.

(b) Determine the gradient of the graph.

(c) Consider your graph and comment on the results obtained from the investigation. Is your line of best fit good enough for you to deduce an order with confidence? Identify any anomalous results.

(d) State **two** ways in which the method of performing this experiment could be improved, other than by repeating the experiment. In each case, explain why the accuracy of the experiment would be improved.

B2 A solution that was prepared by dissolving 46.0g of glycerol ($C_3H_8O_3$) in 250 g of water (H_2O) at 25°C was heated at constant temperature in a closed container. After some minutes, it was observed that the volume of the solution started decreasing as the pressure above the solution was increasing. Then, after a few minutes again, it was observed that there was no change in the volume of solution and the pressure above the solution remained constant despite continued heating at constant temperature.

(i) If the vapour above the solution was isolated and heated to 139°C and then allowed to cool to –10 °C, sketch the cooling curve of this vapour and clearly indicate the 5 stages that it will undergo during cooling

(ii) State two factors that affect vapour pressure

(iii) Calculate the boiling point of solution at 101325Pa

(iv) Calculate the freezing point of the solution

(v) Calculate the vapour pressure of the solution at 25°C, if the vapour pressure of water at 25°C is 3173.1Pa

(vi) If the osmotic pressure of this solution at 25°C is 0.245 atm and that of 2.0m potassium iodide at 25°C is 0.465atm. Calculate the van't Hoff factor.

B3 The label on the bottle of white wine describes it as containing 12% v/v alcohol (C_2H_5OH) and having a total acidity of 7 g dm^{-3}.

(a) Assuming the alcohol content is 120 g dm^{-3} of wine, calculate the concentration of ethanol in $moldm^{-3}$.

(b) (i) What do you understand by the terms weak and strong when applied to acids?

(ii) An aqueous solution of an acid HA of concentration 0.010 $moldm^{-3}$ has a pH of 2.0. Explain with reasons whether HA is strong or weak acid.

(c) Assume that the acid present is tartaric acid which behaves effectively as RCOOH (M_r = 150).

Calculate

(i) The concentration in moles dm^{-3} of tartaric acid.

(ii) pH of the wine.

(K_a= 1.0 x 10^{-3} mol dm^{-3})

(d) On keeping for sometime wine develops a fruity taste as the following equilibrium is set up

$$RCOOH + C_2H_5OH \rightleftharpoons RCOOC_2H_5 + H_2O$$

(i) Write an expression for equilibrium constant K_c. The equilibrium concentration of $RCOOC_2H_5$ is 0.015 $moldm^{-3}$. Calculate the equilibrium concentration of tartaric acid and ethanol.

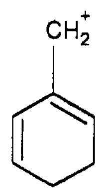
(ii) Assuming concentration of water remains constant at 50.0 $moldm^{-3}$ throughout calculate K_c and the final pH of the wine.

B4 There are four isomeric compounds with the molecular formula C_3H_6O.

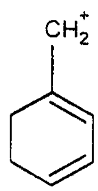
(a) (i) Write the structures of any three (03) isomers and classify each isomer according to its functional group.

(ii) Applying the IUPAC Rules of nomenclature, write the names of each of the isomers in (a) (i) above.

(b) Reactive species **A** and **B** shown below have the same molecular formula C_7H_7 and both are primary carbocations. Applying an appropriate concept for stability show which one of the two species is more stable? (Molecular structures must be shown)



Reactive species **A**



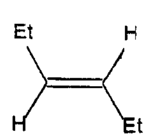
Reactive species **B**

(c) The following names are incorrect. Propose their skeletal (bond line) structures and provide their proper IUPAC names.

(i) 1-Hydroxy-4, 4-dimethylcyclohexane

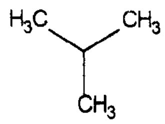
(ii) 2-Isopropyl-4-methylpentane

B5 (a) When 3-hexene, structure shown below, is mixed with bromine in the presence of carbon tetrachloride, the brown colouration of the reaction mixture disappears immediately. Write the mechanism of this reaction showing clearly how the bromide ions are added to the 3- hexene.

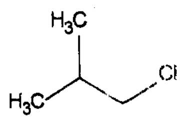


3-hexene

(b) Predict the products of the following reactions: ***(Write the products only)***

(i)  $\xrightarrow[hv]{Cl_2}$ **C** (Mono chlorinated product)

(ii) Product **C** $\xrightarrow[\text{Dry ether}]{Mg}$ Product **D**

(iii) Product **D** +  $\xrightarrow{\text{Dry ether}}$ Product **E**

(c) n-Butane is a gas that is used in cigarette lighters. If you were provided with ethyl bromide, ethyl iodide, copper (I) iodide and lithium metal show how you would synthesise n-butane in a laboratory using pentane as a solvent.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

INTRODUCTORY BIOCHEMISTRY- C212

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

INSTRUCTIONS TO CANDIDATES:

WRITE YOUR COMPUTER NUMBER ON ALL ANSWER BOOKLETS

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

SECTION **A: ANSWER ALL QUESTIONS.**

SECTION **B. ANSWER ANY THREE QUESTIONS**

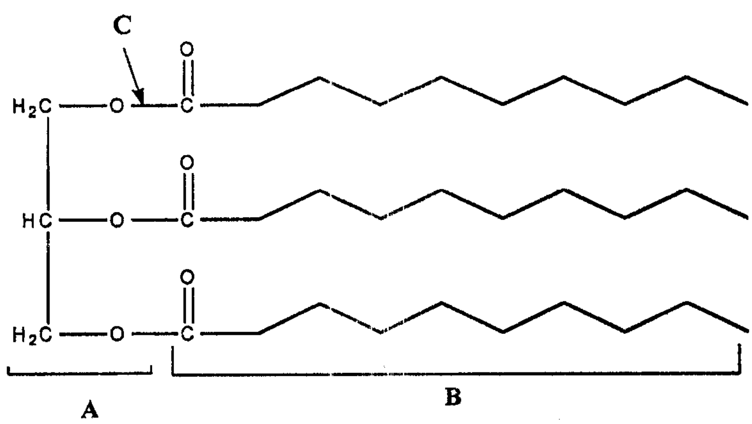
ALL QUESTIONS CARRY EQUAL MARKS

SECTION A ANSWER ALL QUESTIONS

A1. a) Glucose exists in two forms, a linear form and a ring form. Show how to form the ring form of glucose from the linear from. Mention the name of this form of glucose.

b) Write the chemical structure of lactose, its monosaccharides and the type of bond it has.

c) The diagram below shows a structure of a lipid molecule



i) Name the parts labeled A, B and C.

ii) Name this type of lipid

iii) Name the chemical reaction used to form the bonds between A and B

iv) State one function of this type of lipid in living organisms

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A2. a) Draw the structures of the following biomolecules.
i) glutamate ii) tripeptide of Gly-ala-val

b) What is the meaning of the terms amphoteric and zwitterion?

c) Why are proteins important for all organisms?

d) Name two elements likely to be found in proteins but not in carbohydrates or fats?

SECTION B ANSWER ANY THREE

B1. a) The enzyme that determines the rate of glycolysis is phosphofructokinase. Explain how this enzyme is regulated

b) Which reactions in the glycolytic pathway are irreversible? Give one reason why these reactions irreversible.

c) How many ATP molecules are generated when 1 mole of glucose is broken down by the glycolytic pathway?

d) Explain the fate of pyruvate under aerobic and anaerobic conditions. Is NADH generated in these processes? Explain.

e) True or False. Is DHAP a direct substrate of glycolysis?

B2. a) The pK_a of formic acid is 3.77 at 25 °C. What is the pH of a 0.01M solution of formic acid in water? (Formula HCOOH)

b) What is a buffer?
A buffer has the following composition: 0.001 M acetate ,0.001 M acetic acid and pH=5. If 1 ml of 0.01 M HCl is added, what will be the pH change if pKa of acetic acid is 4.76 and assuming that volume remains constant?

B3. The Michaelis-Menten equation $v = \frac{V_{max}[S]}{K_M + [S]}$ can be used to derive an alternative equation, the Lineweaver-Burk equation. This gives a linear plot when the reciprocal of velocity and substrate concentration are plotted.

a) Derive the LWB equation from the MM equation above.

b) Use the LWB equation to plot the following set of data and estimate K_m and V_{max} in the absence and presence of inhibitor. What type of inhibition is this?

	Velocity(μmoles/min)	
$[S] \times 10^{-5}$	No inhibitor	Inhibitor
0.3	10.4	4.1
0.5	14.5	6.4
1.0	22.5	11.3
3.0	33.8	22.6
9.0	40.5	33.8

B4. The following information is found on the label for a food drink per 100g. This will help you answer parts a, b and c.

Fat	8.5g
Protein	7g
Carbohydrate	73g

a) Using the standard conversion factors, calculate the energy yield of this drink if a male takes a total of 10g.

b) Will this energy be sufficient to meet the daily requirements of a male whose RDA is 2900kcal of energy?

c) If in addition to the drink he now takes four glasses of wine (25ml each), 15g margarine and 400g steak, will his RDA be met energy wise? Density of wine is 1.5 g/ml.

d) If this man is 70kg and has a height of 1.75m, what is his BMI?

B5 a) Protein hierarchy follows the following sequence; primary, secondary, tertiary and quartenary. Write a note on each giving examples of outstanding features in each level

c) Explain the principles underlying any two of the following biochemical techniques

i. I.E.F

ii. 2 Dimensional Electrophoresis

iii. Salting in and salting out

END OF EXAMNINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY
2005 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS
C225: ANALYTICAL CHEMISTRY
TIME: 3 HOURS

ANSWER QUESTION 1 AND ANY 4 OTHER QUESTIONS IN THIS PAPER

1. (a) A sample has been analysed several times using UV– visible spectrophotometer and gave the following absorbances:

    0.5026, 0.5029, 0.5023, 0.5031, 0.5025, 0.5032, 0.5027, 0.5026

    Calculate the mean, standard deviation and the 95 % confidence limits of the mean

   (b) Vitamin B_2 in pumpkin seeds was determined by measuring its fluorescence intensity. A calibration curve was prepared by measuring the fluorescence intensities of a series of standards of increasing concentration. The following data was obtained.

Fluorescence intensities:	2.1	5.0	9.0	12.6	17.3	21.0	24.7
Concentration in pg/L :	0	2	4	6	8	10	12

   i) Calculate the slope, intercept and the hence derive the regression line.
   ii) If the sample extracted from the pumpkin seeds gave a fluorescence intensity of 4.5 what was the concentration in μg/L?

2. (a) Briefly explain the Mohr titrations and give reasons why pH control is important for this titration.

   (b) In the standardisation of silver nitrate ($AgNO_3$), a student weighed 1.5g of sodium chloride, which had been dried at 120°C for 2 hrs, and dissolved it in a 250 mL volumetric flask and made up to the mark. She transferred 25.0 mL of this solution into a conical flask and titrated it with $AgNO_3$ solution.
   (Na = 23.00, Cl = 35.45)
   (i) Calculate the concentration of $AgNO_3$, if 35.2 mL of $AgNO_3$ was required to reach the end point
   (ii) What possible indicator would you use and what will be the indication of endpoint?

   (c) With the help of chemical equation(s), explain how too concentrated and too dilute indicator you proposed to use in 2 (b) (ii) would affect the end point.

   (d) Given that the solubility product of Ag_2CrO_4 is 1.1×10^{-12}, would you expect a precipitate to form in a solution resulting from addition of equal volumes of 0.00015M of $AgNO_3$ and 0.0000025M Na_2CrO_4, assuming no volume changes?

3.(a) A 2.6 g sample of the plant tissue was analyzed and found to contain 3.6μg Zinc. What is the % of Zinc in the plant tissue?

(b) 25.0 μL serum sample was analyzed for glucose content and found to contain 26.7 μg.

Calculate i) the concentration in mg/L,

ii) the new concentration in ppm, if the serum sample in 3 (b) was diluted to 1mL with glucose free serum.

(c) The ore contains 5 % Mn on a dry weight basis. If a wet ore sample weighing 6.00 g and has 20% moisture content is dissolved and diluted to $100cm^3$. What is the molarity of Mn in this solution? (Mn = 54.94)

(d) A solution contains 12.6 ppm of dissolved $(NH_4)_2SO_4$ (which completely dissociate into NH_4^+ and SO_4^{2-}). Calculate the concentration of NH_4^+ in g/L (N= 14.00, H = 1.00, S = 32.00, O = 16.00)

4. (a) Define the term polyfunctional acid

(b) Calculate the equilibrium concentrations of different species in a 0.01M phosphoric acid solution at pH = 5 (K_{a1}=$1.1x10^{-2}$, K_{a2} =$7.5x10^{-8}$, K_{a3} =$4.8 x10^{-13}$).

(c) What would be the pH at 0.0 mL and 50.0 mL addition of the titrant for the titration of 50.0 mL of 0.100M acetic acid with 0.100M NaOH. K_a of acetic acid is $1.75x10^{-5}$

5. (a) Explain briefly what is meant by gravimetric analysis

(b) State the steps required in the gravimetric analysis

(c) What problems are encountered in precipitate formation and state briefly how you would minimise each problem .

(d) Aluminium in an ore sample is determined by dissolving it and then reprecipitating with a base as $Al(OH)_3$ and igniting to Al_2O_3, which is weighed. What weight of Aluminium was in the sample if the ignited precipitate weighed 0.2385g (Al = 26.98, O = 16.00, H = 1.00)

6 (a) What do you understand by the terms complex formation equilibrium constant and complex dissociation equilibrium constant? Show how the two are related.

(b) Calculate the complex formation equilibrium constant for the two–coordinate $Fe(SCN^{-})^{+}_{2}$ complex ion from the following data:

$Fe^{3+}(aq) + SCN^{-}(aq) \Leftrightarrow Fe(SCN)^{2+}$ $\quad K_{f1} = 890$

$Fe(SCN)^{2+} + SCN^{-}(aq) \Leftrightarrow Fe(SCN^{-})^{+}_{2}$ $\quad K_{f2} = 2.6$

(c) Describe ways in which the end point of the redox titrations can be detected (include 2 examples of this)

(d) A solution of $Na_2S_2O_3$ is standardized iodometrically against 0.126g of $KBrO_3$ needing 44.97 mL of $Na_2S_2O_3$. What is the molarity of $Na_2S_2O_3$?

[$BrO_3^- + 6$ I- +6H+ $\rightarrow Br^- + 3I_2 + 3H_2O$, $\quad 3I_2 + 6S_2O_3^{2-} \rightarrow 6I^- + 3S_4O_6^{2-}$]

[$KBrO_3$ (MW) = 167.01]

ANNEX

VALUES OF t FOR V DEGREES OF FREEDOMS FOR VARIOUS CONFIDENCE LEVELS.

V	CONFIDENCE LEVEL 90%	95%	99%	99.5%
1	6.314	12.706	63.657	127.32
2	2.920	4.303	9.925	14.089
3	2.353	3.182	5.841	7.453
4	2.132	2.776	4.604	5.598
5	2.015	2.571	4.032	4.773
6	1.943	2.447	3.707	4.317
7	1.895	2.365	3.500	4.029
8	1.860	2.306	3.355	3.832
9	1.833	2.262	3.250	3.690
10	1.812	2.228	3.169	3.581
15	1.753	2.131	2.947	3.252
20	1.725	2.086	2.845	3.153
25	1.708	2.060	2.787	3.078
∞	1.645	1.960	2.576	2.807

Values of F at 95% confidence level

	$v_1 = 2$	3	4	5	6	7	8	9	10	15	20	30
$v_2 = 2$	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.5
3	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.70	8.66	8.62
4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.86	5.80	5.75
5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.62	4.56	4.50
6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	3.94	3.87	3.81
7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.51	3.44	3.38
8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.22	3.15	3.08
9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.01	2.94	2.86
10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.85	2.77	2.70
15	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.40	2.33	2.25
20	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.20	2.12	2.04
30	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.01	1.93	1.84

TABLE. A3

REJECTION QUOTIENT, Q, AT DIFFERENT CONFIDENCE LIMITS

Number of observation	Confidence Level		
	Q90	Q95	Q99
3	0.94	0.970	0.994
4	0.76	0.829	0.926
5	0.64	0.710	0.821
6	0.56	0.625	0.740
7	0.51	0.568	0.680
8	0.47	0.526	0.634
9	0.44	0.493	0.598
10	0.41	0.466	0.568
15	0.338	0.384	0.475
20	0.300	0.342	0.425
25	0.277	0.317	0.393
30	0.260	0.298	0.372

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY
SEMESTER II, 2005
PHYSICAL CHEMISTRY C265

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.

Useful Information and Constants:

R= 8.314 $J mol^{-1} K^{-1}$, h= 6.63×10^{-34} Js, $N_A = 6.02 \times 10^{23}$ mol^{-1}, k_B= $1.381 \times 10^{-23} JK^{-1}$,
1 atomic mass unit = 1.6605×10^{-27} kg, V_m = 22.4 dm^3 mol^{-1}, F = 96 500 C mol^{-1}

Atomic mass/g mol^{-1}: Cu 63.5, Ag 108

$Ag^+(aq) + e^- \rightarrow Ag(s)$ $E° = +0.80$ V
$Cu^+(aq) + 2e^- \rightarrow Cu(s)$ $E° = +0.34$ V
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$ $E° = -0.76$ V

SECTION A: Answer all questions

A1. A sample of air held in a graduated cylinder over water has a volume of 88.3 mL at a temperature of 18.5 °C and a pressure of 741 mmHg. What would the volume of air be if it were dry and at the same temperature and pressure? (Vapour pressure water at 18.5 °C, 16 mmHg).

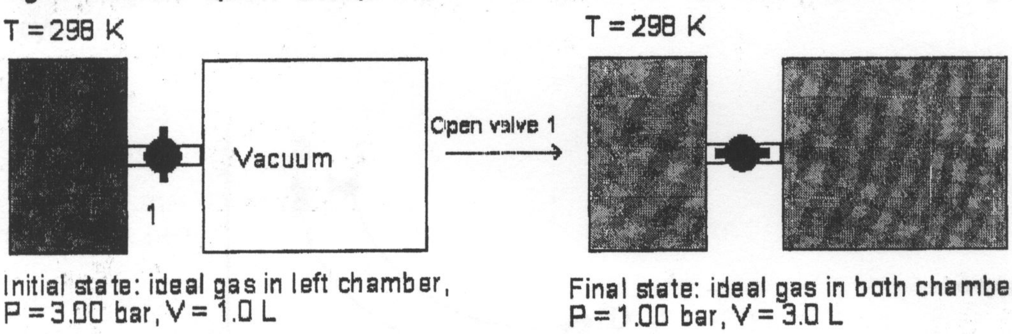
A2. A 20 g chunk of dry ice (CO_2) is placed in an "empty" 0.75 litre wine bottle and tightly corked. What would be the final pressure in the bottle after all the CO_2 has evaporated and the temperature has reached 25 °C?

A3. (a) For a fixed amount of gas at constant pressure, the temperature of the gas is found to increase when the volume increases. Explain.

(b) A balloon is inflated to a volume of 2.5 L in a warm living room (25 °C). Then it is taken outside on very cold winter's day (– 24 °C). Assume that the quantity of the gas and the pressure remain constant. What will be the volume of the balloon when it is outdoors?

A4. The dissociation constant of water $2H_2O\ (l) \leftrightarrows H_3O^+(aq) + OH^-(aq)$ changes from 1.0×10^{-14} at 25 °C to 9.62×10^{-14} at 60 °C. Does the pH of water or its neutrality change when the temperature is increased from 25 °C to 60 °C?

A5 The diagram below depicts an experimental set-up involving an ideal gas.



(a) Describe the process occurring on opening the tap.

(b) Calculate heat, work, and the change in internal energy in this process.

A6 What are the values of K_p for the equilibrium between liquid water and its vapour at 25 °C, 100 °C , and 120 °C ? The vapour pressure of water at these three temperatures is 23.8 torr, 760 torr and 1489 torr respectively. Comment on the type of system used at the different temperatures.

A7 (a) What do you understand by the term *rate law for a reaction*?

(b) 'A' reacts with 'B' in a one-step reaction to give 'C'. The rate constant for the reaction is 2.0×10^{-3} M^{-1} sec^{-1}. If 0.50 mole of 'A' and 0.30 moles of B are placed in a 0.5 litre-box, what is the initial rate of the reaction?

A8 Given $Zn(s) \rightarrow Zn^{2+}(aq) + e^-$, calculate E for a Zn electrode in which Zn^{2+} = 0.025 M

SECTION B: Answer any four (4) questions

B1 (a) A chemist carried out the following reaction in the laboratory at 25 °C.

$$CO(g) + \frac{1}{2} O_2(g) \rightarrow CO_2(g) \quad \Delta E = -282 \text{ kJ}$$

Calculate ΔH for the reaction.

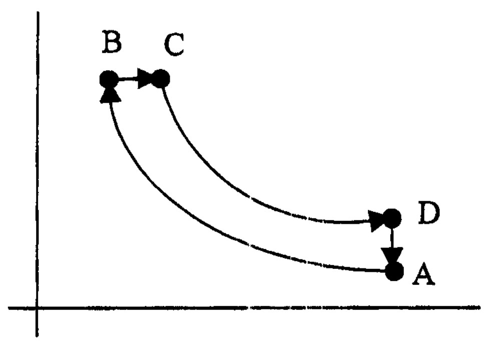
(b) (i) What is meant by the term standard enthalpy change of combustion?

(ii) When 1.00 g of ethanol was burnt under a container of water, it was found that 100 g of water was heated from 15 °C to 65 °C. The process was known to be 70 % efficient. Calculate the enthalpy change of combustion per mole of ethanol. (Specific heat capacity of water 4.18 J g^{-1} K^{-1})

(c) Using the data calculated in (b) above and the data provide below, calculate the enthalpy change of formation of ethanol from its elements.

Enthalpy change of formation of carbon $= -393.5$ kJ mol^{-1}
Enthalpy change of formation of hydrogen $= -285.8$ kJ mol^{-1}

(d) The diagram below shows a $p - V$ diagram for an idealised diesel engine cycle.



Describe and identify the four types of processes involved in the diesel cycle depicted above.

B2 (a) State Le Chatelier's principle

(b) In relation to the following equilibria,

Equilibrium 1: $H_2O(g) + C(s) \rightleftharpoons H_2(g) + CO(g) \quad \Delta H = +131 \text{kJ mol}^{-1}$
Equilibrium 2: $2CrO_4^{-}(aq) + 2H^+ \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$

Use the Le Chatelier principle to predict and explain the effect of

(i) increasing the pressure on Equilibrium 1
(ii) increasing the temperature on Equilibrium 1
(iii) increasing the $[H^+(aq)]$ on Equilibrium 2

(c) Calculate the enthalpy change, $\Delta H°$, for the reaction

$$N_2(g) + O_2(g) \leftrightarrows 2NO(g),$$

given the equilibrium constants 4.08×10^{-4} for a temperature 2000 K and 3.60×10^{-3} for a temperature of 2500 K.

(d) The skeletons of several varieties of microscopic organisms that inhabit the oceans are made of $CaCO_3$, consequently there is a continual rain of this substance toward the bottom of the ocean which forms a blanket of $CaCO_3$. This is not true for Pacific Ocean, except for undersea mountains, which is deeper than the Atlantic Ocean. Explain this observation.

B3 (a) (i) What do you understand by the terms *strong* and *weak* acids?

(ii) An aqueous solution of HA of concentration 0.01 mol dm^{-3} has a pH of 2.0. Explain with reasons whether HA is a strong or weak acid.

(b) Explain why solutions containing aluminium ions, Al^{3+}, are often acidic. (Hint: it is thought that the ion $Al(H_2O)6^{3+}(aq)$ is present.)

(c) Blood is maintained at a pH of 7.4 by the so called primary buffers in the plasma and secondary buffers in the erythrocytes. Identify the buffers in plasma responsible for maintaining pH and explain how these buffers prevent the pH of blood decreasing.

(d) Use the following standard-state free energy of formation data to calculate the acid-dissociation constant (K_a) of formic acid:

Compound	$\Delta G_f°$(kJ mol^{-1})
$HCO_2(aq)$	-372.3
$H^+(aq)$	0.00
$HCO_2^-(aq)$	-351.0

B4 (a) According to Connors et al (Chemical stability of pharmaceuticals,2nd Ed, New York, 1986), the first order rate constant K_1, for the decomposition of ampicillin at pH 5.8 and 35 °C is $K_1 = 2 \times 10^{-7}$ sec^{-1}. The solubility of ampicillin is 1.1 g/100 mL. If it is desired to prepare a suspension of a drug containing 2.5 g/100 mL, calculate

(i) the zero-order rate constant

(ii) the shelf-life, i.e. the time in days required for the drug to decompose to 90% of its original concentration (at 35 °C) in solution.

(ii) If the drug is formulated in solution rather than in suspension at this pH, what is the shelf life?

(b) Garret and Carper (J. Am Pharm. Assoc., Sci. Ed. 44, 515, 1955) determined the zero-order rate constant for the degradation of a multisulfa preparation. The results obtained at various temperatures are shown below:

°C	40	50	60	70
k	0.00011	0.00028	0.00082	0.00196

(i) Plot these results according to the Arrhenius relationship and compute the activation energy E_a.

(ii) Extrapolate the results to 25 °C to obtain *K* at room temperature.

(iii) The rate of decrease of absorbance of the coloured preparation at a wavelength of 500 nm was found to be zero-order and the initial absorbance A_0 was 0.470. This preparation should be rejected when the absorbance falls to below 0.225. Predict the predicted shelf-life of the preparation at 25 °C.

B5 (a) Distinguish between primary and secondary batteries. Give one example of each type.

(b) A student took out her car battery from the car after it developed a serious fault. After a long time she was able to have her car repaired but was surprised that her battery was "flat". Explain why the battery was no longer working despite being relatively new.

(c) Electro-refining is process used to produced high purity grade copper. Copper obtained from the initial stage of processing contains impurities of some zinc and silver. Describe in detail how this impure copper is purified electrolytically, explaining what happens to the zinc and silver impurities. Use relevant E° data.

(d) Using inert electrodes, a current was passed through two beakers containing aqueous silver nitrate and aqueous copper(II)sulphate, connected in series. After 30 min, 0.100 g of silver was deposited from the first solution

(i) How many moles of silver were deposited?
(ii) How much current passed?
(iii) What mass of copper was deposited from the aqueous copper(II)sulphate?

END OF EXAMINATION

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END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

BIOCHEMISTRY- C312

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

INSTRUCTIONS TO CANDIDATES:

WRITE YOUR COMPUTER NUMBER ON ALL ANSWER BOOKLETS

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

SECTION **A: ANSWER ALL QUESTIONS.**

SECTION **B. ANSWER ANY THREE QUESTIONS**

ALL QUESTIONS CARRY EQUAL MARKS

SECTION A ANSWER ALL QUESTIONS

A1. a) Define photosynthesis. Explain why photosynthesis is important for all organisms

b) Draw a labeled diagram of a chloroplast as seen with an electron microscope. Show clearly on the diagram where the chlorophyll is found within the chloroplast.

c) Name the metallic element that occurs in chlorophyll a and b

d) Give one oxidation reaction and another reduction reaction that occur in the light-independent stage of photosynthesis. Which enzyme fixes carbon dioxide during photosynthesis.

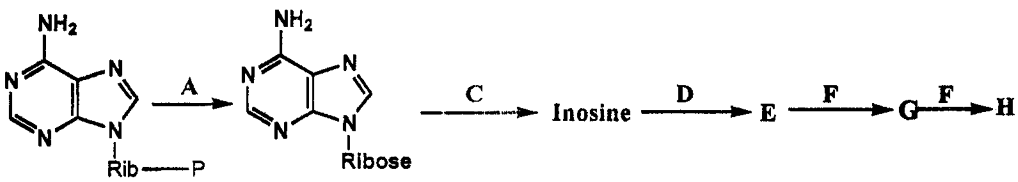
e) Under what conditions does a C_4 plant have an advantage over a C_3 plant? Where does CO_2 fixation occur in a C4 plant? Give tow examples of such C_4 plants.

A2. After complete hydrolysis, a lipid yielded the following composition: 1 mole of oleic acid, 2 moles of palmitic acid and 1 mole of glycerol. How much energy will you get from complete oxidation of the lipid contents if hydrolysis of ATP to ADP =7.3kcal/mol?

SECTION B ANSWER ANY THREE

B1. a) Using unique symbols as radioisotope tags, draw a well labeled diagram of the purine skeleton ring. Explain by indicating the label in the precursor compounds.

b) Answer the following questions with the help of the diagram below



AMP B

i. Give the name of the enzyme A.

ii. What is the compound labeled B?

iii. What genetic condition will be present when enzyme C is defective?

iv. Draw the structure of inosine

v. What is the other product of enzyme D?

vi. Name product E

vii. Apart from E and G, name the common reactants for enzyme F.

viii. Suggest the name of a potent inhibitor of the enzyme labeled F

ix. True or False. All purines degrade to compound G.

x. What condition occurs when excess H accumulates in body fluids?

B2. Discuss the various mechanisms that ensure fidelity in the biosynthesis of the following biomolecules: a) DNA b) RNA and c) protein.

B3. Elucidate the first three common degradation reactions of branched chain amino acids giving names of all compounds, enzymes and co-enzymes

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B4. How many factors are involved the initiation stage of protein synthesis? List the functions of these factors and also explain the GTPase timer mechanism the process of protein synthesis.

B5 Write short notes on DNA polymerase III and RNA polymerase II. What are the functions of the following protein subunits?

a) Tau (τ)

b) Sigma (σ)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF CHEMISTRY

EXAMINATION C 322, 2005

Answer any four questions, each question has 25 points.

Time: Three hours

1. A, Explain the principle of electro gravimetric method and draw the scheme for it.

   B, A solution containing 85.0mg of copper was electrolyzed at a constant current of 0.350A, causing metallic copper to deposit on a Pt cathode. What was the percentage of copper remaining in the solution after 16.0 min?

   C, A solution contains 0.10 M silver (E^0 = 0.799V) and 0.10 M copper (E^0=0.337V). We wish to separate the silver from the copper by plating it out on a platinum cathode at controlled current. Calculate the percent of silver remaining in solution when its decomposition potential due to its decreasing concentration becomes equal to that required for the decomposition of copper. Assume no over voltage, concentration polarization, or IR drop; that is decomposition potential = back emf.

   D, Explain the principle of potentiometric titration?.
   What are the differences between potentiometric titration and amperometric titration respectively? Draw a graph for them.

   E, Explain glass membrane electrocle and identify all potential in it.

   F, Explain function potential, boundary potential, asymmetry potential, alkaline and acid error in glass electorde in it.

G, A sample of vanadium are weighing 6.317g was dissolved in acid and passed through reductor. The resulting solution was collected in a 100.0 ml volumetric flask and diluted to mark with 0.1M HCl. A 20.0 ml aliqust of the prereduced solution required 18.74 ml 0.01146M KMn04 to reach the end point.

Calculate the percentage of V_2O_5 in the ore (M.M. V_2O_5 = 181.88)

2. A, Explain principle of coulometric method.

Sketch the scheme for coulometric titration.

B, A protein sample is analyzed by a Kjeldahl procedure by digesting it with sulfuric acid to convert protein nitrogen to ammonium sulfate. The ammonia produced is determined by adjusting the pH to 8.6 and titrating coulometrically with electrogenerated hypobromite.

$$Br^- + 2OH^- \rightarrow O\,Br^- + H_2O + 2e$$

$$2NH_3 + 3O\,Br^- \rightarrow N_2 + 3\,Br^- + 3\,H_2O$$

If the titration is performed using 19.30 miliampers current and the end point occurs at 120.0 seconds, how many milligrams protein were present in the sample?

One gram of nitrogen is contained in each 6.25g protein.

C, For the determination in question 2b, you are asked to design a constant – current source that will read out directly in micrograms of protein titrated.

What current must it supply so that seconds of titration will be equal to micrograms of protein?

D, A 2.000g sample of iodized salt is dissolved in H_2O and electrolyzed at 0.72 V vs. SCE to oxidized I^- to I_2. A charge of 150 mC passes before the current reaches its residual current value 15 µ A. Electrolysis time is 31 min

Calculate the percentage of KI in the salt (M.M. KI = 166.01)

E, Trace of $C_6H_5NH_2$ can be determined by reaction with an excess of electronically generated Br_2

$$C_6H_5NH_2 + 3\ Br_2 \rightarrow C_6H_3B_3NH_2 + 2H^+ + 3Br^-$$

The polarity of the working electrole is then reversed, and the excess Br_2 is determined by a coulometric titration involving the generation of Cu (I)

$$Br_2 + 2Cu^+ \rightarrow 2Br^- + 2Cu^{2+}$$

Suitable quantities of KBr and Cu SO_4 were added to a 250 ml of sample containing aniline.

Calculate the number of micrograms of C_6H_5 NH_2 in the sample from the data: (Aniline: 93.12)

Working Electrode Functioning As	Generation Time with a Constant Current of 1.51m A, min
Anode	3.76
Cathode	0.270

3 A, Explain the principle of polarographic method and draw the scheme for polarography.

B, Explain pulse polarography and basic differences with classical palorography.

C, Characterize diffusion current, kinetic current, adsorption current and residual current.

D, The diffusion current of lead in an unknown solution is 5.6 μA. One milliter of a

1.00mM lead solution is added to 10.0 ml of the unknown solution and the diffusion current of the lead is increased to 12.2μA.

What is the molar concentration of lead in the unknown solution? (A.M. Pb = 207.19)

E, Calculate the diffusion coefficient of zinc. The concentration of zinc in polarophic cell is 0.5 mM, diffusion current is 4.5μA; calculate m and t from (100 drops of Hg falls after 4.0 min with a weight of 0.360g) (A.M.Zn = 65.37)

F, An organic substance is reduced polarographically. At a concentration of 2 mM, it gives a wave with diffusion current 0.12μA when a capillary with a flow rate 3.4 mg/second and a drop time of 2.7 seconds is used. If the diffusion coefficient of the compound in the supporting electrolyte has been determined by other means to be 0.9 $X10^{-5}$ cm^2 / second, what is the Z value for the polarographic reduction of the compound?

G What is the relative decrease of concentration of Cd^{2+} in percentage after electrolysis on the mercury drop electrode which lasts 10 minutes? Electrolysis is provided on the potential of the limit diffusion current. Suggest the current at which the elctronysis is constant.

Condition: (200 drops/10 min weight 1.20g, D = 9.0 $X10^{-6}cm^2$ /s C = 1m M and V = 10.0 ml) (A.M.Cd = 112.40).

4 A Define

(i) Mobile phase

(ii) Stationery phase

(iii) Retention time

(iv) Partition ratio

(v) Capacity factor

(vi) Selectivity factor

(vii) Plate height

(viii) Longitudinal diffusion

(ix) Eddy diffusion

(x) Column resolution

B, The retention time of an organic compound on a 100 cm liquid chromatographic column was 10.0 min. The width of the chromatographic peak was 24 s. Calculate the height equivalent of a theoretical plate for the column?

C, Calculate the resolution between two adjacent chromatographic peaks which have retention time of 22.9 and 27.5 min, and peak widths of 5.8 and 6.1 min

D, The following data were obtained by gas liquid chromatography on a 50 – cm packed column.

Compound	tR, min	W½, min
Air	1.9	-
Methyliyclohexane	10.0	0.76
Methyliyclohexene	10.9	0.82
Toluene	13.4	1.06

Calculate:

1. an average number of plates from the data
2. the average plate height for the column
3. calculate the resolution for methylcyclohexane and methylcyclohexene
4. calculate the resolution for methylcyclohexene and toluene
5. calculate the resolution for methylcyclohexane and toluene

E, If V_s and V_m for the column were 19.6 and 62.6 ml respectively, and non retained air peak appeared after 1.9 min calculate:

1. capacity factor for each of the three compounds
2. partition coefficient for each of the three compounds
3. selectivity factor for methylcyclohexane and methylcyclohexene
4. selectivity factor for methylcyclohexene and toluene
5. selectivity factor for methyliclohexane and toluene.

5 A, Explain the principle of gas chromatography and sketch the scheme for it.

B, Explain relationship between specific retention volume Vg and partition coefficient K in all forms which you know.

C, Describe the detector which do you know for gas chromatography and sketch them.

D, Explain briefly High-performance liquid chromatography (HPLC), and sketch the scheme for it.

E, Use the retention data given below to calculate the retention index of 1-hexene.

Sample	Retention time (min)
Air	0.571
n-petance	2.16
n-hexane	4.23
n-hexene	3.15

A GLC column was operated under the following conditions: column.

1.10 X 2.0mm packed with chromosorb P, weight of stationery liquid added, 1.40g; density of liquid 1.02g/ml, pressure: inlet 25.1 psi above room; room 748 torr measured outlet flow rate: 24.3 ml/min

temperature: room 21.2°C; column, 102.°0

retention times: air, 18.05 methylacetate 1.98 min methylpropionate 4.16 min, methyl n- butyrate, 7.93 min peak widths at base: 0.19, 0.39 and 0.79 min respectively, calculate:

(i) the average flow rate in the column

(ii) the corrected retention volumes for air and three esters

(iii) the specific retention volume for the three components

(iv) partition coefficients for each of the esters

(v) a corrected retention volume and a retention time for methyl n-hexonate

G, Calculate from 5e part

(vi) k^1 for each compound

(vii) α values for each adjacent pair of compounds

(viii) The average number of theoretical plates and plate height for the column

(ix) The resolution for each adjacent pair of compounds.

The University of Zambia
School of Natural Sciences
2005 Academic year second semester
Final Examinations
C342 Inorganic Chemistry 111

TIME: THREE HOURS
Instructions: Answer any FOUR questions.
All questions carry equal marks.

---

1. (a) Propose a structure for $Ir_4(CO)_{12}$. All carbonyls vibrate in a single frequency. Find the electron count on the metal.

   (b) Show with drawings the two important types of orbital overlap that explain the metal-alkene bonding in $[PtCl_3C_2H_4]^-$.

   (c) Give the oxidative addition product of $Pt(PPh_3)_4$ and $(CF_3)_2CO$. What are the factors on which the equilibrium
   $L_mM^n + XY \rightleftarrows L_mM^{n+2}XY$ depends?.

2. (a) The reactions of $Ni(CO)_4$ in which phosphanes or phosphites replace CO to give the family $Ni(CO)_3L$ occur at the same rate for different phosphanes or phosphites. Is the reaction dissociative (D) or associative(A)?. Why?. Also give the rate law.

   (b) What are the major barriers to electron transfer reactions proceeding through an outer sphere mechanism?. What constitute the activation energy of such a reaction?.

   (c) $I^- > Br^- > Cl^- > F^-$
   From the above given mini trans effect series explain why I^- is a better trans director than Cl^- by considering σ effects (or any other theory of your choice).

3. (a) H_2SO_4 has been used to prepare stable solution of ions which cannot exist in more basic solvents like water. For example, when I_2 and HIO_3 in mole ratio 7.0 are dissolved in H_2SO_4, the I_3^+ cation is formed. Write the balanced equation.

(b) Complete the reaction and explain the action of $e^-_{(am)}$.

$Mn_2(CO)_{10} + 2e^-_{(am)} \rightarrow$

Explain the colour of metal-ammonia solution?.

(c) Predict the products

(1) $Zn(C_2H_5)_2 + 2SO_2 \rightarrow$

(2) $4KBr + 4SO_2 \rightleftarrows$

4.(a) Explain the increase in hydrolysis that take place from Lanthanum to Lutecium. How is it useful in separation of lanthanides? .

(b) The physical properties like atomic volume, density and melting point of Europium and Ytterbium do not tally with the usual trend. Why?. Which are the two other elements that show the same behaviour?.

(c) Lanthanides are sometimes analogues to alkaline earths. Discuss reasons why there might be a resemblance between Ln^{3+} and Ca^{2+}?.

5. (a) How does a nuclear reaction differ from a chemical reaction ?.

(b) What can be the probable nuclear reaction of CH_3I with a thermal neutron?. What are the expected products ?. What is this process called?, what is its importance?.

(c) In what way the mode of decay of nuclear reaction related to (a) the ratio of neutrons and protons ? (b) size ?.

6. (a) Justify the exhibition of variety of oxidation states by actinides.

(b) What is the principle behind Uranium-Lead dating ?

A sample of Uranium ore is found to contain 1.8 mg of the lead-206 and 5.0 mg of U-238. Calculate the age of the ore. The half life of U-238 is 4.5×10^9 years.

(c) What are transuranium elements?. How do we synthesize transuranium elements?. Give two examples with balanced nuclear reactions.

END OF EXAMINATION

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 Heliur
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** 20.1 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** 39.9 Argor
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** 83.8 Krypto
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** 131.2 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** 222.0 Rado
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 [illegible]	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 [illegible]	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 [illegible]	102 **No** 259.10 Nobelium	103 **Lr** 262.11 Lawrencium

Department of Chemistry-UNZA

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY SEMESTER II 2005 EXAMINATIONS

ORGANIC CHEMISTRY III – C352 **DECEMBER 05, 05**

TIME ALLOWED: THREE (3) HOURS.

INSTRUCTIONS:

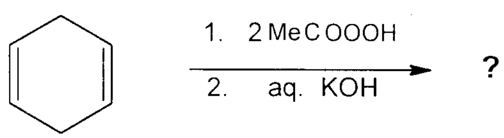
1. **This paper has five (5) questions. Answer any four (4) questions.**
2. **Each question carries thirty marks.**
3. **Marks for each part of the question are indicated.**

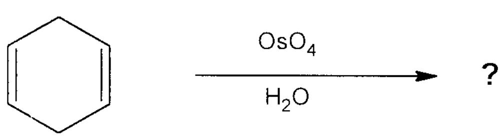
QUESTION ONE.

(a) Is the presence of a chiral atom a necessary condition for a molecule to exhibit optical activity? Justify your answer.

(b) Explain how and why it is possible to distinguish between dehydrohalogenation products of (2*R*)-bromobutane and (2*S*)-bromobutane with the aid of ^{1}HNMR spectroscopy.

(c) (i) Predict the stereochemical structure of the products of the following reactions.





(ii) State, in each case, whether the product obtained in (i) above is/are optically active, meso coimpound(s) or a racemic mixture.

(iii) Which of the products of the reactions in (i) above would be expected to react with propanone (acetone) in an acidic medium. Show this reaction, if any.

QUESTION TWO.

(a) State the structural features in R-H that promote both the removal of the proton by base and the stabilization of the resultant carbanion (R^-). Briefly explain how each of the structural feature aids the removal of a proton and stabilization of the resultant carbanion.

(b) Deduce the structures of compounds **A-G** for the reaction sequence below.

$CH_2(CO_2CH_2CH_3)_2 \xrightarrow[\text{2. } CH_2{=}CHCOCH_3]{\text{1. } NaOCH_2CH_3/EtOH}$ **A** ($C_{11}H_{\cancel{2}18}O_5$)

A $\xrightarrow[\text{2. } H^+,\ H_2O,\ \Delta]{\text{1. } NaOH,\ H_2O}$ **B** ($C_6H_{10}O_3$)

B $\xrightarrow{H^+,\ CH_3CH_2OH}$ **C** ($\cancel{C_8H_{16}O}$) $C_8H_{14}O_3$

C $\xrightarrow[\cancel{\text{2. } H^+,\ H_2O}]{\text{1. } NaOCH_2CH_3/EtOH}$ **D** ($C_6H_8O_2$)

D $\xrightarrow[\text{2. } CH_3I]{\text{1. } NaOH}$ **E** ($C_7H_{10}O_2$)

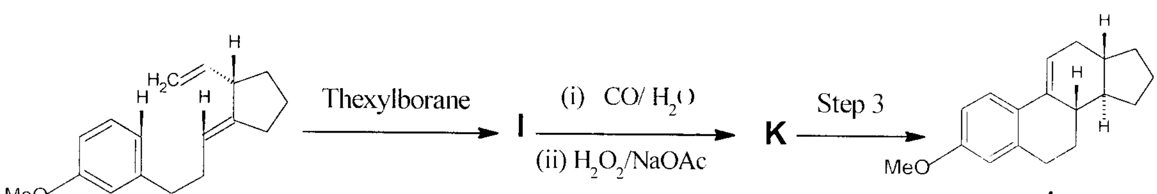
E $\xrightarrow[\text{2. } CH_2{=}CHCOCH_3/\Delta]{\text{1. } NaOH}$ **F** ($C_{11}H_{16}O_3$)

F $\xrightarrow[\Delta]{NaOH/H_2O}$ **G** ($C_{11}H_{14}O_2$)

(dehydration)

QUESTION THREE.

(a) The reaction sequence below demonstrates the construction of the steroid skeleton **L** using the boron chemistry.



H **L**

(i) Name the reagent required for step **3**.

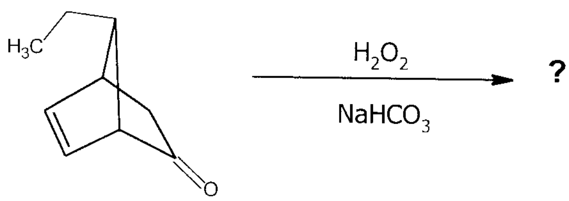
(ii) Deduce the structures of compounds **I** and **K**

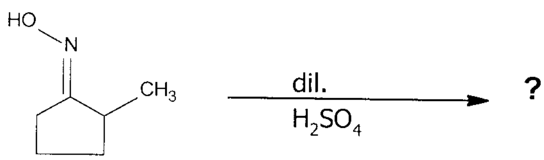
(iii) Propose the mechanism for the conversions **H** to **I** and **K** to **L**.

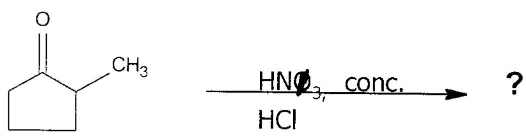
(b) The classical Skraup synthesis of quinoline is exemplified by the reaction of aniline with glycerol under acidic/oxidative conditions to produce quinoline. Give the mechanism for the formation of quinoline and show how you could convert it to 2-methylaminoquinoline.

QUESTION FOUR.

Suggest the likely products and write the mechanisms of **three (03)** of the following reactions.

(i) 

(ii) 

(iii) 

(iv)  (A spirocyclic system)

QUESTION FIVE.

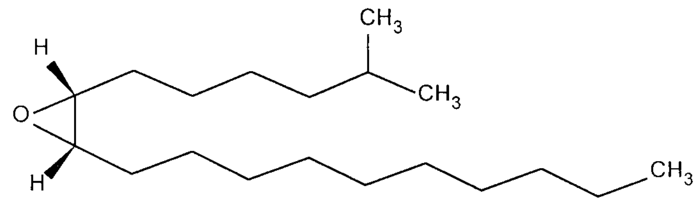
(a) Pyrrole can be formylated using trichloromethane and sodium hydroxide.

(i) Give the structure of the product.

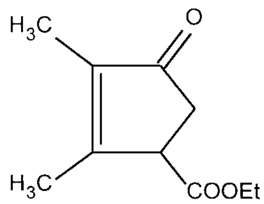
(ii) Account for the orientation in the electrophilic substitution.

(iii) Propose a mechanism for the formation of formylated pyrrole.

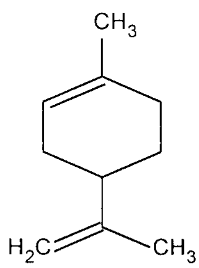
(b) Propose a reasonable laboratory synthesis of **any two (02)** of the following compounds. Clearly show the necessary reagents and the reactions conditions.



An insect pheromone



α, β -Unsaturate



Lemonene

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY SEMESTER II, 2005 EXAMINATIONS
C475: MEDICINAL CHEMISTRY

NOVEMBER, 2005

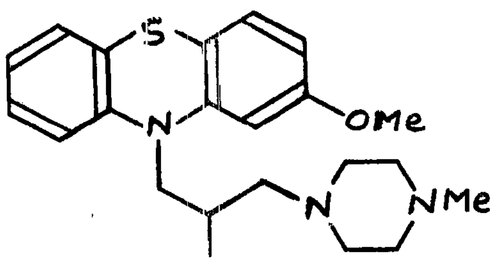
INSTRUCTIONS:

1. TIME ALLOWED FOR THIS PAPER IS THREE (3) HOURS
2. THIS PAPER CONTAINS FIVE QUESTIONS. ANSWER ANY FOUR (4) QUESTIONS.
3. EACH QUESTION CARRIES THIRTY (30) MARKS.
4. MARKS ALLOCATION FOR QUESTIONS IS SHOWN, [x].

QUESTION ONE

(a). Propose a synthesis of a major tranquilizer, **A**, structure shown below, from readily available non-heterocyclic starting materials. [12]

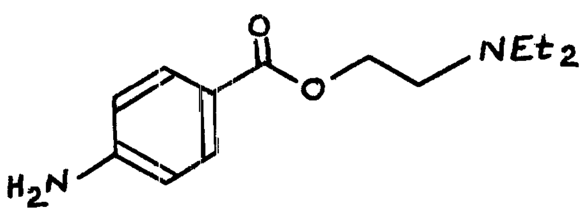
Tranquilizer A:



(b). Discuss the structure – activity relationships in phenothiazines. [8]

(c). Following an *i.v.* injection of a drug **B**, structure shown below, ethanal, p-amino-benzoic acid and 2-aminoethanol (as glucoronide) were found to be present in the urine of the patient.

Drug B:



(i) Propose a likely metabolic pathway for the drug **B** to account for the presence of the observed metabolites in the patient's urine. [8]

(ii) Suggest an analogue of the drug **B** to prolong it's duration of action. [2]

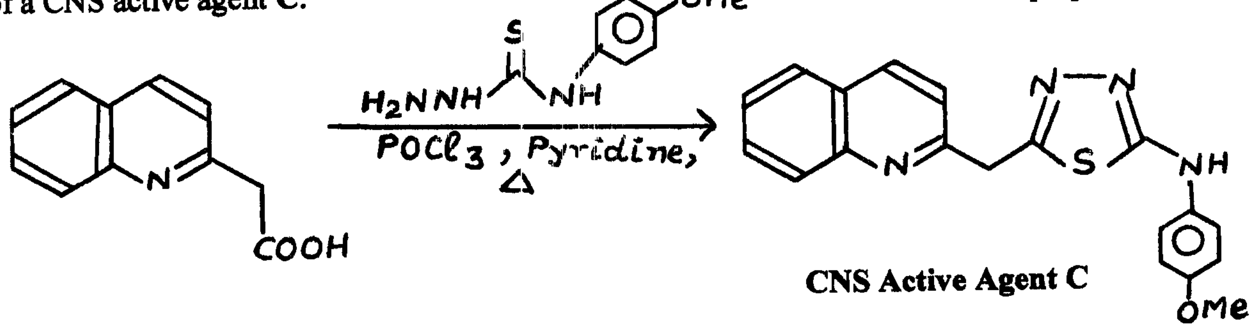
QUESTION TWO

(a). Plant materials are widely used as traditional medicines(TM) for the treatment of various human diseases on an empirical basis in several countries including Zambia.

(i) Outline a general procedure for the extraction of bio-active molecules from the TM of plant origin. [5]

(ii) How will you screen the TM for the presence of cyanogenetic glycosides and saponins? State the principles of your tests and the significance of the results obtained. [12]

(b). Suggest plausible mechanisms of the reactions involved in the following synthesis of a CNS active agent C. [10]



CNS Active Agent C

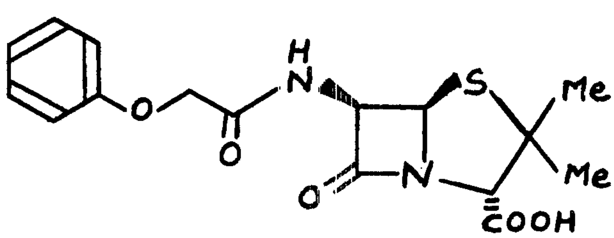
(c). More than normal volumes of anaesthetic gases are required to induce optimum level of anaesthesia in obese patients and such patients take longer duration to recover fully from the anaesthetic effects of gases after surgery. Provide an explanation for this observation. [3]

QUESTION THREE

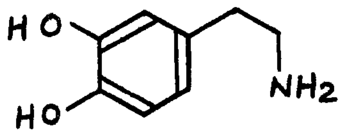
(a). Give a brief account of the pharmacological actions of flavonoids. [5]

(b). Naturally occurring penicillins are orally inactive as they are sensitive to acids. Design an analogue of 'Pen V', a naturally occurring penicillin, structure shown below, with a view to minimize its acid sensitivity. State your rationale. [6]

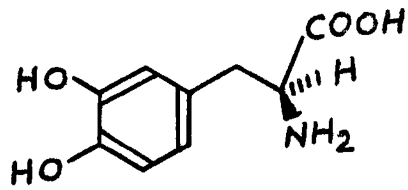
Pen V:



(c). Deficiency of a neurotransmitter 'Dopamine' has been implicated to be the principal cause underlying the aeteology of Parkinson's disease. However, dopamine can not be used for the treatment of Parkinson's disease due to bio- availability constraint. A drug called 'L-DOPA' was designed which is widely used for the treatment of Parkinson's disease.



Dopamine



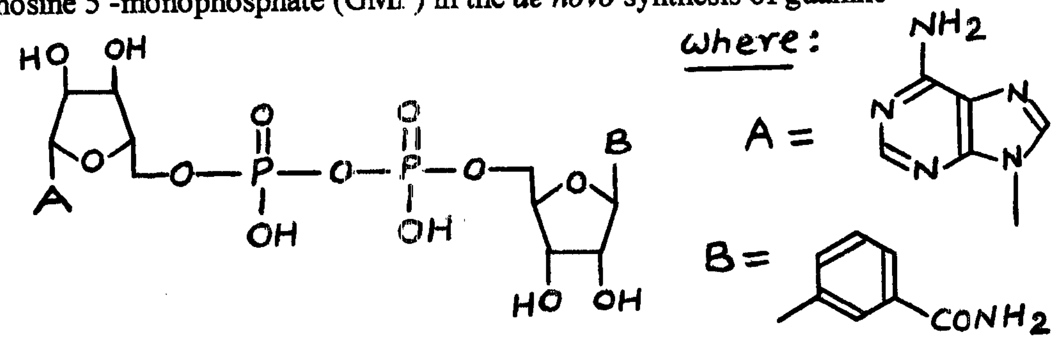
L-DOPA

(i) Why Dopamine is **not** bio-available? [2]

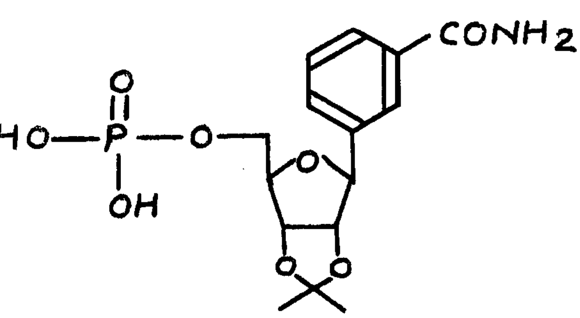
(ii) Explain the rationale for the use of 'L-DOPA' for the treatment of Parkinson's disease. [5]

(d). Most modern drug therapy is based on the concept of enzyme inhibition. For example, Benzamide Adenine Dinucleotide (BAD), an anticancer agent, structure shown below, inhibits the NAD-dependent conversion of inosine 5′-monophosphate (IMP) to guanosine 5′-monophosphate (GMP) in the *de novo* synthesis of guanine nucleotides.

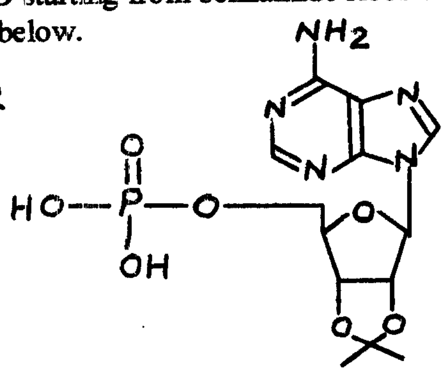
BAD:



Show how would you synthesize BAD starting from benzamide riboside and adenosine riboside, structures shown below. [12]



Benzamide Riboside



Adenine Riboside

QUESTION FOUR

(a). One of the three critical steps covered in drug discovery is the development step. What does this step involve? [6]

(b). Define the term 'pharmacokinetics' and name the processes involved. [6]

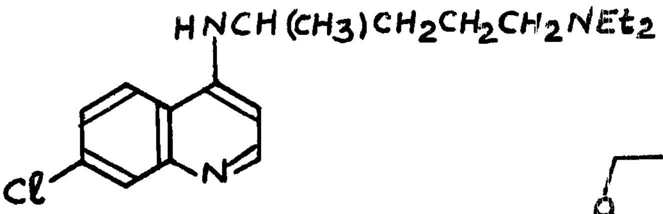
(c). Write short notes on any **three (3)** of the following: [12]

- **(i)** Chemotherapeutic drugs
- **(ii)** Pharmacodynamic drugs
- **(iii)** The *first-pass* effect
- **(iv)** Two-phase biotransformation of drugs

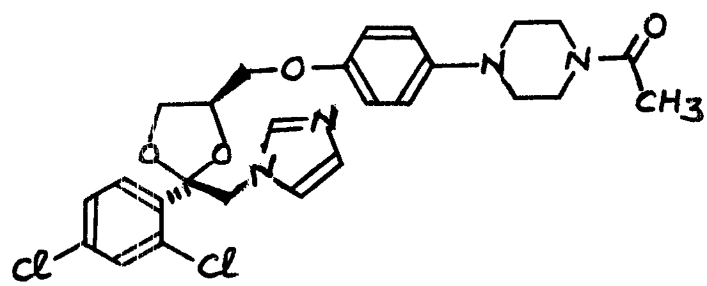
(d). Give three examples of how the effect of one drug is altered by the presence of another drug when drug-drug interaction occurs. [6]

QUESTION FIVE

(a). Describe the mode of action of compounds **D** and **E**, structures shown below. [12]



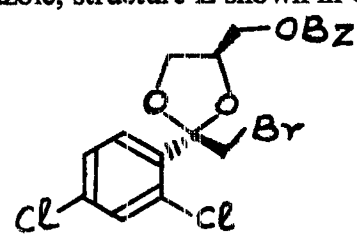
Compound D



Compound E (Ketokonazole)

(b). Assuming you were provided with a compound **F**, structure shown below, show how you would synthesize ketokonazole, structure **E** shown in **Q5(a)** above. [10]

Compound F:



(c). 2- Aminopyridine is a component of a sulfa drug, sulfapyridine. Show how you would synthesize it from pyridine and give mechanisms of the reactions involved in your synthesis. [8]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF COMPUTER STUDIES

2005 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATION

CS 4012 – Advanced Operating Systems and Distributed Systems

Instructions:

- Answer any five (5) questions
- All questions carry equal marks (20 marks)
- Time allowed: Three (3) hours
- The exam is closed book

Question 1

(i) Transparency is one of the defining features of a distributed system. The concept of transparency can be applied to several aspects of a distributed system. BRIEFLY discuss the following types of transparency:

(a) Failure transparency
(b) Persistence transparency
(c) Concurrency transparency
(d) Access transparency

(ii) Which one of the above types of transparency is violated by distributed systems that are based on explicitly message exchange between processes? Justify your answer.

(iii) Why is it not always a good idea to aim at implementing the highest degree of transparency possible?

Question 2

(i) Briefly describe the two divergent philosophies concerning operating system kernel design. Give two advantages of one of them over the other.

(ii) What is the difference between a distributed operating system and a network operating system?

(iii) An experimental file server is up 3/4 of the time and down 1/4 of the time, due to bugs. Why is it sometimes so hard to hide the occurrence and recovery from failures in a distributed system?

(iv) What is an open distributed system and what benefits does openness provide?

Question 3

(i) In this problem you are to compare reading a file using a single-threaded file server and a multithreaded server. It takes 20ms to get a request for work, dispatch it, and do the rest of the necessary processing, assuming that the data needed are in a cache in main memory. If a disk operation is needed, as is the case one-third of the time, an additional 80ms is required, during which time the thread sleeps. How many requests/sec can the server handle if it is single threaded? If it is multithreaded?

(ii) Constructing a concurrent server by spawning a process has some advantages and disadvantages compared to multithreaded servers. Mention one advantage and three disadvantages.

(iii) Give two reasons why it would make sense to limit the number of threads in a server process.

(iv) In general, a multithreaded file server is better than a single-threaded server. Are there any circumstances in which a single-threaded server might be better? Give an example.

Question 4

(i) Describe the work done by the software in each protocol layer when the TCP/IP Model is implemented over Ethernet. How does a TCP/IP host resolve the hardware address of another TCP/IP host on the same Ethernet network?

(ii) Would you consider a URL such as *http://www.acme.org/index.html* to be location independent? What about *http://www.acme.nl/index.html*?

(iii) What is the advantage of the client-server model over connection-oriented protocols such as TCP/IP?

Question 5

(i) In an RPC system the function of the client stub is to take its parameters, pack them into a message, and send them to the server stub. Name and discuss three (3) parameter passing mechanisms in procedure calling.

(ii) Discuss how the Lightweight RPC mechanism works and its rationale.

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

Question 6

(i) Various classification schemes for multiple CPU computer systems have been proposed over the years. One such scheme is based on the number of instruction streams and the number of data streams. Using this classification scheme multiple CPU computer systems can be classified as SISD, SIMD, MISD or MIMD. MIMD computers can further be sub-divided based on three major characteristics.

(a) Name and briefly explain the three (3) characteristics.

(b) What is the difference between a MIMD computer and a SIMD computer?

(ii) In Interprocess communication, discuss the following:

(a) Blocking and Non-blocking primitives

(b) Buffered and Non-buffered primitives

(c) Multiple process addressing

Question 7

(i) A distributed operating system should support *encapsulation* and *protection* of resources inside servers. Some mechanisms required to *access* these resources include *naming*, *communications* and *scheduling.* Briefly discuss the following terms in the context of distributed operating systems: *encapsulation, naming, communications* and *scheduling.*

(ii) Figure Q6.1 shows the architecture of a microkernel. What are the functions of the following components of a microkernel

(a) Process manager

(b) Communication manager

(c) Memory manager

(d) Thread manager

(e) Supervisor

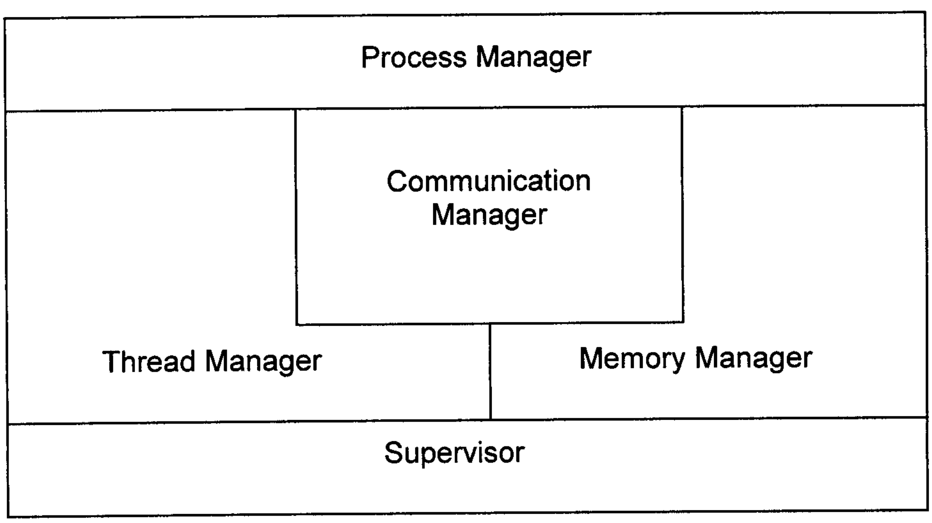


Figure Q6.1: Architecture of a microkernel

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATION

DECEMBER 2005

CST 2012 Programming II

INSTRUCTION(S): There are two parts in this paper **I** and **II**. Part I consists 20 multiple-choice questions and you are required to answer all. Part II has five (5) questions and you are required to answer any four (4) of them according to the instructions before each question. All questions in Part II have an equal weight. Good Luck!

DURATION: 3 Hours

PART I – 20 Multiple choice questions. Answer all 20 Marks.

1 Which of the following statements registers a panel object p as a listener for a button variable jbt?
   A addActionListener(p);
   B jbt.addActionListener(p);
   C jbt.addActionEventListener(p);
   D jbt.addEventListener(p);

2 Moving a mouse generates a(n) __________ event.
   A ItemEvent
   B MouseEvent
   C MouseMotionEvent
   D ActionEvent
   E ContainerEvent

3 Pushing the mouse key generates a(n) __________ event.
   A ItemEvent
   B WindowEvent
   C MouseMotionEvent
   D ComponentEvent
   E ContainerEvent

4 Which component cannot be added to a container?

A JPanel
B JButton
C JLabel
D None of the above

5 The interface __________ should be implemented to listen for a hitting the enter key on the keyboard.
A MouseListener
B ActionListener
C FocusListener
D WindowListener
E ContainerListener

6 The method in the ActionEvent __________ returns the reference of the button.
A getActionCommand()
B getSource()
C paramString()
D getID()

7 The method __________ sets the background color to yellow in JFrame f.
A setBackground(Color.yellow)
B f.setBackground(Color.YELLOW)
C f.setBackground(Color.yellow)
D setBackground(Color.YELLOW)

8 The method __________ sets the font (Helvetica, 20-point bold) in Graphics object g.
A g.setFont(new Font("Helvetica", Font.bold, 20))
B g.setFont(new Font("helvetica", BOLD, 20))
C g.setFont(Font("Helvetica", Font.BOLD, 20))
D g.setFont(new Font("Helvetica", Font.BOLD, 20))

9 The method __________ can be used to get the dimension of the frame.
A getDimension()
B getWidth()
C getHeight()
D getSize()

10 Analyze the following code:

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

```
}

class A
{
 String s;

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

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

A The program does not compile because Test does not have a constructor Test().
B The program would compile if the constructor in the class A were removed.
C The program compiles, but it has a runtime error due to the conflict on the method name print.
D The program runs just fine.
E a and b

11 Given the following code:

```
class C1 {}
class C2 extends C1 { }
class C3 extends C2 { }
class C4 extends C1 {}

C1 c1 = new C1();
C2 c2 = new C2();
C3 c3 = new C3();
C4 c4 = new C4();
```

Which of the following expressions evaluates to false?
A c1 instanceof C1
B c2 instanceof C1
C c3 instanceof C1
D c4 instanceof C2

12 When you implement a method that is defined in a superclass, you __________ the original method.
A overload
B override
C copy
D call

13 What modifier should you use on a class so that a class in the same package can access it but a class in a different package cannot access it?

A public
B private
C protected
D Use the default modifier.

14 What modifier should you use so that a class in a different package cannot access the class, but its subclasses in any package can access it?

A public
B private
C protected
D Use the default modifier.

15 What is the output of running class C?

```
class A
{
 public A()
 {
  System.out.println(
    "The default constructor of A is invoked");
 }
}

class B extends A
{
 public B()
 {
  System.out.println(
    "The default constructor of B is invoked");
 }
}

public class C
{
 public static void main(String[] args)
 {
  B b = new B();
 }
}
```

A none
B "The default constructor of B is invoked"
"The default constructor of A is invoked
C "The default constructor of B is invoked"
"The default constructor of B is invoked"
D "The default constructor of A is invoked"
"The default constructor of A is invoked"

16 The relationship between a child (sub) class and a parent (super) class is referred to as a(n) ____ relationship.

A has-a
B is-a
C was-a
D instance-of

For questions 17 – 18, consider the following class definition:

```
public class Test
{       private int x;

        public test(int newValue)
        {
                x = newValue;
        }
}
```

17 Which of the following is true about the class Test?

A it has no parent class
B it's parent class is Object
C it's parent class is Java
D it can not be extended
E it has a default child called Object

18 If q1 and q2 are objects of Test class, then q1.equals(q2)

A is a syntax error since equals is not defined in the test class
B is true if q1 and q2 both store the same value of x
C is true if q1 and q2 reference the same test object
D is never true
E throws a NullPointerException

19 Given a Graphics object g, to draw an outline of a rectangle of width 20 and height 50 with the upper-left corner at (20, 20), you use __________.

A g.drawRect(20, 50, 20, 20)
B g.drawRectFill(20, 20, 20, 50)
C g.drawRect(20, 20, 20, 50)
D g.drawRectFill(20, 50, 20, 20)

20 If your applet does not have the init() method, which of the following will happen?

A Your program will not compile.
B Your program will compile, but not execute.
C You must have a main method.
D Your program will run just fine since the init() method is defined in the Applet class.

PART II – Short Answers and Programming. All four (4) out of five (5) questions according to the instructions given.

1)

a) Define the following
   i) Inheritance
   ii) Polymorphism

b) Distinguish between
   i) Abstract classes and Interfaces
   ii) Applet and Application

c) Consider the following scenario:

You are required to implement a framework of classes that simulate graphical objects. Each object has to know how to draw itself. All graphical objects however, are either filled with a particular color or not filled. Assume the only graphical objects are circles and rectangles.

   i) In the in heritance hierarchy, what would be more appropriate at the root between an interface and an abstract class.
   ii) Justify why you would prefer one to the other in i above
   iii) Write the code for this super class in this hierarchy giving just the important components mentioned in the scenario and necessary constructors if possible. (No more than 15 lines)

2) Analyse the code given below.

ExamApplet.java *

```
public class CirceApplet extends Applet{
    private double radius;
    private int x;
    private int y;

    public init(){
        radius = getParameter("RADIUS");
        x = getParameter("X");
        y = getParameter("Y");
    }

    public void paintComponent(Graphics g){
        //A. Set the color of g to red
        //B. Draw the circle with the parameters radius, x and y
        //    where (x, y) is the pivot point of the circle
    }
}
```

a) Suggest two packages that need to be imported
b) What is the purpose of the init method?
c) What method is called immediately after the init method?
d) What does the getParameter method do?

e) Create an HTML file that will initiate radius to 50, x to 10, y to 20 and an alternative massage in a case where the browser cannot load the applet
f) What code would be at A.
g) What code would be at B.

3) You are given a task of implementing a payroll system for a newspaper company. The company has three types of employees, salaried employees and commissioned employees. Every employee has a Man number, which uniquely identifies the employee in the organisation, a name and address. However, the evaluation of the salary varies from one type of employee to the other as follows: Salaried employees have a weekly salary; a commission employee has a commission rate and the gross sales for the week. Each employee object is to implement the toString method that returns a string, which appropriately describes the type of employee e.g. Salaried Employee: salary is $10000. The hierarchy of employees will have the Employee class at the root.
   a) Why should the Employee class be an abstract class?
   b) Describe the two attributes that will be in this class. (You may chose name of your choice as long as you explain what they represent)
   c) Give one method you think should be abstract
   d) Write the code for Employee, and CommissionEmployee.

4)
   a) Define the following
      i) Event-driven programming
      ii) Layout manager of a container
   b) Outline (using an example of your choice) a logical series of events needed for the program to respond to the events generated by a user. (In no more than four sentences)
   c) Distinguish between
      i) JFrame and Panel
      ii) Flowlayout and GridLayout
   d) Write the program, which has the graphical user interface consisting of a button, and two textfields. The user enters a number in Fahrenheit in the first textfield. When the button is pressed the program converts the number to Celsius and displays it in the second textfield, which is not editable. No panels used, all components are added to the frame. Set the frame to flowlayout, size 200 by 400, not editable, and should be visible at startup.

5) Analyse the program below and answer the questions that follow.

```
3  public class Mystery{
4      public static void main(String[] args){
5          String s = "I hate to know that I just have to like Java!";
6          StringTokenizer stok = new StringTokenizer(s);
7  
8          // A
9          while(stok.hasMoreTokens()){
10             System.out.println(stok.nextToken());
11         }
12     }
13 }
```

a) What are the return types of the following methods of the StringTokenizer?
   i) hasMoreTokens(),
   ii) nextToken(),

b) After compiling the program above the following error was reported by JCreator:

cannot resolve symbol class StringTokenizer	Mystery.java	C:\Program Files\Xinox Software\JCreato	line 6
cannot resolve symbol class StringTokenizer	Mystery.java	C:\Program Files\Xinox Software\JCreato	line 6

   i) What is the cause of these errors?
   ii) What need to be done to correct the program?

c) According to the code above, what will be the delimiter character that stok will use?

d) Hence after the errors have been corrected, what will be the output after running the program?

e) Modify code after the A mark so that the program keeps count of the tokens that stok will generate.

f) Write the method called LexicalAnalyser that, given a string s, it returns an array of tokens extracted from s. The string is tokenised using the space or the semicolon.

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

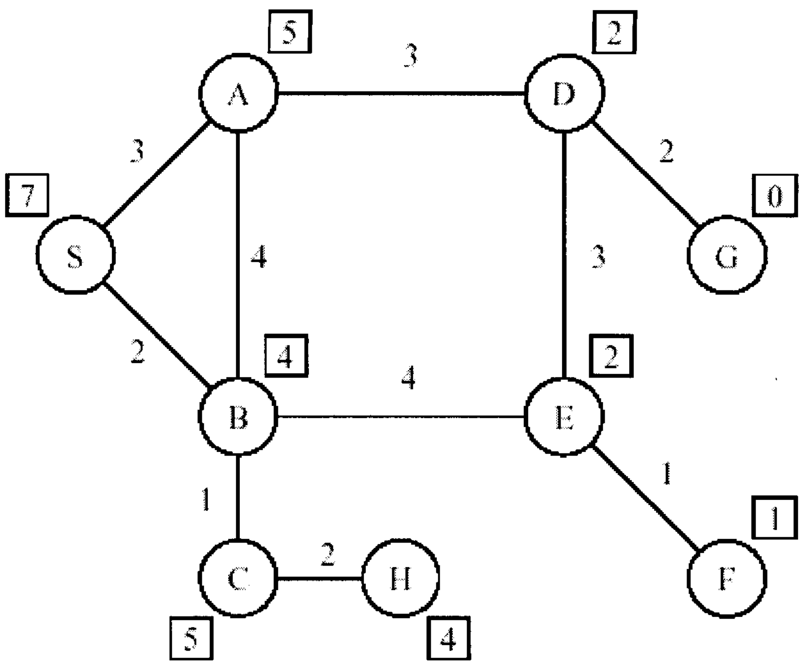
***********COMPLIMENTS OF THE SEASON************

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
Examination December 2005

CST3032 – Introduction to Artificial Intelligence

INSTRUCTIONS: Answer any **Five (5) out of Six (6) Questions**. All questions have equal weight. Good luck!
DURATION: 3 Hours

1.
  a. Describe what an intelligent agent is, in terms of its environment, sensors and actuators.
  b. Explain the following models of agents (In not more than two sentences)
    i. Simple reflex agent
    ii. Model-based agents
    iii. Goal-based agent
    iv. Utility-based agent
  c. Give two examples of Artificial Intelligent systems and state the type of agent that is used to implement them.
  d. Given the figure below



What path is followed by the following search?
  i. Uniform-cost
  ii. Best-first

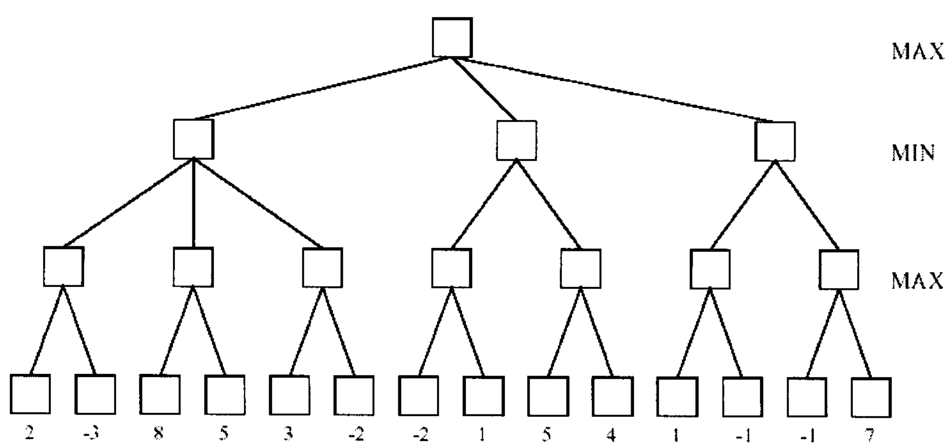
iii. Hill-climbing
iv. A*

2. Consider a state space where the start state is the number one and the successor for state n returns two states 2n and 2n+1
   a. Draw the portion of the state space for states 1 to 15. Suppose the goal state is 11,
      i. What is the branching factor of the tree?
      ii. What is the depth of the tree?
      iii. How many open nodes are in the tree?
      iv. How many closed nodes are in the tree?
   b. List the order the order in which nodes will be visited for
      i. Breadth-first search
      ii. Depth-first search

3.
   a. Describe the four components that are used to formally define a problem as a search.
   b. Given the following situation.

      You have three jugs, measuring 12 gallons, 8 gallons and 3 gallons, and a water faucet with unlimited supply of water. You can fill the jugs up from the faucet or from any other jug or you can empty them to the ground. You need to measure out 1 gallon of water.
      i. Formulate this problem as a search by describing the four components of a search. (For the operators give no more than 8 of them necessary to solve the problem)
      ii. Draw a search tree with depth less than 2 that contains the solution. (No ancestor to be added to the children. All jugs are empty initially)

4.
   a. Distinguish between the following search mechanisms
      i. Depth-first search and Breadth-first search
      ii. Uniform cost and greedy best-first search
      iii. IDS and IDA*
   b. Why is it possible to implement a game as a search?
   c. Shown below is the game tree where the root is MAX



Fill in the bank boxes and indicate which move MAX takes.

i. Without pruning
ii. With alpha-beta pruning.

5.

a. Using scheme, implement the functions that do the following:
   i. (*sum l*) which adds the contents of a list *l* of integers.
      E.g (*sum '(1 2 3)*) = 6
   ii. (*multiply m n*), which returns the product of m and n using recursive addition where m and n are positive integers greater than 0.
b. Write the pseudocode for the breadth-first search.
c. Given the following functions

   (*goal? node*) returns true if node is a goal, false otherwise.
   (*successors node operators*) returns the children of node under the actions in operators.

   Implement breadth-first search (*bfs node-list operators*), which returns true if goal is found otherwise returns false. *node-list* is the queue of nodes to initiated with the start node and operators is the list of operators.

6.

a. Define the following
   i. Admissible heuristic
   ii. Monotonic heuristic
   iii. Complete search algorithm
b. Prove the following statements
   i. Breadth-first search is a special case of uniform-cost search
   ii. Breadth-first search, depth-first search are special cases of best-first search.
   iii. Uniform-cost search is a special case of A* search.
c. The heuristic path algorithm is a best-first search in which the objective function is $f(n) = (2 - w)g(n) + wh(n)$, g is the cost from the start and h is a heuristic function.
   i. For what values of w is this algorithm guaranteed to be optimal?
   ii. What kind of search does this algorithm perform when
      (1) $w = 0$
      (2) $w = 1$
      (3) $w = 2$
d. Let h1 and h2 be admissible heuristics and $h = mh1 + (a - m)h2$, in terms of a, express the range of values of m for which h is admissible. Show the derivation.

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

********COMPLIMENTS OF THE SEASON!********

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS
EM312: ENGINEERING MATHEMATICS

TIME: THREE HOURS
INSTRUCTIONS: ANSWER ANY FOUR QUESTIONS FROM QUESTIONS 1-5 AND ONE QUESTION FROM QUESTIONS 6-7

---

1. **(a)** Determine what surface the equation

$$r^2 - 2r\sin\theta(\cos\varphi + 2\sin\varphi) - 6r\cos\theta = -5$$

represents. Note that θ is the angle between the position vector $\mathbf{r}$ and the z axis. [4]

(b) **(i)** Sketch the cylinder whose directrix is given by

$$z - \sin^2 y = 0, \quad -\frac{\pi}{2} \le y \le \frac{\pi}{2},$$

and whose generatrix is parallel to the x axis. [2]

(ii) A mosquito at the point $P(x, y, z) = (3, \frac{\pi}{2}, 1)$ on the cylinder flies in a straight line towards the point $(5, 4, 2)$. What is the angle between the mosquito's trajectory and the normal line to the surface at that point? [7]

(c) A certain plane Π_1 contains the points $(1, 2, -4)$, $(2, 3, 7)$ and $(4, -1, 3)$, while a second plane Π_2 contains the point $(1, 2, 3)$ and is normal to the vector $\mathbf{N} = \hat{\mathbf{j}} + \hat{\mathbf{k}}$.
(i) Obtain the equations of the two planes. [5]
(iii) Determine the angle between them. [2]

2. **(a)** A lamina of uniform density is in the form of a semi-circular disk of radius a. Calculate its centroid. [5]

(**b**) It is required to evaluate the integral

$$I = \iint_{\Omega} e^{(x-y)/(x+y)} dxdy$$

where Ω is the region in the first quadrant between the lines $x + y = 1$ and $x + y = 2$. Use the transformations $x = u + v$ and $y = u - v$ to evaluate the integral. [11]

(**c**) The angular velocity of a certain rotating body is $\mathbf{w} = \omega\widehat{\mathbf{k}}$, where ω is a constant.

(**i**) Obtain the velocity vector field for the body. [2]

(**ii**) Determine whether the velocity field is irrotational or incompressible. [2]

3. (**a**) (**i**) Prove that if the vector field $F(x,y,z) = \widehat{\mathbf{i}}P(x,y,z) + \widehat{\mathbf{j}}Q(x,y,z) + \widehat{\mathbf{k}}R(x,y,z)$ is exact, then

$$\frac{\partial P}{\partial y} = \frac{\partial Q}{\partial x}, \ \frac{\partial P}{\partial z} = \frac{\partial R}{\partial x} \ \text{ and } \ \frac{\partial Q}{\partial z} = \frac{\partial R}{\partial y} \quad [3]$$

(**b**) (**i**) Show that the vector field $F(x,y,z) = \widehat{\mathbf{i}}yz + \widehat{\mathbf{j}}xz + \widehat{\mathbf{k}}xy$ is exact. [2]

(**ii**) Show that the potential function from which it may be derived is $f(x,y,z) = xyz + c$. [4]

(**iii**) Calculate $\int_{\mathbf{x}_0}^{\mathbf{x}_1}(\widehat{\mathbf{i}}yz+\widehat{\mathbf{j}}xz+\widehat{\mathbf{k}}xy)\cdot d\mathbf{x}$ where $\mathbf{x}_0 = (1,2,3)$ and $\mathbf{x}_1 = (0,0,0)$. [2]

(**c**) (**i**) Explain how Green's theorem may be adapted to calculate areas. [3]

(**ii**) A plane body is made by welding a semicircular disk of radius a to the half-ellipse whose semi-major axis is a and whose semiminor axis is b. The flat part of the ellipse has length $2a$, so that it aligns perfectly with the semi-circle. Use Green's theorem to show that the area of the welded plane body is

$$A = \frac{1}{2}\pi(a^2 + ab) \quad [6]$$

4. (**a**) The temperature distribution on a plate is given by

$$T(x,y) = 1 - \frac{x^2}{a^2} - \frac{y^2}{b^2}$$

An insect at the point (a, b) seeks to escape the heat by moving in the direction of least increase of temperature. At what angle does the insect start off? [4]

(b) Obtain the flux of the vector field $\mathbf{V} = -3x\hat{\mathbf{i}} - y\hat{\mathbf{j}} + 3z\hat{\mathbf{k}}$ over the surface $S : z = 4 - x - y;\ x \geq 0,\ y \geq 0,\ z \geq 0$. [10]

(c) Evaluate the line integral

$$I = \int_C \mathbf{F}(x, y) \cdot d\mathbf{x}$$

where $\mathbf{F}(x, y) = \hat{\mathbf{i}} \ln x + \hat{\mathbf{j}} \ln y$ and C is the curve $\mathbf{x}(t) = \hat{\mathbf{i}}2t + \hat{\mathbf{j}}t^3$, $1 \leq t \leq 4$. [6]

5. (a) A military hut is made by using a hemispherical roof of radius 10 m mounted over cylindrical walls of height 5 m and floor radius 10 m.

(i) Explain why the z coordinate of any point on the roof is given by

$$z = 5 + \sqrt{100 - x^2 - y^2} \quad [2]$$

(ii) Use the expression

$$V = \iint\limits_{\Omega} f(x, y)\,dx\,dy$$

to calculate the volume of the hut. [9]

(b) Use the divergence theorem to compute the integral

$$I = \iint\limits_{S} \mathbf{F} \cdot \mathbf{n}\,d\sigma$$

where $\mathbf{F} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}} + z\hat{\mathbf{k}}$ and S is the cylinder $x^2 + y^2 \leq 4$, $0 \leq z \leq 3$. [4]

(c) Calculate the area of the part of the surface $z = \dfrac{y^4}{4} + \dfrac{1}{8y^2}$ which lies over the region $\Omega = \{(x, y) : 0 \leq x \leq 3, 2 \leq y \leq 4\}$. [5]

] The data shown below represents the yield on consecutive batches of ceramic substrate to which a metal coating has been applied by a vapor-deposition process.

94.1	87.3	94.1	92.4
93.2	84.1	92.1	90.6
90.6	90.1	96.4	89.1
91.4	95.2	88.2	88.8
88.2	86.1	86.4	86.4
86.1	94.3	85.0	85.1
95.1	93.2	84.9	84.0
90.0	86.7	87.3	93.7
92.4	83.0	89.6	87.7
87.3	95.3	90.3	90.6
86.6	94.1	93.1	89.4
91.2	97.8	94.6	88.6
86.1	93.1	96.3	84.1
90.4	86.4	94.7	82.6
89.1	87.6	91.1	83.1

(a) Construct a stem-and-leaf plot using the first 2 digits for a stem

(b) Find the median, and the first and third quartile.

(c) Calculate the sample mean, sample variance and sample standard deviation.

(d) How do the mean and median compare?

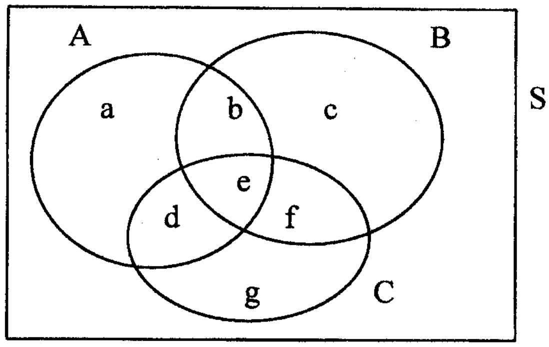
(e) Which one among the two in (d) is the appropriate measure of central tendency to use? Briefly state why.

] (a) Two digits are selected at random from the digits 1 through to 9 (1 and 9 included) and the selection is without replacement (the same digit cannot be picked on both selection)

(i) How many elements does the sample space have?

(ii) If the sum of the two digits is even, find the probability that both digits are odd.

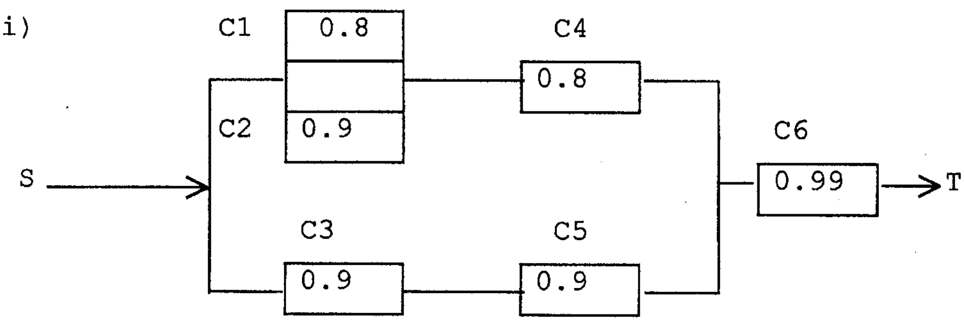
(b) (i) In the venn diagram below, A, B, and C are events and S is the sample space. The lower case letters: a, b, c, d, e, f and g represent the probabilities associated with their respective regions (i.e the region enclosing the letter).



Verify the fact below, i.e. show that the right hand side is indeed equal to the left hand side.

$$\Pr(A \cup B \cup C) = \Pr(A) + \Pr(B) + \Pr(C) - \Pr(A \cap B) - \Pr(A \cap C) - \Pr(B \cap C) + \Pr(A \cap B \cap C)$$

(ii)



Consider the series-parallel assembly shown above. The values show the reliabilities for the six components, that is each value is a probability that component j will function properly. The components operate (and fail) in a mutually independent manner and the assembly fails only when the path from S to T is broken. Calculate the reliability of the assembly using a step-by-step approach, i.e. first identify the available paths and calculate the probability that assembly functions properly.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 155: INTRODUCTION TO PHYSICAL GEOGRAPHY

TIME: Three Hours

INSTRUCTIONS: Answer questions <u>one</u> and any other <u>three.</u> All questions carry equal marks. Use of a Philip's University Atlas is allowed and you are encouraged to use illustrations wherever appropriate.

---

1. Write short explanatory notes on **all** of the following:
   (a) Atmospheric components of energy flux.
   (b) Water balance equation.
   (c) Relational Explanation.
   (d) Greenhouse effect
   (e) Relative humidity.

2. **Either,**
   (a) Outline the benefits of a Systems Approach to explanation in Geography.
   Or,
   (b) Show how the study of Physical Geography is significant to human populations' sustainable adaptation, modification and dependence on the environment.

3. Compare and contrast exogenous and endogenous sources of energy. Give an example of a surface feature created by each source of energy.

4. What is evapotranspiration and what role does it play in the hydrological cycle?

5. Explain the importance of vegetation as a link in the development of soil.

6. Outline the major crustal plates comprising the earth and discuss the implications of their evolution.

7. With use of diagrams, discuss three theories of slope development.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR DISTANCE EDUCATION FINAL EXAMINATIONS

GEO 155: INTRODUCTION TO PHYSICAL GEOGRAPHY

TIME: Three Hours

INSTRUCTIONS: Answer questions one and any three others.

Question one is **compulsory** and it carries 40 % of the total marks for this paper. You are encouraged to make use of illustrations and examples wherever appropriate. The use of an approved calculator and a Philip's University Atlas is allowed.

---

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

   (a) Coalescence theory.
   (b) Types of plant succession
   (c) Two laws of thermodynamics
   (d) Wet or saturated adiabatic rate
   (e) Eluviation and illuviation
   (f) Isosytacy and rillenkarren
   (g) Three products of hydrolysis
   (h) Drainage pattern and channel pattern

2. To what extent is the 'Big bang' theory true in the explanation of the existence of the universe?

3. With the aid of a diagram, outline how various factors interact in the formation of soils on earth.

4. 'Vegetation distribution on earth is a consequence of a number of controlling factors which interact in a complex fashion.' Discuss.

5. Discuss the role of endogenetic processes in mountain building.

6. With the aid of a diagram, describe the recycling of one type of material of your choice and explain the importance of this process on earth.

END OF EXAMINATION

COMPUTER NUMBER: ....

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR DISTANCE EDUCATION FINAL EXAMINATIONS

GEO 175: INTRODUCTION TO MAPPING TECHNIQUES

PAPER I: PRACTICAL

MAP READING ANALYSIS AND INTERPRETATION

TIME: Three Hours

INSTRUCTIONS: Answer all questions
The use of a Philip's University Atlas and an approved calculator is allowed. Candidates are encouraged to make use of illustrations wherever appropriate.

MATERIALS PROVIDED:

A4 Metric graph paper
A4 Tracing paper
Topographic Map Sheet 1528 A4

SECTION A: GENERAL QUESTIONS

Answer all questions in this section in the spaces provided on this question paper.

1. (a) What are stereoscopic pairs? [2 marks]

(b) Assume that the size of an ordinary air photograph is 20 centimetres by 20 centimetres, (20cm x 20cm). What is the equivalent ground area in kilometres covered by the photograph with a mean scale of 1:20,000? [5 marks]

(c) Using the contour method, draw an annotated diagram to show an escarpment at 50 metre intervals with a river flowing on the dip slope with its source near the summit. [5 marks]

(d) With the help of a diagram, describe a dendritic drainage pattern and briefly, explain the characteristics of the area on which it develops.[5 marks]

(e) Draw a graphic/line scale in metric units on a scale of 1:20,000, given that the maximum available space is 17 centimetres. (5 marks)

(f) Convert the scale of 1:50,000 to a scale in words. [3 marks]

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

(a) Essential components of a good map [5 marks]

(b) Quantitative methods of showing relief on a map [5 marks]

(c) Oblique air photographs [5 marks]

(d) Vertical exaggeration on a profile [5 marks]

(e) Map reference number [5 marks]

SECTION B: QUESTIONS BASED ON MAP SHEET 1528 A4

Answer question three in the spaces provided on this question paper and question four on either a sheet of metric graph or plain papers provided using topographic map sheet 1528 A4.

3. (a) When was the first edition of map sheet 1528 A4 published and by whom? [2 marks]

(b) If you were driving eastwards along the Great East Road to Chipata, what other map sheet would you require? [1 marks]

(c) Identify and name all the cultural features in Grid Square 4189. [1 mark]

(d) Map sheet 1528 A4 uses a vertical interval of 20 metres. What does this mean? [2 marks].

(e) Using map evidence only, explain how one could read a four-figure grid reference on map sheet 1528 A4. [4 marks]

(f) What drainage pattern does the Chalimbana River and its tributaries generally exhibit? [2 marks]

(g) What pieces of evidence are there to show that Lusaka is the capital city? [2 marks]

(h) What is the approximate size of Lusaka North Forest Reserve No. 28 in square kilometres and state the method that you have used. [2 marks]

(i) What is the direction of ZQ 104 trigonometrical Station in Grid Square 5198 from ZT 16 trigonometrical station in Grid Square 5595

(i) as a compass direction [1 mark]

(ii) as a bearing from grid north. [1 mark]

(j) Using map evidence only, suggest reasons that could have influenced the location and site of the International Airport. [2 marks]

(k) Calculate the average gradient along a straight line between ZT 5 trigonometrical Station in Grid Square 3605 to grid reference point 350055. [3 marks]

(l) What is the approximate distance along the main tarred road from the road junction in Grid Square 3798 to the road junction in Grid Square 4198 in kilometres? [2 marks]

4. Using the most appropriate method, draw a map at half the original scale showing the area extending from eastings 35 – 47 and northings 90 – 02 and on it show the following features:

(a) Great North and Great East Roads

(b) Railway line

(c) City Airport

(d) Ng'ombe and Chibolya compounds

(e) Lusaka North Forest Reserve

(f) National Assembly and Civic Centre

(g) Chamba River and Kalikiliki Dam. [25 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR DISTANCE EDUCATION FINAL EXAMINATIONS

GEO 175: INTRODUCTION TO MAPPING TECHNIQUES

PAPER I I: THEORY

CLASSIFICATION OF NUMERICAL DATA, CONSTRUCTION OF TABLES, STATISTICAL DIAGRAMS AND MAPS

TIME: Three Hours

INSTRUCTIONS: Answer any four questions

The use of a Philip's University Atlas and an approved calculator is allowed. Candidates are encouraged to make use of illustrations wherever appropriate.

---

1. A sample consists of 200 observations, recorded to the nearest integer ranging in value from 154 to 321. If it is decided to use eight classes of width 21 units and to begin the first class at 153.5.

   (a) Explain the term class boundary and then find the class boundaries of the eight classes.

   (b) Explain the term class limit and then calculate the class limits of the eight classes.

   (c) Explain the term class mark and thereafter calculate the class marks of the eight classes.

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

   (a) Scales of measurement

   (b) Scatter diagrams

   (c) Cumulative frequencies

   (d) Dot maps

   (e) Three entry tables

3. Density is defined as the number of persons per square kilometre. Table 1 shows population density of the Western Province of Zambia by district.

Table 1: Population Density by District in 1990

District	Density (persons / km²)
Kalabo	5.8
Kaoma	4.8
Lukulu	3.1
Mongu	14.1
Senanga	4.5
Sesheke	2.2
Total	4.8

Source: GRZ (1990) *Preliminary Report of the 1990 Census of Population, Housing and Agriculture,* CSO, Lusaka, P13

(a) Using the outline map (Figure 1) provided and the data in Table 1, draw the most suitable statistical map.

(b) What are the merits and limitations of the technique that you have employed?

4. Briefly, explain using suitable sketches, two different methods of presenting data diagrammatically showing the whole divided into its component parts.

5. Examine Figure 2 showing an outline base map and the appropriate data with marked spot heights and their values.

(a) Interpolate contours at 100 metre intervals beginning the first contour at 200 metres.

(b) What are the merits and limitations of the method that you have used?

6. Study the data given in Table 2:

Table 2: Population Size in Lusaka Province by District, 2000

	District	Male ('000)	Female ('000)	Total ('000)
	Chongwe	73	72	145
	Kafue	83	79	162
	Luangwa	11	11	22
	Lusaka	546	558	1,104
Total		712	720	1,432

Source: GRZ (2001) *Preliminary Report of the Census of Population and Housing*, CSO, Lusaka, P9

(a) Prepare a suitable visual display to show the data in Table 2.

(b) Outline and discuss the merits and limitations of the technique that you have selected and used in part (a).

END OF EXAMINATION

COMPUTER NUMBER.......................

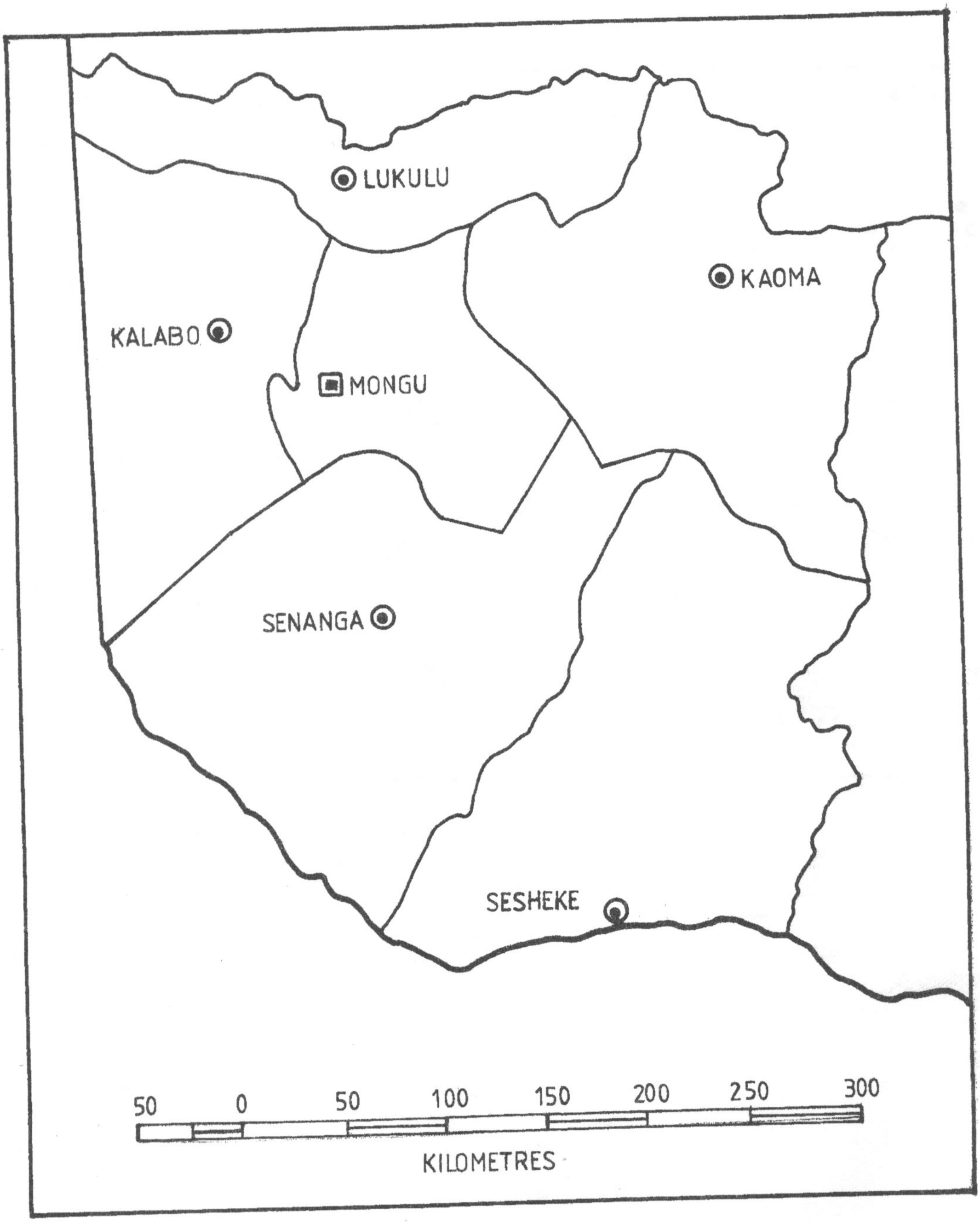


Figure 1

Computer No.................

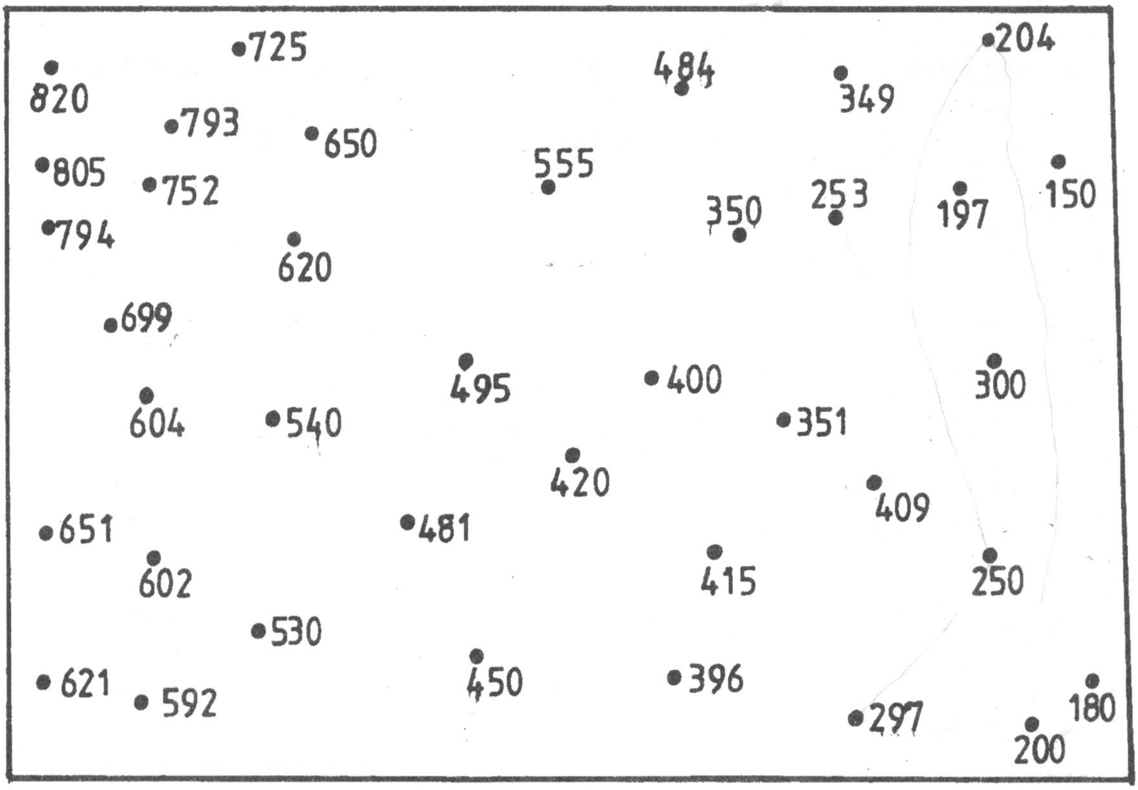


Figure 2

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR DISTANCE EDUCATION FINAL EXAMINATIONS

GEO 211: THE GEOGRAPHY OF AFRICA

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. Outline the critical environmental factors that affect 'tropical agriculture' in Africa.

2. Show how the Neolithic Revolution was experienced in Africa.

3. What is 'the Socio-economic crisis' in Africa?

4. To what extent are African Religions and Philosophy relevant to development in the present age?

5. Explain the roles of land reform, and tourism in the development of Kenya after independence.

6. Compare and contrast the development strategies of Ghana and Côte d'Ivoire (Ivory Coast) after independence.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 212: 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 and candidates are encouraged to use illustrations wherever appropriate.

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1. Discuss the agrarian and social structures that existed in the four main pre-colonial kingdoms in Zambia and explain how colonialism undermined them.

2. Examine the assertion that 'the Zambian government has to a large extent achieved its objective to balance the distribution of industry'.

3. Evaluate the measures taken by the Zambian government to reverse the downward trend in the performance of the mining sector from 1991 to date.

4. Describe the major characteristics of air streams that create the inter- tropical Convergence Zone (ITCZ) and explain how they influence the variations in precipitation in Zambia.

5. 'Zambia's involvement in regional cooperation and intergration is to a large extent a disadvantage to her than an advantage.' Discuss this statement with reference to Zambia's being both a member of the Common Market for Eastern and Southern Africa (COMESA) and Southern African Development Community (SADC).

6. Discuss the importance of coal, wood fuel, water and solar power as energy resources for Zambia and show the merits and demerits of using them.

END OF EXAMINATIONS

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 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 Philip's University Atlas and a certified calculator is allowed.

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1. A survey of 200 families known to be regular television viewers was undertaken. They were asked which of the channels 1, 2, 3 or 4 they watched most frequently during an average week. The replies are summarized in Table 1.

Table 1: Summarized Replies of the Survey

REGION	CHANNEL 1	CHANNEL 2	CHANNEL 3	CHANNEL 4
NORTHERN	29	16	42	23
CENTRAL	6	11	26	7
SOUTHERN	15	3	12	10

Source: Hypothetical Data, 2005.

Was there any association between the channel watched most frequently and the region at 0.05 level of significance?

2. Use data provided in Table 2 to prove whether *Kudus* have (on average) significantly the same life span in Luangwa, Kafue and Nsumbu National Parks. Assume that all the *Kudus* whose ages were studied in each sample were randomly selected. Use the 0.01 significance level.

Table2: Life span (in years) of *Kudus* in Nsumbu, Luangwa & Kafue National Parks

Nsumbu:	12 05 14 11 16 13 18 19 11 11 12 13 10 15 16
Luangwa:	13 07 16 15 13 07 08 09 10 13 12 12 06 05 08 09
Kafue:	18 16 19 18 15 25 15 17 23 18 20 14 23

Source: Hypothetical Data, 2005.

3. The mass of loaves of bread from a certain bakery is normally distributed with mean mass of 500g and standard deviation of 20g.

   (a) Determine what percentage of the output would be below 475g and what percentage would be above 530g.
   (b) The bakery produces 1000 loaves daily at a cost of K3200 per loaf and can sell all those above 475g for K8000 each but is not allowed to sell the rest. Calculate the expected daily profit.
   (c) A sample of 25 loaves of bread yielded a mean mass of 490g. Does this provide evidence of a reduced population mean?

4. Assuming there was no corruption in the Police force of a certain country use data provided in Table 3 to find out if it would be in order to conclude that the more police persons there were in an area the significantly less robberies there would be. Note that both data sets provided in Table 3 are normally distributed and that you are allowed 95 percent accuracy in your analysis.

Table 3: Number of Police Persons and Robberies in Selected Areas

Number of Police persons	Number of robberies per week
04	23
06	18
07	19
12	12
12	18
17	10
19	16
08	14
03	20
13	09
20	02

Source: Hypothetical Data, 2005.

5. A researcher interviewed thirty-five (35) different farmers in Foni village in order to find out how much sunflower they had harvested (in kgs) for the 2004/2005 farming season.

Table 4: Sunflower Harvests (in kgs) for 2004/2005 Farming Season

1)	40.5
2)	7.9
3)	12.0
4)	50.5
5)	18.2
6)	6.4
7)	35.7
8)	24.8
9)	11.3
10)	15.1
11)	38.7
12)	23.0
13)	19.7
14)	48.4
15)	5.5
16)	42.5
17)	20.3
18)	34.6
19)	27.6
20)	11.2
21)	15.3
22)	38.8
23)	46.9
24)	13.8
25)	12.9
26)	46.3
27)	29.5
28)	15.7
29)	47.8
30)	26.3
31)	34.4
32)	8.8
33)	28.4
34)	42.2
35)	33.2

Source: Hypothetical Data, 2005.

Prove whether the sample was biased.

6. Assuming data highlighted in Table 5 were normally distributed, determine if soils in the fields sampled in Mgubudu area were significantly suitable than those in Muswishi area. Make your decision using the 0.05 level of significance.

Table 5: Number of five centimetre circumference pebbles found in every square meter area of selected fields in Mugubudu and Muswishi areas

Mugubudu area														
19	16	19	13	15	18	14	17	19	19	10	15	18	17	14
Muswishi area														
08	10	06	12	12	05	13	11	06	05	02	12	08	10	09

Source: Hypothetical Data, 2005.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 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 and candidates are encouraged to use illustrations wherever appropriate.

---

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

   (a) Human reactions to environmental hazards between events
   (b) Voluntary risk
   (c) Structural paradigm of hazard
   (d) Determinate perception
   (e) Descriptive event tree technique

2. "Environmental hazards exist at the interface between the natural event and the human use systems" (Smith, 1992:10). Discuss.

3. With the help of a diagram, explain the relationship between the severity of environmental hazard, probability and risk.

4. 'Although community loss is the major characteristic of disasters, all definitions ignore the fact that in virtually every disaster, some gains also arise.' Discuss.

5. Describe the chronological stages involved in any comprehensive hazard management that involves both assessment and response.

6. Explain the major differences between risk assessment and risk perception.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 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. Use of a Philip's University Atlas is allowed and candidates are encouraged to use illustrations wherever appropriate.

---

1. Analyse the statement that 'Sudan has had different experiences in handling the refugee situation compared to Zambia.

2. Assess Petersen,s (1958:265) statement that "the distinction between conservative and innovative migration challenges the notion that persons universally migrate in order to change their way of life."

3. Examine refugees survival strategies in both rural and urban areas in any African setting.

4. 'The simple push-pull model is too hypothetical to be of any relevance to the Zambian situation." Discuss.

5. Assess how 'the tripartite approach' in protecting refugees has progressed in Zambia.

6. Describe the essential assumptions and major features of Todaro's model of migration in relation to urban employment.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 952: GEOGRAPHICAL HYDROLOGY

TIME: Three Hours

INSTRUCTIONS: Answer any **four** questions. All questions carry equal marks Use of a Philip's University Atlas is allowed and candidates are encouraged to use illustrations wherever appropriate.

---

1. Explain any three methods used to measure and evaluate each of the main components of the hydrological cycle and outline the merits and demerits of these methods.

2. Write short explanatory notes on **all** of the following:

   (a) Hydrograph
   (b) Land use hydrology
   (c) Hydrometric networks
   (d) Drought
   (e) Hydrometeorology

3. Describe general guidelines that may be followed in the building up of a complete inventory of a ground water basin.

4. Outline the five key elements of a total flood warning system and the roles of the stakeholders involved in the implementation of the system.

5. 'Water is a resource'. Discuss.

6. What are the major limiting factors in precipitation measurements over a drainage area?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 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 and candidates Are encouraged to use illustrations wherever appropriate.

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

   (a) General Maps
   (b) Elements of typographic design
   (c) The co-ordinate system
   (d) Traditional cartography
   (e) Conformal and Equivalent map projections

2. With the help of examples, explain how some elements of symbolisation can be used to order data.

3. Using specific examples, explain how the three categories of symbols can be used to portray ordinal and interval data.

4. 'The graphic representation of a map should be of high quality.' Discuss.

5. How does the principle of "less is more" apply to the drafting of effective maps?

6. Describe the Munsell colour system and outline how colour can be used to improve the ability of maps to communicate effectively.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

GEO 995: ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT I

TIME: Three Hours

INSTRUCTIONS: Answer questions one and any other three. All questions carry equal marks. Use of a Philip's University Atlas is allowed and candidates are encouraged to use illustrations wherever appropriate.

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

   (a) Ecofeminism.
   (b) The Gaia Hypothesis.
   (c) The Life table in population dynamics.
   (d) Resource conservation and preservation.
   (e) Precautionary principle.

2. Show how the relationship between individual behaviour and processes at the group or population level influence natural resource exploitation.

3. 'Food access is determined by institutional characteristics such as property rights, political stability, and social security systems'. Elucidate this statement with reference to Genetically Modified Crops.

4. Outline and explain the three potential problems in management of wild animal populations that require management's attention.

5. Outline the four basic conditions for the continuance of human life on earth where scientists are generally agreed.

6. Explain the roles of each category of designated protected areas in Zambia.

7. 'The lack of congruence between ecosystems and human use systems is responsible for natural resources degradation.' Discuss.

END OF EXAMINATION

THE UNIVERSITY OF UNIVERSITY
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR FINAL EXAMINATIONS

M 111: MATHEMATICAL METHODS I

TIME: **THREE (3) HOURS**

INSTRUCTIONS: **(i) Answer Any Five (5) Questions.**
(ii) No Calculators in this paper should be used.

Q1. (a) Let $A = \{ x : -8 < x \leq 5 \}$
$B = (0, \infty)$
$C = \{ -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7 \}$

Find

(i) $A \cap B$
(ii) $A \cup C$
(iii) $A' \cap (B \cup C)$

(b) Let the roots of the equation $3x^2 - (p-4)x - (2p+1) = 0$ be α and β.

(i) Find the quadratic equation whose roots are $\alpha + 2$ and $\beta + 2$.

(ii) Find the value of p for which the equation $3x^2 - (p-4)x - (2p+1) = 0$ has equal roots.

(c) The rate (R) at which chemical is produced in a certain reaction depends on temperature (T) according to formula ;

$R(T) = T + 3\sqrt{T}$, where T varies with time (t) according to $T = 3(t+1)$.

(i) Express R as a function of time t.
(ii) Find R when $t = 2$.

Q2. (a) (i) Express $0.87\overline{87}$ in the form $\frac{a}{b}$ where a and b are integers.

(ii) Express $\dfrac{3\sqrt{5}+4}{2\sqrt{5}-1}$ in the form $a + b\sqrt{5}$ where a and b are rational numbers.

(b) If $f(x) = 2x + 3$ and $g(x) = \sqrt{x-1}$, determine

(i) $(f \circ g)(x)$
(ii) $(g \circ f)(x)$
(iii) $(f \circ g)(5)$
(iv) The domain of $(f \circ g)(x)$ and of $(g \circ f)(x)$.

(c) Express the following complex numbers in the form $a + bi$ where a and b are rationals.

(i) $\dfrac{3i}{5+2i}$ (ii) $5i(2+6i) + (-2+5i)^2$

(d) Given that $x + 1$ and $x - 2$ are factors of $x^4 - x^3 + ax - bx + b$. Find the values of a and b.

Q3. (a) Differentiate from the first principle $f(x) = \dfrac{1}{x}$

(b) Let $g(x) = \dfrac{3x}{x-3}$

(i) Show that $g(x)$ is a one-to-one function.
(ii) Find the inverse of $g(x)$ if it exists and its domain.
(iii) Find $g'(x)$.

c) The graph of the quadratic function $f(x) = ax^2 + bx + c$ is symmetric about the line $x = -3$, it passes through the point $O(0,0)$ and has its maximum value $f(x) = 12$ i.e. $f(-3) = 12$.

(i) Find the values of a, b and c.
(ii) Sketch the graph of $f(x)$
(iii) On the same axes sketch the graph of $g(x) = \dfrac{4}{3}x + 8$
(iv) Hence use your sketches to write down the solution of $f(x) > g(x)$.

Q4. a) Let S be a set of elements. Define a binary operation '*' on S. An operation * is defined on the set $S = \{3, 5, 7\}$ in the table below:

*	3	5	7
3	3	5	7
5	7	3	5
7	5	7	3

e.g. $5 * 3 = 7$

(i) Is this operation a binary operation on S ?
(ii) Is the operation commutative ?
(iii) Evaluate $(7 * 5) * 3$

b) Solve the following equations:

(i) $\sqrt{3-x} = x-1$

(ii) $|x-3| = 5-2x$

c) Solve the following inequalities:

(i) $|3x-1| < 6$

(ii) $\dfrac{x+4}{x+1} < \dfrac{1}{2}$

Q5. a) Let $z_1 = 1+i$ and $z_2 = 1+i\sqrt{2}$. Find

(i) $\overline{z_1 z_2}$ (ii) $|z_2|^2$

b) If A and B are sets.

(i) Prove that $(A \cap B)' = A' \cup B'$
(ii) Simplify as much as possible $[(A \cap B') \cup (A' \cap B')]'$

c) A farmer has 120 meters of fencing wire and wants to enclose a rectangular plot of land that requires fencing on only three sides since it is bounded by a river on one side.

(i) Find the length and the width of the plot that will maximize the area.

(ii) Find also the area of the plot.

d) Solve the equation for x and y.

$$\frac{1}{x+iy} + \frac{1}{1+3i} = i$$

Q6. a) Prove the identities

(i) $\sec x = \cos x + \sin x \tan x$

(ii) $\dfrac{1+\cos x}{\sin x} + \dfrac{\sin x}{1+\cos x} = 2\operatorname{cosec} x$

b) Find $\dfrac{dy}{dx}$

(i) $y = x\cos x + \sin x$

(ii) $x + \sqrt{xy} = 2y$

c) Find the equation of the tangent line to the curve $x^2 - xy + y^2 = 7$ at the point $(2, 3)$.

Q7. a) Find the following limits

(i) $\lim\limits_{x \to 4} \dfrac{1}{2x-3}$

(ii) $\lim\limits_{x \to \infty} \dfrac{x^3 - 4x}{2x^3 + x^2 + 1}$

(iii) $\lim\limits_{x \to 1} \dfrac{x-1}{x^2-1}$

b) Find the general solution to the equation $\sin 2x = \cos x$.

c) Given that $f(x) = 1 + \sqrt{3}\cos 2x$.

(i) Solve the equation $f(x) = \dfrac{5}{2}$ for $x \in [-\pi, \pi]$.

(ii) Determine the amplitude, period and the phase shift of the graph of $f(x)$.

(iii) Sketch the graph of $f(x)$ on the interval $[-\pi, \pi]$.

End of Examination.

THE UNIVERSITY OF UNIVERSITY
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR
SECOND SEMISTER FINAL EXAMINATIONS

M 112 : MATHEMATICAL METHODS II - A

ME: **THREE (3) HOURS**

STRUCTIONS:
1. Answer any **Four (4)** questions.
2. Write down your computer number on all your answer booklets.
3. Calculators or Mathematical tables are **not** to be used in this examination.

(a) (i) Prove by mathematical induction that $(n+2)! > 3^n$ for any integer $n \geq 1$.

(ii) Using Cramer's rule, solve the following systems of linear equations

$$\begin{aligned} x - y + 2z &= -5 \\ -x + 3z &= 0 \\ 2x + y &= 1 \end{aligned}$$

(b) (i) Obtain the coefficient of x^{-12} in the expansion of $\left(2x^3 - \frac{1}{x}\right)^{20}$

(ii) Find the center, and radius of the circle whose equation is $r - 5\,Cos\theta = 0$.

(c) Given $W = -1 + i$ *and* $Z = -2i$

(i) Express W and Z in polar form where $\theta \in (0, 2\pi)$

(ii) Express WZ in polar form where $\theta \in (0, 2\pi)$

(iii) Find the square roots of **Z** in Cartesian form

(a) Given the system of linear equations

$$x + y + 2z = -8$$
$$2x + 3y - z = 3$$
$$3x + y - 2z = 4$$

(i) Write the system of linear equations in matrix notation, $AX = Z$

(ii) Find the inverse of the matrix A in (i)

(iii) Solve the system of linear equations using the matrix inverse method.

(b) (i) Sketch the graph of the conic described by the equation $y^2 - 4x - 12y + 28 = 0$, showing all the important features.

(ii) Find the following integral.

$$\int \frac{x^2+3}{x^2-1}\,dx$$

(c) Given points $A(6, 3, 3)$, $B(3, 1, -1)$ *and* $C(-1, 10, 2)$

(i) Find the unit vector perpendicular to both vectors $\overrightarrow{AB}$ *and* $\overrightarrow{BC}$.

(ii) Find the area of the triangle ABC.

(a) (i) Find the equation of hyperbola such that for any point on the hyperbola, the difference between its distances from the points $(-3,0)$ and $(-3,3)$ is 2.

(ii) Find the vertices, center and foci of the hyperbola in (i)

(iii) Find the asymptotes of the hyperbola in (i)

(iv) Sketch its graph.

(b) Given that $f(x) = 8x - e^{2x}$

(i) Find the critical point of f(x)

(ii) State whether the critical point is a local maximum or local minimum.

(c) (i) Find the possible values of x for which

$2^{2x+1} = 3(2^x) - 1.$

(ii) Find $\frac{dy}{dx}$, given that $y = \left(x^2+1\right)^x$.

(a) Given the equation of an ellipse as

$4x^2 + 8y^2 - 12x + 16y + 1 = 0$

(i) Find the center and vertices

(ii) Find the foci and eccentricity

(iii) Sketch the graph of the ellipse

(b) (i) Use the De-Mouvre's theorem to simplify

$$\frac{\left[3\left(Cos\frac{\pi}{4} + i\,Sin\frac{\pi}{4}\right)\right]^3}{\left[2\left(Cos\frac{7\pi}{12} + iSin\frac{7\pi}{12}\right)\right]^6}$$

in the form $a + ib$ where $a, b \in \Re$.

(ii) Find the equation of the tangent to the curve of $y = 4\,(x + 1)^2$ at $(-2, 4)$

(c) Evaluate the following integrals.

(i) $\int_0^1 x\,\ell n(x+1)\,dx$ (ii) $\int_{\frac{\pi}{3}}^{\pi} Sinx\ Cos^4 x\ dx$

(a) (i) Find the perpendicular distance between two parallel lines

$3x + 4y + 5 = 0$ and $3x + 4y + 8 = 0$

(ii) Find the equation of the normal to the curve $3x^2 + 2y^2 - 21 = 0$ at the point $(-1, 3)$

(b) (i) Expand $(1+x)^{\frac{1}{4}}$ in ascending powers of x up to and including x^2.

(ii) Find the approximate value of $\sqrt[4]{0.75}$ using the expansion in (i). Leave your answer as a fraction (rational number).

(c) Given the function $f(x) = -x^2 + 6x + 7$

(i) Sketch the graph of $f(x)$

(ii) Find the area bounded by $f(x)$, the line $x = -2$, the y-axis and the x-axis.

6. (a) (i) Find the perpendicular distance from the line $y = 3x - 1$ to the point $(2, -1)$

(ii) Given that $a = i - j - 2k$, $b = 3i - j + 2k$ and $c = -4i + 2k$, find $a \bullet b \times c$

(b) (i) Given that $y = Sin\left(x^2 + 1\right)e^{x^2 + 1}$, find $\frac{dy}{dx}$.

(ii) Evaluate $\int \frac{1}{(x-2)(x-1)^2}\, dx$.

(d) A manufacturer wants to design an open water tank with a rectangular base. The length i to be twice the width and a total surface area of the tank to be $216m^2$. What dimension will produce a tank with maximum volume.

END OF EXAMINATION
GOOD LUCK

THE UNIVERSITY OF UNIVERSITY
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR
SECOND SEMISTER FINAL EXAMINATIONS

M 114 : MATHEMATICAL METHODS II - B

TIME: **THREE (3) HOURS**

INSTRUCTIONS:
1. Answer any **Five (5)** questions.
2. Write down your computer number on all your answer booklets.
3. Calculators or Mathematical tables are **not** to be used in this examination.

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1. a. (i) Use the binomial expansion to show that

$$\frac{x^2}{\sqrt{4-x^2}} = \frac{1}{2}x^2 + \frac{1}{16}x^4 + kx^6 + \dots \text{ for some constant } k.$$

(ii) State the value of k and range of values of x for which series expansion in (i) is valid.

(iii) Approximate the value of the integral $I = \int_0^1 \frac{x^2}{\sqrt{4-x^2}}\,dx$ by integrating the first three terms in the series expansion of $\frac{x^2}{\sqrt{4-x^2}}$ given in (i).

b. Find the value of n for which the coefficients of x, x^2 and x^3 in the expansion of $(1+x)^n$ are in arithmetic progression.

c. Find the equation of the tangent to the circle $x^2 + y^2 + 2x + 4y = 0$ at the origin.

2. a. (i) Write the exponential form of the function $y = \sinh x$.

(ii) Given that $\sinh x = 1$, find the value of $\cosh x$.

(iii) Derive the derivative of $\sinh x$.

(iv) Evaluate $\int_{-1}^{1} \sinh 2x dx$.

b. Find the local extreme points of $f(x) = 2\sin x + \cos 2x$ on $(0, 2\pi)$.

c. (i) Find a unit vector that has the opposite direction to $-5\,i + 12\,j$.

(ii) Given points $A(6, 3, 3)$ $B(3, 1, -1)$ and $C(-1, 10, -2.5)$, find angle ABC .

(iii) Area of triangle ABC .

3. a. Determine the solution of the following system of linear equations using the Cramer's rule :

$$x + y + z = 1$$

$$2x - y + z = 2$$

$$2x + 2y + 2z = 0$$

b. (i) Sketch the graphs of functions $f(x) = e^{2x}$ and $g(x) = e^{-2x}$ on the same Cartesian axes.

(ii) Find the area enclosed between the two curves given in (i) , the ordinates $x = -1$, $x = 1$, and the x – axis .

(iii) Evaluate $\int_0^{\pi/4} \tan^2 x \sec^2 x \, dx$

c. Water is pouring into a conical cistern at a rate of 8 cubic metres per minute. If the height of the cistern is 12 metres and the radius of its circular opening is 6 metres, find the rate at which water level is rising when the water is 4 metres deep.

4. a. Given the curve $y = \dfrac{x}{x^2+1}$

(i) Find horizontal and vertical asymptotes, if there are any.

(ii) Sketch it and mark points of relative extrema and inflection on your sketch.

(iii) Find the area bounded by the curve, the ordinates $x = -1$, $x = 1$ and the x – axis.

b. The rate of growth of the population of a city is predicted to be $\dfrac{dp}{dt} = 5000t^{1.5}$ where p is the population at time t and t is measured in years from the present. Suppose the current population is 100,000, find the population after one year from the present.

c. (i) Evaluate $\int_1^2 \ln x \, dx$

(ii) Sketch the graphs of $f(x) = \log_e x$ and $g(x) = \log_{\frac{1}{e}} x$ on the same Cartesian axes. Using (i) find the area of the region bounded by the curves of $f(x)$ and $g(x)$ and ordinate $x = 2$.

5. a. Let the sum of a series of n terms be denoted by s_n and let a_n be the nth term of the series.

(i) Given $s_n = \dfrac{n}{n+1}$ for all positive integers n, find a_n.

(ii) Write the series of n terms whose sum is $\dfrac{n}{n+1}$.

(iii) Find the sum of the series $\dfrac{1}{1x2} + \dfrac{1}{2x3} + \ldots + \dfrac{1}{79 \times 80}$

b. Given the function $f(x) = \arcsin x$.

(i) Define the domain of $f(x)$.

(ii) Define the range of $f(x)$

(iii) Find the following : $f\left(-\frac{1}{2}\right)$, $f(1)$, $f(0)$, $f\left(\frac{1}{2}\right)$ $f(-1)$, $f(2)$

(iv) Let $g(x) = \arcsin x - 1$. Sketch the graph of $f(x)$ and $g(x)$ on the same Cartesian axes.

(v) Find the equation of the tangent to the curve of $f(x)$ at $x = -\frac{1}{2}$.

(vi) Solve for $x \in R$, $4 \arcsin\left(\frac{x}{2}\right) = \pi$

c. (i) Find the general solution of the equation $\cos 3x + \cos x = 0$.

(ii) Find reals $R > 0$ and α such that $\cos x - \sin x = R\cos(x + \alpha)$.

(iii) Using the identity given in part (ii), find the greatest and least value of $\cos x - \sin x$ and state the smallest positive value of x for which these occur.

6. a. Given $z_1 = 1 - i$, $z_2 = -2i$

(i) Express z_1 and z_2 in polar form.
(ii) Express $z_1 z_2$ in polar form.
(iii) Find the principal argument of $z_1 z_2$.
(iv) Find square roots of z_2 and plot them on an argand diagram.

b. Given the system of linear equations :

$$x + y + 2z = -8$$
$$2x + 3y - z = 3$$
$$-3x + y - 2z = 4$$

(i) Express the above system of linear equations in matrix form.
(ii) Compute the inverse of the coefficients matrix.
(iii) Find the solution of the system.

c. (i) Sketch the conic described by the equation $y^2 - 4x - 12y + 28 = 0$ and indicate on your sketch focus / foci and directrix / directrices of the conic.

(ii) Find the angle between the straight lines represented by equation $x^2 - y^2 = 0$.

(iii) Find the center and radius of the circle whose equation in polar coordinates is $r - 5\cos\theta = 0$.

End of Examination

THE UNIVERSITY OF UNIVERSITY
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR
SECOND SEMISTER FINAL EXAMINATIONS

M 162 : INTRODUCTION TO MATHEMATICS , PROBABILITY AND STATISTICS II

TIME: **THREE (3) HOURS**

INSTRUCTIONS:
1. Answer any **Five (5)** questions.
2. Show all necessary working.

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1. a) (i) Evaluate $\lim\limits_{x \to -1} 3x(2x-1)$

(ii) Find the derivative of $f(x) = x^2 - 6x$ from first principles.

b) Given the curve $y = 2 - 4x^2 + x^3$.

(i) Find the equation of the tangent to the curve at the point $(1, -1)$.
(ii) Find the coordinates of the point where the tangent meets the curve again.

c) (i) Resolve $\dfrac{2x^2 + 2x + 3}{(x+2)(x^2+3)}$ into partial fractions and hence , or otherwise ,

(ii) Evaluate $\displaystyle\int \frac{2x^2 + 2x + 3}{(x+2)(x^2+3)}\, dx$

2. a) Find $\dfrac{dy}{dx}$ if

(i) $y = \dfrac{2x+1}{x^2-1}$

(ii) $x^2 + 2xy + y^2 = 3$

b) Given the function $y = x^3 - 6x^2$, find the

(i) minimum point
(ii) maximum point
(iii) inflection point and sketch the graph indicating the points on your graph.

c) A company has 13 Tongas, 13 Bembas, 13 Lozis and 13 Ngonis. One person is chosen at random from this company to play at a tournament. Find the probability the person

(i) is Lozi
(ii) is Ngoni or Bemba
(iii) is not Tonga

3. a) A bag contains five balls each bearing one of the numbers 1, 2, 3, 4, 5. A ball was drawn from the bag, its number noted and then put back into the bag. This was repeated 50 times and the table below shows the resulting frequency distribution.

Number	1	2	3	4	5
Frequency	x	11	y	8	9

If the mean is 2.7,

(i) determine the value of x and y.
(ii) state the mode and median of this distribution.

b) A random variable X has probability density function

$$f(x) = \begin{cases} kx(2-x) , & 0 \le x \le 2 \\ 0 , & otherwise \end{cases}$$

(i) show that $k = \frac{3}{4}$

(ii) find $P(1 \le X \le 2)$

(iii) find $E(X)$

(iv) find $Var(X)$

c) From a group of 10 people, 4 are to be chosen to serve on a committee.

(i) In how many different ways can the committee be chosen?

(ii) Among the 10 people there is one married couple. Find the probability that both the husband and the wife will be chosen.

(iii) The group of 10 people consists of 3 teenagers. Find the probability that the 3 teenagers will be chosen.

4. a) The following table gives the distribution of marks obtained by 30 pupils in a test.

74	47	44	29	72	59	49	62	39	71
62	18	52	47	61	36	15	70	47	82
88	19	55	54	60	72	63	60	91	81

(i) Construct a frequency distribution, taking equal class intervals $10-19$, $20-29$, ..., $90-99$.

(ii) Draw a histogram and frequency polygon on the same graph.

b) The probability distribution for a random variable X is shown in the table :

x	1	2	3	4
$P(X=x)$	0.13	0.41	0.21	0.25

(i) Find the cumulative distribution function of X.

(ii) Find $P(X \geq 3)$

(iii) Find $E(X)$

(iv) Find $Var(X)$

5. a) Given the set of numbers 101, 106, 99, 108, 76, 87, 102, 93.

Find the

(i) range

(ii) mode

(iii) median

(iv) mean using the assumed mean $\bar{x}_a = 99$.

(v) variance

(vi) standard deviation.

b) A box contains 4 black, 6 white, and 2 red balls. Two balls are picked out of the box without replacement. Find the probability that ;

(i) the first ball picked is black and the second one is white.

(ii) the second ball picked is white.

(iii) the first two balls picked are of the same colour.

c) Consider the word F A C E T I O U S .

(i) In how many ways can the letters of this word be arranged in a line? What is the probability that an arrangement begins with F and ends with S ?

(ii) In how many ways can 4 letters chosen from this word be arranged in a line?

6. a) For events A and B it is known that

$$P(A) = \frac{2}{3}, \quad P(A \cup B) = \frac{7}{12} \quad \text{and} \quad P(A \cap B) = \frac{5}{12}.$$

(i) Find $P(B)$.

(ii) Find $P(B \mid A)$.

(iii) Are A and B independent events ? Explain.

(iv) Are A and B mutually exclusive events ? Explain.

b) The probabilities that a boy goes to school by car , bicycle or on foot on any day are 0.2 , 0.3 and 0.5 respectively. The probabilities of his being late by these methods are 0.1 , 0.3 and 0.6 respectively.

(i) Find the probability that he is late for school.
(ii) If he is late, what is the probability that he traveled by car ?

c) A fair coin is tossed three times.

(i) Draw a probability tree for this experiment. List all the possible outcomes.

(ii) Let X be the number of heads obtained. Write down the probability distribution of X .

End of Examination.

THE UNIVERSITY OF UNIVERSITY
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR FINAL EXAMINATIONS

M 212 : MATHEMATICAL METHODS IV

TIME: **THREE (3) HOURS**

INSTRUCTIONS:
1. **You must write your computer Number on each answer booklet used.**
2. **Indicate the number of each question attempted in the first column on the Main Answer booklet.**
3. **There are six (6) questions in this paper. Candidates must answer any FIVE (5) questions only.**
4. **No Calculators**

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1. a) For the surface $z = x^2 + 2xy - 3y^2$

   (i) Find dz and Δz.

   (ii) Using the total differential, estimate the value of $\dfrac{(3.02)(1.97)}{\sqrt{8.95}}$

   b) Solve the equation $y'' - y = e^{2x}$ by variation of parameters method.

2. a) Find the curvature of the helix given parametrically by
   $x = a\cos wt$, $y = a\sin wt$, $z = bt$.

   b) Let **a**, **b**, **c** be a right hand set. Show that the volume of a parallelepiped that has edges **a**, **b**, **c** is given by **a** . **b** x **c**.
   (vol = **a** . **b** x **c**).

3. a) Find the stationary points of the function $z = x^2 - xy + 2y^4$.
   Hence, determine the nature of the stationary points.

   b) Solve the following Differential Equations

   (i) $\dfrac{d^2y}{dx^2} + y = 10e^{2x}$, $\begin{matrix} y(0) = 5 \\ y'(0) = 14 \end{matrix}$

4. a) (i) Let $f(x, y) = x^2 y^3 \sin \pi x y$. Find f_{xy} at $(1, 2)$

(ii) Solve the Differential Equation $y'' - 4y' - 5y = 5x^3 - 7x^2$.

b) If $u = f(x, y)$ and $x = r\cos\theta$ and $y = r\sin\theta$, prove that

$$\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial u}{\partial y}\right)^2 = \left(\frac{\partial u}{\partial r}\right)^2 + \frac{1}{r^2}\left(\frac{\partial u}{\partial \theta}\right)^2$$

5. a) (i) Let $f(x, y) = \dfrac{xy^2}{x^2 + y^4}$. Show that $f(x, y)$ is not continuous at $(0, 0)$.

(ii) Solve the Differential Equation

$$\frac{dy}{dx} = 2x(1 + y^2)\ ; \quad y(1) = 0$$

b) Show that the mixed partial derivatives are equal for the function

$$f(x, y) = \sin^{-1}\left(\frac{x^2 - y^2}{x^2 + y^2}\right)$$

6. a) Solve the Differential Equation $(3x^3 + y^3)\,dx + xy^2\,dy = 0$.

b) Find the Principal Normal Component $\overline{N}$ for the curve traced by

$$\overline{R} = \frac{t^2}{2} i + \frac{t^3}{3} j$$

End of Examination

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
16TH DECEMBER 2005

M232 REAL ANALYSIS II

INSTRUCTIONS: 1 Answer **any five (5)** questions.
2. Indicate the number of each question attempted on the main. answer book.

TIME ALLOWED: Three (3) hours

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1. (a) Define convergence of an infinity series $\sum a_n$ of real numbers.

   (b) Prove that the series $\sum_{n=1}^{\infty} \frac{3n-2}{n(n+1)(n+2)}$

   converges, and hence find its sum.

   (c) Discuss the convergence and divergence of the series $\sum_{n=0}^{\infty} x^n$.

2. (a) State and prove the limit form of comparison test for convergence or divergence of infinite series.

   (b) Determine whether or not the series converges

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

   (c) Prove that for a rational number α, the series $\sum_{n=1}^{\infty} \frac{1}{n^\alpha}$

   Converges for $\alpha > 1$ and diverges for $\alpha \leq 1$.

3. (a) State

(i) D'Alembert's ratio test for convergence or divergence of series

(ii) Alternating series test.

(b) Determine whether the series converge or diverge:

(i) $\sum_{n=1}^{\infty} \frac{3^n}{4^n \sqrt{n}}$ (ii) $\sum_{n=2}^{\infty} (-1)^n \frac{1}{\log n}$

(c) Prove that if $p > 1$, the series $\sum_{n=2}^{\infty} \frac{1}{n(\log n)^p}$ converges and if $p \leq 1$, the series diverges

4. (a) State what is meant by

(i) absolutely convergent series.

(ii) conditionally convergent series

(b) Prove that

(i) the series $\sum_{n=1}^{\infty} \frac{(-1)^n \sin^2 n\alpha}{n^2}$, where α is a real number, is absolutely convergent

(ii) the series $\sum_{n=1}^{\infty} (-1)^n [\sqrt{n^2+1} - n]$ is conditionally convergent.

(c) Find the interval of convergence of the series $\sum_{n=1}^{\infty} \frac{(x-3)^{n-1}}{(n+1)^2}$

5. (a) Define

(i) divergence of a real valued function $f(x)$ which tends to ∞ as $x \to \infty$

(ii) convergence of a real valued function $f(x)$ which tends to a finite limit l as $x \to \infty$

(b) (i) Prove, using your definition in (a)(i), that the function

$$f(x) = \frac{x^5}{x^3 + 1}$$

tends to ∞ as $x \to \infty$.

(iii) Prove that $\lim_{x \to \infty} \frac{1}{x+2} = 0$.

(c) Prove that the function

$$f(x) = \frac{x^3 \sin x}{x^2 + 1}$$

does not tend to any limit as $x \to \infty$.

6. (a) Define continuity of a real valued function f at a point c.

(b) Let $f : Y \to Z$ and $g : X \to Y$ be two real valued functions such that $(a - R, a + R) \subset X$ and $(b - s, b + s) \subset Y$ for some positive real numbers R and s and also such that

(i) g is continuous at a

(ii) $g(a) = b$

(iii) f is continuous at b.

Prove that the composite function $(fog)(x) = f[g(x)]$ is continuous at a.

(c) Examine the continuity of the function $f(x)$ on $\Re$:

$$f(x) = \begin{cases} \sqrt{|x|}\sin\left(\frac{1}{x}\right), & x \neq 0 \\ 0, & x = 0 \end{cases}$$

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR
SECOND SEMISTER FINAL EXAMINATIONS

M 292 – INTRODUCTION TO PROBABILITY

TIME: **THREE (3) HOURS**

INSTRUCTIONS: 1. Answer any **Five (5)** questions.
2. Use of calculators is allowed.

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1. a) Define the following terms :

(i) Sample space.
(ii) Mutually exclusive events.
(iii) Independent events.

b) In a sample space, event A and B are independent, events B and C are mutually exclusive, and A and C are independent. Given that $P(A \cup B \cup C) = 0.7$, $P(B) = 0.4$ and $P(C) = 0.1$, Find $P(A)$.

c) In a sample space, events A and B are such that $P(A) = P(B)$, $P(A \cap B) = P(A \cup B)^C = \frac{1}{5}$.
Find :
(i) $P(A)$ (ii) P(exactly one of the events A and B occurs).

d) (i) Suppose A and B are two events.

Prove that if $A \subset B$ then $P(A) \leq P(B)$.

(ii) Prove that if A and B are independent events then A and B^C are independent events.

2. a) State and prove Bayes' theorem.

b) A manufacturer of hand calculators has three different plants A, B and C. The proportions of defective calculators produced by the plants are 0.01, 0.02 and 0.04 respectively. Plant A produces 50%, plant B produces 30% and plant C produces 20% of the calculators.

A customer purchases a calculator, find the probability that

(i) it is defective.
(ii) It was produced at plant A given that it is defective.

c) (i) Let X be an exponential random variable with mean 3.

Find $P(X \geq 3 \mid X \geq 2)$

(ii) Show that an exponential random variable X with parameter λ has the property that $P(X > t + S \mid X > t) = P(X > S)$.

(iii) The length of life in hours X, of an electric component has an exponential probability density function with mean 400 hours. Suppose the component has been in operational for 300 hours. Find the probability that it will last for another 600 hours.

3. a) Consider the following density function :

$$f(x) = \begin{cases} Kx & , \quad 0 \leq x < 2 \\ K(4-x) & , \quad 2 \leq x \leq 4 \\ 0 & , \quad \textit{otherwise} \end{cases}$$

(i) Find the value of K for which f is a probability density function.

(ii) Find the $P(X \leq 1)$

(iii) Find $P(X > 3)$

b) The probability that a ball draw at random from an urn of balls is defective is 0.3. If a sample of 5 balls is taken, find the probability that it will contain

(i) no defective balls.
(ii) 4 or 5 defective balls.

c) Demand for a particular item is characterized by the following discrete distribution :

$$P(D) = \begin{cases} K\,\dfrac{d^2}{16} & , \quad d = 1,2,3,4,5 \\ 0 & , \quad \textit{otherwise.} \end{cases}$$

(i) Find the appropriate value of K.
(ii) Evaluate the mean and variance of demand.

4. a) The joint distribution of X and Y is as shown in the table.

		X = 1	X = 2
Y	1	$\frac{1}{4}$	$\frac{1}{16}$
	2	$\frac{1}{8}$	$\frac{1}{16}$
	3	$\frac{1}{16}$	$\frac{1}{4}$
	4	$\frac{1}{16}$	$\frac{1}{8}$

(i) Find the marginal distributions of X and Y.
(ii) Find $P(X \leq 2)$
(iii) Evaluate $E[Y \mid X = 2]$.
(iv) Evaluate ρ_{XY}

b) Suppose X has the probability density function

$$f(x) = \begin{cases} 2e^{-x} & , \quad x > 0 \\ 0 & , \quad \textit{elsewhere} \end{cases}$$

(i) Find the probability density function of $Y = e^{-X}$
(ii) $E(Y)$.

5. a) The moment generating function of a random variable X is

$$M_X(t) = (\cdot 3\, e^t + \cdot 7)^n$$

(i) Find the mean and variance of X.
(ii) Identify the probability distribution of X.

b) The joint probability density function of X and Y is

$$f(x,y) = \begin{cases} 6xy\,(2 - x - y), & 0 \le x < 1,\ 0 \le y \le 2 \\ 0, & elsewhere \end{cases}$$

(i) Find the marginal p d f of x.
(ii) Find the marginal p d f of y.
(iii) Evaluate $P(x > \frac{1}{2} \mid Y < 1)$

c) Derive the moment generating function of a Poisson random variance X and use it to find its mean and variance of a Poisson distribution.

6. a) The moment generating function of a random variable is given by

$$M_X(t) = \left(\frac{\lambda}{\lambda - t}\right)^n$$

(i) Identify the probability distribution of X.
(ii) Identify the probability distribution of X when n = 1.
(iii) Find E(X) and Var(X)

b) Let $f(x,y) = \begin{cases} 1, & 0 < y < 2x,\ 0 < x < 1 \\ 0, & elsewhere \end{cases}$

Find (i) $f(y \mid x)$
(ii) $E(Y \mid x)$
(iii) $E[E(X \mid Y)]$

c) Derive the mean and variance of the Beta distribution.

$$f(x,y) = \begin{cases} \dfrac{1}{B(a,b)} \, x^{a-1} (1-x)^{b-1}, & 0 < x < 1 \\ 0, & elsewhere \end{cases}$$

End of Examination

THE UNIVERSITY OF UNIVERSITY
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR SECOND SEMISTER FINAL EXAMINATIONS

M 325 : GROUP AND RING THEORY

TIME: **THREE (3) HOURS**

INSTRUCTIONS: **Attempt Any Five (5) Questions.**

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1. (a) Let R be a commutative ring and let a, b, c be elements of R.

   (i) Prove that if $a \mid b$ and $a \mid c$ then a divides every linear combination $sb + tc$ where $s, t \in R$.

   (ii) If further R is an integral domain such that $b \mid a$ and $a \mid b$, show that there exists a unit $u \in R$ such that $b = ua$.

   (b) Find the greatest common divisor $gcd(326, 78)$ and express it in the form $326t + 78w$ where t and w are integers.

   (c) Show that if α is an integer, then $\alpha^2 \equiv 0, 1$ or $4 \bmod 8$.

2. (a) State Lagrange's Theorem.

   (b) Let $G = S_3$. If $H = \langle(1\ 2)\rangle$ and $K = \langle(1\ 3)\rangle$ are subgroups of G.

   (i) Find HK.

   (ii) Determine with reason whether or not HK is a subgroup of G.

   (c) Let $\alpha = (1\ 2\ 3\ 4\ 5)(1\ 2\ 3)(4\ 5)$ and $y = (1\ 2\ 4)(1\ 3\ 5)(1\ 4)(2\ 5)$ be elements of S_5. Find

   (i) the inverse and parity of α.

   (ii) the number of permutations in S_5 whose cycle structure is the same as that of α.

   (iii) $\alpha y \alpha^{-1}$.

3. (a) Define a group G.

(b) Let X be a set. If U and V are subsets of X, define $U - V = \{ x \in U : x \notin V \}$. If $\beta(X)$ is the family of all subsets of X equipped with addition given by $A + B = (A - B) \cup (B - A)$ for all $A, B \in \beta(X)$. Show that $\beta(X)$ with this operation is a group. Assume associativity i.e. $(A + B) + C = A + (B + C)$.

(c) Let G be a group of order 4. Show that G is an abelian group.

4. (a) Let $(G, *)$ and (H, o) be two groups with the given operations $*$ and o respectively.

(i) Define a homomorphism $f : G \rightarrow H$.

(ii) Define the kernel of the homomorphism $f : G \rightarrow H$.

(iii) Show that the kernel of a homomorphism f is a normal subgroup of G.

(b) Let $GL(2, Q) = \{ A : \det A \neq 0 \}$ be a group of all non singular 2×2 matrices over the rationals. Let Q^{x} be the multiplicative group of non zero rationals and define a mapping

$\varphi : GL(2, Q) \rightarrow Q^{x}$ by
$\varphi(A) = \det A$ for $A \in GL(2, Q)$

(i) Show that φ is a homomorphism.

Define the special linear group by
$SL(2, Q) = \{ A \in GL(2, Q) : \det A = 1 \}$.

(ii) Prove that $SL(2, Q)$ is a normal subgroup of $GL(2, Q)$.

5. (a) Let R be a commutative ring. Define

(i) An integral domain.
(ii) A subring of R.
(iii) An ideal of R.

(b) If I and J are ideals in a commutative ring R, show that $I \cap J$ is also an ideal in R.

(c) Show that the polynomial $f(x) = x^4 + 3x^3 + 5x^2 + 4x + 2$ is not irreducible in $Z[x]$ by obtaining its factorization.

6. (a) Let G be a group

(i) Define what is meant by G acts on a set X.

(ii) Define also the orbit of $x \in X$.

(iii) Show that G acts on itself by conjugation i.e. if $g \in G$, let $\alpha_g : G \to G$ be $\alpha_g(x) = g x g^{-1}$ for all $x \in G$.

(b) Let G be a finite group. Prove that G has a unique Sylow p – subgroup H, for some prime p, if and only if H is a normal subgroup of G.

7. (a) State Eisenstein Criterion for irreducibility.

(b) Determine irreducibility in $Q[x]$ of

(i) $f(x) = 2x^4 + 3x^3 + 3x^2 + 9x + 6$

(ii) $f(x) = x^4 + 15x^3 + 7$

(c) Find the roots of the equation $x^2 + 1 = 0$ in Z_5.

Hence show that the set $\{a + bx : a, b \in Z_5\}$ where $x^2 + 1 = 0$ in Z_5, is not an integral domain.

End of Examination

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR
SECOND SEMISTER FINAL EXAMINATIONS

M 332 : REAL ANALYSIS IV

TIME: **THREE (3) HOURS**

INSTRUCTIONS: Attempt ~~All~~ ANY FIVE Questions.

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1. a) Let D be an interval or ray and $f: D \to \mathbf{R}$.
   (i) When is f said to be differentiable at $c \in D$?
   (ii) When is f said to be differentiable on D?

   b) Let D be an interval or ray and $f: D \to \mathbf{R}$. If f is differentiable at $c \in D$, prove that f is continuous at c.

   c) Let $f: [a, b] \to \mathbf{R}$. Suppose f has a derivative at $c \in [a, b]$ and $\exists\, \delta > 0 \ni f$ is injective on $(c - \delta, c + \delta)$. Prove that the inverse function f^{-1} has a derivative at $f(c)$ and that

$$\frac{1}{f'(c)} = (f^{-1})'(f(c)), \ \textit{provided} \quad f'(c) \neq 0.$$

2. a) Let $a, b \in \mathbf{R}$, $a < b$. Define the following:
   (i) a partition of $[a, b]$; (ii) a refinement of a partition of $[a, b]$.

   b) For any partition P of $[a, b]$ For $f: [a, b] \to \mathbf{R}$
   Let $U(f, P)$ be the upper Riemann sum and $L(f, P)$ be the lower Riemann sum.
   Let $f: [a, b] \to \mathbf{R}$ be bounded and P_1 and P_2 be partitions of $[a, b]$. If P_2 is a refinement of P_1 show that
   (i) $U(f, P_2) \le U(f, P_1)$; (ii) $L(f, P_1) \le L(f, P_2)$.

   c) For any bounded $f: [a, b] \to \mathbf{R}$, Let
   $\overline{\int_a^b} f(x)\, dx$ *and* $\underline{\int_a^b} f(x)\, dx$ denote the upper and lower Riemann integrals, respectively.
   Let $f: [a, b] \to \mathbf{R}$ be bounded. Prove that

$$\underline{\int_a^b} f(x)\, dx \le \overline{\int_a^b} f(x)\, dx .$$

3. a) Let D be an interval or ray and $f: D \to \mathbf{R}$.
   (i) When is f said to have a relative maximum at $c \in D$?
   (ii) When is f said to have a relative minimum at $c \in D$?

b) Let D be an interval or ray and $f : D \to \mathbf{R}$ have a derivative at $c \in D$.

(i) If $f'(c) > 0$, show that $\exists\, \delta > 0 \ni x \in D,\ c < x < c + \delta$ $\Rightarrow f(c) < f(x)$.

(ii) If $f'(c) < 0$, show that $\exists\, \delta > 0 \ni x \in D,\ c - \delta < x < c$ $\Rightarrow f(c) < f(x)$.

c) State and prove Rolle's theorem.

4. a) Let $f : [a, b] \to \mathbf{R}$. When is f said to be Riemann integrable on $[a, b]$?

b) If $f, g \in R([a, b])$ (f and g are Riemann integrable on $[a, b]$), prove that $f + g \in R([a, b])$ and

$$\int_a^b (f+g)(x)\,dx = \int_a^b f(x)\,dx + \int_a^b g(x)\,dx$$

c) (i) If $f \in R([a, b])$, show that

$$\lim_{n\to\infty} \sum_{i=1}^{n} h f(a+ih) = \int_a^b f(x)dx, \quad where \quad h = (b-a)/n$$

(ii) Use the result of c) (i) and that $\dfrac{n^2}{(n+r)^3} = \dfrac{1}{n}\dfrac{1}{\left(1+\dfrac{r}{n}\right)^3}$

to show that

$$\lim_{n\to\infty}\left[\frac{1}{n} + \frac{n^2}{(n+1)^3} + \ldots + \frac{1}{8n}\right] = \frac{3}{8}$$

5. a) Let $\alpha : [a, b] \to \mathbf{R}$ be monotonically increasing and $f : [a, b] \to \mathbf{R}$ be bounded. When is f said to be Riemann integrable with respect to α on $[a, b]$?

b) Let $\alpha : [a, b] \to \mathbf{R}$ be monotonically increasing and $f : [a, b] \to \mathbf{R}$ be bounded. Prove that f is Riemann integrable with respect to α on $[a, b]$ if and only if $\forall\, \varepsilon > 0\ \exists$ a partition P of $[a, b]$ such that $\displaystyle\sum_{j=1}^{n}(M_j - m_j)\big(\alpha(x_j) - \alpha(x_{j-1})\big) < \varepsilon$,

where
$$P = \{x_0, x_1, \ldots, x_n\}$$
$$M_j = \sup\{f(x) : x \in [x_{j-1}, x_j]\}$$
$$m_j = \inf\{f(x) : x \in [x_{j-1}, x_j]\}$$

c) Theorem : If g' exists and f and g' are Riemann integrable on $[a, b]$, then f is Riemann – Stieltjes integrable on $[a, b]$ with respect to g and $\int_a^b f(x)\, d g(x) = \int_a^b f(x) g'(x) d x$.

Use the theorem above to evaluate $\int_0^{\pi} \cos x \, d(\sin x)$.

6. a) Suppose $n \in \mathbf{N}$, that f and its derivatives $f', f'', \ldots, f^{(n-1)}$ are defined and continuous on $[a, b]$ and that $f^{(n)}$ exists in (a, b). If $\alpha, \beta \in [a, b]$, prove that $\exists \gamma$ between α and β such that

$$f(\beta) = f(\alpha) + \frac{f'(\alpha)}{1!}(\beta - \alpha) + \frac{f''(\alpha)}{2!}(\beta - \alpha)^2 + \ldots +$$

$$\frac{f^{(n-1)}(\alpha)}{(n-1)!}(\beta - \alpha)^{n-1} + \frac{f^{(n)}}{n!}(\beta - \alpha)^n$$

b) Suppose $n \in \mathbf{N}$, that f and its derivatives $f', f'', \ldots, f^{(n)}$ are continuous on $[a, b]$. Prove that

$$f(b) = f(a) + \frac{f'(a)}{1!}(b - a) + \ldots + \frac{f^{(n-1)}(a)}{(n-1)!}(b - a)^{n-1} + R_n,$$

where $R_n = \dfrac{1}{(n-1)!} \int_a^b (b - t)^{n-1} f^{(n)}(t)\, dt$

7. a) (i) Let $\alpha : [a, b]$ be a finite interval. Suppose f is not bounded in a neighbourhood of any end points a or b. Discuss

$$\int_a^b f(x)\, d x .$$

(ii) Let $a \in R$. Define $\int_a^{\infty} f(x)\, d x$.

b) Let $f : [0, 1] \to \mathbf{R}$ be defined by $f(x) = x^{-2}$. Show that f does not have an improper integral.

c) Let $[a, b]$ be a finite interval. Suppose $\exists\, k \in \mathbf{R} \ni$ $\forall \varepsilon \in (0, b - a)$, $f \in R\,([a + \varepsilon, b])$ *and* $f(x) \geq 0$ $\int_{a+\varepsilon}^b f(x)\, d x < k$. Prove that $\int_a^b f(x)\, d x$ exists.

End of Examination

THE UNIVERSITY OF UNIVERSITY
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR
SECOND SEMISTER FINAL EXAMINATIONS

M 362 : LINEAR MODELS AND DESIGN OF EXPERIMENTS

TIME: **THREE (3) HOURS**

INSTRUCTIONS: 1. Answer any **Four (4)** questions.
2. Show all essential working.

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1. a) Consider the simple linear regression model $Y_i = \beta_0 + \beta_1 x_i + \varepsilon_i, \quad i = 1, 2, \ldots n$ where $\varepsilon_i \overset{iid}{\sim} N(0, \sigma^2)$.

(i) Obtain the least squares estimators $(\hat{\beta}_0, \hat{\beta}_1)$ *of* (β_0, β_1).

(ii) Show that $\operatorname{Cov}(\hat{\beta}_0, \hat{\beta}_1) = \dfrac{-\sigma^2 \bar{x}}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$

b) The grades of a class of 9 students on a test (x) and on the final examination (Y) are as follows :

x	77	50	71	72	81	94	96	99	67
Y	82	66	78	34	47	85	99	99	68

$$\left[\sum_{i=1}^{n} x_i = 707,\ \sum_{i=1}^{n} Y_i = 658,\ \sum_{i=1}^{n} x_i^2 = 57557,\ \sum_{i=1}^{n} Y_i^2 = 51980,\ \sum_{i=1}^{n} x_i Y_i = 53258\right]$$

consider fitting the model $Y_i = \beta_0 + \beta_1 x_i + \varepsilon_i,\ \varepsilon_i \sim N(0, \sigma^2)$.

(i) Estimate $\hat{\beta}_0$ *and* $\hat{\beta}_1$.

(ii) Copy and complete the ANOVA table

Source	SS	df	MS	F
Regression				
Error			379.14	
Total				

Test the hypothesis that $\beta_1 = \beta_2 = 0$. Use $\alpha = 0.05$.

(iii) Estimate the standard errors of $\hat{\beta}_0$ *and* $\hat{\beta}_1$.

2. a) Consider the multiple regression model

$$Y = X\beta + \varepsilon \quad \text{where} \quad \varepsilon \sim N(0, \sigma^2 I).$$

Prove that

(i) $\hat{\beta} \sim N\left(\beta , \sigma^2 (X^T X)^{-1}\right)$

(ii) $r \sim N\left(0, \sigma^2 (I - H)\right)$ where $r = Y - \hat{Y}$ and H is the hat matrix.

b) A consumer – product marketing experiment involved different advertising and promotion strategies in eight sales regions. TV advertising, newspaper adverting and retailer incentive (absent or present) were systematically varied in order to monitor the changes in market shares relative to the previous quarter. The data are given in the table.

x_1	x_2	x_3	Y
– 1	0	– 1	1.2
0	– 1	– 1	1.5
0	1	– 1	2.2
1	0	– 1	2.3
– 1	0	1	1.9
0	– 1	1	1.4
0	1	1	2.8
1	0	1	2.3

where :

x_1 : TV advertising which was either increased by 10% , kept the same or decreased by 10% (coded 1 , 0 , – 1) .

x_2 : News paper advertising also varied as TV advertising.

x_3 : Retailer incentive absent or present (coded – 1 , 1)

Y : Changes in market shares.

(i) For the model $Y = X\beta + \varepsilon,\ \varepsilon \sim N(0, \sigma^2 I)$. Write down the X matrix and Y vector and hence compute $\hat{\beta}$.

(ii) Copy and complete the ANOVA table.

Source	SS	df	MS	F
Regression				
Error			0.06375	
Total				

Test the hypothesis that $\beta_1 = \beta_2 = \beta_3 = 0$. Use $\alpha = 0.05$.

(iii) Find a 95% confidence interval for the mean value of the market share change when TV advertising is kept the same, when news paper advertising is increased by 10% and the retailer incentive is absent.

3. a) Define each of the following terms :

(i) Blocking.
(ii) Randomization.
(iii) Replication.

b) Why are blocking, randomization and replication necessary ?

c) A manufacturing firm wants to investigate the effects of 5 colour additives on the setting time of a new concrete mix. To elimate variations in the setting times due to day - to - day changes and different workers, a 5 x 5 Latin square design was used in which the letters A , B , C , D and E represent the 5 additives. The setting times , in hours , for the 25 molds are shown in the following table :

Worker	Day				
	1	2	3	4	5
1	A 8	B 7	D 1	C 7	E 3
2	C 11	E 2	A 7	D 3	B 8
3	B 4	A 9	C 10	E 1	D 5
4	D 6	C 8	E 6	B 6	A 10
5	E 4	D 2	B 3	A 8	C 8

(i) Write down a model for the above data. State all the assumptions and explain all the terms in the model.

(ii) Can we say that the colour additives have any effect on the setting time of the concrete mix? Use $\alpha = 0.05$.

(iii) Use the LSD method to compare the mean setting times of the colour additives. Use $\alpha = 0.05$.

(iv) Write down a contrast comparing colour additives D and E to the other additives. Are these two different from the other additives? Use $\alpha = 0.05$.

4. a) Define each of the following terms :

(i) confounding.
(ii) interaction.
(iii) a contrast.

b) Given the model $Y = X\beta + \varepsilon, \ \varepsilon \sim N(0, \sigma^2 V)$ where V is a diagonal matrix. Show that :

(i) the weighted least squares estimator of β is $\tilde{\beta} = (X^T V^{-1} X)^{-1} X^T V^{-1} Y$

(ii) $\text{Var}(\tilde{\beta}) = \sigma^2 (X^T V^{-1} X)^{-1}$

c) An experiment was run to determine whether four specific firing temperatures affect the density of a certain type of brick. The experiment led to the following data :

Temperature	Density				
1	21.8	21.9	21.7	21.6	21.7
2	21.7	21.4	21.5	21.4	
3	21.9	21.8	21.8	21.6	21.5
4	21.9	21.7	21.8	21.4	

(i) Write down a model that might be suitable for these data stating all the model assumptions. Explain all the terms in the model. Estimate all the parameters in your model.

(ii) Does the firing temperature affect the density of the brick? Use $\alpha = 0.05$.

(iii) Is it appropriate to compare the means using the LSD method? Justify your answer.

(iv) Compute a 95% confidence interval for mean of temperature 4 .

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR
SECOND SEMISTER FINAL EXAMINATIONS

M 422 - MODULE AND FIELD THEORY

TIME: **THREE (3) HOURS**

INSTRUCTIONS: Attempt any **Five (5)** questions.

SECTION A - (MODULE THEORY)

1. What is the meaning of each of the following terms :

   (i) M is a finitely generated R – module.
   (ii) a subset S of M is an R – ideal of m.

   a) *Show that if each element m of an R – module M has a unique* expression of the form

   $$m = r_1 m_1 + r_2 m_2 + \ldots + r_t m_t$$ then each m_i satisfies the condition $0(m) = 0$, where $0(m) = \{ r t R \mid r m = 0 \}$

   b) Show that the subset T of R defined by $T = \{ m \in M \mid 0(m) = 0 \}$ is an R – submodule of M and all the elements in M / T satisfy the same condition as m above.

2. Define each of the following terms :

   (i) the map $\phi : M \to N$ from an R – module M to an R – module N is an R – homomorphism.

   (ii) the kernel ker ϕ of the R – homomorphism ϕ.

   a) Prove that ker ϕ is an R – submodule of M.

   b) Prove further that the quotient module M / Ker ϕ is isomorphic to the image of ϕ in N.

3. What is the meaning of lack of the following terms

(i) M is an internal direct sum of it R – submodules.
(ii) M is freely generated by the set $\{ m_1, m_2, \dots, m_r \}$

a) Prove that if M_1 and M_2 are R – submodules of m, then $(M_1 + M_2)/M_1 \cong M_2/M_1 \cap M_2$.

b) Confirm that if $M = M_1 \oplus M_2$ and M is generated by r elements, then M_1 can be generated by r elements.

SECTION B - (FIELD THEORY)

4. Define the terms

(i) a field extension $L : K$
(ii) the degree $[L : K]$ of the field extension $L : K$

a) Prove that if $L : K$ is a finite field extension, then L is algebraic over K.

b) For the field extension $Q\left(\sqrt{2}, \sqrt{3}, \sqrt{5}\right) : R$, determine the degree of each of normal extension over prime ground field.

5. What is meant by each of the following :

(i) the Galois group of field extension $L : K$
(ii) intermediate fields of the field extension $L : K$

a) show that the Galois group of a polynomial $f(x)$ over the field is a subgroup of the symmetric group S_n of degree n, where n is the degree of $f(x)$.

b) Construct a splitting fields for the polynomial $x^4 + 3x^2 - 18$ over (i) Q (ii) Z_7 ; in each case find the Galois group of the splitting field over the ground field.

6. Define each of the following terms :

(i) the splitting field for a polynomial function $f(x)$ over $k[x]$.
(ii) a normal field extension $M : K$ of the extension $L : K$.

a) Prove that a finite normal extension $L : K$ is a splitting field of some polynomial $g(x) \in k(x)$.

b) Determine the splitting field of $f(x) = x^4 - 3x^2 + 4 \in Q[x]$. Hence determine the Galois group of $f(x)$ over Q. Hence or otherwise determine all the normal extensions of M of such that $L \subseteq M \subseteq Q$, where L is the splitting field of $f(x)$.

7. What is meant by each of the following terms :

(i) the polynomial equation $f(x) = 0$ is <u>solvable by radicals</u> ?
(ii) the polynomial $f(x)$ is <u>irreducible over Q</u> ?

a) Show that $x^6 + 3$ is irreducible over Q , the field of rationals.

b) Show that if β is a root of $x^6 + 3$ then $\frac{1}{2}(1+\beta^3$ is a 6^{th} root of unity. Deduce that Q (β) is the splitting field of $x^6 + 3$ over Q and calculate its Galois group.

[Hint : the other roots of $x^6 + 3$ are of the form
$\alpha^i\beta$ *where* $\alpha = \frac{1}{2}(1+\beta^3)$]
$i = 1, 2, 3, 4, 5$

Hence deduce that Q (β : Q) is solvable by radicals.

End of Examination

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR FINAL EXAMINATIONS

M 912 : MATHEMATICAL METHODS VI

TIME: **THREE (3) HOURS**

INSTRUCTIONS:
1. You must write your computer Number on each answer booklet used.
2. Indicate the number of each question attempted in the first column on the Main Answer booklet.
3. There are six (6) questions in this paper. Candidates must answer any FIVE (5) questions only.
4. No Calculators

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1. (a) (i) Evaluate $\int_0^1\int_0^{\pi}\int_0^{2\pi} e^{\rho^3}\rho^2 \sin\varphi \, d\theta \, d\varphi \, d\rho$

   (ii) Verify through iterated integration that: The area of a circle with radius r is πr^2.

   (b) Using the power series method, solve the equation:
   $$2x(1-x)\,D^2y + (1-x)Dy + 3y = 0$$

2. (a) Verify Green's Theorem for the integral $\int_C y^3dx + (x^3 + 3xy^2)dy$ Where C is the path from (0,0) to (1,1) along the graph $y = x^3$ and from (1,1) to (0,0) along the graph $y = x$.

   (b) Solve the simultaneous Differential Equation
   $$Dx + Dy + y = t$$
   $$D^2x + 3x + D^2y + 7y = e^{2t}$$
   Such that $Dx = -\frac{19}{3}$ and $Dy = 3$ when $t = 0$.

3. (a) (i) Find the Fourier integral representation of the function
   $$f(x) = \begin{cases} 1 : & |x| < 1 \\ 0 : & |x| > 1 \end{cases}$$

   (ii) State and prove the Parseval Theorem.

   (b) Using Stokes' Theorem, evaluate the line integral $\int_C -y^3dx + x^3dy - z^3dz$

4. (a) (i) Verify the formula for the volume of a ball: $\int_w dv = \frac{4\pi}{3}$, where w is a unit ball $x^2 + y^2 + z^2 \leq 1$.

(ii) Let D be the parallelogram bounded by $y = 2x$, $y = 2x - 2$, $y = x$, $y = x + 1$. Sketch D. Hence evaluate $\int_D xydxdy$ by making the change of variables $x = u - v$, $y = 2u - v$

(b) Compute the area of the surface of the sphere S described by $x^2 + y^2 + z^2 = 1$.

5. (a) (i) State and prove Green's Theorem.

(ii) Let w be the region bounded by the planes $x = 0$, $y = 0$, $z = 2$ and the surface $z = x^2 + y^2$, $x \geq 0$, $y \geq 0$. Sketch the region w. Hence, compute $\int_w xdxdydz$.

(b) Find the Fourier series of the function f(x) which is assumed to have the period 2π and plot accurate graphs of f(x) and the first three partial sums.

$$f(x) = \begin{cases} -x & : \quad -\pi < x < 0 \\ x & : \quad 0 < x < \pi \end{cases}$$

6. (a) (i) Evaluate $\int_0^2 \int_0^{\log x} (x-1)\sqrt{1-e^{2y}}\,dydx$, Sketch D.

(ii) Verify stokes' Theorem for $F(x,y,z) = 2zi + xj + y^2k$, where S is the surface of the paraboloid $z = 4 - x^2 - y^2$ and C is the trace of S in the xy- plane. Sketch S.

(b) (i) Let $F(x,y,z) = yzi + xzj + xyk$ and $\sigma op : [-5,10] \rightarrow R^3$, $t \rightarrow (t, t^2, t^3)$.

Evaluate $\int_{\sigma op} F.ds$

(ii) Evaluate the surface integral $\iint_S (x + z)ds$ where S is the first Octant portion of the cylinder $y^2 + z^2 = 9$ between $x = 0$ and $x = 4$. Sketch S.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2005 ACADEMIC YEAR SECOND SEMESTER FINAL EXAMINATIONS

M962: TIME SERIES ANALYSIS

INSTRUCTIONS:

1. Answer any FIVE (5) questions.
2. Calculators are allowed.
3. Show all your work to earn full marks.

TIME: THREE (3) Hours

Q1 (a) Suppose (X_t) is a time series.

(i) State what is meant by X_t is strictly stationary

(ii) State what is meant by X_t is covariant stationary

(b) Suppose that $Y_t = \text{Sin}(\pi t+\theta)$ where θ is a random variable with a uniform distribution in the interval $(-\pi,\pi)$.

(i) Find $E(Y_t)$

(ii) Find $Var(Y_t)$

(iii) Find $\gamma_k = Cov(Y_t, Y_{t+k})$

(iv) Find $\rho_k = Corr(Y_t, Y_{t+k})$

(v) Is Y_t covariant stationary?

Q2 Given (a_t) is a white noise with mean 0 and variance σ_a^2 and (X_t) is a series generated from the white noise process via

$$X_t = \lambda X_{t-1} + a_t - \beta a_{t-1}$$

(a) (i) State the type of model this is when $\lambda \neq 1$

(ii) A state a condition on β for the model to be invertible

(iii) A state a condition on λ for the model to be stationary

(iv) What special name is given to the model when $\lambda = 1$?

(v) What special name is given to the model when $\lambda = 1$ and $\beta=0$?

(b) (i) Using the general model above express the variance of X_t in terms of σ_a^2, λ and β.

(ii) Find $\gamma_1 = Cov(X_t, X_{t-1})$, the first lag covariance.

(iii) Using (i) and (ii) show that the first lag autocorrelation is given by $\rho_1 = \dfrac{(1-\lambda\beta)(\lambda-\beta)}{1-2\lambda\beta+\beta^2}$

A simulation of the model above for $\lambda = 1$ and $\beta=0$ was done yielding 500 observations of X_t. A summary of the relevant statistics is given below.

$$\overline{X} = \sum_{i=1}^{500} \frac{x_i}{500} = 35.869 \qquad \sum_{i=1}^{500} x_i^2 = 747288.3 \qquad \sum_{i=1}^{499} x_i x_{i+1} = 745304.0$$

It can be shown that $\hat{\rho}_1 \cong \dfrac{\sum_{i=1}^{499} x_i x_{i+1} - n\overline{x}^2}{\sum_{i=1}^{500} (x_i - \overline{x})^2}$

(iv) Using the data above find the value of $\hat{\rho}_1$

(v) Based on b(iii), find the theoretical value of ρ_1 when $\lambda = 1$ and $\beta=0$

Q3 (a) It can be shown that if $X_1, X_2, \ldots, X_n$ are random variables:

$$\operatorname{Var}\left(\sum_{i=1}^{n} X_i\right) = \sum_{i=1}^{n} \operatorname{Var}(X_i) + 2\sum_{k=1}^{n-1}\sum_{i=1}^{n-k} \operatorname{Cov}(X_i, X_{i+k})$$

Suppose the series (W_t) has variance γ_0 and autocorrelation function (ρ_k), $k = \pm 1, \pm 2, \ldots$ and that

$$\overline{W} = \frac{W_1 + W_2 + \ldots + W_n}{n} = X_1 + X_2 + \ldots + X_n, \text{ where } X_i = \frac{W_i}{n},$$

$i = 1, 2, \ldots, n$.

(i) Find the variance of X_i in terms of γ_0.

(ii) Express $\operatorname{cov}(X_i, X_{i+k})$ in terms of ρ_k and γ_0.

(iii) Using (i) and (ii) and the variance relationship given above show that $\operatorname{Var}(\overline{W}) = \dfrac{\gamma_0}{n}\left\{1 + 2\sum_{k=1}^{n-1}\left(1 - \dfrac{k}{n}\right)\rho_k\right\}$

(b) Given that $W_t = \mu + a_t$ where (a_t) is a normal white noise process with mean 0 and variance σ_a^2 find:

(i) $E(\overline{W})$, where $\overline{W} = \dfrac{W_1 + W_2 + \ldots + W_n}{n}$

(ii) $\gamma_0 = \operatorname{Var}(W_t)$

(iii) $\rho_k = \operatorname{Corr}(W_i, W_{i+k})$

(iv) $\operatorname{Var}(\overline{W})$

(v) A 95% confidence interval for μ given by $\overline{W} \pm 1.96 * \sqrt{\operatorname{Var}(\overline{W})}$ from 100 values of the a series (W_t) which has a sum of 5240 assuming that (a_t) is a normal white noise process with mean 0 and variance 1.

Q4 (a) Let $Z_t = \alpha_1 Z_{t-1} + \alpha_2 Z_{t-2} + \alpha_3 Z_{t-3} + a_t$ where $E(Z_t) = 0$ for all t and (a_t) is a white noise with mean 0 and variance σ_a^2.

(i) Derive the autocovariance equations:

$$\gamma_1 = \alpha_1\gamma_0 + \alpha_2\gamma_1 + \alpha_3\gamma_2$$

$$\gamma_2 = \alpha_1\gamma_1 + \alpha_2\gamma_0 + \alpha_3\gamma_1$$

$$\gamma_3 = \alpha_1\gamma_2 + \alpha_2\gamma_1 + \alpha_3\gamma_0$$

(ii) Using (i) derive the Yule-Walker equations:

$$\rho_1 = \alpha_1\rho_0 + \alpha_2\rho_1 + \alpha_3\rho_2$$

$$\rho_2 = \alpha_1\rho_1 + \alpha_2\rho_0 + \alpha_3\rho_1$$

$$\rho_3 = \alpha_1\rho_2 + \alpha_2\rho_1 + \alpha_3\rho_0$$

(b) A time series (Z_t) is an AR(3) and has as its first three autocorrelations $\rho_1 = 0.64$, $\rho_2 = 0.22$ and $\rho_3 = -0.12$

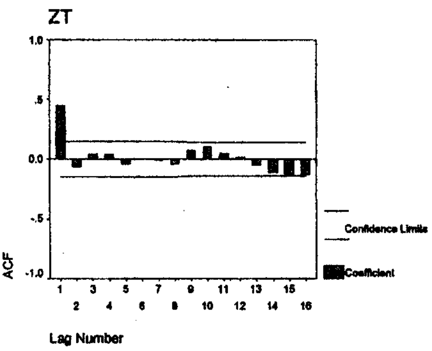
(i) Evaluate the first two partial autocorrelations.

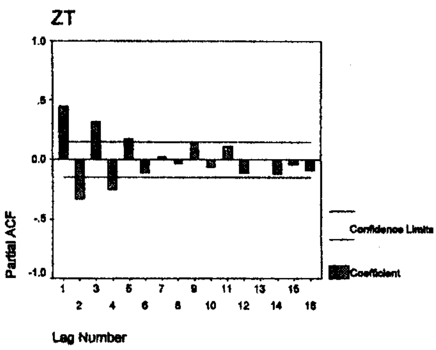
(ii) It can be shown that

$$\alpha_1 = \frac{\begin{vmatrix} \rho_1 & \rho_1 & \rho_2 \\ \rho_2 & 1 & \rho_1 \\ \rho_3 & \rho_1 & 1 \end{vmatrix}}{\begin{vmatrix} 1 & \rho_1 & \rho_2 \\ \rho_1 & 1 & \rho_1 \\ \rho_2 & \rho_1 & 1 \end{vmatrix}} \quad \alpha_2 = \frac{\begin{vmatrix} 1 & \rho_1 & \rho_2 \\ \rho_1 & \rho_2 & \rho_1 \\ \rho_2 & \rho_3 & 1 \end{vmatrix}}{\begin{vmatrix} 1 & \rho_1 & \rho_2 \\ \rho_1 & 1 & \rho_1 \\ \rho_2 & \rho_1 & 1 \end{vmatrix}}, \quad \alpha_3 = \frac{\begin{vmatrix} 1 & \rho_1 & \rho_1 \\ \rho_1 & 1 & \rho_2 \\ \rho_2 & \rho_1 & \rho_3 \end{vmatrix}}{\begin{vmatrix} 1 & \rho_1 & \rho_2 \\ \rho_1 & 1 & \rho_1 \\ \rho_2 & \rho_1 & 1 \end{vmatrix}}$$

Given that $\begin{vmatrix} 1 & \rho_1 & \rho_2 \\ \rho_1 & 1 & \rho_1 \\ \rho_2 & \rho_1 & 1 \end{vmatrix} = \begin{vmatrix} 1 & 0.64 & 0.22 \\ 0.64 & 1 & 0.64 \\ 0.22 & 0.64 & 1 \end{vmatrix} = 0.312624$ and using the Yule-Walker equations solve for α_1, α_2, and α_3 and write down the model.

Q5 (a) The time series Z_t whose ACF and PACF are shown below is either an AR(1) or MA(1).





(i) Based on the graphs make your choice between an MA(1) and AR(1)

(ii) Given that $\rho_1 = 0.45$ find the value of the parameter of your model and write down the model.

(b) Below is a record of the service time in minutes of a trainee at a certain bank:

3.2 4.7 6.6 4.8 4.7 4.7 3.8 6.4 4.1 4.6

(i) Find the sample estimate of ρ_1 and ρ_2, the autocorrelation

(ii) Find the sample estimate of ϕ_{11} and ϕ_{22} the partial autocorrelation.

Q6 (a) (i) State the fundamental theorem of forecasting

(ii) Define the forecasting $\hat{Z}_t(\ell)$ at origin t for lead time ℓ for the model

$$Z_t = c\ a_t + \psi_1 a_{t-1} + \psi_2 a_{t-2} + \ . \ .$$

(iii) Define the forecasting error $e_t(\ell)$

(iv) Write down the expression for the variance of $e_t(\ell)$

(v) Given the model $X_t = \mu + a_t - \theta a_{t-1}$, write down the ℓ-step ahead forecasting $\hat{X}_t(\ell)$ for $X_{t+\ell}$

(vi) Find $\hat{X}_t(1)$ for the model in (v)

(vii) What is peculiar about $\hat{X}_t(\ell)$ for $\ell \geq 2$ in this model in (v)

(b) You are given the model

$$X_t - \mu = \phi(X_{t-1} - \mu) + a_t$$

Or $$X_t = (1 - \phi)\mu + \phi X_{t-1} + a_t$$

(i) Write down the ℓ-step ahead forecast $\hat{X}_t(\ell)$ for the model

(ii) Show that $\hat{X}_t(\ell) = (1 - \phi^\ell)\mu + \phi^\ell x_t$

(iii) What is the limit of $\hat{X}_t(\ell)$ as ℓ increases?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER EXAMINATION – DECEMBER, 2005

MSE 342/352/362

TIME : **THREE (3) HOURS**

INFORMATION

1. There are seven (6) questions in this paper.
2. Each question has possible maximum marks of 20.

INSTRUCTIONS

1. Answer question **one** and
2. Any other **four (4)** questions.

---

1. (a) Critique the following statement (Giving reasons for and against) : "computers should not be used to teach science in the classrooms" [8]

   (b) For each of the following teaching and learning theories, discuss how it impacts on teaching and learning:
      i. Piaget's theory [3]
      ii. Constructivism [3]
      iii. Behaviorism [3]

   (c) Discuss some of the criticisms about the theory of behaviorism. [3]

2. (a) Discuss the significance of using real things, models and charts in the teaching and learning of biology, chemistry or physics. [7]

   (b) Identify four variables a teacher of science should consider when selecting a teaching aid for a particular lesson. [4]

   (c) Discuss the advantages of using an overhead projector (OHP) over the chalkboard in the teaching of science. [7]

   (d) Describe two weaknesses of overhead projector for teaching science. [2]

3. (a) The Permanent Secretary Ministry of Education has requested you to prepare a paper on the "characteristics of an effective science teacher" which she is to deliver to old and new teachers of science in Chipata District. Critically analyse the major characteristics you would include in this paper to support your arguments. [10]

   (b) There are two mistakes made by some teachers when handling issues of discipline. These are:
      i. To over react to children's misdemeanors.
      ii. To become emotionally involved.

   Discuss how you intend to handle discipline problems in your school taking into account these statements. [5]

   (c) Outline the major reasons for teaching science in our schools. Explain what would be the repercussions if science education were ignored in any society. [5]

4. (a) In several schools in Zambia homework is given to pupils as a form of punishment or means of keeping the children indoors. In your view outline the professional reasons what you think about homework. [7]

   (b) The Head of Science Department at Mansa High School is requested to prepare a trip to Maputo in Mozambique consisting of 20 girls 20 boys and two teachers (male and female) to study the fishing industry in this town. Discuss the various procedures she has to go through in order to make the trip a reality. [8]

   (c) One of the major problems new science teachers face is to know the names of their pupils. Which strategy would you apply to quickly learning names of your pupils [5]

5. You are confronted with the following safety issues write down what you would do under the following circumstances:
   (a) A pupil has come in possession of a bottle of Benzene and wants to smuggle it to his home for parents to use. [4]

   (b) A pupil has been attracted to the silky colour of mercury and decides to put some in the mouth [4]

   (c) A pupil suddenly removes a chemical stored in the fridge and leaves it on top of a laboratory bench. [4]

   (d) Pupils want to collect live animals from a game park for their experiments in the laboratories. [4]

(e) A teacher accidentally uses a carbon dioxide fire extinguisher in putting out a fire in an animal room. [4]

6. (a) State and explain the three fundamental aspects of science that will help teachers convey to their learners a more complete picture of the scientific enterprise. [6]

   (b) State and describe methods of science processes [14]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER EXAMINATIONS - DECEMBER 2005

MSE 942

BIOLOGY TEACHING METHODS IV

TIME: **THREE (3) HOURS**

INFORMATION

1. There are six (6) questions in this paper.
2. Each question has possible maximum marks of 20.

INSTRUCTIONS

1. Answer question **one** and
2. Any other **four (4)** questions.

---

1. (a) Define the concept of change and describe the two ways in which change can be looked at. [4]

   (b) Describe at least six (6) Golden rules of change management and explain how they can be applied in biology teaching in high schools. [9]

   (c) According to Newton, "every action has an equal and opposite reaction". Discuss how Newton's law applies to the change situation in an environment of change. Illustrate with concrete examples. [7]

2. (a) Explain how you would illustrate each of the following biosphere, environment, habitat, food chain and ecosystem to pupils so that they can grasp these terms. [5]

(b) The teaching and learning of Ecology in biology has always been misinterpreted to involve several areas of science. In your view, what do you expect the grade 12 pupils to learn in ecology and how will they relate it to their daily lives? [8]

(c) From your experience as a teacher of biology, What aspects of ecology do pupils find difficult to grasp? How do you intend to overcome pupils' difficulties you have identified when you return to your school? [7]

3. (a) Genetics is a modern science in our high schools, which is generally considered to be very difficult by both pupils and teachers.

(i) Discuss the major difficulties faced by teachers and pupils in the teaching and learning of this topic. [5]

(ii) How do you intend to overcome these difficulties when you go to teach this topic at your school? [5]

(b) The teaching and learning of genetics in schools has always been associated with raising several controversies, which require you as a biology teacher to clearly explain to your pupils so that they can relate them to their parents clearly. Discuss some of these controversies, which you think proper teaching of genetics will help to reduce the tensions in the families and society. [10]

4. Human beings are constantly modifying their biological environment to satisfy their needs. In a number of cases, they have interfered with their environment by misusing or completely destroying forests and wildlife. Using concrete examples, discuss this in relation to how your pupils can:

(a) realize the importance of natural resources. [5]

(b) explain to their parents the conservation of natural resources. [10]

(c) explain the consequences of human beings' interference of nature. [5]

5. (a) Explain the meaning of phrase ' individual differences amongst learners'. Give appropriate examples. [2]

(b) Discuss how you can cater for individual differences amongst learners in biology practical work. [6]

(c) Describe with examples, how a biology teacher can make use of individual differences amongst his or her for effective teaching. [6]

(d) Identify and describe strategies available to a teacher of biology for determining individual differences amongst learners. [6]

6. (a) Explain the meaning of the following:

(i) self-evaluation [1]

(ii) reflective practitioner [1]

(b) Discuss the importance of the above practices to a teacher of biology [4]

(c) Develop criteria for evaluating two named features/aspects of your teaching. [8]

(d) A part from self-evaluation, describe two other methods, which can facilitate learning from experience by a biology teacher. [2]

(e) For each method you have given in (d) above , state one merit and one demerit. [4]

END OF THE EXAMINATION

The University of Zambia
Physics Department
University Examinations 2005
Second Semester
P-192 : Introductory Physics- II
(Option A)

All questions carry equal marks. The marks are shown in brackets. Question 1 is compulsory. Attempt four more questions. Clearly indicate on the answer script cover page which questions you have attempted.

Time : Three hours. **Maximum marks = 100.**

Do not forget to write your computer number clearly on the answer book as well as on the answer sheet for Question 1. Tie them together!!

==

Wherever necessary use:

$g = 9.8 \text{m/s}^2$

$P_A = 1.01 \times 10^5 \text{ N/m}^2$

1 cal. = 4.18 J

$\varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$

$c = 3 \times 10^8 \text{ m/s}$

$h = 6.63 \times 10^{-34}$ J-s

1 Pascal =1 N/m^2

$1eV = 1.6 \times 10^{-19}$ J

$e = 1.6 \times 10^{-19}$ C

$m_e = 9.11 \times 10^{-31}$ kg

$k = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$

$\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$

$\rho_{water} = 1000 \text{ kg/m}^3$

$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

Efficiency of a Carnot engine, $e = 1 - T_c/T_h = W/Q_h$

Question 1 : Sample answers : F(a), G(d).... etc. DO NOT guess the answer. For each correct answer, 2 marks. For each wrong answer, (0.67) will be deducted. No answer, zero mark. Minimum total mark for Question 1 is zero. [$10 \times 2 = 20$]

(A) A pendulum clock is in an elevator. The clock will run fast when the elevator is:

a) accelerating downward
b) accelerating upward
c) rising at constant speed
d) falling at constant speed

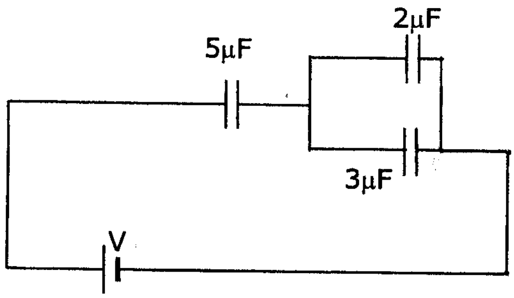
(B) Which of the following statements is wrong:

a) If a metal sheet with a hole is heated, the hole will expand.
b) Higher pressure lowers the boiling point of water in a pressure cooker.
c) Ice radiates heat.
d) If ice is heated on the moon, it will go to gaseous state without becoming water.

(C) A 3 Ω and a 9 Ω resistor are connected in series with one source of *emf* of negligible internal resistance. If the energy produced in the 3 Ω resistor is X, then the energy produced in the 9 Ω resistor is:

a) $3X$ b) $3X$ c) $X/3$ d) X

(D) What is the equivalent capacitance of the circuit shown:

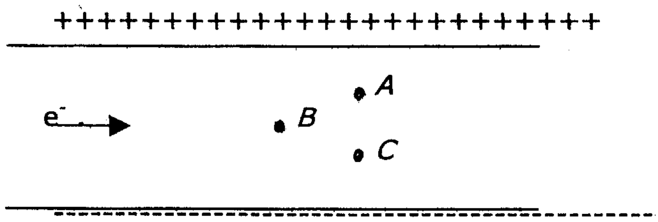


a) 2.1μF b) 1.6 μF c) 2.5 μF d) 10 μF

(E) When a source of sound is moving with a velocity v_s, away from a stationary listener, the apparent frequency heard is:

a) $\dfrac{f}{1-\dfrac{v_s}{v}}$ b) $\dfrac{f}{1+\dfrac{v_s}{v}}$ c) $\dfrac{2fv_s}{v}$ d) $\dfrac{2fv_s}{v^2-v_s^2}$

(F) An electron is placed between two charged parallel plates as shown. Which of the following statements is true?



(I) The electrostatic force at *A* is greater than at *B.*
(II) The work done in moving from *A* to *B* to *C* is the same work done in moving from *A* to *C.*
(III) The electrostatic force is the same at points *A* and *C.*
(IV) The electric field strength decreases as the electron is repelled upward

a) I and II b) I and III c) II and III d) II and IV

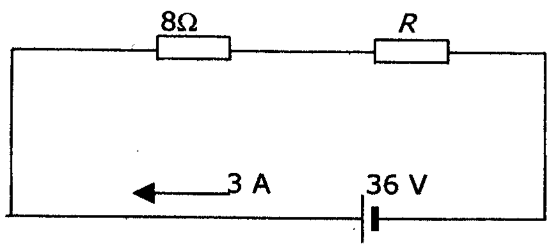
(G) When 20 g of water is heated from 10 °C to 15 °C it requires energy in joules of

a) 418 J b) 23.9 J c) 1912 J d) 47.8 J

(H) A charge moves in a circular orbit of radius *R* because of a uniform magnetic field. If the velocity of the charge is trebled, then the orbital radius will become:

a) *R* b) *R/3* c) 3*R* d) 6*R*

(I) What is the value of the resistor *R* in the circuit shown below?



a) 2 Ω b) 12 Ω c) 10 Ω d) 4 Ω

(J) A current-carrying loop in a magnetic field always tends to rotate until the plane of the loop is

a) at a 45° angle with the field
b) perpendicular to the field
c) parallel to the field

ATTEMPT ANY FOUR QUESTIONS FROM BELOW:

Q.2 (A) In general, in what state of matter does sound travel fastest? Why? [3]

(B) When a high-speed lead bullet strikes a heavy plate, most of the kinetic energy of the bullet is transformed into heat energy. A 5g lead bullet moving at the speed of 200 m/s strikes a steel plate and absorbs 75% of the heat produced on impact.

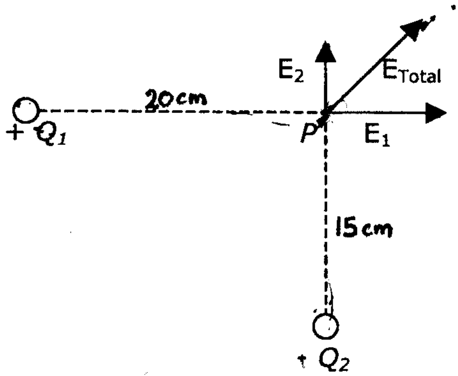
Calculate the bullet's rise in temperature. (c_{Pb} =0.036 cal/g)

[8]

(C) Two positive charges are located 20 cm and 15 cm from a unit test charge at point *P* as shown below. Charge Q_1 is 6 x 10^{-12} C, and the total electric field produced by both charges is 1.806 N/C.

Find the unknown charge Q_2.

[9]



Q.3 (A) Suppose a source of sound radiates uniformly in all directions. By how many decibels does the sound level decrease when the distance from the source is doubled? [10]

(B) A refrigerator maintains an inside temperature of 1.1 °C and pumps heat to a radiator on its back. The temperature of the radiator is 30 °C. The average power consumed by this refrigerator is 110 W and heat is pumped at the rate of 2.15 x 10^2 kcal/h.

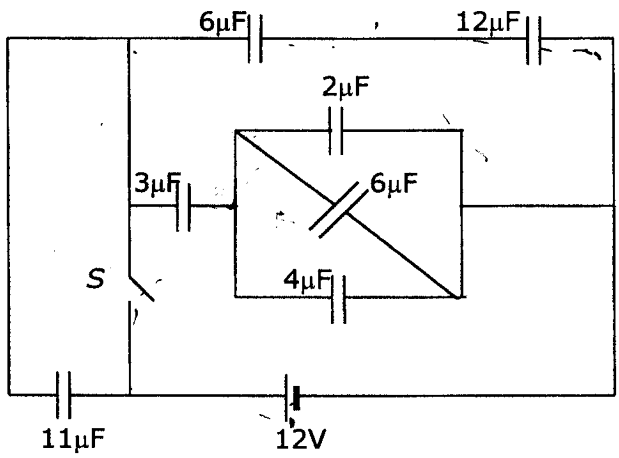
Calculate,

a) the actual COP and

b) the Carnot cycle COP of the refrigerator. [10]

Q.4 (A) A straight 1.6 m long wire weighing 0.15 N per meter is suspended directly above and parallel to a fixed second wire. The top wire carries a current of 30 A, and the bottom wire carries a current of 60 A. If the top wire is held in place by magnetic repulsion due to the bottom wire, how large must the separation between the wires be? [7]

(B) Find the equivalent capacitance of the system with the switch *S* open. [10]



(C) Describe a standing wave. [3]

Q.5 (A) Explain why an oscillating pendulum only approximately represents simple harmonic motion. [2]

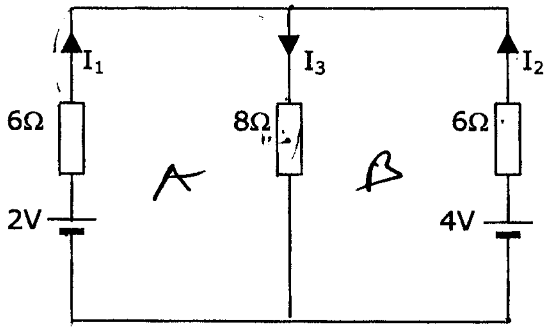
(B) A police car moves at a speed of 120 kph in the same direction as a truck that has a speed of 60 kph. The police siren has a frequency of 1200 Hz. What is the frequency heard by the truck driver when the police car is

a) behind the truck, and
b) ahead of the truck.
(take speed of sound as 340 m/s): [10]

(C) If the actual efficiency of a steam turbine is 25%. The work done by the turbine is 1.20×10^{6} J/min.
Calculate the input heat and the exhaust heat for one minute of operation of the steam turbine. [8]

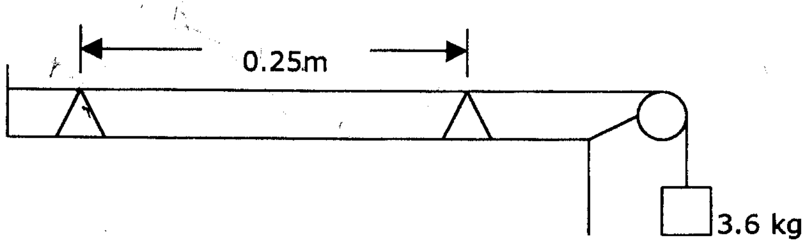
Q.6 (A) Solve the circuit shown in the diagram by Kirchhoff's laws for the current in each branch.

[12]



(B) A horizontal wire has a cross sectional area of 0.8 mm^2 and a density of 9000kg/m^3. A mass of 3.6 kg is suspended from it by means of a frictionless pulley. The wire has bridges that are 0.25 m apart.

When it is plucked in the middle, what is the frequency of vibration? [8]



Q.7 (A) A water heater draws 15A from a 240V power source 10m away. What is the minimum cross section of the wire that can be used if the voltage applied to the heater is not to be lower than 220V? [3]

(B) Three capacitors of values 4 μF, 6 μF and 10 μF are individually charged to 100 V by connecting them, one at time, across a battery. After they are removed from the battery with their charges, the positive plate of one is connected to the positive plates of the others and the negative plate of one is connected to the negative plates of the others.

Find:

a) the potential difference across each capacitor; and
b) the resultant charge on each capacitor. [10]

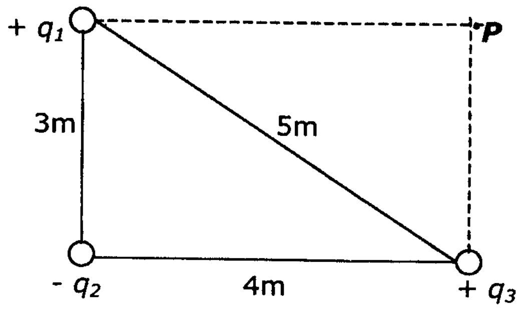
(C) Two parallel wires have equal currents in the same direction. The wires are 2.0 m long and only 5 mm apart. The magnetic force on each wire is 1.152 x 10^{-12} N. Calculate the current in the two wires. [7]

Q.8 (A) An ideal gas at 75 cm mercury pressure is compressed isothermally until its volume is reduced to 75% of the original volume. It is then allowed to expand adiabatically to a volume 20% greater than the original volume.

If the initial temperature of the gas is 17 °C, calculate its final pressure and temperature (use $\gamma = 1.4$) [9]

(B) Three point charges, $q_1 = 1\mu C$, $q_2 = -2\mu C$ and $q_3 = 3\ \mu C$ are fixed at positions shown in the figure below.

a) What is the potential at point P at the corner of the rectangle?
b) How much would work be needed to bring a charge $q_4 = 2.5\mu C$ from infinity and to place it at P?
c) What is the total potential energy of q_1, q_2 and q_3 [11]



END OF P 192 EXAM

Some equations you may find useful : for P-192

$v_f = v_o + at$: $v_f^2 = v_o^2 + 2ax$: $x = v_o t + (½)\,at^2$: $W = mg$: $x = v_{avg.}t$: $p = mv$

$f = \mu F_N$: $Ft = m(v_f - v_o)$: 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. $\text{energy}_{total} = (½)\,mv^2 + (½)\,I\omega^2$: $I = \Sigma mr^2$: $\tau = I\alpha = Fr$: $B = -\Delta P/(\Delta V/V_0)$

kin. $\text{energy}_{rot.} = (½)\,I\omega^2$: $F = (Gm_1m_2)/r^2$: $Y = (F/A)/(\Delta L/L_0)$: $Q/\Delta t = (kA\Delta T)/\Delta L$

$W_{app.} = mg - B.F.$: $P = \rho gh$: $W_{app.} = W[1 - \rho_{fl.}/\rho\,]$: $F = -kx$: $\omega = 2\pi f$

$[\,(½)\,mv^2]_{avg.} = (3/2)kT$: $\Delta Q = mc\Delta T = nC\Delta T$: $\Delta L = \alpha L\Delta T$: $\Delta V = \gamma V\Delta T$: $\Delta W = P.\Delta V$

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$: $Q = \Delta U + W$: $\Delta W = nRT.\ln(V_f/V_i)$: $PV = nRT$: $f = (1/2\pi)\sqrt{(k/m)}$

$I_1\omega_1 = I_2\omega_2$: $\Delta T.E. = f.s$: $v = \pm\sqrt{[(k/m)(x_0^2 - x^2)]}$: $f = (1/2\pi)\sqrt{(g/L)}$: $f = 1/\tau$:

$a_{max} = kx_0/m$: $a_c = \omega^2 x_0$: $P.E. = (½)\,kx^2$: $(½)\,kx^2 + (½)\,mv^2 = (½)\,kx_0^2$: $q = CV$

$a = -kx/m$: $\omega = \sqrt{(k/m)}$: $v = \sqrt{(Y/\rho)}$: $v = \sqrt{(T/(m/L))}$: 1 rev $= 360^0 = 2\pi$ rads : $v = f\lambda$

$v = \sqrt{(B/\rho)}$: : $v = \sqrt{(\gamma RT/M)}$: $0\,K = 273^0C$: area of a right cylinder $= 2\pi rL$

$F = \mu_o I_1 I_2 L/2\pi b$: $x = x_0\cos(\omega t)$: $\rho = (RA)/L$: $E = (½)qV$: $V = kQ/r$

$P = IV = I^2R$: $qV = (½)mv^2$: $W = qV_{AB}$: $F = (k\,q_1\,q_2)/r^2$: $F = qE$: $F = BIL\sin\theta$

$V_{AB} = Ed$: $C = (\varepsilon_o A)/d$: $\Delta R = R_o\alpha\Delta T$: $1/p + 1/i = 1/f$: $n_1\sin\theta_1 = n_2\sin\theta_2$

$I_o = 10^{-12}\,W/m^2$: $I(dB) = 10\log(I/I_o)$: $V = v_o/\sqrt{2}$: $q(t) = q_f\,(1 - e^{-t/\tau})$

torque = (area)NIB $\sin\theta$: $\Sigma\Delta A.E = q_{encl.}/\varepsilon_o$: $f' = f\,(v/(v \pm v_s))$: $f' = f\,(v \pm v_l)/(v)$

$f/f' = [\,1 - (v_l/v_w)\,]/[\,1 - (v_s/v_w)\,]$: $f' = f\,(v \pm v_L)/(v \mp v_s)$

$f_n = (2n - 1)f_1$: $f_b = f_2 - f_1$: $f_n = nf_1$: area of a sphere $= 4\pi r^2$: $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$

$v = v_o\sin(2\pi ft)$: $f_o = (1/2\pi)\sqrt{(1/LC)}$: $1/f = 1/f_1 + 1/f_2$: $n\lambda = d\sin\theta_n$:

$P = IV\cos\varphi$: e.m.f. $= B_{\perp}vd$: $\mu = (\text{area})I$: $\eta = (F/A)/(V/L)$: $I(t) = I_f\,(1 - e^{-t/(L/R)})$

volume of a sphere $= (4/3)\pi r^3$: $\sin(2\varphi) = 2\sin\varphi\cos\varphi$: $\sin(90 - \theta) = \cos\theta$

$I = P/A = P/4\pi r^2$

The University of Zambia
Physics Department
University Examinations 2005
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

$\varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ J-s

1 pascal =1 N/m^2

$1eV = 1.6 \times 10^{-19}$ J

$e = 1.6 \times 10^{-19}$ C

$m_e = 9.11 \times 10^{-31}$ kg

$k = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$

$\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$

$\rho_{water} = 1000 \text{ kg/m}^3$

$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

Efficiency of a Carnot engine,
$e = 1 - T_2/T_1 = \dfrac{\text{work done}}{\text{input heat}} = \dfrac{W}{Q_h}$

The University of Zambia
Physics Department
University Examinations 2005
P-198 : Introductory Physics - II
(Option B)

Answer sheet for Question 1

Computer Number ....

Q1. Put a cross (×) or tick mark (√) in the appropriate box. If it is on the dividing line, it will not be counted.

	a	b	c	d
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				

Do NOT write here.
For official use only :

	Number of parts N	Factor f	Marks f × N
Correct		2	
Wrong		–(0.67)	
	Net Marks :		

Attach this sheet firmly with the main answer book. If you lose this sheet, you will lose the marks for Question 1 !!

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) A type of process that does not need outside energy to reverse is one that takes place at constant :

(a) volume (b) speed (c) temperature (d) pressure.

(B) If a unit charge is taken from one point to another over an equipotential surface, then :

(a) work is done on the charge
(b) no work is done
(c) work on the charge is constant
(d) work is done by the charge.

(C) Given four capacitors each of 12μF capacitance; how does one connect them to obtain equivalent capacitance of 9μF ?

(a) all in series
(b) all in parallel
(c) two in parallel and other two in series
(d) three in parallel and one in series

(D). An example of a non-ohmic resistance is a :

(a) carbon resistance (b) diode
(c) copper wire (d) tungsten wire.

(E) The resistivity of a wire depends upon:

(a) its material
(b) its cross-sectional area
(c) its dimensions
(d) its length.

(F) A current is flowing north along a power line. The direction of the magnetic field below it, neglecting the earth's field, is :

(a) north (b) east
(c) south (d) west.

(G) A current carrying loop is placed in a uniform magnetic field. The torque acting on it does not depend on :

(a) the shape of the loop
(b) area of the loop
(c) value of current
(d) magnetic field.

(H) A $2\mu F$ capacitor is connected to a 50 volt, 400Hz power source. The current that flows is :

(a) 0.25A (b) 3.5A (c) 2.5A (d) 0.20A.

(I) The highest frequencies are found in :

(a) radar waves
(b) radio waves
(c) X-rays
(d) infrared waves.

(J) All real images :

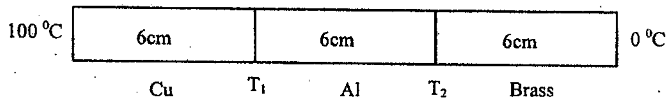
(a) are inverted
(b) can appear on a screen
(c) are erect
(d) cannot appear on a screen.

<u>Attempt any four questions from the following</u> :

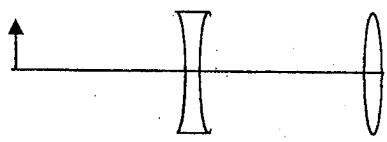
Q2. (a) Three metal rods, one copper, one aluminium, and one brass, are each 6.0cm long and 1.0cm in diameter. These rods are placed end to end in good thermal contact. The free ends of the copper and brass rods are maintained at the boiling point and the freezing point of water respectively.

Find the steady-state temperatures of the copper-aluminium junction and the aluminium-brass junction.

Given, $k_{brass} = 109\,\mathrm{W.m^{-1}.K^{-1}}$, $k_{alumin.} = 235\,\mathrm{W.m^{-1}.K^{-1}}$, and $k_{copper} = 401\,\mathrm{W.m^{-1}.K^{-1}}$ [10]



(b) A diverging lens of focal length 20cm is followed by a converging lens of focal length 30cm. The distance between the lenses is 38cm. An object is placed 30 cm in front of the diverging lens :



(i) Find the position of the final image,
(ii) Find the magnification of the final image. [7]

(c) State the three rules for concave mirrors that can be used to locate the position of images. [3]

Q3. (a) An ideal gas at 75 cm mercury pressure is compressed isothermally until its volume is reduced to 75% of the original volume. It is then allowed to expand adiabatically to a volume 20% greater than the original volume.

If the initial temperature of the gas is 17°C, calculate its final pressure and temperature. Given $\gamma = 1.4$ [9]

(b) A silicon solar cell of frontal area 13cm^2 delivers 0.20A at 0.45V when exposed to full sunlight of energy flux 1.0 x 10^3 W/m^2.

What is the efficiency for conversion of light energy into electrical energy ? [5]

(c) A light ray initially in water enters a transparent medium at an angle of incidence of 37°, and the transmitted ray is refracted at an angle of 25°.

Calculate the speed of light in the transparent medium.
Given, refractive index of water = 1.33 [6]

Q4. (a) A coil has an inductance of 200mH and an unknown resistance *R*. The coil is placed in series with a capacitor of unknown capacitance *C*. The circuit is connected across a 220V, 200Hz source. The current in the circuit is found to be 1.2A; the current lags behind the voltage across the inductor by an angle of 45°.

(i) Find the values of *R* and *C*,
(ii) Find the power dissipation in the circuit. [10]

(b) A reversible engine converts one-sixth of the input heat into work. When the temperature of the source is increased by 65°C, its efficiency is doubled.

Find the original temperature of the source and that of the sink. [10]

Q5. (a) A certain metal wire has a length of 1.50m, radius 0.2 x 10^{-2} m, and a mass of 50.9 x 10^{-3} kg. Under certain conditions, it is possible to produce both longitudinal and transverse waves in this wire.

Determine the required tension in the wire so that the speed of longitudinal waves in it is eight times the speed of transverse waves. Given, Young's modulus for the material of the wire = 70 x 10^9 N.m^{-2}. [11]

(b) A step-up transformer operates on a 220 volts line and supplies a current of 2A to a load. The ratio of primary and secondary windings is 1 : 25.

Determine the secondary voltage, primary current, and the power output of the transformer. [6]

(c) State Faraday's and Lenz's laws of electromagnetic induction. [3]

Q6.(a) An object emits a sound of frequency 440Hz. An observer hears it at a frequency of 400Hz. [Given, speed of sound in air = 340m/s]

(i) If the source is moving, what is its speed ?
(ii) If the observer is moving, what is her/his speed ? [6]

Q6 (b) A galvanometer of resistance 60Ω shows full-scale deflection when a current of 0.015A passes through it.

How can it be made into a voltmeter with two ranges, 15 volts and 150 volts ? [6]

Draw a diagram showing how the resistances are to be connected so that the meter can be operated in either of the ranges through a commutator switch. [2]

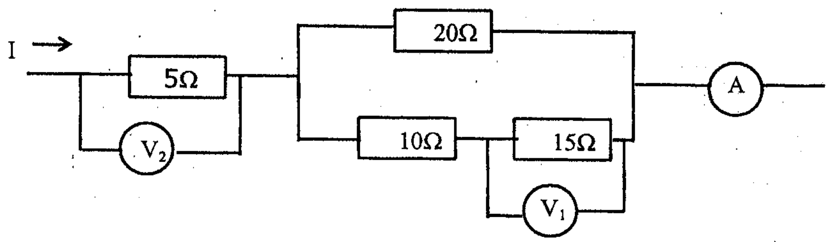
(c) The frequency of the second overtone of a pipe open at both ends is equal to the frequency of the second overtone of a pipe closed at one end.

Find the ratio of the length of the closed pipe to the length of the open pipe. [6]

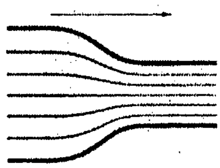
Q7. (a) A quantity of heat equal to 125 J is produced per second in the 20Ω resistor.

Calculate (i) the readings of the voltmeters V_1 and V_2, and

(ii) the reading of the ammeter A. [6]

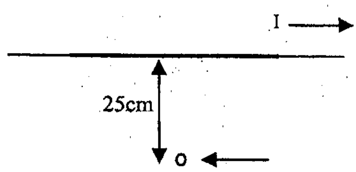


(b) Ethanol of density 791kg/m³ flows smoothly through a horizontal pipe that tapers in cross-sectional area from $A_1 = 1.20 \times 10^{-3}$ m² to $A_2 = A_1/2$. The pressure difference Δp between the wide and narrow sections of the pipe is 4120 Pa.



What is the volume rate of flow R of ethanol ? [8]

(c) A long straight wire carries a current of 40 amperes. An electron is moving parallel to the wire (at a distance of 25cm from the wire) in a direction opposite to that of the current. The speed of the electron is 2.5×10^7m/s.



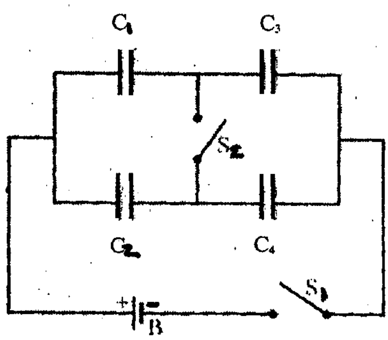
Find the magnitude and direction of the force that acts on the electron. [6]

Q8. (a) The battery B supplies 12V.

Find the charge on each capacitor :

(i) First when only switch S_1 is closed and

(ii) Later when S_2 is also closed. Take C_1 = 1μF, C_2 = 2μF, C_3 = 3μF, and C_4 = 4μF. [11]

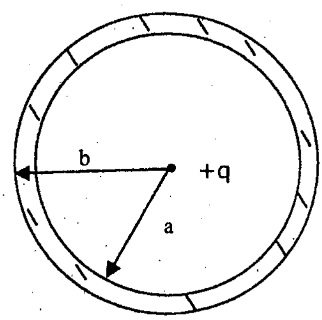


(b) A point charge $+q$ is placed at the centre of an electrically neutral, spherical conducting shell with inner radius a and outer radius b.

What charge appears on :

(i) The inner surface of the shell, and

(ii) The outer surface ?



Find expressions for the net electric field at a distance r from the centre of the shell if :

(iii) $r < a$,

(iv) $b > r > a$, and

(v) $r > b$. Sketch field lines for those three regions.

For $r > b$, what is the net electric field due to (vi) the central point charge and the inner surface charge, and (vii) the outer surface charge ?

[Hint : Use Gauss' law] [9]

== End of P-198 Examination ==

Some equations you may find useful :

$v_f = v_o + at$: $v_f^2 = v_o^2 + 2ax$: $x = v_o t + (½) at^2$: $W = mg$: $x = v_{avg.}t$: $p = mv$

$f = \mu F_N$: $Ft = m(v_f - v_o)$: work $= Fs \cos\theta$: 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 $= 360^0 = 2\pi$ 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 $= \pi r^2 L$

$x = x_0 \cos(\omega t)$: $\rho = (RA)/L$: $E = (½)qV$: $F = (\mu_o I_1 I_2 L)/(2\pi b)$: 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. $= B_\perp vd$: $\mu = (\text{area})I$: $\eta = (F/A)/(V/L)$: $I(t) = I_f(1 - e^{-t/(L/R)})$

$\sin(2\varphi) = 2 \sin\varphi \cos\varphi$: $\sin(90 - \theta) = \cos\theta$: $f' = f(v \pm v_L)/(v \mp v_s)$: $M = -i/p$

$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$: $B_0 = E_0/c$: $I = (½)c\,\varepsilon_0 E_0^2$: $\Sigma B_\parallel.\Delta L = \mu_o.I_{enclosed}$: $E_s/E_p = N_s/N_p$

$A_1v_1 = A_2v_2$: $F_D = 6\pi\eta rv$: $6\pi\eta av_T = (4\pi/3)a^3(\rho - \sigma)g$: $Q = (\pi R^4/8\eta L)(P_1 - P_2)$

$P_1 + (½)\rho v_1^2 + \rho gh_1 = P_2 + (½)\rho v_2^2 + \rho gh_2$: $N_R = \rho vd/\eta$: $V = IZ$: e.m.f.$_{sec}$ $= M(\Delta I_p/\Delta t)$

volume of a sphere $= (4/3)\pi r^3$: $Z^2 = R^2 + (X_L - X_C)^2$: $\varphi = B.A \cos\theta$: e.m.f. $= N(\Delta\varphi/\Delta t)$

$y = y_0 \sin(\omega t - kx);\ k = \dfrac{2\pi}{\lambda}$: fundamental $\Rightarrow$ first overtone $\Rightarrow$ second overtone

The University of Zambia
Department of Physics
University Examinations
Atomic Physics and Magnetism in Matter-P212

Instructions: Answer any five (5) questions only. All questions carry equal marks. The marks are shown in square brackets

Time allowed **three** hours.

Wherever necessary, the following data and formulas and can be used:

$\omega = 2\pi f$

$E = h\nu$

$r_n = \dfrac{\varepsilon_0 n^2 h^2}{\pi m_e Z e^2}$

$h = 6.625 \times 10^{-34}$ Js

$W = \sigma A T^4$

$\sigma = 5.67 \times 10^{-8}$ W/m^2.K^4

$\frac{1}{2} m v^2 = h\nu - W$

$m_e = 9.1 \times 10^{-31}$ kg

$\frac{1}{2} m v_o^2 = \dfrac{kqQ}{r_c}$

$m_p = 1.674 \times 10^{-27}$ kg

Radius of the Sun, $R_s = 6.96 \times 10^8$m

1 Angstrom = 10^{-10} m

Mean distance of the Earth from the Sun = 1.50×10^{11}m.

$\Delta\lambda = \dfrac{h}{m_o c}(1 - \cos\theta)$

$c = 3.0 \times 10^8$ m/s

$I = I_o e^{-\mu x}$

$N = N_o e^{-\lambda t}$

$RR = \phi n \sigma V$

$N_A = 6.023 \times 10^{23}$ /mol

$B = \dfrac{\mu_o I}{2\pi r}$

Boltzmann's constant $k = 1.38 \times 10^{-23}$ J/K

1 u = 931.502 MeV

Q1: (a) Give a brief account of the reasons why certain materials modify magnetic fields produced by applied currents. [6]

(b) Consider an electron in the hydrogen atom moving in the first Bohr orbit of radius $r_o = 0.53 \times 10^{-10}$ m. Calculate the magnetic field produced by this electron at the center of its orbit. Take the rotation frequency of the electron to be $f = 6.6 \times 10^{15}$ Hz. [5]

(c) (i) By considering the overall magnetic field B in the presence of matter, show that the magnetic permeability μ and the magnetic susceptibility χ_m are related through the equation $\mu = \mu_o(1+\chi_m)$, where μ_o is the permeability of free space. [5]

(ii) Explain the meaning of the equation $\int_{CS} B.dS = 0$ or div $\mathbf{B} = 0$ [2]

For which materials is $\mu < \mu_o$ and for which materials is $\mu > \mu_o$? [2]

Q2: (a) Using alpha-particle scattering, Rutherford arrived at the following conclusions (study them carefully and answer the questions that follow):

(i) The atom is mostly empty space.

State the observation that prompted Rutherford to reach this conclusion.

[2]

(ii) The mass of the atom is concentrated in a positively charged tiny entity which he called the atomic nucleus.
State the observation that led Rutherford to this conclusion. [2]

(b) Alpha particles of energy 7.68 MeV are scattered from an aluminium foil Calculate the distance of closest approach. Take $Z = 13$ for aluminium.
[5]

(c) The average kinetic energy of an atom in a heated gas is $\frac{3}{2}kT$ where k is Boltzman's constant and T is the absolute temperature of the gas.

(i) To what temperature should mercury vapour be heated in order to stimulate emission of light of wavelength 2580×10^{-10} m? [4]

(ii) Consider a hypothetical one-electron atom that is assumed not to have the hydrogen energy levels, but obeys Bohr's second postulate. The wavelengths of the first four lines of the spectral series terminating on n= 1 are 1200, 1000, 900 and 840, all measured in Å. The short-wavelength limit of the series is 800 Å.

Find the values of the first five energy levels of this atom in eV and construct the energy level diagram. [7]

Q3: (a) (i) Define a "black-body" and "black-body radiation" [2]

(ii) Radiation emission by a black body at high frequencies predicted by the Rayleigh-Jeans equation came to be known as "ultra-violet catastrophe". Explain the reason for this term. [2]

(b) (i) For black-body radiation, state " Wien's law" and " Stefan's law" [4]

(ii) Show that the Planck radiation formula $I(\nu)d\nu = \frac{8\pi h\nu^3}{c^3}\frac{1}{e^{(h\nu/kT)}-1}d\nu$ reduces to the Rayleigh – Jeans law, i.e., $I(\nu)d\nu = \frac{8\pi\nu^2 kTd\nu}{c^3}$ for low frequencies or long wavelengths. [3]

(c) The average intensity of the Sun's radiation at the surface of the Earth (after correction for absorption and scattering by the atmosphere) is 1.37×10^3 Wm^{-2}. From this information, Calculate

(i) the Sun's luminosity (i.e., energy radiated per second) [4]

(ii) the Sun's surface temperature on the assumption that it is a black-body. [5]

Q4: (a) (i) Define the "photoelectric effect" [2]

(ii) Draw a well labeled diagram of the experimental set-up that was used to investigate the various characteristics of the photoelectric effect and explain how it works, paying particular attention to the following:

- source of photoelectrons;
- acceleration of photoelectrons
- variation of photocurrent with light intensity;
- cutoff frequency and work-function;
- determination of stopping potential [12]

(b) Light of wave-length 4350 Angstrom is incident on a sodium surface for which the threshold wavelength is 5420 Angstroms. Calculate
(i) the work-function in electron volts;
(ii) the stopping potential [6]

Q5 (a) Electrons in an x-ray tube are accelerated through a potential difference of 3000 volts. Suppose these electrons are slowed down in a target, what is the minimum wave-length of the x-rays produced? [4]

(b) X-rays with energies of 200KeV are incident on a target and undergo Compton scattering. Calculate
(i) the energy of the x-rays scattered at an angle of 60° to the incident direction; [6]
(ii) the energy of the recoiling electrons; [2]
(iii) Under what condition will the photon transfer maximum energy to the electron? [2]

(c) The linear absorption coefficient of aluminium and copper are 0.693 cm^{-1} and 13.9 cm^{-1} respectively for the K_α line from tungsten. Calculate the ratio of the intensity of this line that will pass through aluminium to that passing through copper, both of 5 mm thickness. [6]

Q6: (a) Briefly explain the major changes that take place in the nucleus of an atom when it undergoes the following decay processes:
(i) α decay
(ii) β^- decay
(iii) β^+ decay and give a general decay equation in each case [6]

(b) A piece of excavated wood is found to have a mass of 50 grams and shows C-14 activity of 320 disintegrations per minute. Estimate the length of time which has elapsed since this wood was part of a living tree assuming that living plants show a C-14 activity of 12 disintegrations per minute per gram. The half-life of C-14 is 5730 years. [7]

(c) Study the following part of the uranium decay series that is shown below, and answer the questions that follow,

$${}^{238}_{92}U \rightarrow {}^{234}_{90}Th \rightarrow {}^{234}_{91}Pa \rightarrow {}^{234}_{92}U \rightarrow {}^{230}_{90}Th \rightarrow {}^{226}_{88}Ra .$$

(i) What particle is emitted at each decay?
(ii) List the pairs of isotopes occurring in this part of the series.
(iii) If the stable end product of the complete uranium series is *Pb* 206, how many alpha particles are emitted between ${}^{226}_{88}Ra$ and the end of the series? [7]

Q7: (a) The general equation for a nuclear reaction may be written as $a + X \rightarrow Y + b$. Explain the meaning of this equation and the various symbols appearing in it [4]

(b) (i) What is meant by the "Q-value" of a nuclear reaction? [2]

(ii) By calculating the Q-value of the following nuclear reaction, determine whether it is energetically possible: [4]

$${}^{64}_{29}Cu \rightarrow {}^{64}_{30}Zn + \beta^- + \bar{\nu}$$

Take ${}^{64}_{29}Cu$ (63.9297 u)

and ${}^{64}_{30}Zn$ (63.9291 u)

1 u $\approx$ 1.6603X10^{-24} gram

(c) (i) Figure 1 shows the decay scheme of ${}^{198}_{79}Au$. Study it carefully and answer the questions that follow. [5]

- Calculate the energy of the β^- particle leading to the first excited state of ${}^{198}_{80}Hg$;
- Calculate the energy of the β^- particle leading to the ground state of the ${}^{198}_{80}Hg$.
- Calculate the energy of the hardest gamma ray released in this decay.
- Calculate the energy of the softest gamma released in this decay.

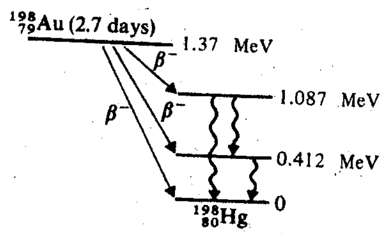


Figure 1

- How many decay channels are there for the ${}^{198}_{79}Au$ atoms?

(ii) A radioactive substance of half-life 100 days which emits β^- particles of energy 5 X10^{-14} J is used to drive a thermoelectric cell. Assuming the cell to have an efficiency of 10%, calculate the number of moles of this substance required to generate 5 watts of electricity.

[5]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF PHYSICS

2005 ACADEMIC YEAR SECOND SEMESTER

FINAL EXAMINATIONS

P252: CLASSICAL MECHANICS II AND SPECIAL RELATIVITY

TIME: THREE (3) HOURS

ANSWER ANY FIVE QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

MAXIMUM MARK: 100

YOU MAY NEED THE FOLLOWING

$$\vec{a} = (\ddot{r} - r\dot{\theta}^2)\hat{r} + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\hat{\theta}$$

$$\frac{d}{dt}\frac{\partial L}{\partial \dot{q}} = \frac{\partial L}{\partial q}; \quad \frac{\partial H}{\partial p} = \dot{q}; \quad \frac{\partial H}{\partial q} = -\dot{p}$$

Q1 (a) (i) A mass m hangs from N uniform springs that are side by side. If each spring has a spring constant k, find the expression for the period of oscillations of the system.

(ii) Repeat (i) with the springs connected end to end with m at the bottom. [6]

(b) An experiment is set up to determine the damping constant k of a weakly damped oscillator by observing the frequency of oscillation ω' and positions of maximum displacement x_1 and x_2 after every 4 oscillations. Find k in terms of x_1 and x_2. [5]

(c) A particle of mass m is suspended from a fixed point O by a light rigid rod of length l.

(i) Using the expressions for the radial and transverse components of acceleration show that the angle θ which the rod makes with the downward vertical satisfies the equation

$$\ddot{\theta} + \frac{g}{l}\sin\theta = 0$$ [3]

(ii) Obtain an energy equation in the form

$$\frac{1}{2}\dot{\theta} + V(\theta) = E$$ [3]

and plot $V(\theta)$ against θ.

(iii) If $\dot{\theta} = \omega$ when $\theta = 0$ show from the graph in (ii) that the particle will oscillate or move in a circle about O depending on whether

$$\omega^2 < \frac{4g}{l} \text{ or } \omega^2 < \frac{4g}{l}$$ [3]

Q2 (a) Explain what is meant by strong damping in a harmonic oscillator and write down the general solution. [2]

(b) A strongly damped simple harmonic oscillator at rest in its equilibrium position is jolted into motion. Show that the oscillator reaches its maximum displacement a time T later given by

$$K'T = \ln\left[\frac{K + K'}{K - K'}\right]$$ [6]

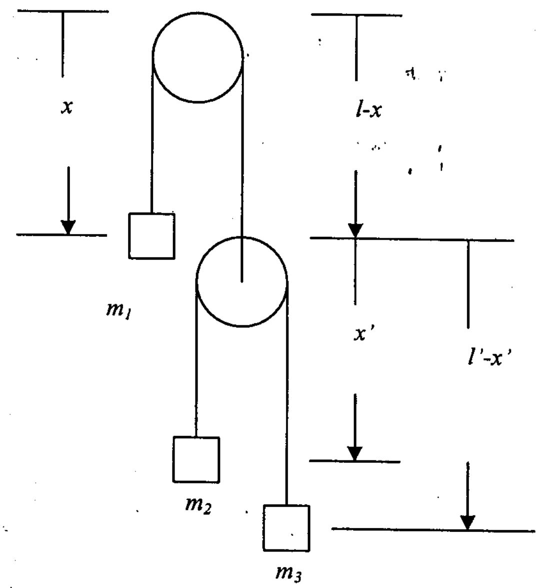
(c) Derive the formula for the energy of a wave in a string of mass m and length L and use it to find the energy per unit length when the wave is represented as

$y = A\sin k(x - vt)$ where $k = n\pi$, n being a positive integer. [12]

Q3 (a) (i) What is the fundamental difference between analytical mechanics and ordinary Newtonian mechanics? [2]

(ii) What are holonomic constraints? [2]

(b) Find the accelerations of all the bodies shown in the figure using the Lagrange method. The pulleys have equal masses m = 2 kg. The other masses have value m_1 = 8 kg, m_2 = 3 kg and m_3 = 2 kg . Neglect the mass of the string and the length of the string in contact with the pulleys. The moment of inertia of the pulleys can be taken as that of a disk, i.e., $I = \frac{1}{2}mr^2$. [12]



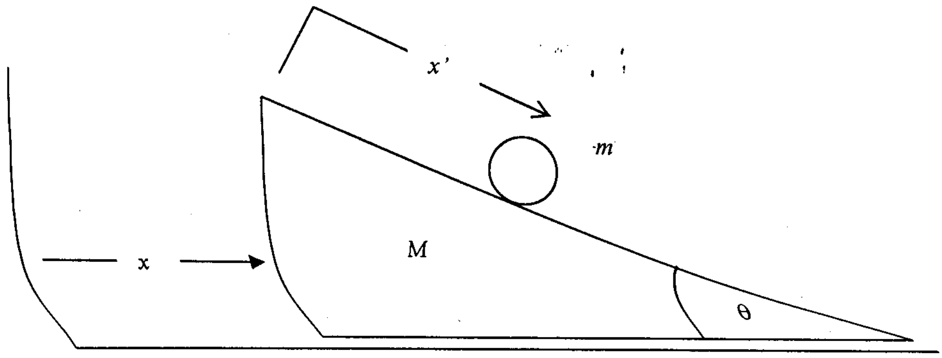
(c) After the system starts from rest, by how much do the other masses including the lower pulley move if m_1 moves 1metre. [4]

Q4 (a) What are ignorable coordinates?

(b) Find the acceleration of a solid uniform sphere of mass m rolling down a perfectly rough plane inclined at an angle θ with the horizontal using Hamilton's canonical equations (moment of inertia of a solid sphere is

$I = \frac{2}{5} mr^2$). [6]

(c) Suppose the inclined plane in (b) was a wedge which is free to slide on a smooth horizontal surface as shown in the diagram. Find the accelerations in the system using the Lagrange method. [11]



(d) Determine which coordinate is ignorable in (c) and hence find the associated constant of the

motion for the system. [2]

Q5 (a) Derive Hamilton's canonical equations from the definition of the generalised momentum and the Hamiltonian. [4]

(b) Two blocks of equal mass m are connected by a flexible cord. One block is placed on a smooth horizontal table, and the other block hangs over the edge. Find the acceleration of the system using Hamilton's canonical equations. [6]

(c) The configuration of a double pendulum can be specified by the two angles θ and ϕ. The generalised momenta associated with these two angles are

$$P_\theta = ml^2 \dot{\theta} + ml^2 - 2mgl\sin\theta \quad \text{and} \quad P_\phi = ml^2\phi + mgl\sin\theta .$$

(i) Find the Lagrangian. [3]

(ii) Find $\ddot{\theta}$ and $\ddot{\phi}$ using the Lagrange method. [7]

Q6 (a) Derive the expression for the relativistic addition of velocities and point out the essential differences with the Newtonian addition of velocities. [4]

(b) The inertial frames S and S' are in standard configuration. Two events occur on the x-axis a distance d apart in the frame S and a distance d' apart in the frame S'. Prove that if the events occur simultaneously in the frame S then the velocity V between the frames is given by

$$V = [1-(d/d')^2]^{1/2}c$$

and the time interval between the occurrence of the events as measured in S' is

$$[1-(d/d')^2]^{1/2}\, d'/c$$ [7]

(c) Suppose a 1 m long stick pointing in the x direction moves along the x axis with speed $0.8c$, with its midpoint passing through the origin at $t = 0$. Assume an observer is situated at the point $x = 0$, $y = 1$ m.

(i) Where (in the observer's frame) are the end points of the meter stick at $t =$ 0 sec? [3]

(ii) When does the observer see the midpoint pass through the origin? [3]

(iii) Where do the end points appear to be at this time? [3]

Q7 (a) Find what percentage of the speed of light a 2 per cent Lorentz – Fitzgerald contraction in the length of a moving rod corresponds to. [4]

(b) At what velocity is a free particle moving if its total energy is $4n$ times its rest mass energy? [3]

(c) A rigid rod appears to have a length L and makes an angle α with the x axis as viewed by an observer in the inertial frame S. The rod is at rest in a frame S' which moves with a constant velocity V relative to S. Find the angle between the rod and the x'-axis of the rest frame. [6]

(d) Two spaceships, each measuring 50m in its own rest frame, pass by each other travelling in opposite directions. Instruments on spaceship A determine that the front end of spaceship B requires 2×10^{-6} sec to traverse the full length of A. A clock in the front end of B reads exactly 02:00 hrs as it passes by the front end of A What will the clock read as it passes by the rear end of A? [7]

END OF EXAMINATION

The University of Zambia

Physics Department

University Examinations

Second Semester 2005

P332

Statistical Physics and Thermodynamics

Time: Three (3) Hours **Marks:**100

Instructions

ATTEMPT ANY FOUR(4) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS. MARKS ARE INDICATED FOR EACH OF THE QUESTIONS

Useful formulas

Stirling's formula: $\ln n! \approx n \ln n - n$

$$S = k \ln \Omega; \quad kT = \frac{1}{\beta}; \quad \beta = \frac{\partial \ln \Omega}{\partial E};$$

$$\frac{\partial \ln \Omega}{\partial x_\alpha} = \beta \overline{X}_\alpha; \quad S = k(\ln Z + \beta \overline{E});$$

$$PV = \nu RT;$$

$$S' = S" = N'k[\ln V' + \tfrac{3}{2} \ln T + \sigma];$$

$$dQ = dE + pdV$$

Gas constant $R = 8.314$ J/mole. K

1. (a) Consider the random walk problem with $p = q$, where p denotes the probability that the step is to the right and q the probability that the step is to the left. Let $m = n_1 - n_2$ denote the net displacement to the right with n_1 being the steps to the right and n_2 the steps to the left. After a total of N steps, calculate the mean values; (i) $\overline{m}$ and (ii) $\overline{m^2}$ [7+8]

   (b) Consider an isolated system consisting of a large number N of very weakly interacting localized particles of spin $\frac{1}{2}$. Each particle has a magnetic moment μ which can point either parallel or anti parallel to an applied field B. The energy E of the system is then $E = -(n_1 - n_2)\mu B$, where n_1 is the number of spins aligned parallel to B and n_2 the number of spins aligned antiparallel to B. Consider the energy range between E and $E + \delta E$ where δE is very small compared to E but is microscopically large so that $\delta E \gg \mu B$. What is the total number of microstates $\Omega(E)$ lying in this range? [10]

2. (a) For a system of magnetic moments in a solid of volume V at temperature T, the change $d\overline{E}$ in the internal magnetic energy is given by

$$d\overline{E} = TdS + \mu_0 H dM$$

   where S is the entropy, M the magnetization and H the applied magnetic field.

   i. Derive the differential for the Gibbs free energy $G(T, H)$
   ii. Derive Maxwell's relation using dG

   [15]

   (b) A 0.1 kg piece of metal of constant specific heat capacity $C = 5.0 \times 10^5$ J kg^{-1}K^{-1} initially at 500 K is placed in thermal contact with a cold heat reservoir at 300 K. Calculate the entropy change of the composite system of metal and reservoir. [10]

3. (a) The number of states of an ideal diatomic classical gas consisting of N identical molecules in a volume V in the energy range from E to $E + \delta E$ is

$$\Omega(E) = BV^N E^{\frac{5N}{2}}$$

   where B is a constant

   i. Obtain the equation of state of such a gas

ii. Obtain the heat capacity of such a gas

iii. Two such gases, one with volume V_1 and N_1 molecules and the other with a volume V_2 and N_2 atoms, are brought into thermal contact. Show that equilibrium is achieved between them when the distribution of energy between them is such that;

$$\overline{E_1} = \frac{N_1(E_1 + E_2)}{N_1 + N_2}$$

and

$$\overline{E_2} = \frac{N_2(E_1 + E_2)}{N_1 + N_2}$$

iv. Calculate the amount of heat each gas absorbs in the process.

[15]

(b) A collection of N particles is in equilibrium with a heat reservoir at absolute temperature T. If only the states with energy $\epsilon_1 = 0$ and $\epsilon_2 = \epsilon$ are accessible to the particles, show that the heat capacity at constant volume of the of the particle is

$$C_V = \frac{Nkx^2e^{-2x}}{(1 + e^{-x})^2}$$

where $x = \beta\epsilon$ and k =Boltzmann's constant

[10]

4. (a) i. Discuss the concept of canonical and grand canonical ensembles. What are the basic differences between the two? [4]

ii. In the case of the grand canonical ensemble can we apply the basic assumption that all (micro)states with the same number of particles of N and the same amount of energy E are equally probable? [3]

iii. By considering a small system A in a weak thermal interaction with a heat reservoir A', show that in equilibrium the probability of the system A being in a state r of energy E_r is given by

$$P_r = \frac{e^{-\beta E_r}}{\sum_r e^{-\beta E_r}}$$

[6]

(b) A thermally insulated container is divided into two compartments, the right compartment having volume b times as large as the left one. The left compartment contains ν moles of an ideal gas at temperature T and pressure p. The right compartment also contains ν moles of an ideal gas at the temperature T. The partition is now removed. Calculate

i. the final pressure of the gas mixture in terms of p.
ii. the total change of entropy if the gases are different.
iii. the total change of entropy if the gases are identical.

[12]

5. (a) Starting from the first law of thermodynamics

$$dE = TdS - pdV$$

show that

i.

$$C_V = \left(\frac{dE}{dT}\right)_V$$

ii. the variation of internal energy with volume at constant temperature is given by

$$\left(\frac{\partial E}{\partial V}\right)_T = T\left(\frac{\partial p}{\partial T}\right)_V - p$$

[15]

(b) A van der Waals gas obeys the equation of state

$$\left(p + \frac{a}{v^2}\right)(v - b) = RT$$

where $v = V/\nu$ is the molar volume and ν is the number of moles. Using the equation

$$\left(\frac{\partial E}{\partial v}\right)_T = \left(\frac{\partial p}{\partial T}\right)_V - p$$

show that its molar internal energy ϵ is given by

$$\epsilon(T, v) = C_v T - \frac{a}{v} + B$$

where B is a constant and C_v is its temperature-independent molar heat capacity. [10]

6. (a) By equating the Gibbs free energy or chemical potential on two sides of the liquid-vapor coexistence curve derive the Clausius-Clapeyron equation

$$\frac{dp}{dT} = \frac{q}{T(V_v - V_L)}$$

where q is the heat of vaporization per particle and V_L is the volume per particle in the liquid and V_v is the volume per particle in the vapor. [$12\frac{1}{2}$]

(b) Assuming the vapor follows the ideal gas law and has density which is much less than that of the liquid, show that $p \approx \exp(-q/kT)$ when the heat is independent of T. [$12\frac{1}{2}$]

End of P332 Examination

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 ACADEMIC YEAR
SECOND SEMESTER UNIVERSITY EXAMINATIONS
P-342: INTRODUCTORY DIGITAL ELECTRONICS

TIME ALLOWED: **THREE** HOURS

INSTRUCTIONS: Answer **any four** questions only. All questions are of equal marks. The individual marks are shown in square brackets.

Q1 (a) (i) Convert 25.625_{10} to its binary equivalent. [3]

(ii) Convert the number 101.101_2 to its decimal equivalent [3]

(b) (i) Specify two main reasons why the complement method of subtraction is more popular in digital computers than the ordinary method. [2]

(ii) Using the 1's complement method, subtract 11011 from 01101 and check the final result by using the decimal equivalents of these numbers. [6]

(iii) Using 2's compliment, subtract 1010 from 1101 and check your result using the decimal equivalents of these numbers. [6]

(c) (i) What are binary coded (BCD) decimals? [1]

(ii) Find the equivalent decimal value for the BCD coded number: 0001010001110101 [2]

(iii) Convert the hexadecimal number F8E6 to the corresponding decimal number. [2]

Q2 (a) Explain the action of the circuits in figures 1 and 2; derive their corresponding truth tables and hence state the logic functions they perform. [14]

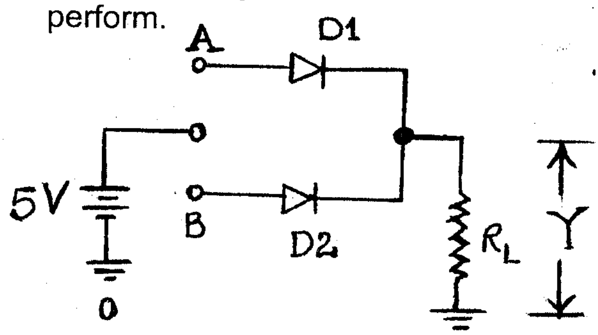


Figure 1

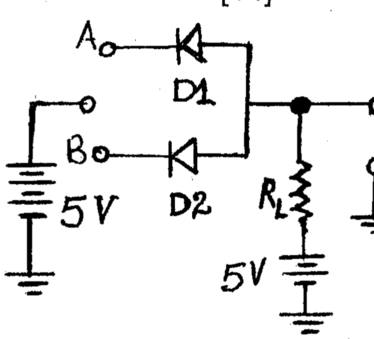


Figure 2

(b) (i) Explain the action of the circuit in figure 3 and derive its truth table. What kind of gate is it? [5]

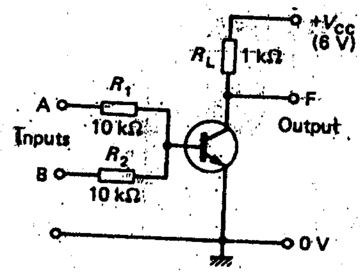


Figure 3

(ii) Show that figure 4 is a NAND gate. [6]

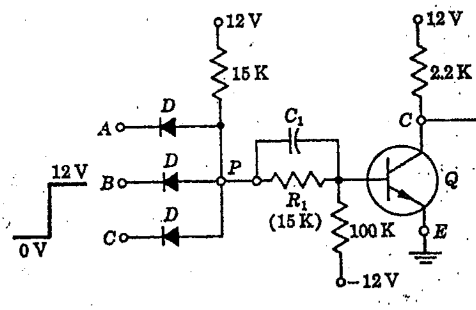


Figure 4

Q3 (a) What logic operation is performed by the interconnected NAND gates in figure 5? [6]

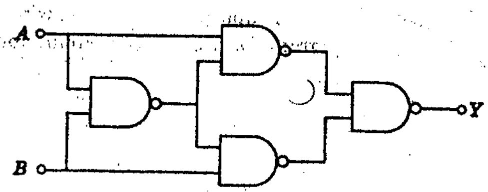


Figure 5

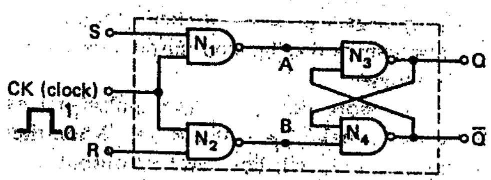
(b) (i) Define the following terms: [4]

- Fan in and fan out
- Noise immunity and propagation delay time.

(ii) Draw a well labeled basic circuit of the *RS* flip flop (or a bistable multivibrator) and explain its functions as a memory element. How is it triggered from one state to another? [10]

(c) Figure 6 is a clocked *SR* flip flop. Study it carefully and answer the questions that follow:

Figure 6



(i) Why is it called a clocked flip flop?
(ii) What is the function of S and R inputs?
(iii) What is the capacity of this flip flop?
(iv) What is the major disadvantage of this flip-flop?
(v) What is the purpose of including AND gates [5]

Q4 (a) (i) Explain what is meant by the following terms: [6]

- Level triggering of a flip-flop
- Negative-edge triggering
- Leading edge triggering

(ii) Figure 7 is a complete logic diagram of a D latch.

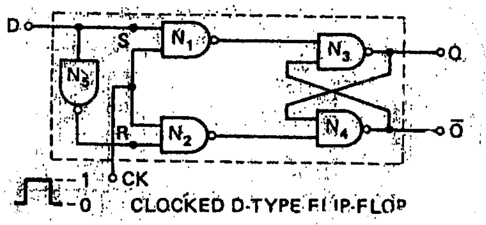


Figure 7

- What is the advantage of having a single input to the latch?
- What is the function of the gate labeled N5?
- By reference to the same diagram, complete the following table for the signals applied to its input [6]

Input			Outputs before clock pulse		Outputs after clock pulse	
D	S	R	Q	$\bar{Q}$	Q	$\bar{Q}$
0	0	1	1	0		
0	0	1	0	1		
1	1	0	1	0		
1	1	0	0	1		

(b) Figure 8 is a complete logic diagram of the JK flip-flop. State the behavior of the flip flop when the J and K inputs assume the following values:
(i) $J = K = 1$
(ii) $J = 1$ and $K = 0$ [4]
(iii) $J = 0$ and $K = 1$
(iv) $J = 0$ and $K = 0$.

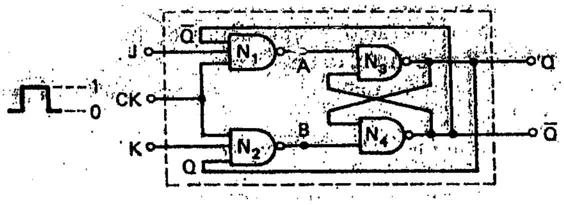


Figure 8

(c) (i) What is a counter and how is its modulus determined? [2]

(ii) Figure 9 is a mod-8 counter. Draw in the necessary wiring to modify the counter to a mod-6 counter. Verify the modified counter performance by way of a timing diagram clearly showing the truncating point. [7]

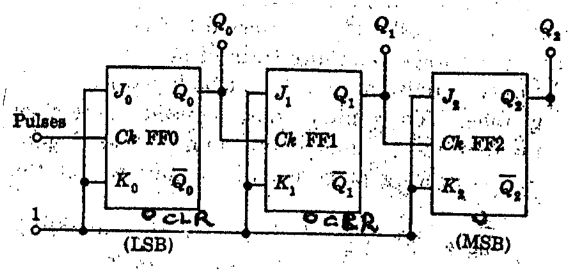


Figure 9

Q5 (a) Distinguish between a ROM and a RAM taking into account the following:

(i) memory accessibility [2]
(ii) memory volatility and [2]
(iii) read and write capability [2]

(b) (i) What is meant by "memory capacity"? [2]
(ii) What is the "bit capacity" of a memory that has 512 addresses and can store a byte at each address? Express this memory capacity in kilobits. [2]

(c) A memory circuit IC has 4 pin address lines and 4 data line input pins. The output port has 4 data lines.

(i) Draw a well labeled block diagram of this memory map, clearly showing the following:

- Position of primary address lines, i.e. address lines before the decoder; [2]

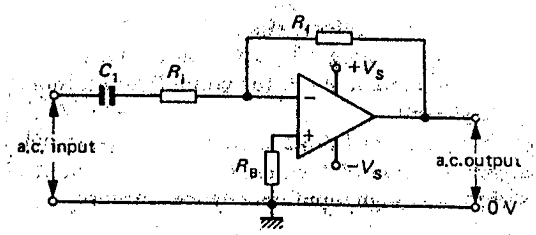
- Position and number of address lines after the decoder [2]
- The position of data input and output lines; [2]
- The number and positions of storage cells [3]
- Is this memory block a ROM or a RAM? Support your answer [3]

(c) What are sequential memories? What are their main disadvantage? [3]

Q6 (a) Figure 10 is a diagram of an op amp with two inputs; the inverting and non-inverting.

(i) State the reason why the two inputs are called inverting and non inverting. [2]
(ii) What are the three most important properties that an op amp must have in order to perform adequately? [3]
(iii) Why is the 0V point called virtual ground? [2]

Figure 10



(b) A digital to analogue converter has 10 inputs.
(i) What is the total binary input combinations will it handle? [2]
(ii) What is the step-size of this D/A if it is connected to a 5V supply? [2]
(iii) Calculate the D/A's percent resolution. [2]
(iv) What is the maximum output from the D/A? [2]

(c) Figure 11 is a diagram of a binary weighted resistor D/A. Suppose the same is connected to a 5V supply in which case a binary 1 corresponds to +5V.

(i) Find the current flowing in each arm. [4]
(ii) Calculate the analogue output corresponding to the digital waveform input in figure 12 in the following time intervals: t_o - t_1; t_1 - t_2; and $t_2 - t_3$. Take R = 25 ohms. [6]

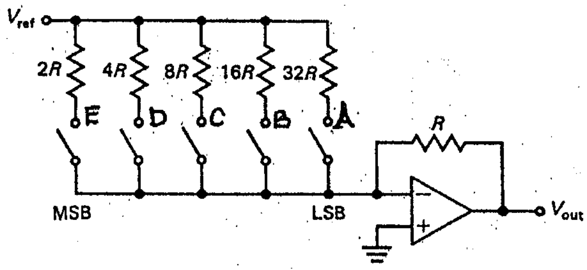


Figure 11

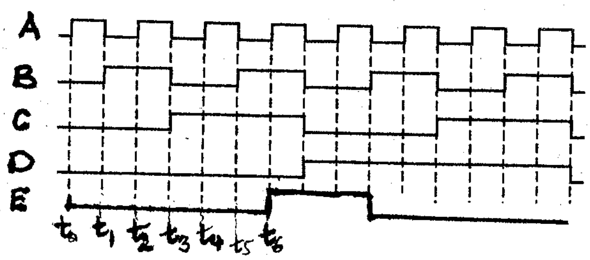


Figure 12

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2005 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

Q 1 (a) Draw the logic circuit for the following equation

$$X = \overline{A\,\overline{B}\cdot(A+C)} \;+ \overline{A}\,B \cdot \overline{A+\overline{B}+\overline{C}}$$

Use De Morgan's theorem and Boolean algebra to simplify the equation. Draw the simplified circuit. [13]

(b) Discuss the function of the following signals of 8085 microprocessor. [12]

(i) RESET (ii) HOLD (iii) READY (iv) ALE (v) INTR (vi) $IO/\overline{M}$

Q 2 (a) Simplify the circuit shown in figure 1 down to its SOP form, then draw the logic circuit of the simplified form using a 74LS54 AOI gate. [10]

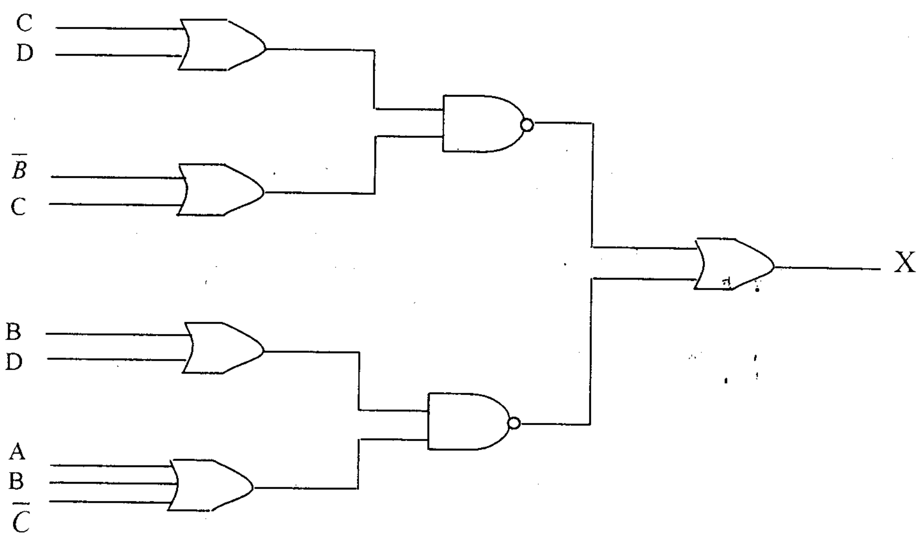


Figure 1

(b) Write a program to add the following five data bytes stored in memory locations starting at 2060H. If the sum generates a carry, stop the addition, and display 01H at the output port. Otherwise, continue adding and display the sum. [15]

Q 3 (a) Simplify the following equation using the Karnaugh mapping procedure.

$$X = \overline{B}\left(C\overline{D} + \overline{A}\,D\right) + \overline{B}\;\overline{C}\left(A + \overline{A}\,\overline{D}\right)$$ [8]

(b) Explain with the aid of a figure the bus organization of the 8085/8080A microprocessor. [10]

(c) Determine the content of the accumulator after the following program has run. [7]

```
MVI C, 7FH
MVI B, 3EH
MOV A,B
RLC
RLC
ANI 7FH
HLT
```

Q 4 (a) Design a two's complement adder/subtractor circuit for performing the operation 62-34 and briefly explain how it operates. [15]

(b) The following block of data is stored in memory locations from XX55H to XX5AH. Transfer the data to the locations XX80H to XX85H in the reverse order (e.g., the data byte 22H should be stored at XX85H and 37H at XX80H). [10]

Data (Hex): 22, A5, B2, 99, 7F, 37

Q 5 (a) Find the output of the program given below. The memory location 2475H contains 00H and the memory location 3794H contains 11H. With appropriate figures, show the contents of registers upon execution of each instruction. [14]

```
LXI    B,2475H
LXI    D,3794H
LDAX   B
MOV    L,A
LDAX   D
STAX   B
MOV    A,L
STAX   D
HLT
```

(b) The available user memory of 8085 microprocessor ranges from 2000H to 23FFH. A program of data transfer and arithmetic operations is stored in memory locations from 2000H to 2050H, and the stack pointer is initialized at location 2400H. Two sets of data are stored, starting at locations 2150H and 2280H. Registers HL and BC are used as memory pointers to the data locations. A segment of the program is shown below.

```
2000        LXI SP, 2400H
2003        LXI H, 2150H
```

2006	LXI B, 2280H
2009	MOV A, M
200A	PUSH H
200B	PUSH B
200C	PUSH PSW
200D	⋮
201F	↓
2020	POP PSW
2021	POP H
2022	POP B

(i) Explain how the stack pointer can be initialized at one memory location beyond the available user memory. [3]

(ii) Illustrate the contents of the stack memory and registers when PUSH and POP instructions are executed. [6]

(iii) Explain the various contents of the user memory. [2]

Q 6 (a) A set of ten current readings is stored in memory locations starting at XX60H. The readings are expected to be positive. Write a program to

(i) Check each reading to determine whether it is positive or negative
(ii) Reject all negative readings
(iii) Add all positive readings
(iv) Output FFH to PORT 1 at any time when the sum exceeds eight bits to indicate OVERLOAD; otherwise display the sum.

Data (Hex) : 28, D8, C2, 21, 24, 30, 2F, 19, F2 and 9F. [17]

(b) Write short notes on [8]

(i) EPPROM and EEPROM
(ii) Peripheral I/O and Memory mapped I/O
(iii) Cache memory
(iv) DMA

END OF P442 EXAMINATION

UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS
2005 SECOND SEMESTER UNIVERSITY EXAMINATIONS

P452
SELECTED TOPICS IN THEORETICAL PHYSICS

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 parentheses next to the question.*
MAXIMUM MARKS:	100
DATE:	Monday, 5th December 2005.

QUESTION 1

In figure 1 AB is a straight frictionless wire fixed at point A on a vertical axis OA such that AB rotates about OA with constant angular velocity ω. A bead of mass m is constrained to move on the wire.

(i) Write the Lagrangian for the bead. (12 marks)

(ii) Obtain Lagrange's equations of motion for the bead. (5 marks)

(ii) Solve these equations. (8 marks)

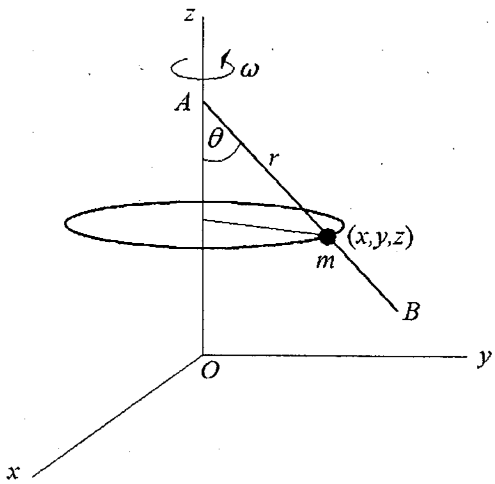


Figure 1: For question 1.

QUESTION 2

(i) Derive Hamilton's equations by means of a Legendre transformation.

(5 marks)

(ii) A particle of mass m moves in a force field of potential V. Using spherical polar coordinates write the Hamiltonian for the system and from this obtain Hamilton's equations of motion for the system.

(17 marks)

(iii) Write down the Hamilton-Jacobi equation corresponding to the Hamiltonian of part (ii).

(3 marks)

QUESTION 3

(i) Prove the symplectic condition for restricted canonical transformations. Does the symplectic condition hold when the canonical transformation depends on time?

(10 marks)

(i) Prove directly that the transformation

$$
\begin{aligned}
Q_1 &= q_1, \qquad & P_1 = p_1 - 2p_2, \\
Q_2 &= p_2, \qquad & P_2 = -2q_1 - q_2,
\end{aligned}
$$

is canonical.

(15 marks)

QUESTION 4

(i) Explain the meaning of Noether's theorem.

(4 marks)

(ii) Explain the difference between the variations $\delta\eta_\rho$ and $\bar{\delta}\eta_\rho$.

(2 marks)

(iii) Give three restrictions made in the derivation of Noether's theorem.

(4 marks)

(iv) In the derivation of Noether's theorem we are led to the general result

$$\int_\Omega \frac{d}{dx_v}\left[\frac{\partial \mathcal{L}}{\partial \eta_{\rho,v}}\bar{\delta}\eta_\rho + \mathcal{L}\delta x_v\right] dx_\mu = 0.$$

By expressing δx_r and $\delta\eta_\rho$ in terms of r-parameters ϵ_r, i.e.

$$\delta x_v = \epsilon_r \chi_{rv}, \qquad \delta\eta_\rho = \epsilon_r \Psi_{r\rho},$$

derive the expression for the conserved quantity. (15 marks)

QUESTION 5

(i) Find the equations for the rocket frame axes from the perspective of the laboratory frame. Also find the equations for the lines corresponding to $x' = 1, 2, 3$ and $ct' = 1, 2, 3$. Show these lines on a spacetime graph of the laboratory frame.

(15 marks)

(ii) What do the lines $ct' = 0, 1, 2, \ldots, n$ represent physically.

(1 marks)

(iii) Show how to calibrate the ct' and x' axes.

(3 marks)

(iv) Demonstrate time dilation graphically.

(3 marks)

(v) Demonstrate length contraction graphically.

(3 marks)

QUESTION 6

(i) Explain what is a 1-form and the meaning of $\langle \tilde{\mathbf{k}}, \mathbf{v} \rangle$. Include a diagram.

(2 marks)

(ii) Explain the meaning of the gradient 1-form $\mathbf{d}f$ and the directional derivative. Derive an expression which relates the gradient 1-form to the directional derivative.

(8 marks)

(iii) Show how basis 1-forms are obtained. Show the basis 1-forms and the corresponding basis vectors in a diagram (indicate the positive sense).

(3 marks)

(iv) Express the directional derivative and gradient 1-form in component form.

(6 marks)

(v) Derive the equation of transformation of the basis vectors in different Lorentz frames. Repeat for four vectors, 1-forms and basis 1-forms.

(4 marks)

(vi) Write down the tensor $\mathbf{S}$ of rank $\begin{pmatrix} 2 \\ 1 \end{pmatrix}$ and show its output when the basis 1-forms and basis vectors are inserted. Show the output for general 1-forms and vectors.

(2 marks)

——— **END** ———

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY OF ZAMBIA
SECOND SEMESTER EXAMINATIONS 2005
P455 QUANTUM MECHANICS II

TIME : THREE HOURS
ANSWER : ANY FOUR QUESTIONS
MAXIMUM MARKS : 100

Useful information:

1.

$$\begin{vmatrix} H'_{11} - E^{(1)} & H'_{12} & \cdots & H'_{1\alpha} \\ H'_{21} & H'_{22} - E^{(1)} & \cdots & H'_{2\alpha} \\ \cdots & \cdots & \cdots & \cdots \\ H'_{\alpha 1} & H'_{\alpha 2} & \cdots & H'_{\alpha\alpha} - E^{(1)} \end{vmatrix} = 0$$

2. The first two harmonic oscillator eigenfunctions are

$$\psi_0(x) = \frac{1}{\pi^{1/4}\sqrt{x_0}} \exp\left[-\frac{1}{2}\left(\frac{x}{x_0}\right)^2\right]$$

$$\psi_1(x) = \frac{1}{\pi^{1/4} x_0^{3/2}} x \exp\left[-\frac{1}{2}\left(\frac{x}{x_0}\right)^2\right],$$

here $x_0 = \sqrt{\hbar/m\omega}$.

3. The energy levels of the one-dimensional harmonic oscillator are given by

$$E_n = (n + \frac{1}{2})\hbar\omega$$

4. The first-order transition probability in time-dependent perturbation the-
ry is

$$c_{ba}^{(1)} = (i\hbar)^{-1} \int_{t_0}^{t} H'_{ba}(t') \exp(i\omega_{ba} t') dt'$$

5.

$$\int_0^\infty y^n e^{-\alpha y} dx = \frac{n!}{\alpha^{n+1}}, \ \alpha > 0$$

6.

$$\int_{-\infty}^{\infty} e^{ip_x(x-x')/\hbar} dp_x = 2\pi\hbar\delta(x - x')$$

7.

$$\int_{-\infty}^{\infty} e^{-x^2} dx = \sqrt{\pi}$$

8. If $f(x)$ is an odd function, then

$$I = \int_{-a}^{a} f(x)dx = 0$$

9. For a particle in a box with walls at $x = 0$ and $x = L$,

$$\psi_n(x) = \sqrt{\frac{2}{L}} \sin \frac{n\pi x}{L}$$

and

$$E_n = \frac{\pi^2 \hbar^2 n^2}{2mL^2}$$

---

1. (a) A particle of mass m moves in a two-dimensional harmonic-oscillator potential $V = \frac{1}{2}m\omega^2(x^2 + y^2)$.

(i) Obtain the eigenfunctions of the system for the ground state and the first excited state. [5 marks]

(ii) Show that the energy is given by

$$E_{n_x,n_x} = (n_x + n_y + 1)\hbar\omega \qquad [2 \text{ marks}]$$

(b) If the particle in fact has charge q and is acted upon by a weak electric field in the x direction, so that the term $H' = qkx$ is added to the Hamiltonian, obtain the new energy of

(i) the ground state of the particle [5 marks]

(ii) the first excited state. [13 marks]

(2) (a) A system is acted upon by a time-dependent perturbation of the form

$$H' = h(\mathbf{r})e^{i\Omega t}$$

Show that such a system preferentially emits energy in units of $\hbar\Omega$ as a result of this perturbation. [8 marks]

(b) A one-dimensional harmonic oscillator of mass m, charge e and with angular frequency ω is in the ground state. A perturbation of the form

$$H'(t) = \begin{cases} -qex, & 0 \leq t \leq \tau \\ 0 & \text{otherwise} \end{cases}$$

acts on the oscillator.

(i) Show that the oscillator cannot stay in the ground state. [5 marks]

(ii) Find the probability of transition to the $n = 1$ state. [12 marks]

3. (a) Explain why the expression

$$\langle E \rangle = \frac{\int \phi^* H \phi d\tau}{\int \phi^* \phi d\tau}$$

is an upper limit to the ground-state energy of a particle with Hamiltonian H. [5 marks]

(b) An idealised ping-pong ball of mass $m = 1.2 \times 10^{-3}$ kg is bouncing on a recoilless table top. Hence its total energy is conserved.

(i) Explain why the Hamiltonian is

$$H = -\frac{\hbar^2}{2m}\frac{d^2}{dy^2} + mgy \quad [2\,\text{marks}]$$

(ii) Assuming that motion takes place between the limits $0 \leq y \leq \infty$, use the trial function

$$\phi_\alpha = Cye^{-\alpha y}$$

with α as the variational parameter and C as the normalisation constant to obtain an estimate to the ground-state energy. [18]

4. (a) (i) The Hamiltonian of the harmonic oscillator is

$$H = \frac{p^2}{2m} + \frac{1}{2}kx^2$$

If the ladder operators

$$a_\pm = \frac{1}{\sqrt{2}}\left[\frac{p}{(m\hbar\omega)^{1/2}} \pm i(\frac{m\omega}{\hbar})^{1/2}x\right]$$

satisfy the commutation relations

$$[H, a_\pm] = \pm\hbar\omega a_\pm$$

prove that one is a raising operator while the other is a lowering operator. [4 marks]

(ii) Show that the ground state ψ_0 of the harmonic oscillator satisfies the equation

$$\frac{1}{\sqrt{2}}[-i\left(\frac{\hbar}{m\omega}\right)^{1/2}\frac{d}{dx} - i(\frac{m\omega}{\hbar})^{1/2}x]\psi_0 = 0 \quad [3\,\text{marks}]$$

(ii) Prove that the solution of this equation is

$$\psi_0 = \left(\frac{m\omega}{\pi\hbar}\right)^{1/4} \exp(-\frac{m\omega}{2\hbar}x^2) \quad [5\,\text{marks}]$$

(iii) Explain how to generate all the states of the harmonic oscillator and show that their energies are given by

$$E_n = (n + \frac{1}{2})\hbar\omega. \quad [5\,\text{marks}]$$

(b) Tritium is an isotope of hydrogen with a nucleus consisting of one proton and two neutrons. Both neutrons and protons are spin-1/2 particles. What are the possible values for the total spin of the tritium nucleus? [8 marks]

5. **(a)** In momentum space, the operator for the position x is $i\hbar\frac{d}{dp_x}$. Show that the commutator of x and p_x is the same whether computed in coordinate or in momentum space. [5 marks]

(b) Two angular momenta $\mathbf{J}_1$ and $\mathbf{J}_2$ are added to give $\mathbf{J}$. During this, the Clebsch-Gordan coefficients $\langle j_1 j_2 j | m_1 m_2 m\rangle$ appear.

(i) Explain why $|j_1 - j_2| \leq j \leq j_1 + j_2$. [3 marks]

(ii) Deduce that $\langle j_1 j_2 j | m_1 m_2 m\rangle = \langle j_1, j_2, j_1 + j_2 | + j_1, +j_2, j_1 + j_2\rangle = 1$. [7 marks]

(c) The harmonic oscillator Hamiltonian is

$$H = \frac{p^2}{2m} + \frac{1}{2}kx^2$$

(i) Write down the time-dependent Schroedinger equation in momentum space and hence obtain the time-independent Schroedinger equation in momentum space. [6 marks]

(ii) Explain what the form of eigenfunctions must be. [4 marks]

6. (a) Two non-interacting particles are in a box of dimension L with walls at $x = 0$ and $x = L$.

(i) What is the Hamiltonian of the system? [2 marks]

(ii) Obtain the first-excited state energy and eigenfunction of the system if the particles are bosons [5 marks]

(iii) Obtain the first-excited state energy and eigenfunction of the system if the particles are fermions [6 marks]

(b) N identical non-interacting spin-1/2 fermions are confined in a cubic box of dimension L at absolute temperature $T = 0$. Given that the energy levels of a particle of mass m in a cube of side L are

$$E_n = \frac{\hbar^2\pi^2}{2mL^2}n^2,$$

where

$$n^2 = n_x^2 + n_y^2 + n_z^2,$$

and that the wave function for such a state is

$$\psi_{n_x,n_y,n_z,m_s}(q) = \psi_{n_x,n_y,n_z}(x,y,x)\chi_{\frac{1}{2},m_s},$$

(i) show that the total number of individual particle states for energies up to E is

$$N_s = \frac{1}{3\pi^2}\left(\frac{2m}{\hbar^2}\right)^{3/2} VE^{3/2},$$

where $V = L^3$; [8 marks]

(ii) prove that the highest value of energy occupied by the N particles at absolute temperature $T = 0$, i.e., the Fermi energy, is

$$E_F = \frac{\hbar^2}{2m}(3\pi^2\rho)^{2/3},$$

where $\rho = N/V$. [4 marks]

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