THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2007 FIRST SEMESTER EXAMINATIONS

COURSE/CODE		COURES /TITLE
BS	111	Cell biology and genetics Theory paper
BS	221	Form, function and diversity of Plants
BS	319	Biostatistics
BS	321	Ethnology and Evolution
BS	341	Microbiology Theory paper !
BS	351	Entomology
BS	411	(Insect ecology) Paper II
BS	475	Population ecology (Theory paper II)
BS	491	Fresh water Biology Theory paper
BS	411	Insect behaviour and Ecology Theory Paper 1
C	101	Introductory Chemistry I
C	245	Inorganic Chemistry 1
C	251	Organic Chemistry 1
C	311	Biochemistry
C	341	Inorganic Chemistry II
C	351	Organic Chemistry III
C	361	Chemical Kinetics and nuclear chemistry
C	411	Advanced biochemistry
C	421	Applied analytical chemistry
C	451	Organic chemistry
C	491	Organic Industrial Chemistry
CS	3251	Electronic for computing I
CS	3011	Algorithms and date structure
CST	3141	Object Oriented analysis and design
CST	4121	Requirements and specifications
CST	4131	Advanced object – oriented programming

GEO	175	Introduction to mapping techniques
GEO	175	Introduction to mapping techniques (Practical)
GEO	271	Quantitative techniques in geography I
GEO	381	Environment and development I
GEO	451	Land resources survey
GEO	481	Environment and development II
GEO	911	Population geography
GEO	921	Economic geography
GEO	931	Rural geography
GEO	951	Climatology
GEO	961	Soils geography
GEO	971	Aerial photography and photo interpretation (paper II)
M	111	Mathematical methods I
M	222	Linear Algebra
M	331	Real Analysis III
M	335	Topology
M	411	Theory of functions of a Complex variable I
M	421	Structure and representations on groups
MSE	441/451/461	Biology physics and chemistry teaching methods III
P	191	Introductory Physical I
P	251	Classical mechanics I
P	261	Electricity and magnetism
P	361	Electromagnetic theory
P	411	Nuclear Experiment techniques
P	415	Mathematical methods for physicists
P	421	Solid state physics I
P	441	Analog electronics II

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER

FINAL EXAMINATIONS

BIO5011: RESEARCH STATISTICAL METHODS

PAPER II

TIME: THREE HOURS

INSTRUCTIONS: ANSWER ALL TWO QUESTIONS AND USE ILLUSTRATIONS WHEREVER POSSIBLE

Question 1. In a systematic study of the four species of *Tylosema*, a geophytic plant genus, the following characters were described.

Species	Longest stems (m)	Tendrils	Leaf petiole	Leaf blade length	Leaf blade width	Leaf bilobe depth
fassoglense	6	Forked	Long	Long	Wide	Shallow
esculentum	3	Forked	Short	Intermediate	Intermediate	Deep
humifusum	1	Absent	Short	Short	Narrow	Deep
angolensis	3	Absent	Intermediate	Intermediate	Intermediate	Intermediate

1.1 Prepare an Excel spreadsheet of the above data for cluster analysis using Systat and generate an output (15 marks).
1.2 Import the Excel data file into Systat (5 marks).
1.3 Explain the procedure for using the data to develop a cluster dendrogram and generate the necessary outputs (15 marks).
1.4 Describe the similarities among the four species based on the results of cluster analysis (15 marks)

Question 2. In a seed predation study, a researcher placed 100 seeds of *Bauhinia* (*Piliostigma*) *thonningi* tree on two locations: one in unburnt grassland and the other in burnt grassland. The disappearance of the seeds (interpreted as predation) was monitored over a 14-day period and the results were as follows.

Observation day	Number of seeds removed	
	Unburnt grassland	Burnt grassland
0	0	0
4	99	35
7	1	44
11	0	21
14	0	0

2.1 Prepare an Excel spreadsheet of the above data for survival analysis using StatistiX and generate an output (15 marks).
2.2 Import the Excel data file into StatstiX (5 marks).

2.3 Compare the differences in the pattern of seed predation in the burnt and unburnt grassland locations and explain the procedure and tests used in the analysis (30 marks).

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER

FINAL EXAMINATIONS

BIO5135: ECOLOGY AND MANAGEMENT OF TROPICAL DRY FORESTS

PAPER I

TIME: THREE HOURS

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS AND USE ILLUSTRATIONS WHEREVER POSSIBLE

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1. Discuss dry forest formations in Sub-Saharan Africa as defined by White (1983).

2. How does vegetation structure determine the fire regime characteristics across dry forest types in Africa.

3. What are the key features of a fire regime.

4. Contrast between seed and seedling shadows of a dry forest tree.

5. Discuss seed dormancy and germination patterns in dry forests.

6. Critique the forest policy and law in Zambia in relation to community based natural resources management.

7. Discuss characteristics of plant invasions.

8. How can the effectiveness of biological control of invasive plants be assessed.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

BIO 5145: ECOLOGY AND WILDLIFE MANAGEMNT (Paper II)

TIME: THREE (3) HOURS

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

1. Biologists monitoring populations of Impala (*Aepyceros melampus*) on Chete Island in Lake Kariba, Sinazongwe between 1958 and 1985 gave figures as given in the table below. The island is approximately 5km^2 and is generally covered by a thicket of *Combretum* sp. Mean annual rainfall is 900mm. The island is a protected area and is regularly patrolled by game scouts. However, fishermen in the lake are allowed to land fish in certain parts of the island. For nearly 12 years the island was exposed to liberation war between 1968 and 1980, and part of the island was defoliated with herbicides. Impalas are polygamous and only a male breeds with a herd of females. Non breeding males form a bachelor herd. Using the information and data provided, explain the population trends, and discuss factors which could be most significant to this population on the island.

Table: Impala population at Chete Island, Lake Kariba, based on transects ground counts.

Year of Census	Total population	Juveniles	Males	Females
1958	75	8	20	47
1968	136	6	54	76
1975	150	10	40	100
1980	308	40	58	210
1985	263	65	60	138
1990	232	72	65	95

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

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

(a) *Tragelaphus spekei*
(b) *Equus burchelli*
(c) *Damaliscus lunatus*
(d) *Hystrix africaeaustralis*
(e) *Hippotragus niger*

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

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

4. An unusual combination of environmental circumstances provided a unique abundance of resources for small animals on Chilwa Island, Lukanga swamps in Central province. As a result there appears to be a potential for uncontrolled growth in the local population of Rats a rodent species. The species is mainly monogamous but can be promiscuous when the population is overcrowded. Assuming that you are the Team Leader among the Ecologists and Researchers assigned to visit the island to document what is happening in detail, and to answer your various questions that have been raised by other researchers on the problem, d*esign a study that you could use to investigate the kinds of questions an Ecologist might ask to understand the causes and consequences of what will happen to the species and the community of the island.*

END OF EXAMINATION

INFORMATION FOR QUESTION TWO (2)

THE MAP AND THE DESCRIPTION OF THE AREA:

Vegetation types:

A: Termitaria grassland

B: Munga woodland

C: Chipya woodland

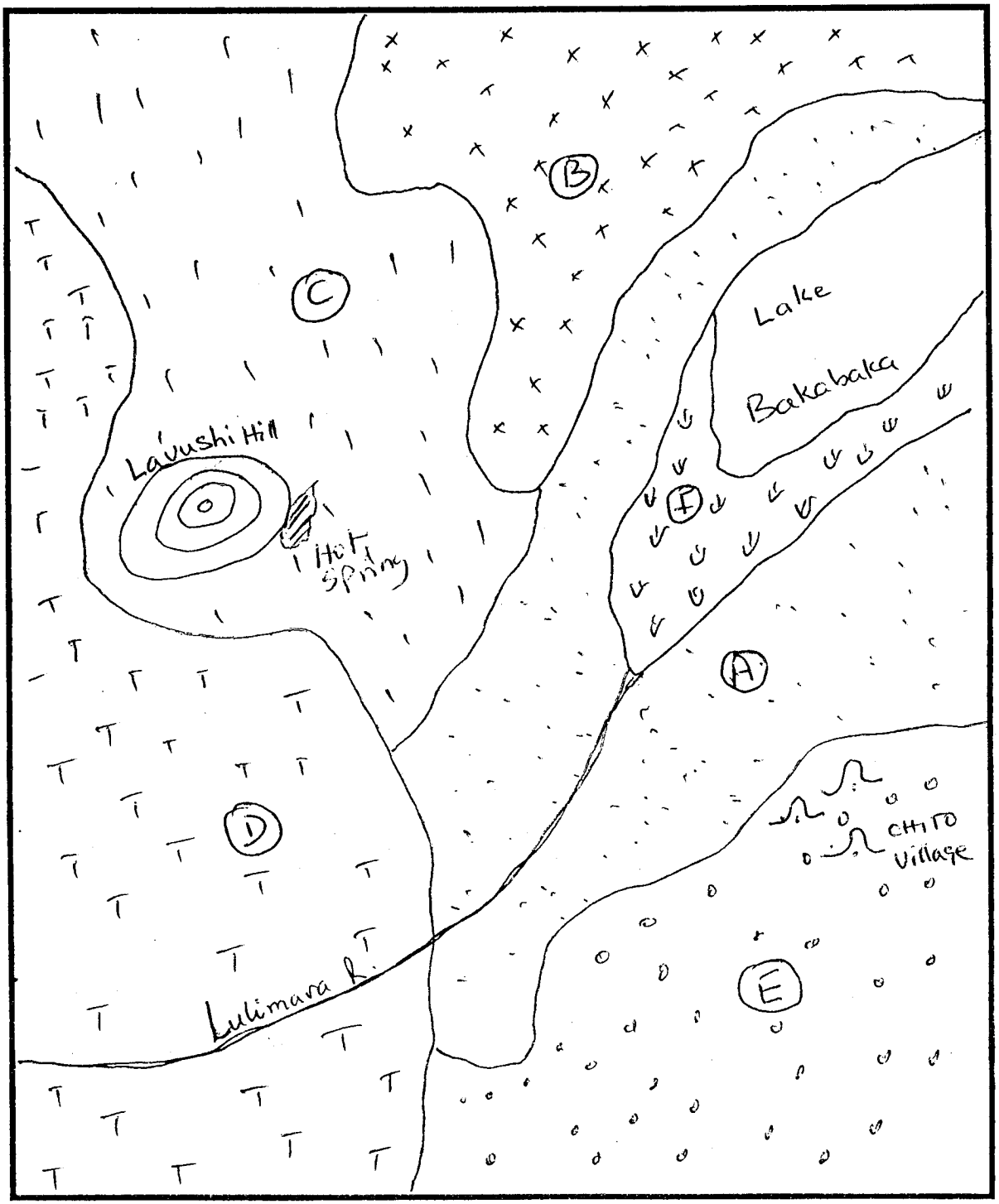
D: Miombo woodland

E: Hyparrhenia grassland

F: Swamp

The area is located in the western part of Mpika District in Chief Chiundaponde, Northern Province of Zambia. Average annual rainfall is approximately 1300 mm. Lake Bakabaka is a fresh water lake, and has fish. The river is perennial with riparian vegetation mainly *Diospyros sp* and *Zyzygium sp.* The Hot spring is salty. There is only one village of about seven household (or about 40 people). Its main activity is fishing. Farming is done at a low scale in vegetation type E. Hunting is important. The area is being considered for protection because of its importance to biodiversity. Now answer Question 2 above.

MAP FOR QUESTION 2



THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

TIME: THREE (3) HOURS

BIO 5421 (11): INTEGRATED PEST AND VECTOR MAMAGEMENT

INSTRUCTIONS: ANSWER FIVE (5) QUESTIONS. TWO QUESTIONS FROM SECTION A, TWO QUESTIONS FROM SECTION B AND THE LAST QUESTION FROM EITHER SECTION A OR B.

SECTION A

1. Define precision farming. Discuss:
   a) The goal of precision farming
   b) The merits and demerits of precision farming.

2. An insect outbreak has been reported on maize fields in Sinazongwe area. Farmers are very worried about this pest. Outline the procedures and tools you would use to contain this pest to the satisfaction of farmers in Sinazongwe area.

3. Outline the Institutional and infrastructure requirements needed for the successful Implementation of IPVM in Zambia.

4. Write short and concise notes on **all** of the following:

   i. The promise of Agriculture expert system
   ii. Chaining
   iii. Integrated Pest Management (IPM)
   iv. Research and Development in IPVM

SECTION B

5. a) What is the definition of an Insect Pest Vector Management Model?
   b) What are models used for in IPVM programs?
   c) What types of models are used in IPVM models?

6. a) What are the steps involved in developing IPVM models?
   b) How are IPVM models validated?

7. In Zambia, Maize is attacked by a number of pests. Rootworm and fat john attack the underground stem of young maize seedlings causing the whole plant to die. Cutworms cut maize seedlings just above the ground level. Stalk borers attack maize stalks and cobs. Termites attack plants just before harvest and the larger grain borer, grain weevils, Flour beetles attack maize in storage. Construct a conceptual model for the maize system.

8. Malaria is one of the major health problems in Zambia. Malaria parasites are transmitted by female mosquitoes. Adult mosquitoes lay eggs in water. Eggs hatch into larvae which pupate after a few days. Adult mosquitoes emerge from the pupa and after a few days female mosquitoes feed on humans. Female mosquitoes pick up malaria parasites when they feed on infected human hosts. Malaria parasites develop in the mosquitoes and are transmitted to humans during subsequent feeding. Susceptible human hosts fall sick after a few days and may die if the disease is not treated. However, some humans may recover and become immune. All the life stages of the mosquitoes have parasites and predators, and their development is affected by environmental factors.

   a) Define and name the state, rate and driving variables in malaria disease transmission.

   b) Draw a flow chart showing the qualitative relationship of the state, rate and driving variables for malaria.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

TIME: THREE (3) HOURS

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END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
THE SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER EXAMINATIONS
FINAL EXAMINATIONS

BS111: CELL BIOLOGY AND GENETICS

TIME: THREE HOURS

INSTRUCTIONS:

1. **Answer all questions**
   Section A: Cell biology (1-50)
   Section B: Genetics (51-100)

2. **Each question carries 4 marks**

3. **A wrong answer carries –1 mark**

4. **"I do not know" carries 0 mark**

5. **Use the answer sheet provided to record the answers**

6. **Copying of any kind will lead to disqualification**

7. **Fill in the computer number on your answer sheet**
   Double check the computer number

8. **Do not turn this page until requested to do so**

Section A: Cell biology (1-50)

1. The bond between Na^+ and Cl^- ions is called...
   1. an ionic bond
   2. hydrophobic interaction
   3. a covalent bond
   4. an ester bond
   5. temporal bond
   6. I do not know

2. Which of the following statements is **true**?
   1. There are no proteins in the structure of a cell membrane
   2. Lysosomes are the site for protein synthesis in a cell
   3. DNA is present in both chloroplasts and mitochondria
   4. A larger cell is metabolically more efficient
   5. Life is made up of multicellular organisms only
   6. I do not know

3. The difference between *Escherichia coli* (*E. coli*) and a cell of an onion peel is that ...
   1. the onion cell has no cell wall while *E. coli* has one
   2. the nucleus of an onion cell is visible with naked eyes while that of *E. coli* is not
   3. the onion cell has DNA while that of a bacterium does not
   4. *E. coli* has a definite nucleus while the onion cell has free floating DNA
   5. The cells of *E. coli* are much smaller than those of an onion cell
   6. I do not know

4.

Structure	Endoplasmic Reticulum	(a)	Nucleolus
Function	(b)	Movement	(c)
location	Eukaryotic cell	Prokaryotic cell	Nucleus

   1. (a) Capsule (b) protein synthesis (c) lipid synthesis
   2. (a) cilia (b) synthesis of lipoproteins (c) carrier of hereditary information
   3. (a) Flagella (b) protein synthesis (c) ribosome synthesis
   4. (a) Cytoplasm (b) translocation within the cell (c) cell division
   5. (a) Cell wall (b) cytoskeletal support (c) protein synthesis
   6. I do not know

5. Glucose is an isomer of ....
   1. Glyceraldehyde
   2. Fructose
   3. Dihydroxyacetone
   4. Sucrose
   5. Lactose
   6. I do not know

6. The bond that occurs between the amino acids guanine and cytosine is a …
… bond
   1. single ionic
   2. double ionic
   3. triple hydrogen
   4. double hydrogen
   5. single covalent
   6. I do not know

7. A phosphodiester bond is a part of …
   1. chromosomes
   2. proteins
   3. lipids
   4. carbohydrates
   5. ribosomes
   6. I do not know

8. The sequence of nitrogenous bases that get expressed in a chromosome are the ones that …
   1. are part of the nucleoplasm
   2. are found on the endoplasmic reticulum
   3. are found along the total length of a chromosome
   4. occur on the spacer deoxyribonucleic acid
   5. occur on the nucleosome
   6. I do not know

9. Sucrase is for sucrose as Cellulase is for cellulose. Lactase is for …
   1. lactic acid
   2. lectin
   3. lactose
   4. fructose
   5. galactose
   6. I do not know

10. Which of the following molecules would yield the highest chemical energy in a cell?
   1. Starch
   2. Oleic acid
   3. Glucose
   4. Sucrose
   5. Amylose
   6. I do not know

11. How does water pass through the plasma membrane?
   1. Through permanent micro openings
   2. By active transport
   3. With the help of permease proteins
   4. With the assistance of the lipid bilayer
   5. By facilitated diffusion
   6. I do not know

12. Why is sucrose a non reducing sugar?
    1. Its functional group is made up of methyl groups
    2. It has lost its functional group though the formation of the disaccharide
    3. The reactive carbon four has been deactivated
    4. The number of hydrogen atoms in the molecule has been reduced
    5. The carboxylic groups in the molecule are all engaged in chemical bonding
    6. I do not know

13. Amylase and lipase are examples of …
    1. carbohydrates
    2. secondary structures of proteins
    3. haemoglobin
    4. tertiary structures of proteins
    5. lipids
    6. I do not know

14. When a nucleoside is hydrolysed it yields …
    1. a ribose sugar and a cytosine
    2. a nucleic acid and a phosphate group
    3. a hexose sugar and guanine
    4. water and a nitrogenous base
    5. a nucleotide and water
    6. I do not know

15. Give an example of a purine and a pyrimidine.
    1. adenine and guanine
    2. cytosine and adenine
    3. guanine and uracil
    4. thymine and cytosine
    5. uracil and thymine
    6. I do not know

16. Identify the organelle in the electron micrograph.
    1. Mitochondrion
    2. Chloroplast
    3. Chloroplast
    4. Nucleus
    5. Golgi body
    6. I do not know

17. Why is glucose soluble in water?
    1. Glucose forms ionic bonds with water
    2. Glucose fails to form bonds with water
    3. Glucose forms hydrogen bonds with water
    4. Glucose is a non reactive molecule
    5. Glucose does not have a functional group on it
    6. I do not know

18. Which part of a cytoskeleton takes part in the movement of a cell?
    1. microtraberculae
    2. microfilaments
    3. microtubules
    4. flagella
    5. cilia
    6. I do not know

19. In what state are proteins in the stomach?
    1. They precipitate out of solution
    2. It will act as a buffer and get the $-NH_3^+$ neutralised
    3. They will exist as neutral proteins
    4. The proteins will go into solution
    5. They will lose the COO^- neutralised
    6. I do not know

20. Which of the following statements is **false**?
    1. Water as a solid sinks in water
    2. proteins act as buffers in the blood system of a mammal
    3. plasmids are structures contained in bacteria
    4. Vacuoles are present in plant and animal cells
    5. An ester bond is used in the synthesis of triglycerides
    6. I do not know

21. Which of the following statements is **true**?
    1. Mitochondria are not capable of duplicating themselves
    2. Polysaccharides readily dissolve in water to form a solution
    3. The cell wall acts as a selectively permeable barrier in plant cells
    4. The DNA molecule is made up of a ribose-phosphate backbone
    5. The cell membrane is the same in plant and animal cells
    6. I do not know

22. The organelle that is responsible for the production of energy in a cell is called the ...
    1. golgi body
    2. mitochondrion
    3. chloroplast
    4. endoplasmic reticulum
    5. nucleus
    6. I do not know

23. Why is sucrose a non reducing sugar?
    1. Its functional group is made up of methyl groups
    2. Its reaction site has already participated in a chemical reaction
    3. The reactive carbon four has been deactivated
    4. The number of hydrogen atoms in the molecule has been reduced
    5. The molecule has lost its hydroxyl groups
    6. I do not know

24. Amylase and lipase are examples of …
    1. carbohydrates
    2. secondary structures of proteins
    3. haemoglobin
    4. tertiary structures of proteins
    5. lipids
    6. I do not know

25. When an organic compound loses hydrogen atoms in a chemical reaction it gets …
    1. reduced
    2. oxidised
    3. hydrolysed
    4. gains electrons
    5. gains energy
    6. I do not know

26. Which of the following statements is **correct**?
    1. Photosynthesis takes place in the stroma of the chloroplast
    2. Proteins get denatured at 37 ^{0}C
    3. Fructose is an alternative source of energy to glucose in a cell
    4. Plant cells do not have protoplasm
    5. Animal cells do have an envelope around the chromosomes
    6. I do not know

27. Which of the following statements about water is **correct**?
    1. It readily gains and loses heat
    2. It acts as an electrolyte
    3. Carbohydrates are generally insoluble in water
    4. It can not hold on to the walls of its container and therefore flows readily
    5. Water expands as soon as the temperature drops
    6. I do not know

28. Living organisms are made of chemical compounds that contain …
    1. carbohydrates
    2. blood
    3. lipids
    4. carbon
    5. proteins
    6. I do not know

29. The shape of the secondary structure of proteins is caused mainly by …
    1. the number of amino acids in a chain
    2. the frequency of one amino acid in the chain
    3. the amino acid sequence in the chain
    4. the coiling and folding of the total chain of amino acids
    5. ionic bonding between adjacent amino acids
    6. I do not know

30. All organic molecules are formed …
    1. through the formation of ionic bonds
    2. by atoms carrying electrons
    3. between atoms with the same number of electron in the outer shell
    4. when protons lose or gain electrons
    5. by combining carbon, hydrogen, nitrogen and oxygen
    6. I do not know

31. The fluid mosaic outer surface of a cell is composed of …
    1. glycoprotein
    2. lipoprotein
    3. cellulose
    4. protoplasm
    5. phospholipids
    6. I do not know

32. The growth of cells is limited by the ratio of …
    1. the number of organelles to the cytoplasm
    2. the number of organelles to the cytoplasm
    3. surface area to volume
    4. mitochondria to volume
    5. the size of a nucleus to the cytoplasm
    6. I do not know

33. Which of the following chemical compounds helps the cell to be selectively permeable?
    1. glycoproteins
    2. phospholipids
    3. polar proteins
    4. receptors
    5. Ribonucleic acids
    6. I do not know

34. Which of the following pair of cell components are in all cells?
    1. The cytoplasm and cell wall
    2. Cytoplasm and flagella
    3. DNA and mitochondria
    4 Ribosomes and the nucleus
    5. The cytoplasm and its protoplasm
    6. I do not know

35. Which of the following organelles is responsible for energy production in a cell?
    1. Mitochondrion
    2. Endoplasmic reticulum
    3. Ribosomes
    4. Golgi body
    5. The nucleus
    6. I do not know

36. The organelle responsible for the repackaging of lipids and proteins into lipoproteins in a cell ~~are called cell~~ is the …
    1. nucleus
    2. cell membrane
    3. lysosome
    4. chloroplast
    5. the Golgi body
    6. I do not know

37. The formation of ATP in a cell involves the …
    1. hydrolysis of ADP.
    2. The addition of a phosphate group to ADP
    3. synthesis of nitrogenous bases such as guanine and uracil
    4. the addition of protons to adenine monophosphate
    5. release of energy by AMP
    6. I do not know

38. DNA and RNA are similar in that both have …
    1. thymine as a nitrogenous base in the molecule
    2. a single strand of molecule
    3. nucleotides containing sugars, nitrogen bases and a phosphate group
    4. the same sequence of nucleotides
    5. genetic information
    6. I do not know

39. Which organelle is not present in prokaryotic cells?
    1. DNA
    2. Cell wall
    3. Nucleolus
    4. Golgi body
    5. cytoplasm
    6. I do not know

40. Which of the following statements is correct?
    1. Genetic material is made up of protein
    2. The vacuole of a plant cell never exceeds fifty percent cell volume
    3. The DNA is made up of a nucleoside back bone
    4. DNA is contained in the nucleus
    5. There are no genes in bacteria
    6. I do not know

41. Which of the following statements is **not correct**?
    1. Plant are composed of prokaryotic cells
    2. Animals are composed of eukaryotic cells
    3. Plant cells contain chloroplasts
    4. Prokaryotic cells are evolutionary older cells than eukaryotic cells
    5. Plant cells grow like animal cells do
    6. I do not know

42. What is a cytosol?
    1. It is a membrane bound organelle
    2. It is the cytoplasmic matrix of a cell
    3. It is the nucleus part of a cell
    4. It is the aqueous portion of a cell
    5. It is the site for the synthesis of the cytoplasm
    6. I do not know

43. A nucleus and a mitochondrion are surrounded by …
    1. a cell wall
    2. a single membrane
    3. a double membrane
    4. cytoplasm
    5. single phospholipid layer
    6. I do not know

44. Lysosomes …
    1. are the site for enzyme synthesis
    2. are a transport system for metabolic enzymes in a cell
    3. are the site for energy generation in a cell
    4. play no significant role in a cell
    5. used by the cell to remove organic debris
    6. I do not know

45, 46 and 47

	Formula of fatty acid	Melting point (°C)
A.	$C_{18}H_{34}O_2$	13.4
B.	$C_{24}H_{48}O_2$	86.0
C.	$C_{18}H_{32}O_2$	-5.0
D.	$C_{16}H_{32}O_2$	63.1
E.	$C_{20}H_{40}O_2$	76.5
F.	$C_{18}H_{30}O_2$	- 11.0
G.	$C_{16}H_{30}O_2$	- 0.50
H.	$C_{20}H_{32}O_2$	- 49.5

The empirical formula for a saturated fatty acid is $C_nH_{2n}O_2$; for the unsaturated fatty acid with a single double bond is $C_nH_{2n-2}O_2$ and for an unsaturated fatty acid with a triple bond is $C_nH_{2n-4}O_2$.

45. Which ones are saturated fats?
    1. B, D and E
    2. C, F and G
    3. A, B, D and E
    4. A, B and D
    5. C, F, G and H
    6. I do not know

46. Which are the unsaturated fats with one double bond?
    1. D and G
    2. A and D
    3. G and H
    4. A and C
    5. A and G
    6. I do not know

47. Which of the fatty acids shown in the table above would be solids at room temperature?
    1. A, B and C
    2. E, F and G
    3. B, D and E
    4. F, G and H
    5. C, D and E

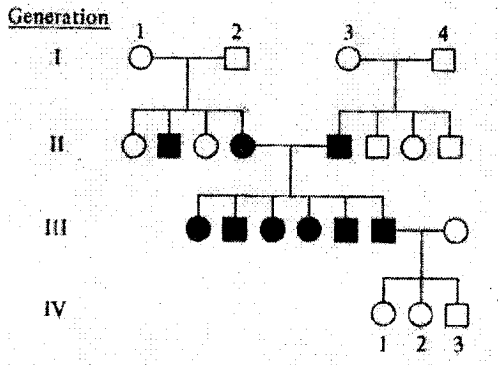
48. Low pH values indicate ...
    1. low H^+ concentration
    2. high OH^- concentration
    3. high proton concentration
    4. alkaline solution
    5. a neutral solution
    6. I do not know

49. The residues of sucrose are ...
    1. glucose and glucose
    2. glucose and galactose
    3. glucose and mannose
    4. glucose and fructose
    5. glucose and ribose
    6. I do not know

50. By what reaction is glucose converted into starch?
    1. A condensation polymerisation
    2. Hydrolysis reaction
    3. By the addition of water to the reacting molecules
    4. By both condensation and hydrolysis
    5. By isomeric reaction
    6. I do not know

Section B: Genetics (51-100)

51. Refer to the pedigree of deafness in human beings. Squares symbolize males, circles females; filled symbols designate deaf individuals; open symbols, individuals with normal hearing.



The type of marriage shown in generation II can be described as:

1. polygamous
2. consanguineous
3. double recessive
4. homozygous
5. heterozygous
6. I do not know

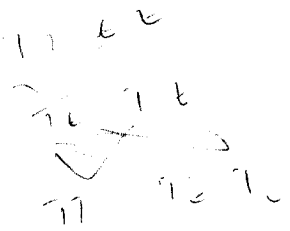
52. Mendel's second law states that:

1. independently assorting alleles occur in same numbers
2. different segregating alleles assort equally
3. different segregating alleles assort independently
4. alleles assort from each other in equal numbers
5. 1 and 4 together
6. I do not know

53. In a certain domestic animal, black colour is due to a dominant allele B and red colour to its recessive allele b. Solid colour is dependent on a dominant allele S and white spotting on its recessive allele s. A solid red male was mated to a black-and-white female. They had five puppies: one black, one red, one black-and-white, and two red-and-white. What were the genotypes of the parents?

1. Male bbss and female BBss
2. Male bbSs and female Bbss
3. Male bbSs and female BbSs
4. Male BbSs and female Bbss
5. Male BbSS and female Bbss
6. I do not know

54. When two parent plants, one with a TT and the other with a tt, are crossed, what is the probability that an F_2 plant has the genotype TT?



1. 50%
2. 25%
3. 100%
4. 75%
5. 30%
6. I do not know.

55. A person with XYY syndrome will have how many Barr bodies in his nuclei?

1. 0
2. 1
3. 2
4. 3
5. either 1 or 2
6. I do not know

56. The SRY gene is

1. a Y-linked gene and carries traits carried and inherited only by males.
2. a holandric gene.
3. codes for a protein called testis determining factor.
4. responsible for the suppression of development of female structures by activating a gene on chromosome 19
5. All of the above are correct.
6. I do not know.

57. The dominant female steroid is called

1. androgen.
2. estradiol.
3. cholesterol.
4. testosterone.
5. none of the above
6. I do not know.

58. Androgens are

1. required to trigger male development in humans.
2. produced by gonads of an XX individual.
3. the female steroids.
4. responsible for the development of ovaries in humans.
5. both 3 and 4 are correct.
6. I do not know.

59. The development of a bee's eggs without fertilization results into a:

1. queen
2. worker
3. drone
4. homozygote
5. hemizygote
6. I do not know

60. If hairy ears (hypertrichosis) is a holandric trait, what kind of children can be produced by a woman married to a man with smooth (non hairy) ear?

1. all children will have hairy ears
2. all daughters and none of the sons will have hairy ears
3. all sons and none of the daughters will have hairy ears
4. all children will have smooth ears
5. half the male children and none of the daughters will have hairy ears
6. I do not know

61. Three statements are made:

A. A recessive sex-linked trait will not be expressed in females
B. If a boy expresses a recessive sex-linked trait, then his father will express it as well
C. When a mother expresses a recessive sex-linked trait, all her male children will express it as well.

Choose the correct alternative

1. all statements are correct
2. all statements are false
3. statements A and B are correct, statement C is false
4. statements A and B are false, statement C is correct
5. statement A is false, statements B and C are correct
6. I do not know

62. Which of the following is an example of a sex limited trait?

1. milk production in cows
2. haemophilia
3. non-functional sweat glands
4. pattern baldness
5. defective tooth enamel
6. I do not know

63. In your genetics practical, you determined the relative lengths of the various stages of mitosis. Which one did you find to be longest stage?

1. interphase
2. prophase
3. metaphase
4. anaphase
5. telophase
6. I do not know

64. In which of the following is a special type of mitosis involved?
1. egg production in bee ovary
2. replacement of epidermis in the human skin
3. sperm production in human testes
4. growth
5. sperm production in bee testes
6. I do not know

65. Which of the following statements best defines Mendel's idea of dominance?

1. from one parent, only one allelic form of a gene is transmitted through a gamete to the offspring
2. in crossing between pure (homozygous) organisms for a contrasting character of a pair, only one character of the pair appears in the first filial generation
3. in sexually reproducing organisms, no two individuals have the same heredity
4. the segregation of one factor pair occurs independently of any other factor pair
5. None of the above
6. I do not know

66. In the human blood groups the alleles I^A and I^B are _____, where as both alleles are _____ to I^O.

1. incompletely dominant, codominant
2. dominant, codominant
3. codominant, dominant
4. dominant,recessive
5. None of the above is correct.
6. I do not know.

67. In the human blood group the three alleles, I^A, I^B and I^O give _____ possible genotypes and _____ phenotypes.

1. 3, 2
2. 4, 6
3. 6, 4
4. 3, 6
5. 12, 4
6. I do not know.

68. A woman of blood group A has a child whose blood group is O. Which one of the following is the correct blood group of the child's father?

1. A
2. B
3. AB
4. O
5. 1, 2 and 4 are correct.
6. I do not know.

69. Which of the following statements is not true?

1. The rhesus (Rh) factor is a substance on the surface of the red blood cells.
2. Individuals who have the Rh factor are said to be Rh^+.
3. Rh^- Individuals are homozygous dominants who lack the alleles that are responsible for the production of the Rh factor.
4. A single locus with at least eight alleles is responsible for the production of the Rh factor.
5. Rh^- individuals make antibodies that react with blood cells from Rh^+ individuals.
6. I do not know.

70. What is the probability for a heterozygote who is Ss to produce S gametes?

1. 75%
2. 45%
3. 25%
4. 50%
5. None of the above.
6. I do not know.

71. Alleles

1. are alternate forms of a gene for two or more characteristics.
2. are alternate forms of a gene that govern the same trait and occupy corresponding loci on homologous chromosomes.
3. are genes for each trait that occur at a particular site in a chromosome called a locus.
4. for a gene code for different traits.
5. are found at the same locus on non-homologous chromosomes.
6. I do not know.

72. Plant and animal breeders, as well as genetic investigators, often wish to know whether an individual carrying a dominant character is homozygous or heterozygous. An appropriate backcross will usually give the answer. Given that the parental cross is tall plants (TT) x short plants (tt), which of the following crosses is the appropriate one?

1. TT x tt
2. Tt x Tt
3. TT x TT
4. Tt x tt
5. TT x Tt
6. I do not know

73. Several black guinea pigs were crossed and produced 31 black and 10 white offspring. What would you predict the genotypes of the parents to be?

1. BB x BB
2. BB x Bb
3. Bb x Bb
4. bb x bb
5. 1 and 2 together
6. I do not know

74. Chi squared test

1. can be used only with data that fall into discrete categories.
2. is used to test the significance of deviations between numbers observed in an experiment or investigation and numbers expected from a given hypothesis.
3. is used to determine whether or not differences between two or more sets of data are likely to be real and not attribute to chance or sampling.
4. All of the above are true.
5. Only 2 and 3 are correct.
6. I do not know.

75. The fruit fly possesses a gene for body colour pattern and a gene for eye colour intensity.

S = the allele for normal body, s = the allele for speck body
D = the allele for dark eyes, d = the allele for light eyes

The following cross is executed: SsDd x ssDd. The table below specifies the phenotypes found in the offspring and their observed numbers

Phenotype	Observed number
Normal body, dark eyes	93
Normal body, light eyes	18
Speck body, dark eyes	74
Speck body, light eyes	37

Determine whether these genes are linked or not, using the χ^2 test. The χ^2 table is appended to this exam paper.

The probability is:

1. between 1 and 5%
2. between 5 and 10 %
3. between 10 and 20%
4. 20%
5. greater than 90%
6. I do not know

76. The AAXO genotype in man produces a phenotype complication known as:

1. Mongoloid idiocy
2. Klinefelter syndrome
3. Turner's syndrome
4. 'Cri du chat' syndrome
5. None of the above
6. I do not know

77. A child who is trisomic for chromosome 21 demonstrates symptoms of

1. Klinefelter's syndrome.
2. Turner's syndrome.
3. Down's syndrome.
4. haemophilic syndrome.
5. All of the above.
6. I do not know.

78. Which one of the following does not cause variation in chromosome structure?

1. Inversions.
2. Deletions.
3. Duplications.
4. DNA replication.
5. translocation.
6. I do not know.

79. Which one of the following statements is not true?

1. Deletion of a portion of chromosome 5 results in 'cri du chat' syndrome.
2. Duplications occur when homologous chromosomes break at different points and then connect to wrong partners.
3. Duplications occur when nonhomologous chromosomes break at different points then connect to wrong partners.
4. Inversion results when a broken segment is inserted in a reverse order.
5. Translocations can make synapsis in meiosis difficult and therefore sometimes lead to aneuploidy.
6. I do not know.

80. Pseudo dominance is a phenomenon observed during which chromosomal aberration?

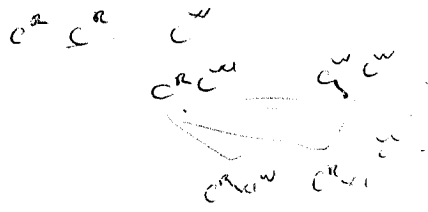
1. translocation
2. deficiency
3. interchange
4. inversion
5.duplication
6. I do not know

81. Which of the following human variations cannot be inherited?

1. blood group
2. length of hair
3. language spoken
4. sex
5. left-handedness
6. I do not know

82. Four-O'clocks are plants which posses one gene for flower colour. Their flowers can be red, pink and white. When two four-O'clock plants are crossed, 48 pink four-O'clocks and 52 white four-O'clocks are produced. The phenotypes of the parents are;

1. pink and white
2. pink and red
3. pink and pink
4. red and white
5. red and red
6. I do not know



83. In the evening primroses, a cross between pure breeding red-flowered variety and a pure breeding white-flowered variety gave a progeny of pink-flowered variety only. This example illustrates the phenomenon of:

1. incomplete penetrance
2. duplicate recessive epistasis
3. co-dominance
4. incomplete dominance
5. sex-linkage
6. I do not know

84. Coat colours of the shorthorn breed of cattle can be red governed by the genotype C^RC^R, roan (a mixture of red and white) by the genotype C^RC^W and white by the genotype C^WC^W.

If red shorthorns are crossed with roans, what fraction of the progeny would be roan?

1. ¼ 2. $^1/_3$ 3. ½ 4. $^2/_3$ 5. ¾ 6. I do not know

85. In Durham shorthorn cattle when a red-coated animal (RR) is crossed to a white coated animal (rr) an offspring with roan coat colour is produced. The determination of coat colour in these animals is an example of:

1. Partially dominant genes
2. Completely dominant genes
3. pseudoalleles
4. incompletely dominant alleles
5. codominant alleles
6. I do not know

86. In epistasis

1. one gene alters the effect of another.
2. a portion of a chromosome is inverted.
3. a portion of a chromosome is deleted.
4. the behaviour of two genes is entirely independent.
5. nothing changes from generation to generation.
6. I do not know.

87. Wild mice have grey-coloured fur a condition known as agouti. Occasionally, a mouse with yellow fur is born. A self cross between mice with yellow fur produces offspring in the ratio of 2 yellow to 1 agouti because

1. the yellow allele is lethal in the homozygous (YY) condition.
2. the ratio 2 to 1 is a typical Mendelian ratio.
3. all yellow mice are homozygous, and the heterozygotes are either not conceived or die in the uterus.
4. all yellow mice are heterozygous, and the homozygotes are either not conceived or die in the uterus.
5. Both 1 and 4 are correct.
6. I do not know.

88. Which of the following statements is not true?

1. Lethal alleles persist in a population by being passed on in a heterozygous form.
2. Lethal alleles can only cause problems when two heterozygotes mate and produce a foetus with two lethal alleles.
3. Lethal alleles in two doses cause yellowing of the coat, but when expressed in a single dose, results in a premature death of the organism.
4. Lethal alleles in a single dose cause yellowing of the coat, but when expressed in two doses, results in a premature death of the organism.
5. Dominant alleles can also persist in the population if individuals carrying the allele survive long enough to reproduce.
6. I do not know.

89. The absence of legs in cattle (amputated) has been attributed to a recessive lethal gene. A phenotypically normal bull is mated with a phenotypically normal cow and they produce an amputated calf. The same parents are mated again. What is the chance of the next calf being normal?

1. 10% 2. 20% 3. 50% 4. 75% 5. 100% 6. I do not know

90. In the mouse coat colour is determined by two genes A >a, A = agouti, a = black; C >c, C = coloured, c = albino. The cross AaCc x AaCc is executed. The offspring contained the following phenotypes and numbers:

agouti	106
albino	50
black	12

This modified Mendelian ratio is caused by:

1. a lethal allele
2. epistasis
3. linked genes
4. incomplete penetrance
5. variable expressivity
6. I do not know

91. Epistasis is:

1. a gene with less than 100% penetrance
2. the cooperation between two genes
3. the inhibition of expression of one gene by another
4. the stimulation of expression of one gene by another
5. the equilibrium between two genes
6. I do not know

92. Albinism is an example of _____ effect.

1. epistatic
2. pleiotropic
3. hyperstatic
4. hypostatic
5. polygenic
6. I do not know.

93. The allele for pea comb (P) in chickens is dominant to that for single comb (p), but the alleles black (B) and white (B') for feather colour show partial dominance. BB' individuals have 'blue' features. If birds heterozygous for both alleles are mated, what proportion of the offspring are expected to be white-feathered and pea-combed.

1. 1/16 2. 3/16 3. 4/16 4. 8/16 5. 9/16 6. I do not know

94. Which of the following is not a characteristic of meiosis?

1. chromosomes arrange themselves in pairs
2. produces daughter cells with half the normal number of chromosomes
3. consists of two divisions, one after the other
4. occurs in cells throughout the body
5. allows the reassortment of characteristics in the offspring
6. I do not know

95. The physical evidence of crossing-over is the ..... that form(s) between non-sister chromatids.

1. recombinant (s)
2. homologues (s)
3. synapse (s)
4. chiasma (ta)
5. 3 and 4 together
6. I do not know

96. A mutant insulin gene will adversely affect sugar uptake by cells, glycogen levels in the liver and muscles, and the amount of sugar in the blood. Such a gene shows:

1. epistasis
2. multiple dominance
3. multiple allelism
4. pleiotropy
5. variable expressivity
6. I do not know

97. Pleiotropism describes

1. a single gene having multiple effects
2. a gene interaction of multiple alleles
3. a single trait influenced by several genes
4. a trait that is not expressed for several generations
5. polygenic inheritance
6. I do not know

98. Which one of the following statements is not true.

1. Females are called homogametic sex because (usually) all their eggs contain an X chromosome.
2. Males are called heterogametic sex because they produce different sperm: approximately 50% contain an X chromosome and 50% have a Y chromosome.
3. Males are called heterogametic sex because they produce different sperm: approximately 75% contain an X chromosome and 25% have a Y chromosome.
4. In females the sex chromosomes consist of two X chromosomes, while in males they consist of an X and a smaller Y chromosome.

5. Apart from carrying genes that determine sex, the X chromosome also carries genes for non-sexual characteristics such as the ability to see particular colours and the ability to clot blood.
6. I do not know.

99. Mendel's breeding experiment with tall and dwarf plants is an example of

1. dihybrid inheritance.
2. monohybrid inheritance.
3. backcross.
4. dominant alleles.
5. multiple alleles.
6. I do not know.

100. The rod-shaped bodies in the cell nucleus that contain the hereditary units are called

1. genes.
2. alleles.
3. nucleotides.
4. chromosomes.
5. gametes.
6. I do not know.

The probabilities associated with values of χ^2

DEGREES OF FREEDOM	PROBABILITY										
	0.01	0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
1	6.6	3.8	2.7	1.6	1.1	0.71	0.45	0.27	0.15	0.064	0.016
2	9.2	6.0	4.6	3.2	2.4	1.83	1.39	1.02	0.71	0.446	0.211
3	11.3	7.8	6.3	4.6	3.7	2.95	2.37	1.87	1.42	1.005	0.584
4	13.3	9.5	7.8	6.0	4.9	4.04	3.36	2.75	2.19	1.649	1.064
5	15.1	11.1	9.2	7.3	6.1	5.13	4.35	3.66	3.00	2.343	1.610
6	16.8	12.6	10.6	8.6	7.2	6.21	5.35	4.57	3.83	3.070	2.204
7	18.5	14.1	12.0	9.8	8.4	7.28	6.35	5.49	4.67	3.822	2.833
8	20.1	15.5	13.4	11.0	9.5	8.35	7.34	6.42	5.53	4.594	3.490
9	21.7	16.9	14.7	12.2	10.7	9.41	8.34	7.36	6.39	5.380	4.168

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

FIRST SEMESTER UNIVERSITY EXAMINATIONS

AUGUST – SEPTEMBER 2007

BS 211

CELL MOLECULAR BIOLOGY AND GENETICS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: Answer five questions. At least question 1 and one question from section A, and two questions from section B. The fifth question may be selected from either section A or section B. Use separate answer books for each section.

SECTION A

MOLECULAR GENETICS

1. Three hypotheses have been proposed to explain the process of DNA replication: semi-conservative, conservative, and dispersive replication. It was demonstrated by Meselson and Stahl that the replication of DNA is semi-conservative.

   Draw diagrams to show the distribution of different types of DNA in a density gradient experiment which Meselson and Stahl would have found in the first two generations if DNA replication was:

   (i) conservative; and
   (ii) dispersive

Compulsory Question

2. Using appropriate illustrations describe the following molecules and explain the role of each in transcription or translation:

(i) Helicase
(ii) Transfer RNA
(iii) Ribosomal RNA
(iv) Polymerase
(v) Polysome

3. Humans have been changing the genetic constitution of organisms since the beginning of agriculture. Morden domestic plants and animals are outcomes of thousands of years of selective breeding.

(i) How is traditional selective breeding different from recombinant DNA technology?

(ii) What are the advantages and disadvantages of recombinant DNA technology?

4. (i) Define chromosomal aberration
(ii) With the aid of diagrams describes the various types of chromosomal Aberrations

SECTION B

CELL MOLECULAR BIOLOGY

5. Explain the process of oxidative phophrylation in mitochondria

6. (a) What is glycolisis?
(b) Give a detailed account of the major chemical steps involved in glycolysis, including the enzymes involved.

7. (a) Isomerization of dihydroxycetone phosphate to glyceraldelyde 3 – phosphate occurs in glycolysis. At 298K k′eq = 0.0475

(i) calculate $\Delta G^{0'}$ for the above reaction.
(ii) ΔG if the initial concentrations of dihydroxyacetone phosphate is 2×10^{-6} M

(b) Penicillin is hydrolysed by penicillinase, which occurs in some penicillin resistant bacteria. The amount of penicillin hydrolysed in one minute in a 10 ml solution containing 10^{-9} g of penicillinase was measured as a function of penicillin. Assume that the concentration of penicillin does not change appreciably during the assay.

(penicillin)	Amount hydrolysed (nanomoles)
1	0.11
3	0.25
5	0.34
10	0.45
30	0.58
50	0.61

Determine the values of K_M and V_{max}

8. Describe the structures of lipid constituents of the following membrane types found in plants / animals. Give an example in each case of where they are found.

   (a) Glycerophospholipids
   (b) Sphingolipids

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

BS 321: ETHOLOGY AND EVOLUTION (Paper I)

TIME: THREE (3) HOURS

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

1. Briefly describe possible behavioural dysfunctions or pathologies that might be caused by damage to the following structures: (a) *Occipital Lobe* of the brain (b) *Pituitary Gland (c) Medulla Oblongata (d) Hypothalamus*

2. Distinguish between Character Displacement and Habituation, and explain why each one is significant to the evolution of species

3. What are the main differences between Lamarckism and Darwinism as they relate to the evolution of altruistic behaviour in social species?

4. What are the observations Darwin made and what inferences did he derive from them as he developed his ideas about "The theory of Natural Selection"?

5. Provide brief definitions of the following terms as used in this course: (a) Associative learning (b)Teleology (c) Konrad Lorenz (d) Speciation (e) Genetic drift

6. Discuss why behaviour can be assumed to be adaptive and evolving, as exemplified by the nest-building behavior of weaver birds.

7. If success in passing on genes determines the evolution of a population, why shouldn't all organisms grow rapidly, reproduce shortly after birth, produce many offspring, reproduce frequently, and take extensive care of young?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BS 411 (1): INSECT BEHAVIOUR AND ECOLOGY

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS

1. Define the following terms on:

   (i) Oviparity
   (ii) Ovoviviparity
   (iii) Evolutionary convergence
   (iv) Adaptive radiation

2. Describe with examples, about orientation as a major part of insect's behaviour. How can knowledge of spatial orientation be exploited to manage pests and vectors of economic importance?

3. Using termites as examples, describe how knowledge of insect feeding behaviour could be utilized in biological control.

4. A great majority of flowering plants are insect pollinated. Giving examples, describe how pollination is linked to aspects of insect behaviour.

5. Giving examples, describe the effects of plant-produced chemicals on phytophagous insects.

6. Giving examples in insects, describe the phenomenon of social behaviour. How can you utilize this behaviour in managing pests and vectors of economic importance?

7. An unusual insect pest is reported in agro-pastoral areas in Eastern province and farmers are worried about this pest. The Government of the Republic of Zambia appoints you to assess the situation especially to understand the ecological impact of the insect. Describe the behavioural aspects you would focus on and give examples of the recommendations you would make.

8. Write brief notes on each of the following:

   (i) Predator – Prey relationship.
   (ii) Mechanisms of aquatic locomotion.
   (iii) Evolutionary stages of class insecta.
   (iv) Mutualism and Pollination.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGICAL SCIENCES

Second semester examinations

February 2007

Bs 412 –Applied entomology

Theory paper (1)

Time: Three (3) Hours

Instructions:

1. Answer Five (5) questions
2. All questions carry equal marks

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1. Describe the life history of a named lepidopterous pest and discuss how the knowledge of its life history might be utilized to manage such a pest.

2. Discuss with examples, how insecticides can be used in the context of integrated pest management programmes. In your answer indicate the formulations and mode of action of these insecticides.

3. Write an essay on beneficial insects in Zambia. Illustrate your answer with examples.

4. Write brief notes on any **four** (4) of the following:
   (i). Sampling technique
   (ii). Insects attacking cultivated plants
   (iii). Panorpoid orders
   (iv). Economic damage
   (v). Pest spectrum

5. Define Integrated Pest Management (IPM). What are the prospects and constraints of the adoption of IPM in Zambia?

6. In your field visit to Mt. Makulu Research Station, you were shown some examples of Biological control programmes. Giving examples, discuss the important elements in the context of pest/parasitoid relationship, which can account for the success or failure of any Biological control programme.

7. A newly discovered Bio-pesticide has been introduced in a country. Describe the method you would use to determine the efficacy of such a Biopesticide.

8. An outbreak of an insect pest has been reported in maize fields in Kanakantapa farmimg block. As an Applied Entomologist, what steps and recommendations would you take to contain such a pest?

END OF EXAMINATION – GOOD LUCK

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

FIRST SEMESTER UNIVERSITY EXAMINATIONS

AUGUST/SEPTEMBER 2007

BS 431 ADVANCED PARASITOLOGY 1
THEORY PAPER

Time: Three (3) Hours

Instructions: Answer **five (5)** questions. Three (3) questions from Section A and Two (2) questions from Section B. The answers for each section should be in separate answer book.

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

Section A

Q1. (a) Define the following terms:

(i) Mutualism
(ii) Commensalism
(iii) Free living organisms

(b) The Acanthocephala represent a group of parasitic worms in all classes of vertebrates but especially in fish and birds. Discuss the transmission of these Parasites under the following sub-questions:

(i) Draw and use a diagram to describe the morphology of the adult male and female worms.
(ii) State the similarities and differences between Acanthocephalans and the nematode.
(iii) List the various larval stages and their hosts in the life cycle of Acanthocephala.
(iv) Explain the role of each host in the life cycle of Acanthocephala.

Q.2 (a) Define parasitism. Discuss the major ecological advantages of parasitism.

(b) Copy and complete the table below.

Table 1. Some common nematode parasites of man

Serial No.	Name of Parasite	Site of Infection	Mode of infection	Disease
1	*Dracunculus medinensis*			
2	*Trichuris trichiura*			
3	*Trichinella spiralis*			
4	*Wuchereria bancrofti*			

Q3. (a) Differentiate between Monogenea and Digenea parasites.

(b) The parasitic transmission of *Polystoma integerrimum* in the excretory bladder of frogs is a mode of transmission to chronological adaptation. Discuss the transmission of this parasite under the following sub-questions.

i. To which group of parasites does it belong?
ii. Draw a labeled diagram and describe the anatomical structure of the parasite mentioned above.
iii. Explain how this parasite exploits the biology of its own hosts for successful transmission.

Q4. (a) Name the agent responsible for attacking the flat fish *Solea solea* and explain the mechanism by which the infective stage of this parasite locates its host.

(b) Draw a labeled diagram showing the structure of mature oncosphere in the cyclophyllidea parasites.

Q5. (a) Give two (2) features which distinguish *Taenea saginata* (tapeworm) from *Ascaris lumbricoides* (round worm).

(b) Draw a labeled diagram representing the development of a young *Taenia solium* worm starting from the mature onchosphere via different stages in the life-cycle of this parasite.

(c) Mention the names of two drugs of choice that are used in the treatment of Taeniasis.

Section B

Q6. Write short notes on each of the following

a. Landscape as a factor determining parasite distribution
b. Computation of Person-time incidence
c. *R-selection* as it relates to life cycle strategies of parasites
d. The effect of *True Positives* and *False Positives* on diagnostic tests
e. How to confirm the existence of an epidemic

Q7 a) Seven persons were followed up for seven years.

i. At the start of year four the number of people with disease was 2. Calculate the prevalence. What type of prevalence is this?
ii. In year six, one person developed the disease. Calculate the incidence Risk.

b) Compare and contrast the regulation of parasite abundance in Microparasites and Macroparasites.

Q8. a) Discus *Chemotherapy* as a tool in parasite control.

b) Discus the phenomenon of *Area Size* as it relates to parasite distribution patterns.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

BS 5011: RESEARCH STATISTICAL METHODS

PAPER I

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE (5) QUESTIONS

Question 1. Display data presented in the table below in a scatter diagram and;

X:	1	2	4	5	8	10	12	15
Y:	5	10	16	18	35	40	46	58

a. Fit a regression line to this scatter diagram and then,
b. Test the significance of the departure of the line from rho.

Question 2. Data for a completely randomized design with 3 treatments and 4 replications per treatment are shown below. The data represent protein percentage in maize at 2, 4 and 9 weeks (= Treatments) after December 1 in Lusaka province for the 2005/06 crop-growing season.

Replications	Weeks after December 1, 2006 (= Treatments)		
	2	4	9
1	33	15	11
2	25	21	9
3	21	14	7
4	29	18	13

Test the Null hypothesis that there are no significant differences in the protein content of maize for the three treatments (i.e. periods in weeks).

Question 3. Given the following data on egg production from 12 hens randomly allocated to two different diets A and B. Which of the two diets is better and why?

Diet A:	166	174	150	166	165	178
Diet B:	158	159	142	163	166	157

Question 4. The following data describe the state of grief of 66 mothers who have suffered a neonatal death (= death of their baby within one month of birth). The table relates this to the amount of support given to them by hospitals and relatives:

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

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

Question 5. The results of a Randomized Block Design (RBD) experiment are presented below in which for some unknown reasons, two cells are blank (i.e. with no results).

TREATMENTS	BLOCKS (Replicates)		
	1	2	3
1	11	13	16
2	18	20	b
3	a	29	30
4	29	30	31

a. Estimate the values of the missing data a and b
b. Test the differences among means using LSR.

Question 6. The Energy Regulation Board of Zambia tested four different blends of petrol for fuel efficiency according to a Latin square design in order to control for the variability of four different drivers and four different models of cars. Fuel efficiency was measured as kilometers per litter (Kmpl) after driving cars over a standard course. The data are given in the table below. Test the null hypothesis that there is no difference in fuel efficiency among the four blends of petrol tested.

Driver	Car Model			
	I	II	III	IV
1	D = 15.50	B = 33.90	C = 13.20	A = 29.00
2	B = 16.30	C = 26.60	A = 19.40	D = 22.80
3	C = 10.80	A = 31.10	D = 17.10	B = 30.30
4	A = 14.70	D = 34.00	B = 19.70	C = 21.60

Question 7. Measurements (in millimeters) of the length of the prothorax and the diameter of the compound eye of 10 adult females of the armoured ground cricket, *Acanthoplus speiseri* Brancsik, collected from the surroundings of the University of Zambia's School of Veterinary Medicine were as follows:

Prothorax length:	13.20	14.00	14.00	13.00	13.00
	12.60	13.00	12.50	13.30	11.45
Compound eye diameter:	1.75	1.70	1.85	1.70	1.80
	1.80	1.80	1.70	1.70	1.90

a. Calculate the product moment correlation coefficient of these two measurements.
b. Test the significance of the correlation

Question 8. Two samples of the Kafue weed, with 6 plants each, were collected from two locations on the Kafue River between Mazabuka and Kafue gorge dam. The lengths of the root systems of the plants (in cm) were as follows:

SAMPLE 1	SAMPLE 2
97	88
104	101
17	87
101	67
31	65
98	43

a. Examine the significance of the difference between the mean root lengths, assuming that population variances are equal.
b. What would be your conclusion regarding the difference between the mean root lengths if population variances were unequal?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

BS 5401: INSECT EVOLUTION AND SYSTEMATICS

THEORY PAPER I

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE (5) QUESTIONS; TWO QUESTIONS FROM SECTION A, TWO QUESTIONS FROM SECTION B AND THE LAST QUESTION FROM EITHER SECTION

SECTION A: INSECT EVOLUTION

Question 1. What is a fossil and what is a fossil record? In your answer also describe what is presently known about the insect fossil record.

Question 2. Discuss the "Paranotal" and "Gill" theories on insect wing evolution. In your view, which of the two theories is more plausible and why?

Question 3. Discuss the monophyletic and polyphyletic hypotheses on arthropod phylogeny. Which of these hypotheses has greatest support today and why?

Question 4. Discuss the raw materials of evolution in an insect population gene pool.

SECTION B: PRINSIPLES OF SYSTEMATIC ENTOMOLOGY

Question 5. Explain the tasks of systematics and indicate at which stage the study of most insect groups at present is, in Zambia and the world, in relation to these tasks.

Question 6. Discuss the three operative principles of nomenclature and explain how a name by which a given taxon is to be officially known by, is selected, in cases where a given taxon has many synonyms.

Question 7. What is Typification? Describe the principal kinds of types recognized by the International Code on Zoological Nomenclature (ICZN).

Question 8. **State the "Rule of Priority" and indicate its start date and limitations in terms of insect nomenclature.**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

BS 5431: IMMATURE INSECTS

THEORY PAPER I

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE (5) QUESTIONS; TWO QUESTIONS FROM SECTION A, TWO QUESTIONS FROM SECTION B AND THE LAST QUESTION FROM EITHER SECTION

SECTION A: IMMATURE INSECTS TAXONOMY

Question 1. Why is it important for man to study immature insects and what are the problems encountered in their classification?

Question 2. Describe forms of four principal types of insect larvae and show how these forms relate to the habitat types they occupy.

Question 3. Write short notes on the following:

i. Hypermetamorphosis.
ii. Holopneustic respiration.
iii. Homologous characteristics.
iii. Ametabolus nymph.

Question 4. Discuss ordinal classification of immature insects, what features are used and why it is difficulty to combine the immatures and imagos in the same classification system.

SECTION B: INSECT PRE-PUPAL AND PUPAL STAGES

Question 5. Discuss the significance of the pupa in the life cycle of a holometabolous insect and explain how adult features form in the pupal stage.

Question 6. Describe forms of the three common types of pupae found in holometabolous insects.

Question 7. Distinguish the terms ~~Pre-pupa~~ Pseudopupa, Pre-pupa and Pupa, giving specific examples of insects exhibiting them in their life cycles.

Question 8. Mosquitoes are known to have active pupae. Describe a pupa of a named mosquito species and compare it with the pupa form of another named holometabolous insect.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C101: INTRODUCTION TO CHEMISTRY I

TIME: THREE (3) HOURS

INSTRUCTIONS:

1. Indicate your **student ID number** (computer number) and **TG number** on **ALL** your answer booklets.

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

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

4. Section **B** has five **(5)** long answer questions. (Total marks = **60**).
   ANSWER QUESTION B1 and ANY THREE QUESTIONS, EACH IN A SEPARATE ANSWER BOOKLET. Questions carry equal marks.

5. Periodic Table is printed on the last page of this question paper.

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

DATA

Avogadro's constant, N_A	6.022×10^{23} mol^{-1}
Molar volume of gas at S.T.P	22.4 dm^3 mol^{-1}
Universal gas constant, R	8.314 J K^{-1} mol^{-1}
	0.0821 L atm K^{-1} mol^{-1}
	8.314 k Pa L K^{-1} mol^{-1}
Planck's constant, h	6.63×10^{-34} J s
Velocity of light, c	3.00×10^8 ms^{-1}
Electron volt, 1 eV	1.602×10^{-19}J
Faraday, 1 F	96485 C mol^{-1}
Joule, 1 J	1 kg m^2 s^{-2}
Mass of proton, m_p	1.00727 amu
Mass of Neutron, m_n	1:008665 amu
Mass of electron, m_e	0.000548593 amu
1 amu	931.481 MeV
Ionisation Energy of Hydrogen Atom IE_H	2.180×10^{-18} J

Standard Electrode Potentials:

$Cl_2(aq) + 2e^- \rightleftarrows 2Cl^-(aq)$;	$E^o = 1.360$ V
$Br_2(aq) + 2e^- \rightleftarrows 2Br^-(aq)$;	$E^o = 1.065$ V
$Ag^+(aq) + e^- \rightleftarrows Ag(s)$;	$E^o = 0.80$ V
$I_2(aq) + 2e^- \rightleftarrows 2I^-(aq)$;	$E^o = 0.6195$ V
$TiO^{2+}(aq) + 2H^+(aq) + e^- \rightleftarrows Ti^{3+}(aq) + H_2O$;	$E^o = 0.10$ V
$Sn^{2+}(aq) + 2e^- \rightleftarrows Sn(s)$;	$E^o = -0.14$ V

SECTION A **ANSWER ALL QUESTIONS**

QUESTION A 1

In the ${}^{2}_{1}H^{-}$ ion, calculate,

(a) the number of protons, neutrons, and electrons,

(b) the binding energy of nucleons in the nucleus. The atomic mass of ${}^{2}_{1}H = 2.0\,14102$ amu

[4 Marks]

QUESTION A 2

Chlorine gas, $Cl_2(g)$ consist of ${}^{35}_{17}Cl_2(g)$ and ${}^{37}_{17}Cl_2(g)$ in accordance with the natural abundance of the two isotopes of Cl. In 1.0 grams of $Cl_2(g)$, calculate,

(a) number of molecules of $Cl_2(g)$,

(b) the percent composition of ${}^{35}_{17}Cl_2(g)$ and ${}^{37}_{17}Cl_2(g)$ in the sample. The atomic masses ${}^{35}_{17}Cl$ and ${}^{37}_{17}Cl$ are 34.96885 and 36.96590 amu respectively.

[4 Marks]

QUESTION A 3

Sodium hydroxide solution of unknown concentration is titrated against 0.4383 g $COOHC_6H_4COOK$, a monoprotic acid, (MW 204.18 g/mol). 24.3 ml of the sodium hydroxide solution is required to reach the endpoint of the titration.

(a) In a titration what is a standard solution?

(b)What is the concentration of the unknown sodium hydroxide solution?

[4 Marks]

QUESTION A 4

A 1.00 liter flask at 298 K contains 5000.0 Pa of nitrogen monoxide and 1000.0 Pa of oxygen. These will react to form nitrogen dioxide according to the reaction below.

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$

Assume the reactants and products behave as ideal gases, use the information above to find:

(a) the limiting reactant,

(b) mass of $NO_2(g)$ produced.

[4 Marks]

QUESTION A 5

Calculate the frequency and energy per quantum for electromagnetic radiation having a wavelength of 580 nm.

[4 Marks]

QUESTION A 6

Find the energy difference (in kJ mol^{-1}) between the ground and first excited states of the hydrogen atom.

[4 Marks]

QUESTION A 7

Iron is a typical ferromagnetic material. Use suitable orbital diagrams to show the origins of the magnetism in the element.

[4 Marks]

QUESTION A 8

Calculate the voltage of the following cell operating at 298 K:
$Sn(s)|Sn^{2+}(0.025M)||Ag^{+}(2.0M)|Ag(s)$

[4 mks]

QUESTION A 9

(a) What is corrosion?
(b) What is cathodic protection? Give an example.

[4 mks]

QUESTION A 10

How many grams of copper are deposited at an electrode in the electrolysis of aqueous copper sulfate by an electric current of 1.75 A operating for 2.30 hours.

[4 mks]

SECTION B **ANSWER B1 AND ANY THREE QUESTIONS**

QUESTION B1

(a) Explain:

(i) Why should water never be added to concentrated acid or alkali?

(ii) Why should the total amount of liquid introduced into a test tube not exceed the half capacity of the test tube?

(iii) What will you do, if you do get some chemicals on your skin?

(b) What are the following used for:

(i). Crucibles, (filter) funnels and test tube racks?

(ii). Test tubes, conical flasks and beakers?

(iii). Pipettes, burettes and volumetric flasks?

(iv). Spatulas, watch glasses and medicine droppers?

(c) Indicate six dangerous or wrong situations in the picture of Fig. B1 (on Page 8)

[TOTAL =15 mks]

QUESTION B 2

Determine percent iron in iron ore sample by redox titration with $KMnO_4$. The iron ore sample was prepared by digesting 0.238 g of ore and dissolving the residue in 50 cm^3 of distilled water and added 1.7 cm^3 of H_2SO_4. Potasium permanganate ($KMnO_4$) solution was prepared by dissolving 0.206g $KMnO_4$ in 100 cm^3 of distilled water. During the redox titration of 50 cm^3 of iron ore solution acidified with 1.7 cm^3 H_2SO_4 it took 10.3 cm^3 of $KMnO_4$ to reach the end point. The half-reactions for the redox reaction are:

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O$$

$$Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$$

(a) What is a Redox reaction?

(b) Why was H_2SO_4 added to the iron ore solution?

(c) Write the ionic reaction of $KMnO_4$ in aqueous solution and calculate the *Molarity* of $KMnO_4$(aq) and MnO_4^- (aq) from the data given above.

(d) Complete balancing the half-reactions above to obtain a balanced Redox reaction.

(e) Determine percent iron in the sample from data and the result of titration above.

[TOTAL =15 mks]

QUESTION B 3

(a) For one atom of the isotope of an unknown element $^{19}_{9}E$ give

(i) the electronic configuration of the atom in the ground state;

(ii) an equation for one typical reaction of the element.

(b) The Fig B3 shows the variation of the first ionization energy of the elements of the first period.

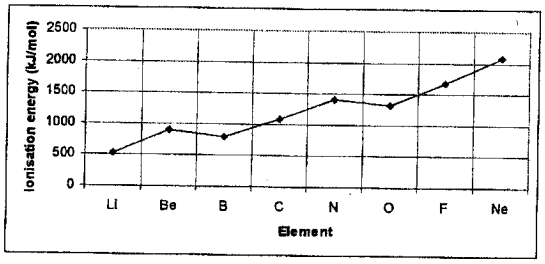


Fig. B 3

(i) Why does the ionization energy increase across the period?

(ii) Explain the irregularity that occurs in moving from nitrogen to oxygen. Illustrate your answer using suitable orbital diagrams.

(c) Use the orbital hybridization theory to show that the molecule $CHCl_3$ is a polar molecule.

[TOTAL =15 mks]

QUESTION B 4

(a) What product is formed at the anode when an acidic aqueous solution containing chloride, bromide and iodide ions in equal concentration is electrolyzed?

(b) Balance the following reaction of permanganate ion in acidic condition:

$$MnO_4^-(aq) + I^-(aq) \rightarrow Mn^{2+}(aq) + I_2(aq)$$

How many moles of iodide ion will be oxidized by one mole of permanganate ion?

(c) A cell with platinum electrodes was setup, under standard state conditions, to utilize the cell reaction in part (b) above. The cell voltage was found to be 0.98 V.

(i) Write the cell in the normal cell notation.

(ii) The electrode potential of the anode is 0.53 V . Calculate the potential of the cathode.

(iii) Calculate ΔG^o, the Gibbs free energy of the cell.

[TOTAL = 15 Marks]

QUESTION B 5

A half cell A consisting of a strip of nickel dipping into a 1 M solution of nickel nitrate, and a half cell B consisting of a strip of zinc dipping into a 1 M solution of zinc nitrate were successively connected with the SHE. The magnitudes of the individual electrode potentials were measured as:

A $Ni^{2+}(aq) + 2e^- \rightleftarrows Ni(s)$ $|E^o| = 0.23$ V
B $Zn^{2+}(aq) + 2e^- \rightleftarrows Zn(s)$ $|E^o| = 0.76$ V

where $|E^o|$ means "the absolute value of E^o "

(a) When both the half cells A and B were connected with the SHE, both metallic electrodes Ni(s) and Zn(s) were found to be negative. What is the correct sign of the electrode potentials?

(b) Among the chemical species Ni(s), $Ni^{2+}(aq)$, Zn(s) and $Zn^{2+}(aq)$, which is

(i) the strongest oxidant?

(ii) the strongest reductant?

(c) What happens when

(i) metallic nickel is dipped into a solution of 1 M zinc nitrate?

(ii) metallic zinc is dipped into a solution of 1 M nickel nitrate?

In each case explain your answer.

(d) Zinc forms a complex ion with hydroxide ion, $Zn(OH)_4^{2-}$:

$$Zn^{2+}(aq) + 4OH^-(aq) \rightarrow Zn(OH)_4^{2-}(aq).$$

If the hydroxide ion were added to the half cell B, would its electrode potential as written be more positive, less positive or be unaffected? Explain your answer.

(e) If the half cells A and B were connected together

(i) which electrode would be negative?

(ii) what would be the cell voltage?

[TOTAL = 15 mks]

END OF EXAMINATION

Fig. B1

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01 Hydrogen				KEY Atomic number **X** Atomic mass Name of the element X												1 **H** 1.01 Hydrogen	2 **He** 4.00 Helium
3 **Li** 6.94 Lithium	4 **Be** 9.01 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium											13 **Al** 26.98 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.65 Copper	30 **Zn** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 71.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 Seleniu m	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
37 **Rb** 85.47 Rubidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** 97.91 Technetium	44 **Ru** 101.07 Ruthenium	45 **Rh** 102.91 Rhodium	46 **Pd** 106.42 Palladium	47 **Ag** 107.87 Silver	48 **Cd** 112.41 Cadmium	49 **In** 114.82 Inidum	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 Telluriu m	53 **I** 126.90 Iodine	54 **Xe** 131.29 Xenon
55 **Cs** 132.91 Caesium	56 **Ba** 137.33 Barium	57 – 71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.84 Tungsten	75 **Re** 186.21 Rhenium	76 **Os** 190.23 Osmium	77 **Ir** 192.22 Iridium	78 **Pt** 195.08 Platinum	79 **Au** 196.97 Gold	80 **Hg** 200.59 Mercury	81 **Tl** 204.38 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 208.98 Bismuth	84 **Po** 208.98 Polonium	85 **At** 209.99 Astatine	86 **Rn** 222.02 Radon
87 **Fr** (223.02) Francium	88 **Ra** 226.03 Radium	89 - 103	104 **Unq** 261.11	105 **Unp** 262.11	106 **Unh** 263.12	107 **Uns** 262.12	108 **Uno** 265.00	109 **Une** 265									

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

Department of Chemistry-UNZA

The University of Zambia
School of Natural Sciences
Department of Chemistry
2007 Academic Year Final Examinations
First Semester
Analytical Chemistry 1- C 225:
September 2007.

TIME: 3 HOURS.

Instructions: **[This Paper Contains Five (05) Questions. Each Question carries 15 marks]**

ANSWER QUESTION 1 AND ANY OTHER THREE (03) IN THIS PAPER.

1. (a). The precision of a method is being established; and the following data are obtained: 22.23; 22.18; 22.25; 22.09 and 22.17%. Is 22.09 a valid measurement at the 95% confidence level? Using the data above, estimate the range within which the true value falls at
   i). 95% CL ii).99%CL

   (b). Calcium in blood is determined by two methods (AAS; and, a new Colorimetric method). The data is as follows:
   AAS (mg/dL) : 10.9, 10.1, 10.6, 11.2, 9.7, 10.0
   Colorimetry (mg/dL): 9.2, 10.5, 9.7, 11.5, 11.6, 9.3, 9.3, 10.1, 11.2
   Determine whether there is significant difference in the precision of the two methods at 95% confidence level.

   (c). Phosphorus was determined in urine by phosphomolybdate method, and the results were as follows:

Standard solution (ppm) :	1.0	2.0	3.0	4.0	5.0
Absorbance:	0.205	0.410	0.615	0.820	1.025

   From the data obtained, determine the regression line and calculate the phosphorus concentration in the urine sample if the absorbance was 0.550.

   (d). A 0.2 g sample containing Cu is analysed. Cu (II) is reduced to Cu (I) by iodide. What is the % Cu in a sample if 20.0 mL of 0.1 M $Na_2S_2O_3$ is needed for titration of the liberated I_2?

2. (a). If 12.40 g of $KHC_2O_4.H_2C_2O_4$ (three ionisable protons) with 15% inert impurities, and 4.85 g of $KHC_8H_4O_4$ (one ionisable proton) are dissolved in water and diluted to 750 cm^3, what is the normality of the solution, assuming complete ionisation?

2. (b). When 10.0 mL of 0.100 M KNO_3 and 20.0 mL of 0.100 M K_2SO_4 are mixed, what would be the new concentration of:

i. K^+ in the resulting solution

ii. NO_3^- in the resulting solution

(c). What is the difference between (a) galvanic and electrolytic cells (b) iodometric and iodimetric titrations?

(d). A divalent metal M^{2+} reacts with a ligand L to form a 1:1 complex $M^{2+} + L \rightarrow ML^{2+}$; $K_f = ML^{2+} / M^{2+} \times L$. Calculate the concentration of M^{2+} in a solution made by mixing equal volumes of 0.2 M M^{2+} and 0.2 M L ($K_f = 1.0 \times 10^3$).

3. (a). Orthoarsenic acid, H_3AsO_4, is a triprotic acid with the following acidity constant values $pK_{a1} = 2.22$, $pK_{a2} = 6.98$ and $pK_{a3} = 11.53$.

i). what is meant by the term 'triprotic'?

ii). write appropriate equations for the first two dissociation constants of orthoarsenic acid.

(b). Calculate the ratio of the concentration of free ions to $Ag(CN)^{2-}$ complex ions in a NaCN solution in which $[CN^-] = 0.01$ M ($K_f = 1.0 \times 10^{21}$).

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

(d). i). How many mole of solid sodium hydroxide must be added to 200.00 cm^3 of 0.100 M HCl in order for the resulting solution to have a pH of 7?

ii). What concentrations are needed to prepare a cyanic acid-cyanate buffer solution of pH = 3.50? ($K_a = 1.2 \times 10^{-4}$ for HCNO).

4. (a). A solution contains 2.50×10^{-4} M $Cu(NO_3)_2$. What is:

i). this copper nitrate concentration in ppm

ii). the concentration of NO_3^- in this solution given that $Cu(NO_3)_2$ is a strong electrolyte (Use Cu = 63.55; N = 14.01; O = 16.00).

(b). A solution contains 75.0 ppm of dissolved $NaNO_3$. Calculate the concentration of nitrate ion expressed as ppb (Use Na = 23.00; N = 14.01; O = 16.00)..

(c). Define or describe the following: - polyprotic systems, distribution diagram and zwitterions.

(d). Calculate the pH of a solution obtained by dissolving 50ml of concentrated ammonia solution (M_{wt} = 17.0g/mol; density 0.90 g/mL; 28.0% w/w) and 2.00 g ammonium chloride (M_{wt} = 53.5 g/mol) in water and diluting to exactly 250 mL (for ammonia, $pK_b = 4.76$).

5. (a). Justify why Cu^{2+} easily forms a complex with NH_3, and explain how your answer relates to Lewis acids and bases.

(b). What is a buffer solution?

(c). A solution is 10^{-3} M in $Cr_2O_7^{2-}$ and 10^{-2} M in Cr^{3+}. If pH is 2.0, what is the potential of the half-reaction?

(d). A sample of iron ore was brought to our laboratory for investigation. The owner of the sample wanted us to establish whether the sample contained copper as well. From the information given, determine the following:

i). how many analytes of interest are there?

ii). what is the matrix in the sample if we analysed for iron only?

iii). what test is needed to tell us whether there is copper, or any other elements in the sample?

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

C251: ORGANIC CHEMISTRY I

TIME: THREE HOURS

INSTRUCTIONS:

1. **Answer any four questions.**
2. **All questions carry equal marks**
3. **Marks allocation for each question is shown.**

Question 1

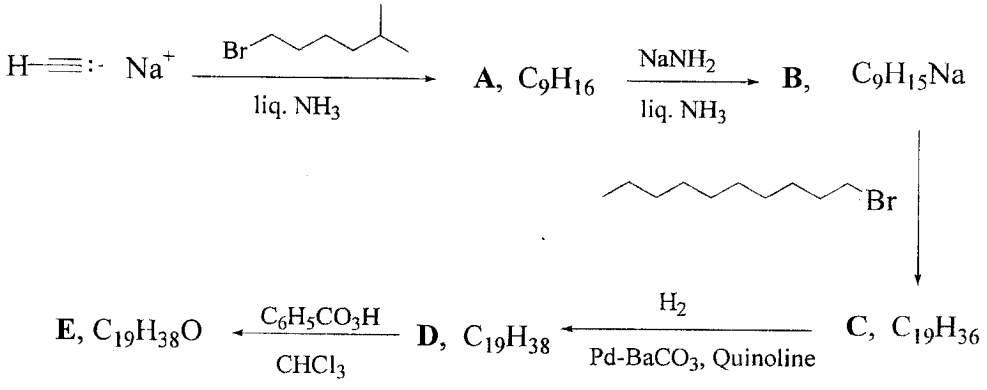
(a) Account for the following facts:

(i) Acetylenic hydrogens are more acidic than ethylenic hydrogens.

(ii) Acetylides cannot be used for preparation of alkynes from secondary or tertiary alkyl halides.

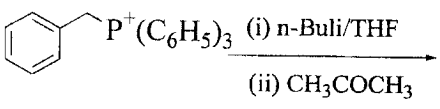
[8 Marks]

(b) Deduce the structure of the gypsy moth sex attractant **E** (a type of pheromone) from the following synthesis and show the structures of the intermediates **A – D**. *Reaction mechanisms are not required to be shown.*

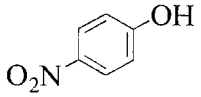


[10 Marks]

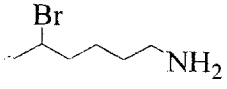
(c) Predict the products and give mechanisms of the following reactions:

(i) 

G, $C_{10}H_{12}$ + other products

(ii) 

?

(iii) 

$C_6H_{13}N$

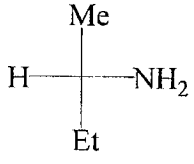
[12 Marks]

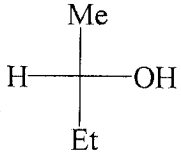
Question 2

(a) Propose a plausible synthesis of the following compounds from the indicated starting materials. Each synthesis may require more than two steps. Show the reagents, including solvents, and the reaction conditions for each step of your proposed synthesis. *Reaction mechanisms are not required to be shown.*

(i) 

from 

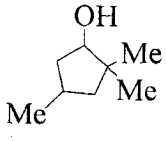
(ii) 

from 

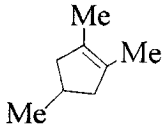
(*S*)-2-aminobutane (*S*)-2-butanol

[16 Marks]

(b) Upon refluxing with concentrated sulfuric acid, compound **H** gave the compound **I,** structures shown below, in good yield. . Provide a reaction mechanism to account for this experimental result.



Compound H



Compound I

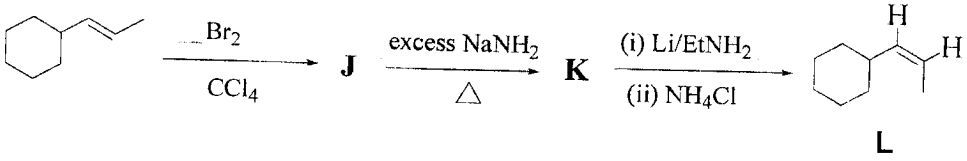
[8 Marks]

(c) A sample containing 20 g of thalidomide per 1000 ml of solution had an observed rotation of 1.03^0 in 2 cm cell using sodium D-line of 589 nm wavelength. Assuming the molecular mass of thalidomide to be 246, calculate the molecular rotation of thalidomide.

[6 Marks]

Question 3

(a) A general synthetic route for preparation of a *cis*-alkene from a *trans*-alkene is shown below:



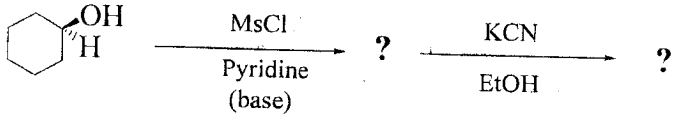
(i) Identify the intermediates **J** and **K**.

(ii) Give mechanism of the reactions involved in the transformation of compound **K** into compound **L**.

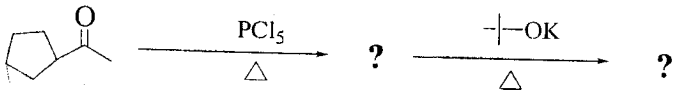
[10 Marks]

(b) Give the structures of the major organic product(s), including stereochemistry where relevant, of the following reactions: *Reaction mechanisms are not required to be shown.*

(i)



(ii)



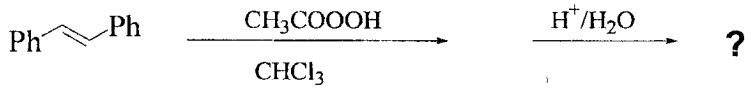
[10 Marks]

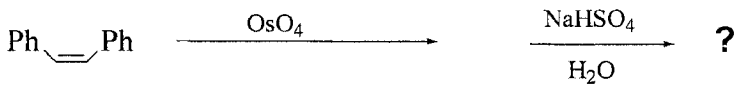
(c) The free-radical chlorination of (*R*)-2-bromobutane leads to, among other products, two isomeric forms of 2-bromo-3-chlorobutane. Both these isomers are optically active. Draw the Newman projection structures of the two isomeric forms of 2-bromo-3-chlorobutane and provide the configurations at the chiral centres of these molecules using the *R/S* system.

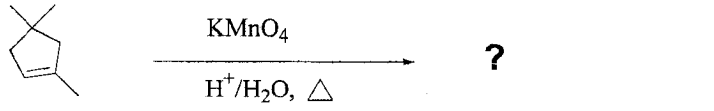
[10 Marks]

Question 4

(a) Give the major organic products and their IUPAC names resulting from each of the following reaction conditions. Specify the stereochemistry where appropriate.

(i) 

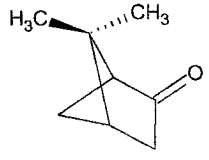
(ii) 

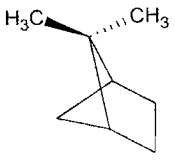
(iii) 

(iv) 

[10 Marks]

(b) Each of the molecules shown below has asymmetric centres. In each case, indicate the asymmetric centres with asterisks, (*). How many stereoisomers can be expected from each of these molecules? Give reasons for your answers.

i) 

ii) 

[8 Marks]

(c) When cis-3-hexene is reacted with acidified hypohalous acid, for example HOBr, (HOBr that has been previously treated with a mineral acid like HBr), a mixture of products is obtained which shows **no** optical activity. Similarly, when trans-3-hexene is treated in the same manner as cis-3-hexene, an optically **inactive** product is again obtained. Give a mechanistic explanation to account for the observed optical **inactivity** in the two reactions, clearly showing the stereochemical structures.

Note: $HOBr + HBr \longrightarrow H_2O^+\text{-}Br + Br^-$

[12 Marks]

Question 5

(a) Explain why:

(i) Propanol, unike propene or butane, is soluble in water.

(ii) n-hexanol is not soluble in water.

[6 Marks]

(b) A Hydrocarbon **M** (C_6H_{12}) reacts with hydrogen bromide to give a compound **N** ($C_6H_{13}Br$). When **N**, in dry ether, is treated with magnesium and then ethanal and the reaction product is hydrolysed with water the result is a product **O**, ($C_8H_{16}O$). Compound **O** gives a yellow precipitate **P** when treated with iodine and aqueous sodium hydroxide. Acidification of the filtrate from this reaction with mineral acid gives **Q** ($C_7H_{14}O_2$).
When **O** is oxidized with chromic acid, 3,3-dimethyl-2-hexanone is produced.

(i) Give structures for **M**, **N**, **O**, **P** and **Q**

(ii) Show the reactions outlined above in a diagrammatic form.

[14 Marks]

(c) Show how you would make the following conversions. *Reaction mechanisms are not Required to be shown.*

(i) 

(ii) $CH_3CH_2CH_2OH \longrightarrow CH_3\overset{\overset{O}{\|}}{C}CH_3$

[10 Marks]

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER

FINAL EXAMINATIONS

C 311: BIOCHEMISTRY I

TIME: THREE HOURS

INSTRUCTIONS: This examination paper consists of three sections, SECTION A, SECTION B and SECTION C. **All questions carry equal marks.** ANSWER **ANY 5** QUESTIONS FROM THE THREE SECTIONS. EACH SECTION MUST BE ANSWERED IN A **SEPARATE ANSWER BOOK.**

Section A

QUESTION 1A.

a) **What** is the molecular explanation for the allosteric behavior of hemoglobin? **Why** does myoglobin not exhibit allosteric behavior? Briefly **explain** (**maximum of 2 sentences**).

b) **How** much iron is in hemoglobin of a 65 kg adult? Assume that the blood is 70 ml/kg body weight and that the hemoglobin is 16 mg/100 ml. (Fe = 56 g/mol and MW of each hemoglobin subunit is approximately 17,000 Daltons)

c) ***True or False.*** *If false,* ***explain why***: Any mutation to the hemoglobin gene will result in development of sickle cell anemia.

[20 marks]

QUESTION 2A.

i) In biochemistry, spectrophotometry may be used to carry out quantitative protein determinations. **What** is the molecular basis of such determinations?

ii) The absorbance of a protein solution measured at 278 nm was 0.846. The protein content of that solution, calculated from quantitative amino acid analysis, was 460 µg/ml. **Calculate** the molar extinction coefficient of the protein given that the molecular weight of the protein is 42 kDa.

iii) Pentapeptide obtained from treatment of protein with cyanogen bromide (CNBr) was shown to contain methionine, aspartic acid, leucine, serine, and tyrosine. For determination of the amino acid sequence, the peptide was cycled through Edman degradation procedure three times. The composition of the peptide remaining after each cycle was as follows:

After cycle 1: methionine, aspartic acid, leucine, serine
After cycle 2: methionine, aspartic acid, serine
After cycle 3: methionine, serine
What is the sequence of the pentapeptide? Briefly **explain** the steps taken to arrive at your answer.

[20 marks]

Section B

QUESTION 3B

a) Define the following
   i) Anabolism
   ii) Catabolism
[5 marks]

b) Why is it important to regulate the processes in part (a) independently? Explain by citing three ways in which metabolic pathways are regulated.
[5 marks]

c) Discuss briefly any one of the three experimental approaches used in the study of metabolic pathways.
[5 marks]

c) Write a note on the classical experiment that was done by David Shemin and David Rittenburg.
[5 marks]

QUESTION 4B

a) Discuss the salient features of the mitochondria that support the Chemiosmotic hypothesis and highlight important observations that were made by Peter Mitchell.
[8 marks]

b) ATP readily transfers its terminal phosphate group to other compounds. What is the phosphoryl potential of ATP in a liver cell given that the concentrations of ATP, ADP and Pi (in mM) are 3.5, 1.8 and 5 respectively.
[4 marks]

c) On average a male Zambian adult weighs 68 kg and needs an intake of 2000 kcal of food per day (24 hrs). The free energy released is used to synthesize ATP, which is then used up for other body functions. Assuming that the efficiency of converting food energy into ATP is 50%, calculate the weight of ATP used by the adult in 24hrs. What percentage of the body weight does this represent?
[8 marks]

Section C

QUESTION 5C

a) What is the mechanism of enzyme action, and what four major factors influence this action and how?

b) In what ways can enzyme activity be inhibited? Use diagrams and detailed equations.

[20 marks]

QUESTION 6C

a) With diagrams, relate the glycolytic pathway to citric acid cycle. How much energy does the body get from the processes?

b) Describe the biosynthesis of glycogen. How is this metabolic activity regulated

i) by enzymes and ii) by hormones

[20 Marks]

END OF EXAMINATION

Section C

QUESTION 5C

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[20 marks]

QUESTION 6C

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b) Describe the biosynthesis of glycogen. How is this metabolic activity regulated

i) by enzymes and ii) by hormones

[20 Marks]

END OF EXAMINATION

The University of Zambia
School of Natural Sciences
Department of Chemistry
2007 Academic Year Final Examinations
First Semester
C 421: Applied Analytical Chemistry
SEPTEMBER, 2007.

TIME: 3 HOURS.

Instructions: [This Paper Contains Five (05) Questions]
ANSWER ANY FOUR (04) QUESTIONS. Each Question Carries 15 marks.

1. (a). Cobalt is found in the minerals such as linnaeite $(Co,Ni)_3SO_4$, in association with sulphide rocks like blende (ZnS). Suggest an appropriate method for each of the following procedures for effective cobalt determination:
   i). Sample dissolution
   ii). Removal of silica from the sample solution

   (b). A solid mixture of calcium hydroxide and calcium chloride was analysed by titrimetry using with HCl. A sample of the material weighing 0.5 g required 24.0 mL of 0.2 M acid. Determine the relative content (%) of the two constituents in the mixture.

   (c). Compare the route by which high molecular mass organic compounds and toxic metals disperse and re-concentrate in the environment and in organisms.
   (d). An iron ore sample was analysed by the dichromate method. 1.6 g of the sample was treated with HCl, then titrated with 0.015 M potassium dichromate. A total of 35.6 cm^3 of the titrant was consumed. Calculate the iron (Fe) content of the sample as Fe_2O_3.

2. (a). i). The chloride content of several aliquots of a pooled blood serum sample was reported as follows: 103, 106, 107, and 114 milliequivalents /L. Upon evaluation of the results, the analyst observed that one value (114) appeared suspect. Determine whether the suspect value could be attributed to accidental error at 90% confidence limit [Table value for four observations is 0.76].
   ii). Describe a flame AAS technique used to determine As in samples.
   iii. Compare/contrast the instrumental analysis of Hg and Mg in water.

(b). Several important parameters, "available P" included, that determine the suitability of soil for various purposes are determined.
   i). What is "available P"?
   ii). Describe how this characteristic is determined in soils

(c). Compare and contrast the instrumental analysis of Hg and Mg in water.
(d). Discuss the significance and analysis of the following:
(i) water hardness
(ii) chlorides
(iii) nitrites in a water sample.

3. (a). In monitoring SO_2 in the environment absorption train using H_2O_2 as an adsorbent is used rather than West and Gaeke reagent. Discuss the advantages and disadvantages of this approach for large scale monitoring.
(b). Atomic absorption Spectrometry (AAS) is a useful tool for fast and accurate determination of metals in many matrices. Give details of how you would tackle the estimation of arsenic in a sample?
(c). The phosphorus content of some soil samples was determined by gravimetry using quinolinium phosphomolybdate agent. A 3.1 g precipitate of quinolinium phosphomolybdate $(C_9H_7N)_3PMo_{12}O_{40}$ was obtained from a 1.0 g sample. Using atomic weights P = 31; O = 16; N= 14 and Mo = 96, calculate the content of phosphorus in the sample as:
i). %P ii). % P_2O_5
(d). Discuss, in detail for each element, the determination of lead and tin in brass.

4. (a). In your lab., you are to analyse water that is known to have been contaminated with Hg and Cd. What instruments and approaches would you apply to determine levels of these 2 toxic elements?
(b). Bronze is an alloy composed of many metallic constituents.
i. Name the main constituents
ii. Describe a method for the estimation of one of the major constituents of bronze
iii. Describe a method for the estimation of one of the minor constituents of bronze
(c). The purity of a 0.287 g sample of Zn $(OH)_2$ is determined by titration with a standard HCl solution, requiring 37.5 mL. The acid was standardised using a 25mL acid aliquot, yielding a 0.462 g precipitate. What is the purity of the Zn $(OH)_2$?

5. (a). Chromic oxide, a green pigment, is often prepared by the reaction between sodium dichromate and ammonium chloride to yield, among other products, NaCl, N_2 and water. Write a balanced equation for the reaction, and calculate how much pigment can be made from 1.0 kg of sodium dichromate [Use Cl = 35.45 $gmol^{-1}$; Cr = 52.0 $gmol^{-1}$; H = 1.01 $gmol^{-1}$; O = 16.0 $gmol^{-1}$; N = 14.01 $gmol^{-1}$; Na = 23.0 $gmol^{-1}$]
(b). If you were presented with a water sample suspected to contain copper and lithium, what instrumental methods would you use to determine the elements?
(c) Define or describe the terms: bio-concentration factor, eutrophication and green house effect. What do these terms signify?
(d). Two methods are available for the determination of calcium carbonate in soils.
i). Compare and contrast the two methods with respect to field use
ii). How would you prepare a soil sample for analysis?

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

C351: ORGANIC CHEMISTRY III

TIME: THREE HOURS

INSTRUCTIONS:

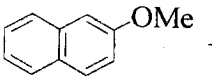
1. **Answer any four questions.**
2. **All questions carry equal marks.**
3. **Marks allocation for each question is shown.**

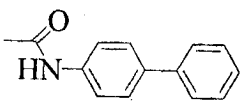
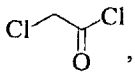
Question 1

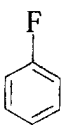
(a) Attempted synthesis of 4-bromo-tertiary butylbenzene by treatment of tertiary butylbenzene with bromine in presence of aluminium bromide gave bromobenzene and 2-methylpropene. Propose a likely mechanism of this reaction.

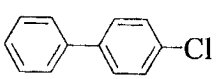
[12 Marks]

(b) Give the structures of the major organic product(s) of the following reactions. Reaction mechanisms are not required to be shown.

(i)  (i) CO, HCl, anhydrous $AlCl_3$ → (ii) H_3O^+

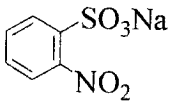
(ii)  (i)  , anhydrous $AlCl_3$, heat → (ii) H_2O

(iii)  (i) C_6H_5Li → (ii) D_2O

(iv)  Cu, △

[8 Marks]

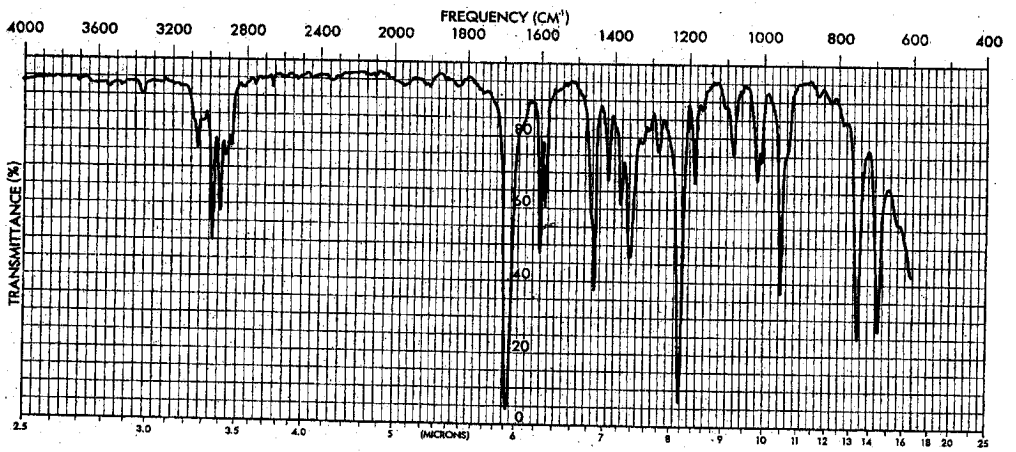
(c) Treatment of *o*-chloronitrobenzene with aqueous sodium sulfite(Na_2SO_3) under certain conditions yields sodium *o*-nitrobenzene sulfonate, structure shown below. Provide a plausible reaction mechanism to account for the formation of this product.



[10 Marks]

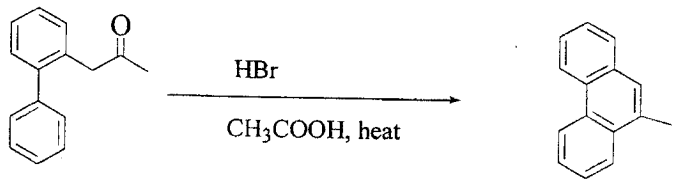
Question 2

(a) The molecular formula of compound **A** is $C_9H_{10}O$. Deduce the structure which would be consistent with the infrared spectrum shown below.



[10 Marks]

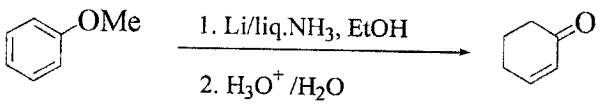
(b) Polycyclic aromatic compounds can be synthesized by a cyclisation reaction known as Bradsher reaction. An example is shown below:



The reaction proceeds by an arenium ion intermediate. On this basis, propose a plausible mechanism for the above reaction.

[10 Marks]

(c) A useful synthetic route to 2-cyclohexenones from methyl phenyl ethers is shown below:

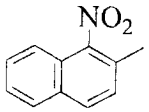


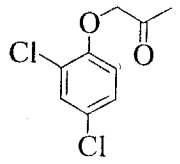
(i) State the type of reactions 1 and 2 in the above synthesis.
(ii) Give the mechanisms of the reactions involved in this synthesis.

[10 Marks]

Question 3

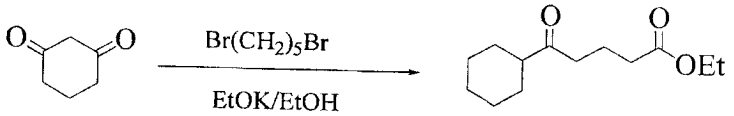
(a) Propose a synthesis of the following compounds from either benzene or toluene or phenol and any other needed reagents. Show the reagents, including the solvents, and reaction conditions for each step of your proposed synthesis.

(i) 

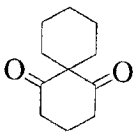
(ii) 

[14 Marks]

(b) Reaction of 1,3-cyclohexanedione with 1,5-dibromopentane in presence of sodium ethoxide in ethanol gave a compound **C**, structure shown below. The reaction proceeds via an intermediate **B**. On this basis, propose a mechanism for this reaction.

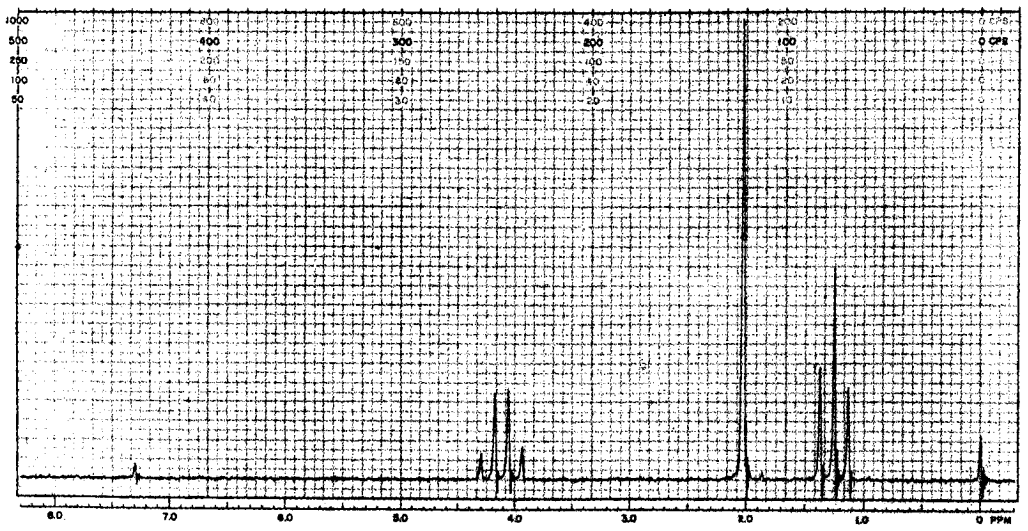


C

intermediate **B** 

[8 Marks]

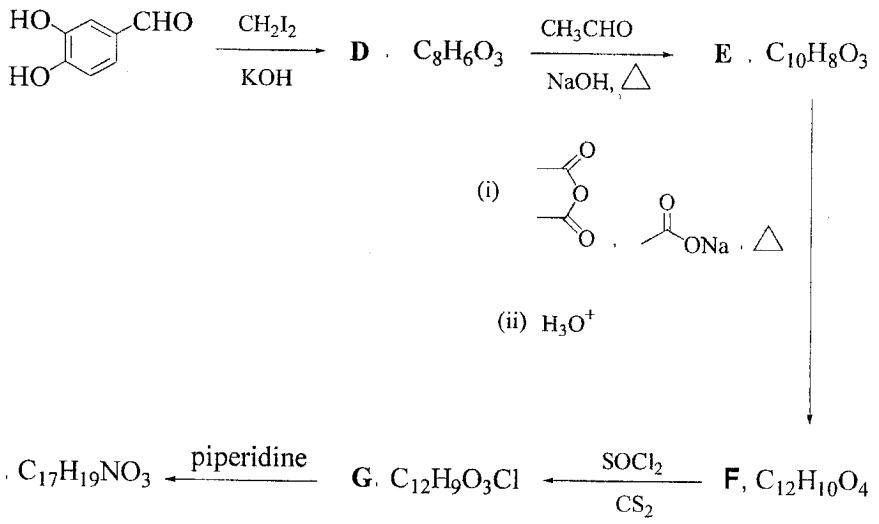
(c) The ^{1}HNMR spectrum of an ester with the formula $C_4H_8O_2$, is shown below. Give its structure and assign the chemical shift values.



[8 Marks]

Question 4

(a) (i) Deduce the structure of an alkaloid, **H**, found in black pepper from the following synthesis. Show the structures of the intermediates **D - G**.



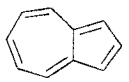
[10 Marks]

(ii) Give the mechanisms of the reactions involved in the formation of compound **F** from compound **E** in the above synthesis.

[6 Marks]

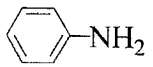
(b) Predict the products and give mechanisms of **any two** of the following reactions:

(i)

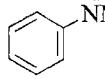


(i) Me_2NCHO, $POCl_3$, RT
(ii) H^+/H_2O

(ii)



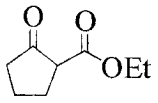
(i) $NaNO_2$(aq), HCl
(ii)



,

, H_2O
low temp

(iii)



(i) NaOH, H_2O, △
(ii) H_3O^+
(iii) △

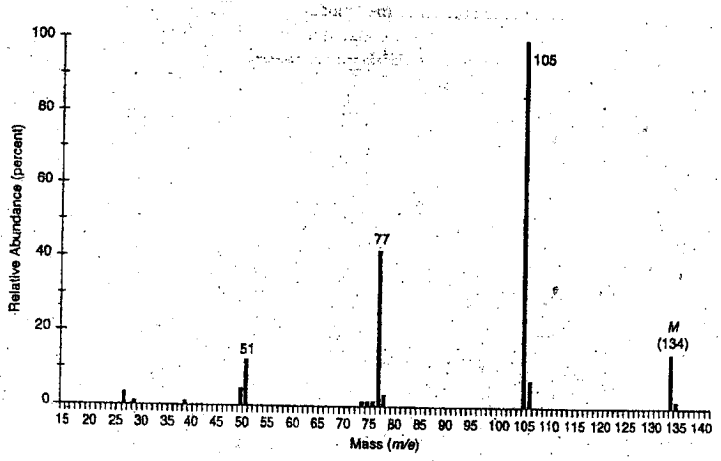
[14 Marks]

Question 5

(a) Compound **I** has the mass spectrum shown below. The infra-red spectrum shows significant bands at:

$\bar{\nu}$ **cm^{-1}**: 3102, 3087, 3062, 3030, 1688, 1598, 1583, 1460, 1449, 1353, 1221, 952, 746 and 691.

There is also a band from aliphatic C-H stretching from 2879 – 2979 cm^{-1}



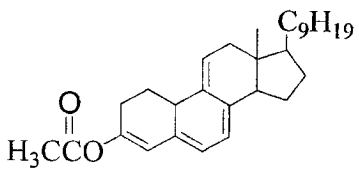
Assign the structure to compound **I** that would be consistent with the IR data and the mass spectrum, given above. Show your reasoning clearly.

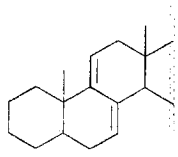
[14 Marks]

(b) The mass spectrum of 2-octanone has peaks at m/e= 43, 58, 85, 113, and 128. Write the mechanism showing the origin of the principal fragments of 2-octanone.

[8 Marks]

(c) Predict the UV maximum for each of the following compounds.

(i) 

(ii) 

[8 Marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C 361 CHEMICAL KINETICS AND NUCLEAR CHEMISTRY

TIME: THREE HOURS

28 AUGUST 2007

INSTRUCTIONS TO THE CANDIDATES

1. **ANSWER ANY FIVE QUESTIONS.**
2. **USE A SEPARATE ANSWER BOOK FOR EACH QUESTION.**

DATA

Boltzmann constant $k_B = 1.38 \times 10^{-23}$ J K^{-1}; h = 6.63×10^{-34} J s; $N_A = 6.022 \times 10^{23}$ mol^{-1}; R = 8.314 J K^{-1} mol^{-1}

Question 1

a) The mechanism for the reaction of hydrogen and bromine is:

1. $H_2 + Br_2 \rightleftarrows 2Br\bullet + H_2$
2. $Br\bullet + H_2 \rightarrow HBr + H\bullet$
3. $2H\bullet + H_2 \rightleftarrows 2H_2$

Write an expression for the rate - $\frac{d[H_2]}{dt}$.

b) The stoichiometric equation for the oxidation of bromide by hydrogen peroxide in acid solution is:

$$2Br^- + H_2O_2 + 2H^+ \rightarrow Br_2 + 2H_2O$$

with $R = k[H_2O_2][H^+][Br^-]$

(i) If the concentration of H_2O_2 were increased by a factor of three, by what factor would the rate of consumption of Br^- ions be increased?

(ii) If under certain conditions the rate of consumption of Br^- ions was 7.2×10^{-3} mol dm^{-3} s^{-1}, what would be the rate of consumption of hydrogen peroxide? What would be the rate of reaction?

c) The rate constant for the neutralization reaction: $H^+ + OH^- \rightarrow H_2O$ was measured to be 1.3×10^{11} dm^3 mol^{-1} s^{-1}. Calculate the half life of the reaction if $[H^+] = [OH^-] = 10^{-4}$ M.

d) Draw labelled sketch diagrams to show the (i) concentration as a function of time for a zero order reaction and (ii) concentration of reactant and product for an equilibrium reaction : *n* - pentane $\rightleftarrows$ *iso* - pentane.

e) The decomposition reaction of azomethane at 600 K :

$$(CH_3)_2N_2 \rightarrow C_2H_6 + N_2$$

is an example of a reaction to which the Lindemann Theory of Unimolecular reactions is applicable. Draw a diagram to show the variation of the observed rate constant $\frac{1}{k_{obs}}$ with the concentration $\frac{1}{[(CH_3)_2N_2]}$. Indicate the order of the reaction at both the low and high concentrations.

Question 2.

In an alkaline solution peroxydisulfate oxidizes sulfite to yield sulfate. The following mechanism has been proposed:

1. $S_2O_8^{2-} + SO_3^{2-} \rightarrow S_2O_7^{2-} + SO_4^{2-}$, k_1
2. $S_2O_7^{2-} + H_2O \rightarrow 2\,SO_4^{2-} + 2H^+$, k_2
3. $H^+ + OH^- \rightarrow H_2O$ *very fast*, k_3

a) What is the net reaction? Determine the intermediate.
b) Which step would you use to derive the rate law? Explain why the other steps would be unsuitable.
c) What is the rate of consumption of the intermediate? The reactant water is clearly a solvent. Under this condition what is the rate of consumption of the intermediate?
d) Derive an expression for the steady state concentration of the intermediate.

Question 3.
There are several methods for determining the order of reaction. In one of the laboratory experiments, you determined the order of a reaction by the Method of Initial Rates.
a) What is the Method of Initial Rates?
b) Outline the theoretical basis for the Method of Initial Rates.

Question 4
The Eyring equation can be applied to physical processes. As an example, consider the rate of diffusion of an atom stuck to the surface of a solid. Suppose that in order to move from one site to another it has to reach the top of the barrier where it can vibrate classically in the vertical direction and in one horizontal direction takes it into the neighbouring site. Find an expression for the rate of diffusion and evaluate it for the W atoms on a tungsten surface (E_a = 60 kJ mol^{-1}). Assume that the vibrational frequency at the transition state is the same as that of the adsorbed atom. Calculate the diffusion constant D at 500 K.
(Site separation = 316 pm, $\nu = 1 \times 10^{11}$ Hz).

Question 5.

a) The rate of reaction between oppositely charged ions is measured at an ionic strength of 0.01 mol dm^{-3}. How will the rate be affected if the ionic strength is raised to 0.05 mol dm^{-3}? If the reaction is between (i) A^+ and B^-; (ii) A^{2+} and B^{2+}?

b) The radiopharmaceutical $^{23}_{11}Na^{131}_{53}I$ was prepared at Amersham Radiochemical Centre, United Kingdom, with a specific activity of $^{131}_{53}I$ ($T_{½}$ = 8.04d) of 3.70 x 10^{10} Bq/ml on 20th August, 2007 at 12.00 GMT. The vial of this radionuclide was received and used at the Nuclear Medicine Department, University Teaching Hospital, Lusaka, Zambia, on 21st August at 15.00 Hours. The mass excess of $^{131}_{53}I$ is - 87.451 MeV.

(i) Calculate the specific activity of $^{131}_{53}I$ at time of use mentioned above.

(ii) Determine the activity of $^{131}_{53}I$ in (i) above when 50 μl was used during the course of treatment of a patient with thyroid carcinoma.

(iii) Calculate the microgram (μg) of $^{131}_{53}I$ in (ii) above.

Question 6.

$^{131}_{53}I$ in a chemical form $^{23}_{11}Na^{131}_{53}I$ is used in clinical Nuclear Medicine. The β^- - rays and gamma - rays from the decay of $^{131}_{53}I$ to $^{131}_{54}Xe$ are used both for therapeutic and diagnostic applications in this field. The diagram below indicates the decay scheme of $^{131}_{53}I$ to the excited state of $^{131}_{54}Xe$ and the resultant gamma - ray emissions. The energy levels of $^{131}_{54}Xe$ in MeV are in bold, and the spins and parity are indicated on the left hand side in the diagram. The mass excess of $^{131}_{53}I$, and $^{131}_{54}Xe$ are - 87.451 and - 88.421 MeV respectively.

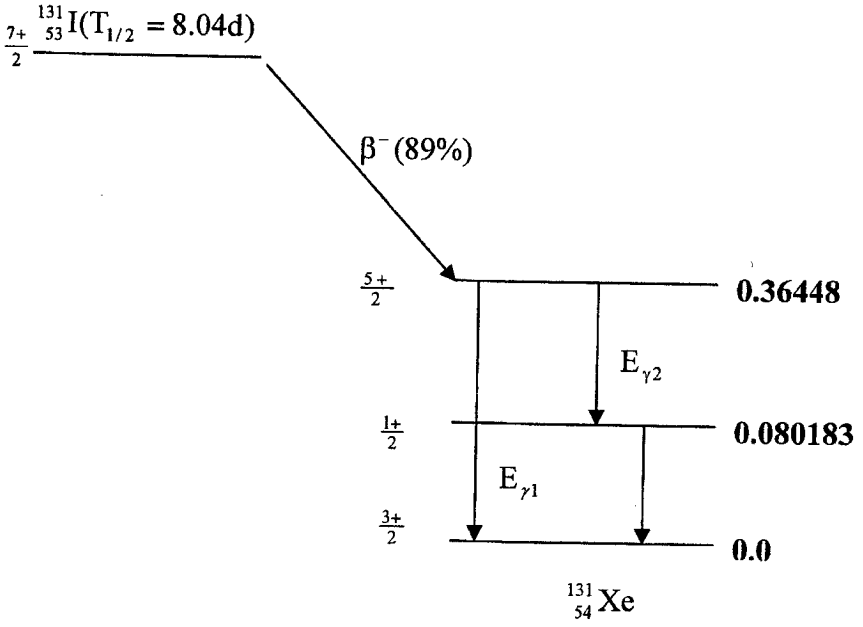
a) Write the β^- decay reaction of $^{131}_{53}I$ to $^{131}_{54}Xe$.

b) Calculate the maximum beta energy, $E_{Q\beta^-}$, of the decay reaction above.

c) Calculate the maximum kinetic energy of β^- - rays produced when $^{131}_{53}I$ decays to 0.36448 MeV excited state of $^{131}_{54}Xe$, which is the β^- energy used in therapeutic applications in clinical Nuclear Medicine.

d) Calculate gamma energies $E_{\gamma 1}$ and $E_{\gamma 2}$ indicated in the diagram below.

e) Determine the minimum angular momentum (l) carried away and multipolarity of $E_{\gamma 2}$.



Decay Scheme of $^{131}_{53}$I to $\frac{5+}{2}$ excited state of $^{131}_{54}$Xe

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR 2007 FIRST SEMESTER
FINAL EXAMINATIONS

C 461: QUANTUM MECHANICS AND MOLECULAR SPECTROSCOPY

TIME : THREE HOURS

13 SEPTEMBER 2007

INSTRUCTIONS TO THE CANDIDATES

1. **ANSWER ALL FIVE QUESTIONS**
2. **USE SEPARATE ANSWER BOOKS FOR (i) QUESTIONS 1,2 AND 3; AND (ii) FOR QUESTIONS 4 AND 5.**

DATA

$h = 6.63 \times 10^{-34}$ J s; $k_B = 1.38 \times 10^{-23}$ J K^{-1}; $R_H = 109677.58$ cm^{-1}; $\int_0^\infty e^{-ax^2} dx = [\frac{\pi}{a}]^{1/2}$

$$\int_0^\infty xe^{-ax^2} dx = \frac{1}{2a}; \quad \int_0^\infty x^2 e^{-ax^2} dx = \frac{1}{2}[\frac{\pi}{a^3}]^{1/2}$$

Question 1.

a) Calculate the number of independent degrees of freedom for water. Sketch each of the normal vibrational modes. Which mode has the highest frequency?

b) Show that the function $\Phi_m = e^{im\phi}$ is an eigenfunction of the operator $L_z = -i\hbar \frac{d}{d\phi}$. What is the eigenvalue?

c) Write the quantum mechanical expression for the energy operator E.

d) What is the ultraviolet catastrophe?

e) The lithium atom (^{3}Li) is a three electron system whose Hamiltonian is $H = \sum_i h_i = h_1 + h_2 + h_3$. Write general expressions for the eigenfunction and the energy of the lithium atom.

f) Distinguish between Eistein and Debye temperatures. Calculate the vibrational frequency of copper whose Eistein temperature is 344 K.

Question 2

a) Write the formula for the energy of a harmonic oscillator.

b) The selection rule for the emission or absorption of radiation by the harmonic oscillator is $\Delta n = \pm 1$. What will be the frequency observed in the spectrum of the harmonic oscillator for the transition $n = 5 \rightarrow n = 4$?

c) If the selection rule was changed to $\Delta n = \pm 2$, what frequency or frequencies would be observed in the spectrum?

d) The harmonic oscillator wavefunctions for the energy levels $n = 0$ and $n = 1$ are:

$$\psi_0 = [\frac{\alpha}{\pi}]^{1/4} e^{-\alpha r^2/2} \text{ and } \psi_1 = [\frac{4\alpha^3}{\pi}]^{1/4} r e^{-\alpha^2/2} \text{ , where } \alpha = \frac{4\pi^2 \nu m}{h}$$

(i) Show that each of the two functions is normalized.

(ii) Show that the two functions are orthogonal .

(iii) Calculate the average value of $\frac{1}{r^2}$ for the state $n = 1$.

Question 3

An electrical discharge through a mixture of hydrogen and helium gases at low pressure causes the emission of spectral lines due to the H-atoms and the He^+ ions. Among others, two spectral lines of nearly the same frequency are observed at approximately 20570 cm^{-1}, one due to H- atoms and the other to He^+ ions.

a) In what spectral regions do the two lines appear?

b) Find the values of the quantum numbers n_1 and n_2 for the stationary states in the H-atom between which the transition producing one of the lines takes place.

c) Find the values of the quantum numbers n_1 and n_2 for the other line, which is produced by a transition of He^+.

d) Calculate the separation , in cm^{-1}, of the two lines.

Question 4

The vibrational modes of carbon dioxide, $^{12}C^{16}O_2(g)$ are (3N-5) of which N-1 are stretching modes. One of the modes of $^{12}C^{16}O_2(g)$ is Raman active and the remaining modes are Infrared active. The data below are pure rotational Stokes lines, $\Delta\omega_R$, of $^{12}C^{16}O_2(g)$, in wavenumbers (cm^{-1}) and J″ are the ground states rotational levels of $^{12}C^{16}O_2(g)$.

J′′	$\Delta\omega_R$ (cm^{-1})
0	2.36
1	3.85
2	5.51
3	7.04
4	8.66
5	10.22
6	11.58

From the information and data given above:

a) Explain which vibrational modes of $^{12}C^{16}O_2(g)$ are Raman and Infrared active, and give reason for your answers.

b) Determine the J′′ → J′ transitions.

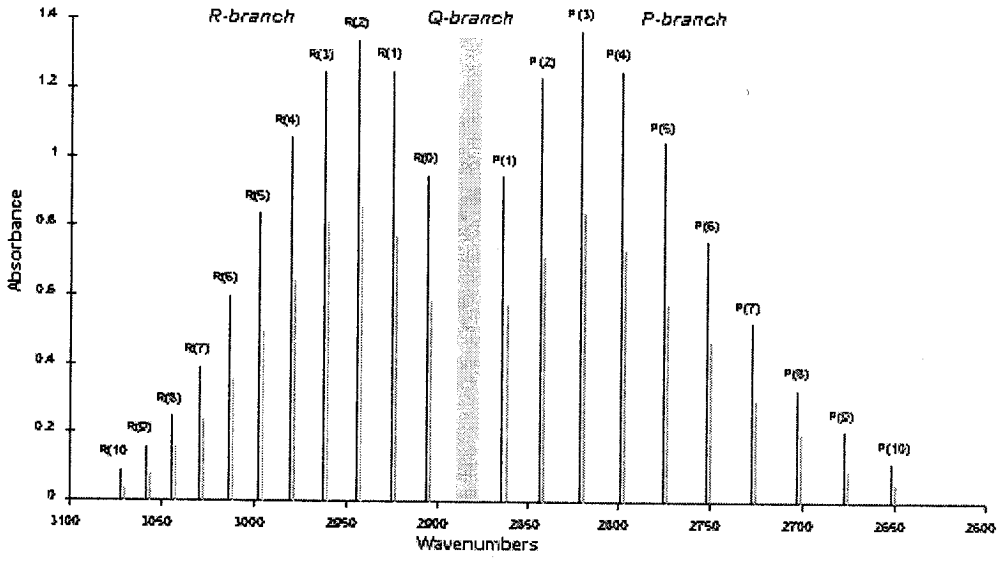
c) Use regression method to determine the ground state rotational constant B of $^{12}C^{16}O_2(g)$ from the above data.

d) Determine its moment of inertia.

e) Calculate the equilibrium bond length of $^{12}C^{16}O_2(g)$. The atomic mass of ^{16}O is 15.9949 amu.

Question 5

The high resolution FT-IR spectrum of gaseous $^{1}H^{35}Cl(75\%)$, $^{1}H^{37}Cl(25\%)$ is shown below:



The spectra lines for the first six lines in R and P-branch of HCl are:

Line	$^{1}H^{35}Cl$	$^{1}H^{37}Cl$	**Line**	$^{1}H^{35}Cl$	$^{1}H^{37}Cl$
	cm^{-1}	cm^{-1}		cm^{-1}	cm^{-1}
R(0)	2906.24	2904.11	P(1)	2865.10	2863.02
R(1)	2925.90	2923.72	P(2)	2843.62	2841.58
R(2)	2944.90	2942.72	P(3)	2821.56	2819.56
R(3)	2963.29	2961.07	P(4)	2798.94	2796.97
R(4)	2981.00	2978.75	P(6)	2775.76	2773.82
R(5)	2998.04	2995.78	P(7)	2752.04	2750.13

R-Branch: $J'' = 0,1,2,3,4,5,...$

P-branch: $J'' = 1,2,3,4,5,...$

The spectra lines above are given by the equation

$$\omega_L = \overline{\omega}_0 + (2B_e - 2\alpha_e)m - \alpha_e m^2 \qquad (1)$$

where $m = J'' + 1$ for the *R*-branch and $m = -J''$ for the P-branch. Selection rules, $\Delta J = \pm 1, \Delta J = 0$ is forbidden.

From the spectral data and information given above:

(a) Define the terms in equation (1)
(b) Calculate the terms in the equation (1) using data for **either** R or P-branch for both $^{1}H^{35}Cl$ and $^{1}H^{37}Cl$ using regression method.
(c) Explain why B_e is different for $^{1}H^{35}Cl$ and $^{1}H^{37}Cl$.
(d) Given $\omega_e = 2990.95\ cm^{-1}$ for $^{1}H^{35}Cl$, calculate its anharmonicity constant, χ_e.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

C491: ORGANIC INDUSTRIAL CHEMISTRY I
TIME: THREE (3) HOURS

INSTRUCTIONS: Answer question 1 and any other four (4) questions.
All questions carry equal marks

QUESTION 1

(a) (i) Chemical processes may be define as batch or continuous processes. Explain the major differences between the two.

(ii) Use simple schematic diagrams to show a counter-current and concurrent process taking place in a tubular reactor.

(b) (i) Explain the significance of size reduction in the chemical manufacturing process.

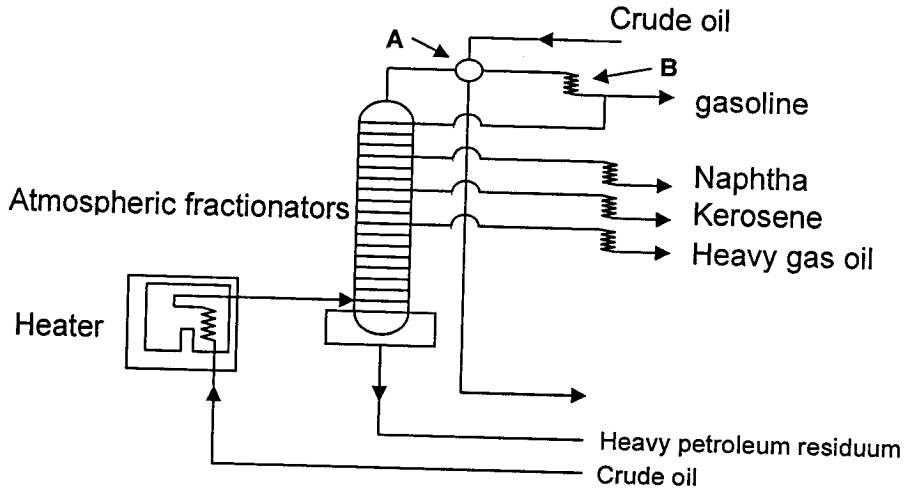
(ii) Use the process for the manufacture of mechanical pulp as an example of open circuit grinding. What is the key element of open circuit grinding?

(c) A common method of transporting fluids is pumping using various types of pumps. The centrifugal and positive displacement pumps are two common types. Compare and contrast the two pumps. Draw schematic diagrams to show the main features of each pump.

(d) A pipe intended for use in the central heating of a house has a diameter of 0.015 m. If the fluid to be used has a density, ρ = 1000 kg/m^3 and viscosity, μ = 0.55x10^3 Ns/m^2, calculate Reynold's number and decide if the system is likely to be effective in heat transfer.

QUESTION 2

The diagram below shows part of a crude oil refining plant producing various cuts of petroleum products.



(a) Outline in brief the process conditions used to obtain the products indicated in the diagram.

(b) A and B are two units in which heat is exchanged. Explain the functions of these two units.

(c) The heavy petroleum residuum indicated in the flow diagram is sent to the vacuum distillation unit. Describe the process taking place in the vacuum flash unit.

(d) Cracking is an important process towards efficient utilization of crude petroleum. One type of cracking used is known as hydrocracking. Outline the main elements and significance of this process.

(e) The antiknock characteristic of gasoline is improved by use of additives such tetraethyl lead (TEL) and methyl-tert butyl ether (MTBE). Give reasons why MTBE is preferred over TEL.

QUESTION 3

(a) A packet of a general purpose washing powder had the following ingredients indicated as part of its formula.

Nansa HS 80 (Sodium dodecyl benzene sulfonate)
Soda ash
Photine (Bis(-triazinylamino)-stilbene disulphonic acid)
STPP (Sodium tripolyphosphate)
Sodium silicate
Octanol
Rosemary

Explain the function(s) of each of the components present in the detergent powder.

(b) Draw a flow chart illustrating the manufacturing of a general purpose detergent powder.

(c) Explain in brief how detergent powder components can be detrimental to the environment.

QUESTION 4

(a) Explain why DDT, an effective anti-mosquito insecticide, has been banned in many countries but Zambia has an active indoor spraying program for the control of malaria using DDT. Give a plausible explanation for its rationale to continue using DDT.

(b) (i) What do you understand by the term bio-insecticides.
(ii) Write brief notes on each of the following: microbial pesticides, plant-incorporated-protectants (PIPs) and biochemical pesticides.

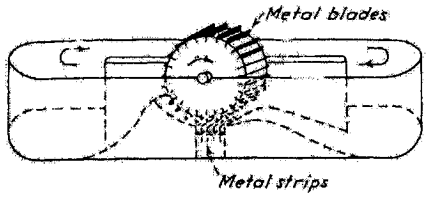
(c) Outline in brief the three modes of application of herbicides to control weeds.

(d) 2,4 –dichlorooxyacetic acid (2,4-D) is non-conventional herbicides. Explain how this herbicides works and outline the advantages associated with its use.

QUESTION 5

(a) Chemical pulping involves dissolving lignin in the wood to create pulp which is eventually used to manufacture paper. A commonly used process is the *Kraft process*. Describe in detail the Kraft process. Include a flow diagram to illustrate the process.

(b) The diagram below shows equipment that is used in the manufacturing of paper.



Describe the process carried out using this equipment and for what purpose.

(c) Additives that may be added at this point include fillers and sizes. What functions do fillers and sizing agents plays in the properties of paper? Give one example of each.

QUESTION 6

(a) Benzene is commonly used organic compound. There three main sources of benzene: coal, crude petroleum and through dealkylation. Describe the procedures used to obtain benzene using the three sources.

(b) Xylenes are an important group of compounds which are found in many domestic products such vanishes, aerosol paints vanish removers and as thinners. Outline in brief the production of xylene. Explain how separation of the different isomers of xylene can be effected.

(c) Aniline is a widely used feedstock in many chemical industries. Describe the production of aniline by ammonolysis.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF CHEMISTRY
FINAL EXAMINATION

TIME: 3HRS **C5211** **2007**

ANSWER ALL QUESTIONS

1 a Explain the principle of ELECTRON SPECTROSCOPY FOR CHEMICAL ANALYSIS (ESCA). (Draw a graph).

b. Describe the principle of Auger electron spectroscopy. Draw schematic representation of the source of Auger electron emission and X-ray fluorescence method.

c. Explain instrumentation for Electron Spectroscopy

d. What type of information can you get from XPS (ESCA).

2. a. Explain Flow-Injection Analysis

b. Draw the principle of Flow-Injection Analysis (Draw it)

c. Explain applications of flow-Injection Analysis

d. Describe Automatic systems.

3. a. Explain the principle of Electron Spin Resonance Spectroscopy (ESR).

b. What type of materials is used for study of ESR

c. Explain resonance condition for ESR

d. Describe for ESR Instrumentation and draw Block diagram of simple ESR spectrometer.

4 a. Describe two ways in which you can do collision induced Dissociation in tandem mass spectrometry in a quadruple ion trap.

b. How are ion resolved in a time of flight mass spectrometer?

c. At what rate are ions scanned in a quadruple mass filter and how do you perform selected Ion Monitoring (SIM).

d. Why is Chemical Ionization (CI) referred to as a soft ionization technique in relation to Electron Ionization (EI)?

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THE UNIVERISTY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

CH 5011
TIME: Three Hours
INSTRUCTIONS: Answer Any 5 Questions

1. (a) Describe electron ionization. During this process there is thermolyzation of an electron energy, how does this occur?
   (b) Sketch the scan function used for tandem in time mass spectrometry in a quadrupole ion trap. What is axial modulation used for?
   (c) How would you improve mass resolution in a linear time of flight mass spectrometer? Sketch your reasoning.
   (d) How does the quadrupole mass filter operate, i.e. how are ions scanned and resolved?
   (e) What is MALDI? What type of molecules can you analyse with this technique? *20 points*

2. Several factors tend to affect chromatographic peaks during analysis, name 2 equations that help in explaining such effects.
   Following data were obtained on a column packed with 15% SE-30 on chromosorb W:

Compound	**t' (min)**	**Peak width (min)**
Ether	1.78	0.31
Hexane	6.78	0.84
Ethylbenzene	18.14	1.64

   Calculate the resolution between ether and hexane, between hexane and ethybenzene. What is the theoretical plate for the column using hexane as standard? *20 points*

3. Name 4 forms of liquid chromatography and explain their principles of separation and application. *20 points*

4. a. Explain instrument components which are used for Atomic X-ray spectrometry
   b. For X-ray spectrometry as a source is use X-ray Tube and Radiosotopes. For monochromator is use, X-ray Monochromator, photon counting, gas, filled transducer ionization chambers and proportional counter and Geiger tube. Draw X ray tube and X ray monochromator. *20 points*

5. **Explain Geiger Tube**
20 points

6. a Describe how to determine the relative viscosity using the Ostwald's viscometer and write down the equation for calculation.

b What are the disadvantages of the capillary viscometers used for the relative viscosity measurements?

c. Describe the following properties of the light:
The speed of the light in vacuum and air, the difference between natural and artificial light, and what is the monochromatic light?

d. State the reflection, refraction and light absorption and write down the scattering effect.
20 points

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF COMPUTER STUDIES

First Semester 2007 Examinations

TITLE OF PAPER: **INTRODUCTION TO PROGRAMMING I**

COURSE CODE: **CST2011**

LEVEL: **SECOND (2) YEAR**

DATE: 10th SEPTEMBER, 2007

DURATION: THREE (3) HOURS

VENUE: LIBRARY BASEMENT

TIME: 14:00 – 17:00 HRS

INSTRUCTIONS:

- There are **three** sections in this exam paper, namely **Section A, Section B** and **Section C.**
- **Section A** is the multiple choice section with **30 Questions.** Each question is worthy **1 Mark. Total Marks 30.**
  ANSWER ALL FROM SECTION A
- **Section B** has 3 questions with other sub questions. **Total 30 Marks**
  ANSWER ALL FROM SECTION B
- Section C has three questions. **ANSWER ANY TWO (2) QUESTIONS.**
- **Note that for multiple choice questions, wrong choices will cost you -0.5 marks.**

GOD BLESS AND GOOD LUCK.

SECTION A: ANSWER ALL. (30 Marks) (1 Mark per Question)

1. How many integral primitive types are in the Java programming language?
   a. 2
   b. 4
   c. 5
   d. 3
2. What is printed by the following?

```
double a;
a = 1 / 2;
System.out.println( a );
```

   a. 0.5
   b. 1
   c. 0
   d. 0.45
   e. 0.0
3. What is printed by the following?

```
int b = (int)(2.5 * 2.0) - (int)3.99;
System.out.println( b );
```

   a. 3 b. 2.0 c. 1 d. 2 e. 4 f. 3.0
4. Which one of the identifiers shown below follows the style convention for naming classes?
   (a) `countNumbers`
   (b) `Print_Alphabet`
   (c) `Spaceinvaders`
   (d) `JellyBeans`
   (e) `myfirstprogram`
5. Which one of the five sections of code below does NOT produce the following output:

```
output: AAAA
```

```
(a) System.out.print("output: ");
for (int i = 1; i < 5; i++) {
System.out.print("A");
}
```

```
(b) System.out.print("output: ");
for (int i = 1; i < 5 && i != 0; i++) {
System.out.print("A");
}
```

```
(c) System.out.print("output: ");
for (int i = 1; i < 5; ) {
i = i + 1;
System.out.print("A");
}
```

```
(d) System.out.print("output: ");
for (int i = 1; i < 10; i = i + 2) {
System.out.print("A");
}
```

```
(e) System.out.print("output: ");
for (int i = 5; i > 1; i--) {
System.out.print("A");
}
```

6. Given the methods declared below, which statement would result in the value 10 being printed to the screen?

```
private int bar(int i) {
return i * 2;
}
private int foo(int i) {
return i + 2;
}
```

(a) `System.out.println(bar(4));`
(b) `System.out.println(foo(bar(4)));`
(c) `System.out.println(foo(4));`
(d) `System.out.println(bar(foo(4)));`
(e) `System.out.println(foo(4) + bar(4));`

7. What is the output produced by the following code?

```
int a = 3;
int b = 7;
if (a > b) {
if (a < b) {
System.out.print("X");
} else {
System.out.print("Y");
}
} else {
System.out.println("Z");
}
```

(a) X
(b) Y
(c) Z
(d) YZ
(e) XZ

8. What is the output produced by the following code?

```
String word1 = "FANTASTIC";
char c1;
int number = 0;
int counter = word1.length() - 1;
while (counter > 0) {
c1 = word1.charAt(counter);
if (c1 == 'T') {
counter = counter - 2;
} else {
counter = counter - 1;
number++;
}
}
System.out.println("output: " + number);
```

(a) output: 5
(b) output: 6
(c) output: 8
(d) output: 4
(e) output: 7

9. The following code processes two arrays of integers.

```
int[] nums1 = {5, 18, 7, 14};
int[] nums2 = {29, 11, 16, 9, 21};
int count = 0;
for (int i = 0; i < nums1.length; i++) {
      for (int j = 0; j < nums2.length; j++) {
            if (nums1[i] > nums2[j]) {
            count++;
            } }
}
```

What will the value of `count` be at the end of this?

(a) 2
(b) 3
(c) 5
(d) 6
(e) 20

10. What is the output produced by the following code?

```
System.out.println(1.0 / 2);
```

(a) `1`
(b) `0.0`
(c) `0`
(d) `0.5`
(e) `1.0 / 2`

11. What is the output produced by the following code?

```
String word = "computer";
System.out.println(word.substring(3, word.length()-
2));
```

(a) `u`
(b) `put`
(c) `mput`
(d) `pute`
(e) `mpute`

12. Consider the following method call:

```
String answer = getSomeAnswer(34, "Fish", 13.0);
```

From the list of method headers below, which is the **only** correct method header which could have been used to define the getSomeAnswer() method?

(a) `public void start()`
(b) `private String getSomeAnswer(double i, String s, double d)`
(c) `private void getSomeAnswer(int i, String s, double d)`
(d) `private String getSomeAnswer(int i, String s, int d)`
(e) `private String GetSomeAnswer(int i, String s, double d)`

13. Which one of the following identifiers is invalid in Java?

(a) `txt2me`
(b) `number_Of_Apples`
(c) `fish&chips`
(d) `TIME`
(e) `u`

14. The following constructor is contained within a class. We also know that the class compiles correctly and follows the java style conventions, but nothing more about this class.

```
public Account(int value, String text){
v = value;
name = text;}
```

Given these three facts, which one of the following statements about the class **may not necessarily be true**?

(a) The class is stored in a file called "`Account.java`".

(b) We can create a new `Account` object with the code: `Account p = new Account(29, "Shane");`

(c) There are instance variables in this class called "`v`" and "`name`".

(d) There are no other constructors in this class.

(e) The class is called "`Account`

15. Suppose that you want to put the following bit pattern into a short primitive variable: 0000 0000 0010 0000

Which of the following options will accomplish this?

A. short mask =0xA0;
B. short mask =0X000A;
C. short mask =0x0020;
D. short mask =0x0040;

16. Consider the following piece of code:

```
float luckyNumber = 1.25;
System.out.println ( "The value of luckyNumber: " + luckyNumber );
```

What is the result?

A. The value of luckyNumber::.
B. The value of luckyNumber: 1.25.
C. This piece of code would not compile.
D. This piece of code would compile, but give an error at execution time.

17. Identify all correct declarations (choose 3)

a. int [] someInts;
b. int [] someInts = 1,2,3,4;
c. int [] someInts = {1,2,3,4};
d. int [] someInts = new int[5];
e. int someInts = {1,2,3,4};

18. Given the following main method in a class called Cycle and a command line of

```
java Cycle one two
```

What will be output?

```
public static void main(String bicycle[]){
    System.out.println(bicycle[2]); }
```

(a) None of these options
(b) Cycle
(c) One
(d) two

19. Which one is true about the default constructors? (Choose one.)

(a)The default constructor is always public
(b)The default constructor inherits the arguments of the superclass constructor
(c)The default constructor is created only when the class has no constructors defined
(d)The compiler creates a default constructor if the class does not have a no-arg constructor defined

20. Which list contains only Java programming language keywords?

(a) `throws, loop, break, assert, do`
(b) `declare, switch, byte, void, if`
(c) `final, continue, volatile, import, float`
(d) `transient, volatile, virtual, strictfp, class`
(e) `instanceof, super, overrides, const, doAnswer:`

21. Consider the following code:

```
1. class Foo {
2. static boolean condition;
3. public static void main(String [] args) {
4. int i = 0;
5. if((++i >= 1) || (condition == false))
6. i++;
7. if((i++ > 1) && (condition = true))
8. i++;
9. System.out.println(i);
```

```
10. }
11. }
```

What is the result of this code?

A. 4
B. 3
C. 2
D. 1
E. Compiler error at line 7
F. Throws exception at runtime

22. What will be the result of attempting to compile and run the following program?

```
public class Integers {
    public static void main(String[] args) {
        System.out.println(0x10 + 10 + 010);
    } }
```

Select the one correct answer.

a. The program will not compile. The compiler will complain about the expression `0x10 + 10 + 010`.
b. When run, the program will print `28`.
c. When run, the program will print `30`.
d. When run, the program will print `34`.
e. When run, the program will print `36`.
f. When run, the program will print `101010`.

23. Which of the following expressions evaluates to true?

Select the two correct answers.

a. `(false | true)`
b. `(null != null)`
c. `(4 <= 4)`
d. `(!true)`
e. `(true & false)`

24. What, if anything, is wrong with the following code?

```
void test(int x) {
    switch (x) {
        case 1:
        case 2:
        case 0:
        default:
        case 4: }
}
```

Select the one correct answer.

a. The variable x does not have the right type for a switch expression.
b. The case label 0 must precede case label 1.
c. Each case section must end with a break statement.
d. The default label must be the last label in the switch statement.
e. The body of the switch statement must contain at least one statement.
f. There is nothing wrong with the code.

25. Given the following code fragment, which of the following lines will be a part of the output?

```
outer:
for (int i = 0; i < 3; i++) {
  for (int j = 0; j < 2; j++) {
    if (i == j) {
      continue outer; }
    System.out.println("i=" + i + ", j=" + j); }
}
```

Select the two correct answers.

a. i=1, j=0
b. i=0, j=1
c. i=1, j=2
d. i=2, j=1

e. i=2, j=2
f. i=3, j=3
g. i=3, j=2

26. Which expression will extract the substring "kap" from a string defined by String str = "kakapo"?

Select the one correct answer.

a. `str.substring(2, 2)`
b. `str.substring(2, 3)`
c. `str.substring(2, 4)`
d. `str.substring(2, 5)`
e. `str.substring(3, 3)`

27. What will be written to the standard output when the following program is run?

```
public class Question27 {
    public static void main(String[] args) {
        String space = " ";
        String composite = space + "hello" + space + space;
        composite.concat("world");
        String trimmed = composite.trim();
        System.out.println(trimmed.length()); }}
```

Select the one correct answer.

a. 5 **b.** 6 **c.** 7 **d.** 12 **e.** 13

28. What will be the result of attempting to compile and run the following code?

```
class MyClass {
  public static void main(String[] args) {
    String str1 = "str1";
    String str2 = "str2";
    String str3 = "str3";
    str1.concat(str2);
    System.out.println(str3.concat(str2)); }}
```

Select the one correct answer.

a. The code will fail to compile since the expression `str3.concat(str1)` will not result in a valid argument for the `println()` method.
b. The program will print `str3str1str2` when run.
c. The program will print `str3` when run.
d. The program will print `str3str1` when run.
e. The program will print `str3str2` when run.

29. True or False. A constructor has the void return type.

30. True or false. The if statement is not a selection statement.

Section B (Answer All Questions 30 Marks)

1.

(i) What is printed by the following? Show your reasoning. [**1 Marks**]

```
int x = 9 - 8 + 7 / 6 - 5 % (4 + 3) * 2 - 1;
System.out.println( x );
```

(ii) What is printed by the following?

```
System.out.println( "n\"n\n\\"+"\"" ); [1 Mark]
```

(iii) What is printed by the following? Show your work . [**1 Marks**]

```
boolean x = false;
boolean y = (x && !x) || (x || !x);
System.out.println(y)
```

(iv) What is the output of the following code? Show your reasoning [**1 Marks**]

```
int answer = 0;
for (int i = 1; i <= 6; i++) {
for (int j = 0; j < 5; j++) {
answer++;
}
System.out.print(answer + " ");
}
```

(v) What is printed by the following? [**2 Mark**]

```
String word = "Art is long, life is short";
int position1 = word.indexOf("long");
int position2 = word.indexOf(',');
word = word.substring(position1, position2);
System.out.println("word: " + word);
```

(vi) Declare and create an array of String elements called allStrings which is large enough to contain 300 String elements: [**2 Marks**]

(vii) Assign the String, "Relax" to the 10th element of the allStrings array in (vi) [**1 Mark**]

(viii) Assign the length of the 10th element of the allStrings array to the int variable called `len` in (vi) [**1 Mark**]

2.

(a)The next 3 questions relate to the Computer class below.

```
public class Computer {
private int memory;
private int processor;
/**
* Constructs a Computer object.
* @param memory The memory in MB.
* @param processor The speed in GHz.
*/
public Computer(int memory, int processor) {
this.memory = memory;
this.processor = processor;
}
/**
* @return The memory value.
*/
public int getMemory() {
return memory;}
/**
* Sets the memory value.
* @param memory
*/
public void setMemory(int memory) {
this.memory = memory;}
}
```

(i) Complete the code to construct a reference to a Computer object with 1024MB of memory and 2GHz processor speed. **[2 Marks]**

(ii) Write the code to print the value of the amount of memory stored in the Computer object you have just constructed in part (i). For example, assuming you have constructed the object correctly in part (i), the output from the code you write below should be: "1024". **[2 Marks]**

(iii) Write the code to add an extra 1024MB of memory to the amount of memory that is currently stored in the myComputer object. **[2 Marks]**

(b)Consider the following code fragment:

```
int x = 9;
int y = -2;
System.out.println("output: " + x%y);
```

What is the output of this code fragment? Explain your answer. **[1 Marks]**

(c)Consider the following code fragment:

```
public class Question{
        public static void main(String[] args) {
                byte x = 21;
                byte y = 13;
                int z = x^y;
                System.out.println(z);
        }
}
```

What is the result of this code fragment? Show your work. **[1 Marks]**

(d)What is the output of the following code? **[2 Mark]**

```
1. class Test {
2.   public static void main(String [] args) {
3.      int x = 0;
4.      boolean b [] = new boolean[3];
5.      b[1] = true;
6.      for (x= 0;x<3; x++) {
7.        System.out.print(" " + b[x]);
8.      }
9.    }
10. }
```

3.

(a)Explain clearly the differences between a logical AND (&) and the conditional AND (&&)? **[3 Marks]**

(b)The code below uses a conditional operator (?:) statement. Convert this code so that it uses the if-else statement. **[3 Marks]**

```
int i=10, j=100;
String myNum= (i < j ? "Yes I is less than J": "No I is greater than J");
```

(c)Why does the following code produce an error and how can I fix it? **[4 Marks]**

```
public class MyProgram{
public void start() {
String personInfo= oweMessage( 35,"Fred" );
System.out.println( personInfo);
}
private String oweMessage( String name, intamount )
{
return name + " You owe: $" + amount;
}
}
```

Section C ANSWER ANY TWO QUESTIONS 40 Marks

Question One

(a) What is the output when the following code is executed?

```
int num1 = 4;
int num2 = 7;
String word1 = new String( "ABRACADABRA" );
String word2 = new String( word1.toUpperCase() );
String word3 = new String( " TO SING " );
System.out.println("1. " + word1.substring(5, 8));
System.out.println("2. " + word1.indexOf("RA"));
System.out.println("3. " + word1.indexOf('P'));
System.out.println("4. " + word1.charAt(3));
if (word2 == word1)
   System.out.println("5. ==");
   else
         System.out.println("5. not ==");
if (word2.equals(word1))
   System.out.println("6. equal");
   else
         System.out.println("6. not equal");
System.out.println("7. " + (word1 == word1));
System.out.println("8. " + (num2/num1>=1 || (num2/3.0>2)));
System.out.println("9. " + ( !(num2 != 7)));
System.out.println("10. " + (num2%2==1 && !(num1>3)));
```

[10 Marks]

(b) Consider the segment of code below, which creates several objects of type `Animal`, and then calls two methods on each of these objects.

```
Animal myFish = new Animal("fish", 0);
Animal myFriend = new Animal("human", 2);
Animal myBug = new Animal("centipede", 100);
System.out.println( myFish.getType() );
System.out.println( myFriend.getType() );
System.out.println( myBug.getType() );
System.out.println( myFish.canWalk() );
System.out.println( myFriend.canWalk() );
System.out.println( myBug.canWalk() );
```

For this question, you need to write a definition of the `Animal` class. You will need to define two instance variables – one to store the type of animal, and one to store the number of legs that the animal has.

You also need to define a constructor method and two instance methods in the `Animal` class. The first instance method, `getType()`, should return the type of the animal. The second instance method, `canWalk()`, should return `true` if the animal has at least two legs, and `false` otherwise.

If you have defined the `Animal` class correctly, the output from the segment of code above should be as shown below:

```
fish
human
centipede
false
true
true
```

[10 Marks]

Question Two

(c) Write a method get24HourTime() which accepts three parameters and returns a String. The three parameters are an int representing the hour value, an int representing the minute value and a String which is either "am" or "pm". The method returns a String representing the time as a 24 hour time value. For example, 2:35pm is "14:35" in 24 hour time.
Note: 12:0pm is "12:0" in 24 hour time and 12.0am is "0:0" in 24 hour time.
For example, executing the TimeAmTo24 program with the completed get24HourTime() method produces the following output:

```
C:\> java TimeAmTo24
20:23
12:0
0:0
7:15
```

```
public class TimeAmTo24{
public void start() {
      System.out.println(get24HourTime(8, 23, "pm"));
      System.out.println(get24HourTime(12, 0, "pm"));
      System.out.println(get24HourTime(12, 0, "am"));
      System.out.println(get24HourTime(7, 15, "am"));
}
public _ _ _ _ _ _  get24HourTime( __ _ _ _ _ _ ){
 //code goes here
}
}
```

[8 Marks]

(a) Define a program called `HalvingProgram` which asks the user to enter an integer, and then repeatedly divides this integer in half until it becomes an odd value (i.e. a value where there would be a remainder of 1 if it was divided by 2).
You should use the `nextInt()` method of the `Scanner` class for reading the input value from the user. The program should then display the word "`Halving:`" and then print the value the user entered, followed by the results of dividing the number repeatedly in half until it becomes an odd value.
An application class called `HalvingApp` will be used to call the `start()` method of your `HalvingProgram` class.
For example, the output below shows how the program should behave given various input values.
The text in **bold** denotes input by the user, not output from the program.

```
c:\cst2011> java HalvingApp
Enter number: 12
Halving:
12
6
3
c:\cst2011> java HalvingApp
Enter number: 11
Halving:
11
c:\cst2011> java HalvingApp
Enter number: 512
Halving:
512
256
128
64
32
```

```
16
8
4
2
1
c:\cs2011> java HalvingApp
Enter number: 2
Halving:
2
1
```

You can assume that the value the user enters is a positive integer value greater than 1. ~~You can also assume that the Keyboard class is available in the same directory as the HalvingProgram class.~~

[12 Marks]

Question Three

(a) The CalculateArea program shown below is supposed to calculate the area of a rectangle, given the width and the height of the rectangle. However, there are 5 syntax errors contained in this source code.

```
public class CalculateArea
      public start() {
            System.out.println("\"Area Calculator"\");
            final double HEIGHT = 5.0;
            double WIDTH = 4.5;
            double area - WIDTH * HEIGHT;
            System.out.println("The area is: " , area);
      }
}
```

An application class called CalculateAreaApp will be used to call the start() method of the `CalculateArea` class The output of the program should be:

```
c:\cst2011> java CalculateAreaApp
"Area Calculator"
The area is: 22.5
```

Locate and correct the 5 syntax errors which prevent the CalculateArea class from compiling. On in your answer sheet, circle the errors where they appear in the code (rewrite) and clearly write the correction to the code.

[10 Marks]

(b) The body mass index (BMI) is the ratio of the weight of a person (in kilograms) to the square of the height (in meters). Write a program BMI.java that prompts the user to enter weight and height, and prints out the BMI.Example output is shown below, where the user has entered the value 56.5 and the value 1.74.

```
<<Welcome to Body Mass Index Program>>
Enter Person's Weight: 56.5
Enter Person's Height: 1.74
The BMI is: 18.66
```

Your program must produce output in exactly the same format as shown above. The use of method for finding BMI is more preferred compared to doing everything in the main method.

[10 Marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Computer Studies

EXAM: 2007 - SEMESTER ONE FINAL

COURSE: CST2021 – INTRODUCTION TO COMPUTER SYSTEMS

DURATION: 3 HOURS

DATE: 6TH SEPTEMBER, 2007

INSTRUCTIONS

- *This paper has a total of **six** questions*
- *You must answer a total of **five(5)** questions*
  - ***Section A** has **two(2)** questions, **answer both***
  - ***Section B** has **four (4)** questions, attempt any **three(3)***
- *All questions carry equal marks(20 marks each)*
- *Clearly number your answers*
- *Use the marks as a guide to the detail required in your answers while keeping your answers concise and relevant.*

SECTION A (Compulsory)

QUESTION ONE (multiple choice questions). Indicate only letter options e.g. 1.e

1. What is the length limit for 10BaseT unshielded twisted-pair cable?
   a. 100 meters
   b. 10 meters
   c. 200 meters
   d. 150 meters
   e. I don't know
2. In a UTP cable, to help eliminate interference from adjacent pairs and other electrical devices;
   a. Each pair is twisted with a different number of twists per inch
   b. Each pair has a different color coded plastic insulation
   c. Each pair is twisted with the same number of twists per inch
   d. Each pair has the same color coded plastic insulation
3. Which cable type is a common choice for connecting networks between buildings?
   a. thick coaxial
   b. thin coaxial
   c. STP
   d. UTP
   e. fiber optic
4. Which network device can regenerate the data signal without segmenting the network?
   a. bridge
   b. hub
   c. router
   d. NIC
5. What are the common connectors used with fiber optic cable? (Choose two)
   a. ST
   b. BNC
   c. RJ 45
   d. SC

6. Which of the following statements correctly describes topologies? (Choose two)
   a. The physical topology of a network refers to the path data travels from a source to a destination
   b. The logical topology of a network refers to the path signals travel from a source to a destination
   c. A logical topology refers to the actual map and layout of a network.
   d. A physical topology describes the actual layout of network devices
7. Which topology does not require a repeater?
   a. bus
   b. star
   c. ring
   d. tree
8. The Internet is an example of which type of network?
   a. LAN
   b. WAN
   c. MAN
   d. PAN
9. 10base5 specification refers to which type of cable
   a. Thin coaxial cable carrying Ethernet signals with a maximum length of 500 meters
   b. Thick coaxial cable carrying Ethernet signals with a maximum length of 500 meters
   c. Thin coaxial cable carrying Ethernet signals with a maximum length of 200 meters
   d. Thick coaxial cable carrying Ethernet signals with a maximum length of 200 meters
10. Which of the following are true about a star topology? (Choose three)
   a. easy to install and wire
   b. requires less cable length
   c. no disruptions to the network when connecting or removing devices
   d. less expensive than the linear bus topologies
   e. easy to detect faults and to remove parts

11. Which of the following are true about Ethernet? (Choose three)
   a. Ethernet uses an access method called CSMA/CA
   b. Ethernet allows for linear bus, star or tree topologies
   c. Ethernet can be transmitted at speeds of 10 Mbps to 1000 Mbps
   d. Ethernet only works on twisted pair and coaxial cables
   e. Ethernet uses an access method called CSMA/CD

12. Which of the following are primary duties of the OSI transport layer? (Choose two)
    a. flow control
    b. path determination
    c. security control
    d. end-to-end connectivity
    e. data representation

13. Which one is an advantage of a client/server network?
    a. less initial cost in implementation
    b. resources and data security are controlled through the server
    c. server cannot be accessed remotely and across multiple platforms
    d. all components work independently

QUESTION TWO (short answer questions)

(a) Briefly state what contribution the following made towards the development of today's modern computer; Ada Lovelace, John Von Neuman, Charles Babbage, George Boole, J. Presper Eckert and J.V. Atanasoff. **[6 marks]**

(b) Briefly explain the two types of data independence **[4 marks]**

(c) Distinguish between Intension and Extension of a database. **[4 marks]**

(d) List three types of database end-users. **[3 marks]**

(e) List any three responsibilities of a Database Administrator. **[3 marks]**

SECTION B (Choose any three (3))

QUESTION THREE

(a) Suppose that a disk unit has the following parameter: block size B = 2400 bytes, interblock gap size = 600 bytes. An employee file has the following fields; NRC 10 bytes, firstname 50 bytes, lastname 50 bytes, department 15 bytes. The employee file has r = 30,000 records, fixed-length format, and unspanned blocking. Write the appropriate formulas and calculate the following values for the above employee file:

i. The record size R, the blocking factor bfr and the number of disk blocks b needed to store the file. **[5 marks]**

ii. Calculate the wasted space in each disk block because of the unspanned organization and the total wasted space to store the entire file. **[5 marks]**

(b) For the following memories state which of the terms apply; possible, reasonable and impossible. Show how you arrive at your decision.

i. 7-bit address, 8-bit cell size, 128-bit memory
ii. 4-bit address, 24-bit cell size, 128-bit memory
iii. 4-bit address, 12-bit cell size, 96-bit memory
iv. 3-bit address, 16-bit cell size, 96-bit memory
v. 8-bit address, 128-bit cell size, 512-bit memory

[5 marks]

(c) Draw a block diagram showing principal components of an I/O module. **[5 marks]**

QUESTION FOUR

(a) A compiler operates in phases, each of which transforms the source program from one representation to another. Consider a particular compiler that outputs assembly code, given the following statement: ***position := initial + rate * 60***, Show the various outputs from each phase of compilation. Assume that all identifiers have been declared to be real numbers and that 60 by itself is declared to be an integer. **[10 marks]**

(b) Suppose that a floppy disk contained 50 tracks, each of which is divided into 10 sectors, with each sector capable of holding 128 characters.

i. Up to how many characters would the disk hold? **[2 marks]**

ii. If the disk were spinning at a rate of 5 revolutions per second, and each character is stored in 8 bits, at approximately what rate would the bits pass by the read/write head. **[4 marks]**

iii. If the disk were spinning at a rate of 300 revolutions per minute (rpm), at approximately what rate would the characters pass by the read/write head? **[4 marks]**

QUESTION FIVE

(a) Suppose the value 57 is stored in memory in 8 bits and later retrieved as a codeword. Using Hamming's algorithm, show how each of the following outputs would have resulted. **[12 marks]**

i. 001101000111
ii. 001101001111
iii. 101101001111

(b) List down the four basic components of the Central Processing Unit, stating the main function of each component. **[8 marks]**

QUESTION SIX

(a) Discuss a conceptual data model in the following context;

- define the term data model
- explain concepts used by a conceptual data model
- Suppose you are developing a database to store the following data; student (full name, year, school, major), course (course code, year, semester). Show how you would use a conceptual model to represent this data. **[10 marks]**

(b) Consider a disk drive with the following characteristics:

- There are 8 surfaces, each with 8000 tracks.
- Tracks hold an average of 250 sectors of 512 bytes each.
- 10% of each track is used by inter-sector gaps.
- The disk rotates at 8000 rpm
- The time needed to move the read/write head through n tracks is 1+0.001n milliseconds.

i. What is the total capacity of the disk?
ii. What is the maximum seek time?
iii. What is the maximum rotational latency?
iv. What is the average rotational latency?
v. If the block size is 4096 bytes, what is the transfer time of a block? **[10 marks]**

THE END

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

Department of Computer Studies

EXAM: 2007 - SEMESTER ONE FINAL

COURSE: CST3031 – INTRODUCTION TO SOFTWARE ENGINEERING I

DURATION: 3 HOURS

DATE: 30TH AUGUST, 2007

INSTRUCTIONS

- *There are 6 questions on 5 pages*
- *Attempt any 5 questions*
- *All questions carry equal marks (20 marks each)*
- *Clearly number your answers*
- *Use the marks as a guide to the detail required in your answers while keeping your answers concise and relevant.*

GOOD LUCK!!

QUESTION ONE

(a) What is a software process model? Describe the four basic activities which are represented in all software process models. [5 marks]

(b) Describe the main features of the spiral model, the evolutionary development model and the formal systems development model. [3 marks each]

(c) For each of the following systems, indicate, giving reasons, what would be the most appropriate type of process to following;

i. A software system to control a medical X-ray machine [2 marks]

ii. A web based tool to allow software developers on different sites to collaborate in debugging their software [2 marks]

iii. An implementation of a new data compression algorithm intended to replace an existing program [2 marks]

QUESTION TWO

(a) Consider a requirements specification for a simple scientific calculator application, intended to run on a palmtop Personal Digital Assistant (PDA). Give, in appropriate language, a plausible example of each of the following, first as a user requirement, (1 mark each) and then as it might be refined into a system requirement (1 mark each).

i. A functional requirement
ii. A usability requirement
iii. A domain requirement
iv. A performance requirement
v. An interoperability requirement

(b) Requirements should state what a system should do, without stating how it should do it. Why is this distinction useful? [2 marks]

(c) What are two key challenges facing software engineering? [2 marks]

(d) Software quality measurement generally starts with high level quality goals, and then identifies metrics that can be used to indicate satisfaction of the quality goals. For each of the following quality goals, explain why the goal is important, and identify a metric that could be used to measure it: [6 marks]

i. Reliability
ii. Efficiency
iii. Usability

QUESTION THREE

(a) Requirements engineering can be defined as *"the branch of software engineering concerned with the real-world goals for, functions of, and constraints on software systems [and] the relationship of these factors to precise specifications of software behaviour, and to their evolution over time and across software families"*. Why is Requirements Engineering considered to be the most important part of software engineering? [4 marks]

(b) RE draws on the cognitive and social sciences to provide both theoretical grounding and practical techniques for eliciting and modelling requirements. Explain how the following sciences relate to requirements engineering: Cognitive psychology, Anthropology, Sociology and Linguistics [10 marks]

(c) Explain the phases involved in carrying out a feasibility study. [3 marks]

(d) State any two inputs and one output of the **requirements engineering** process? [3 marks]

QUESTION FOUR

(a) Software architecture describes a high-level design view of a software system. What are the advantages of explicitly describing the architecture independently from the implementation? [2 marks]

(b) In the first phase of the architectural design activity, a system is decomposed into a set of interacting sub-systems. Enumerate three specific models of the structure that may be developed. [3 marks]

(c) Explain how you would design a system architecture to address the following concerns; performance, security, safety, availability, maintainability. (*Note that each attribute should be treated separately).* [5 marks]

(d) What is a control model concerned with? Explain the two classes of models under the event-based control model. [5 marks]

(e) For any one of the three structures enumerated in part (c), outline three advantages and two disadvantages. [5 marks]

QUESTION FIVE

(a) You are assigned to work on a project to develop a controller for a new satellite. To save money, your manager estimates you could reuse about 90% of the software from one of two similar satellites the company built in the past. One system has no known bugs, but the code is undocumented and uncommented. The other has 25 known non-critical bugs, but every procedure is documented with a procedural abstraction.

i. Company management requires more details on the benefits of this approach. Outline five benefits. [5 marks]

ii. Which system would you choose to work with, and why? [5 marks]

(b) The company you work for has traditionally kept its software maintenance teams separate from development teams. It now wants to move to a mission orientation where a single team will be responsible for the development and maintenance of each software product. What advantages should your company expect from the re-organisation, and what problems might it encounter? [4 marks]

(c) Draw a model showing principal stages of ***development*** with reuse. [6 marks]

QUESTION SIX

(a) Define *black box* and *white box* testing. What are the advantages of each approach? Why are both necessary? [5 marks]

(b) Why is it important to be able to partition the test space into *equivalence classes*? For the following code fragment, describe 3 different test cases, and for each, describe the class of test cases it represents. [6 marks]

```
char * triangle (int x, y, z) {
/*
        requires: The parameters are in ascending order (i.e. x <= y <= z)
        effects: If x, y and z are the lengths of the sides of a triangle,
        this function classifies the triangle using one of the three
        strings, "scalene", "isosceles" or "equilateral". If x, y, and z
        do not form a triangle, the empty string is returned.
*/
```

```
char *r;
r="scalene";
if (x==y || y==z)
r="equilateral";
if (x==z)
r="isosceles";
if (x <= 0 || (x+y) <= z)
r="";
return (r); }
```

(c) The company you work for develops internet applications. To reduce time to market, the company is considering dispensing altogether with integration testing. Instead, the company plans to rely on Beta testing, in which free trial versions of new software will be sent to existing, trusted customers to try out, with the agreement that they will report any problems they encounter. What are the advantages and disadvantages of this approach? [4 marks]

(d) Define the terms Verification and Validation. Why is each insufficient on its own? What makes validation particularly hard? [5 marks]

THE END

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF COMPUTER STUDIES

2007 SEMESTER ONE EXAMINATION

TITLE OF PAPER: **OBJECT-ORIENTED ANALYSIS AND DESIGN**

COURSE CODE: **CST3141**

LEVEL: **THIRD (3) YEAR**

DATE: 28th AUGUST, 2007

DURATION: THREE (3) HOURS

INSTRUCTIONS: **There are Seven questions:-**

- **Answer QUESTION ONE and any FOUR of the remaining SIX questions.**
- **Note that for multiple choice questions, wrong choices will cost you -0.5 marks.**

QUESTION ONE (Multiple Choice) – [20 Marks]

I. Which of the following situations can Activity Diagrams be used?

a. Analyzing a use case.
b. Describing a complicated sequential algorithm.
c. Trying to see how objects collaborate.
d. Trying to see how an object behaves over its lifetime.
e. Representing complex conditional logic.
f. Understanding workflow.

II. Which two statements are true about the relationship between class A and class B?

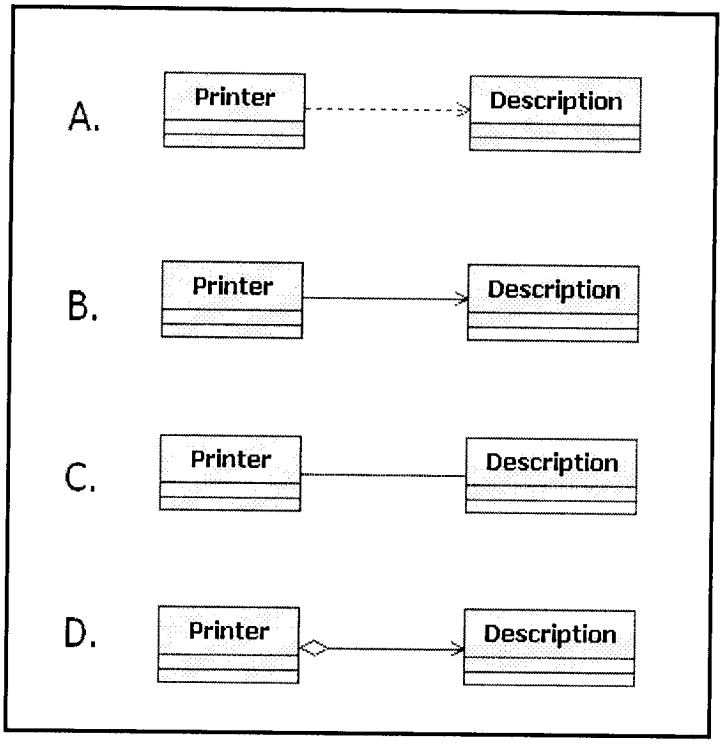
(Choose two.)

```
class A {}
class B {
  private A myA = new A();
}
```

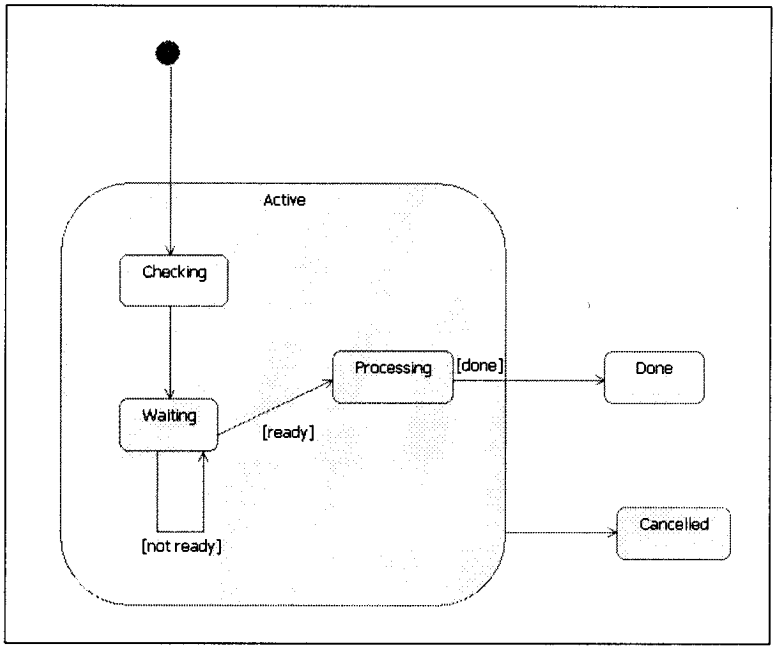
a. A maintains no relationship with B
b. B maintains no relationship with A
c. B maintains a "one to many" relationship with A
d. The relationship can be described with a has-a clause
e. The relationship can be described with an is-a clause

III. Given the following piece of code, how should you model relationship between "Printer" and "Description" classes ?

```
public class Printer {
    ...
    public void printDescription(Description desc) {
        print(desc.getName());
        print(desc.getOrganization());
        ...
    }
}
```

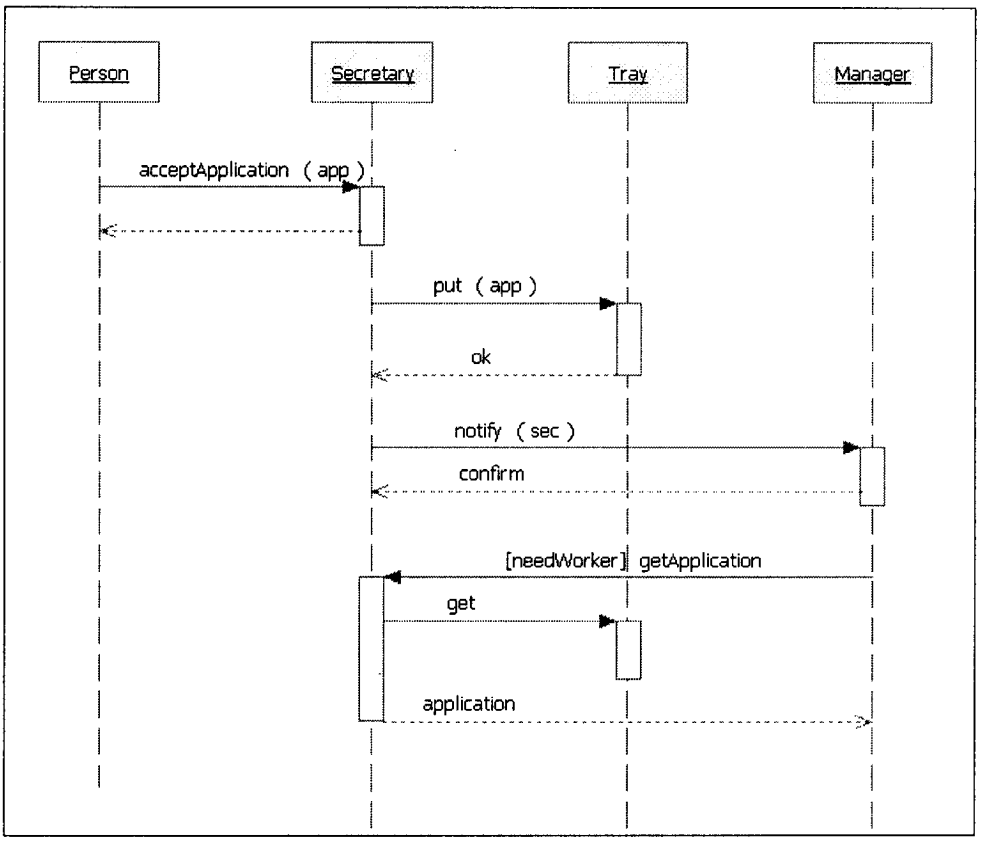


IV. What is true about the State Diagram?



a. 'Active' is a concurrent state.
b. 'Active' is a superstate.
c. 'Active' is an asynchronous state.
d. The State Diagram uses wrong syntax.

V. What method(s) must be implemented by the Secretary class?



a. acceptApplication(...)

b. put(...)
c. ok
d. notify(...)
e. confirm
f. needWorker
g. getApplication
h. get
i. application

VI. What is true about Iterative Development?

a. Development is organized into a series of "mini-projects".
b. The output of an iteration is an experimental prototype (leads to rapid feedback from users
c. One of the benefits of Iterative Development is early feedback.
d. One of the benefits of Iterative Development is late mitigation of high risks.
e. Each iteration includes only one discipline (i.e. Requirements Analysis, Design, Implementation, or Testing).

VII. What is the purpose of a Use Case? (Choose two)

a. Elicits requirements from users in meaningful chunks.
b. Offers useful bits of analysis, design, and coding techniques.
c. Is a basis for system testing.
d. Provides rigorous definition of operation's purpose and class's legal state.
e. Provides class debugging enhancements.

VIII. What is the purpose of Patterns?

a. Shows how several objects collaborate in single Use Case.
b. Provides rigorous definition of operation's purpose and class's legal state.
c. Offers useful bits of analysis, design, and coding techniques.
d. Provides rigorous definition of operation's purpose and class's legal state.

IX. During which phase do you identify projects risks?

a. Construction
b. Inception
c. Elaboration
d. Transition

X. Given the following method, which statements will throw an exception, assuming assertions are disabled?

```
static int inv(int value) {
    assert value > -50 : value < 100;
    return 100/value;
}
```

Select the all correct answers.

```
a. inv(-50);
b. inv(0);
c. inv(50);
d. inv(100);
e. inv(150);
```

QUESTION TWO

(a) Study the code in the file MyJava.java listed below:

```
1  public class MyJava {
2      //instance variables
3      private int x;
4      //instance methods
5    public void setX(int newX){
6        x =newX;
7    }
8    public int getX(){
9        return x;
10   }
11    //Constructor
12   private MyJava(){
13   x = 99;
14   }
15   //static variable
16   private static MyJava it = new MyJava();
17   //static method
18   private static MyJava getIt(){
19     return it;
20   }
21 }
```

Also study the code in the file TestMyJava.java listed below.

```
1  public class TestMyJava {
2       public static void main(String args[]){
3       //Create a MyJava instance
4       MyJava w =MyJava.getIt();
5       //Output the value of its instance variable
6       System.out.println(w.getX());
7       }
8  }
```

(i) Predict the out obtained if the source files are compiled and TestMyJava.java is run. **[2 Marks]**.

(ii) Line 4 of TestMyJava.java was originally written as:

```
MyJava w = new MyJava();
```

This gave rise to a compilation error. What was the problem when calling the MyJava constructor that gave rise to the error? **[3 Marks]**.

(iii) The following lines were added to the end of the main ( ) method.

```
//create another MyJava instance
MyJava w2 = MyJava.getIt();
 W2.setX(55);
System.out.println(w2.getX( ));
System.out.println(w.getX());
```

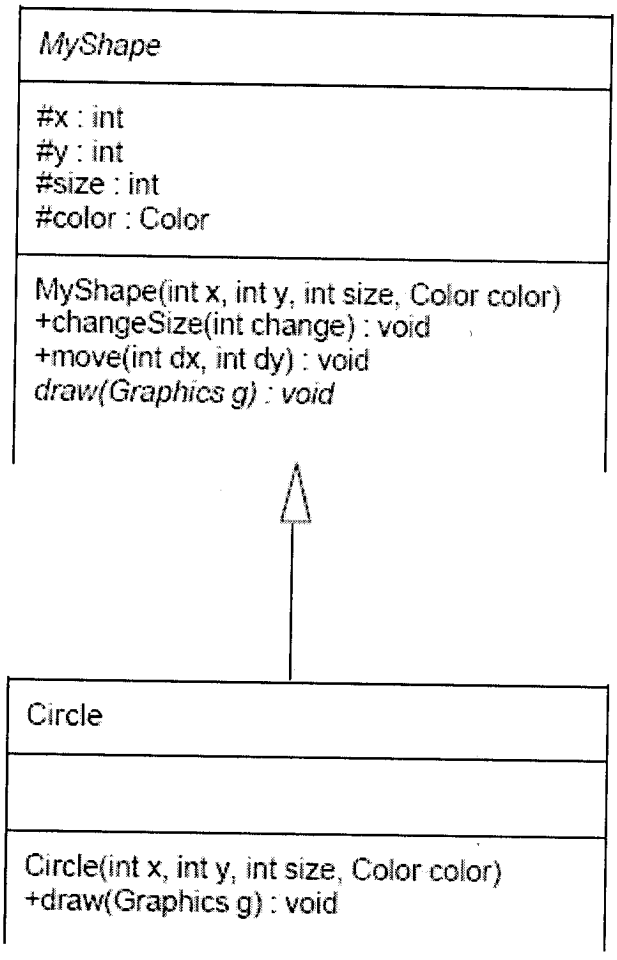
Predict all of the output of the new extended program and explain your answer. **[4 Marks]**.

(iv) This program uses the example of a well-known creational design pattern, which you should be familiar with. Identify the pattern and explain its general structure, with the help of a UML class diagram and explain the benefits of using this pattern. **[6 Marks]**.

(b) Design patterns can be organised into creational, structural and behavioral types. Explain the characteristics of these three types. **[5 Marks]**

QUESTION THREE

(a) Consider the following UML class diagram, which shows an abstract class MyShape with a concrete subclass Circle :



(i) Implement both of these classes in Java, given the following information:

`changeSize` adds `change` to `size`.
`move` adds `dx` to `x` and `dy` to `y`.
`draw` in class `Circle` uses `g.setColor(color);` and `g.fillOval(x, y, size, size);` to draw a Circle object. **[10 Marks]**

(ii) Add an extra class Square to the class diagram, and implement it. A Square is like a Circle, except that it is drawn using `g.fillRect(x, y, size, size);` **[5 Marks]**

(b) A number of tools available to help programmers build multiple file Java Systems. A well-known example of such a tool is Ant. Briefly explain the problems which arise when is a system is made up of many files and describe the sort of assistance a tool like Ant can provide to system builders. **[5 Marks]**

QUESTION FOUR

(a) Study the Java class given below.

```
1.  public class SaveHiLo {
2.          int low = Integer.MAX_VALUE;
3.          int high = Integer.MIN_VALUE;
4.          public void processNum(int num) {
5.                  if (num < low)
6.                      low = num;
7.                  if (num > high)
8.                      high = num;
9.          }
10.         public int getHiVal() {
11.                 return high;
12.         }
13.         public int getLoVal() {
14.                 return low;
15.         }
16.         public int getRange() {
17.                 return high - low;
18.         }
19. }
```

There are still more methods to be added to the class but the developer, who is an inexperienced programmer, has wisely decided to unit test the class incrementally as they develop it. Their initial code to test the class is given below.

```
1.  public class TestingTesting {
2.          public static void main(String[] args) {
3.
4.                  SaveHiLo myHL = new SaveHiLo();
5.                  myHL.processNum(10);
6.                  myHL.processNum(50);
7.                  System.out.println(myHL.getHiVal());
8.                  System.out.println(myHL.getLoVal());
9.                  System.out.println(myHL.getRange());
10.         }
11. }
```

(i) What would you expect this test to output when run? **[2 marks]**

(ii) Criticize the test and give the developer advice about what they could do to improve their testing technique. Give snippets of code as appropriate. **[10 Marks]**.

(iii) The canonical form of classes ensures that instances of those classes will be well behaved at runtime. Two elements of the canonical form are object equality and cloning. Briefly explain the problem with the default methods provided for the object equality and cloning that are inherited from the class Object and explain what a good class should provide in order to follow the canonical form for these two elements. **[8 Marks]**.

QUESTION FIVE

(a) Study the Java program given below.

```
1.  class Burger {
2.      private String type;
3.      private int size = 1;
4.      public Burger(String type) { this.type = type; }
5.      public void increaseSize() { size++; }
6.      public int getSize() { return size; }
7.  }
8.  class MealDeal implements Cloneable {
9.      Burger aBurger;
10.     String aDrink;
11.     public MealDeal(Burger aBurger, String aDrink) {
12.         this.aBurger = aBurger;
13.         this.aDrink = aDrink;
14.     }
15.     public void supersize() {
16.         aBurger.increaseSize();
17.     }
18.     public MealDeal cloneMeal()
19.                             throws CloneNotSupportedException {
20.         return (MealDeal)this.clone();
21.     }
22. }
23. public class MenuProcesser {
24.     public static void main(String[] args)
25.                             throws CloneNotSupportedException {
26.         MealDeal mealA =
27.                         new MealDeal(new Burger("cheese"), "coke");
28.         MealDeal mealB = mealA;
29.         mealB.supersize();
30.         System.out.println("mealA size = "
31.                                         + mealA.aBurger.getSize());

32.         MealDeal mealC =
33.                         new MealDeal(new Burger("bacon"), "tea");
34.         MealDeal mealD = mealC.cloneMeal();
35.         mealD.supersize();
36.         System.out.println("mealC size = "
37.                                         + mealC.aBurger.getSize());
38.     }
39. }
```

(i) What will be output when lines 26 to 31 are executed? Explain your answer.**[4 marks]**

(ii) What will be output when lines 32 to 37 are executed? Explain your answer. **[6Marks]**

(iii) Explain the concept of a "deep copy" and "shallow copy". In your explanation include the weaknesses of the clone method implemented in the Object class. **[5 Marks]**

(iv) The code "throws `CloneNotSupportedException`" appears in the declaration of two of the methods in the program above. If it is removed in either case the program will not compile. Explain why this is. Your answer should include an explanation of the difference between "checked" and "unchecked" (also known as "runtime") exceptions. **[5 Marks]**

QUESTION SIX

a. Give a brief explanation of what following concepts are with respect to OOP.
   (i) Class **[2 Marks]**
   (ii) Message Sending **[2 Marks]**
   (iii) Attribute **[2 Marks]**
   (iv) Encapsulation **[2 Marks]**

b. A master student can take courses at the University of Zambia. Courses can be lectures or lab classes. Each master student must take at least one course. Each course is held by a research department. Each research department has at least one professor and 0 to 30 research assistant. Students, professors and research assistants have a lot in common: They have a name, a first name and a date of birth. Which diagram type should be used to describe this? Draw such a diagram for this. **[12 Marks]**

QUESTION SEVEN

a. What do you understand by a software development process? **[2 Marks]**
b. Explain what Iterative development is and give two its advantages. **[3 Marks]**
c. State the fourth major phases of the iterative development process and briefly describe what happens in each phase. **[5 Marks]**
d. You have been asked to develop a simple dice game in which a player is provided with two die. To play the game the player throws the two die. If the total face up value is seven, the player wins, otherwise they lose. Identify the real world concepts involved in this game and represent them in a conceptual model, indicating the multiplicities. Draw a class diagram by adding some of the important operations of the objects in the conceptual model. **[10 Marks]**

THE END

GOOD LUCK

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

UNIVERSITY EXAMINATION AUGUST 2007

CST 4021 NUMERICAL ANALYSIS I

INSTRUCTION(S) : There are Six (6) questions in this paper and you are required to answer ***ONLY FIVE (5)*** of them. All questions have the same weight. Good Luck!

DURATION : 3 Hours

1.

a. State the Rolles theorem

b. Hence show that the equation $x = 3^{-x}$ has a root in the interval [0, 1]

c. How many iterations of the bisection method are required to approximate the solution of the equation above to 10^{-3} accuracy?

d. Hence approximate the root using the bisection method

2.

a. Find the general expression of the n-th derivative of the function $f(x) = e^{-x}$

b. Hence find the fourth taylor polynomial of f above expanded about $x_0 = 1$

c. Use this polynomial to approximate f(1.1)

d. Find a bound for the error in this approximation

e. Is this bound confirmed by the comparison of the approximation and the actual value of f(1.1) from the calculator?

3.

a. Show that the equation $x^3 - 2x^2 - 5 = 0$ has a root in [1, 4] using the intermediate value theorem.

b. Outline the steps of the Newton-Raphson algorithm

c. Use Newton-Raphson's method to approximate the root of the function above within 10^{-4} accuracy in the interval [1, 4]

4.

a. Outline the steps of the Neville's iterated interpolation algorithm

b. Use Neville's method to obtain the approximation of $\sqrt{3}$ and the values $x_0 = -2$, $x_1 = -1$, $x_2 = 0$, $x_3 = 1$, $x_4 = 2$. [hint consider using $f(x) = 3^x$]

5.

a. Use the following values to construct a fourth Lagrange polynomial to approximate f(1.25). (Round to 5 decimal places)

x	1.0	1.1	1.2	1.3	1.4
f(x)	1.00000	1.23368	1.55271	1.99372	2.61170

b. Suppose the function being approximated is $f(x) = e^{2^x - 1}$, find a bound for the error in the approximation.

6.

a. State the fixed point theorem.

b. Show that the equation $3x^2 - e^x = 0$ has a root in [0, 1]

c. Derive a g from the equation above such that it has a unique fixed point in [0, 1]

d. Approximate this fixed point to the accuracy of 10^{-4}

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

The University of Zambia

School of Natural Sciences

Department of Computer Studies

FINAL EXAM SEMESTER I
SEPTEMBER, 2007

CS 3061 - COMPUTER NETWORKS AND COMMUNICATIONS SYSTEMS

INSTRUCTIONS:

1. This paper has a total of **six questions and two sections**
2. You **must** ***answer*** a total of **five questions**
3. ***Each question Carries 20 Marks***
4. **Section A** has **two questions**, ***answer all the questions in section A***
5. **Section B** has **four questions**, ***choose any three questions of your choice***

TIME:	3 HOUR
DATE:	6TH SEPTEMBER 2007
TOTAL MARKS:	100
VENUE:	NEW DINNING HALL

SECTION A

This section has two questions. Answer all the questions

Question One

a) **Define** the following **[5]**

i) Protocol

ii) Slot Time

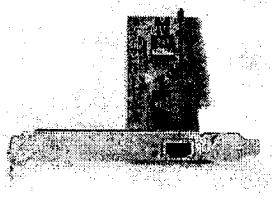
iii) Throughput

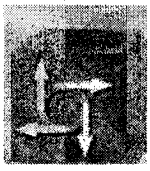
iv) Collision Domain

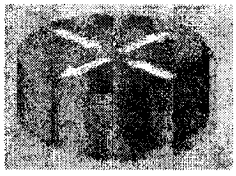
v) Attenuation

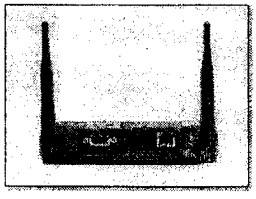
b) ***With the aid of a diagram,* briefly outline** the process of data encapsulation [2]

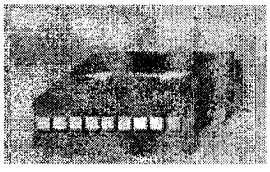
c) **Identify** the following devices used in computer networks and **give the function** of each device**[5]**

i) 

ii) 

iii) 

iv) 

v) 

d) **Draw** a diagram of the *OSI model*. **Give** the **function** of each layer **[8]**

Question Two

a) Briefly describe each of the following in relation to IPv4**[3]**

i) Subnetting

ii) NAT

iii) Private addressing

b) **Identify** the group to which each of the following IP addresses below belongs and then **give** the ***default subnet masks*** for each of the IP address **[2]**

i) 119.234.253.244

ii) 129.12.123.213

iii) 22.173.223.218

iv) 199.67.203.149

c) **Given** the network IP address as ***134.213.0.0*** **[15]**

i) **How many** bits must be borrowed in order to create 5 subnets?

ii) **How many** usable IP addresses will each subnet have?

iii) Using the information in i) and ii) complete the table below for ***8 subnets***

Subnet	Network Address	Usable IP address Range	Broadcast Address
0			
1			
2			
3			
4			
5			
6			
7			

SECTION B

This section has four questions. Choose any three questions

Question One

a) Give **two** functions performed by a ***Router*** **[2]**.

b) What is the difference between ***Switching*** and ***Routing*** **[2]**

c) **Give** any **two** differences between a **multimode** and a **single mode** fiber **[2]**

d) **Define** the following and **give** at least **two characteristics** of each one of them **[2]**

i) **LAN**

ii) **WAN**

e) List any **six** factors that help to determine the throughput of a given network [3]

f) The bandwidth at the Department of Computer Studies in the afternoon was **800kbps**. Calculate how long it would take to download a Windows update with the size of **48MB** [5]

g) The IP address of a given Server Computer is **192.216.135.152** and its MAC address is **8C-AD-00-5B-0F-A4**.

i) Convert the **IP address** to its **binary equivalent** [2]

ii) Convert the **MAC address** to its **binary equivalent** [2]

Question Two

a) **Name** the media type below and give its characteristics **[5]**

i) 1000Base-LX

ii) 10BaseT

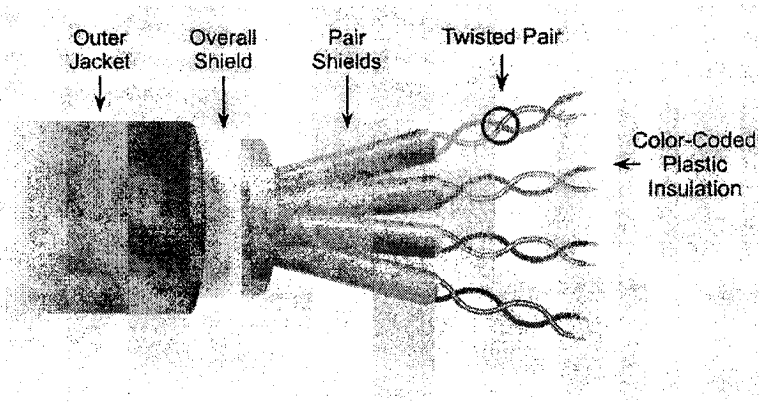
iii) 10GBase-SR

iv) 10Base2

v) 100BaseFX

b) **What** is the difference between a collision and a broadcast? **[1]**

c) **Below** is a Shielded Twisted Pair (STP) cable. **Give** the function performed by each of the feature shown below **[5]**



d) In relation to ***wire maps***, **briefly describe** each of the following terms**[2]**

i) Open circuit

ii) Short circuit

iii) Reversed-pair

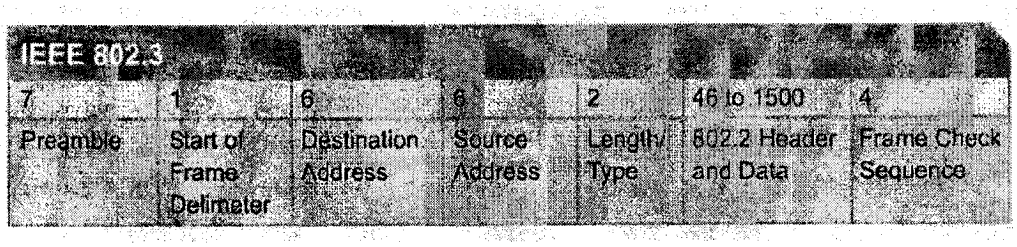
iv) Split-pair

e) **What** are the **five** benefits of a layered system when considering networking models **[3]**

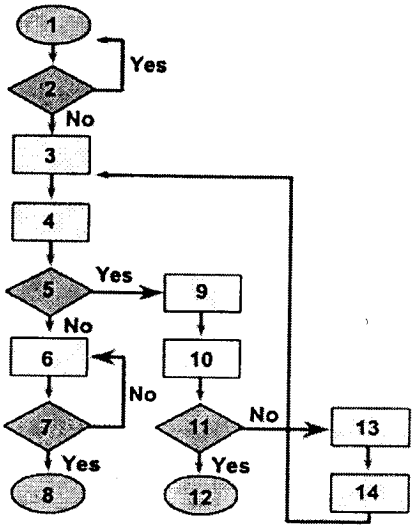
f) **What** is meant by ***Routing Metrics***? **Give** four *routing metrics* used by **IGRP** routing protocol **[4]**

Question Three

a) Below is the IEEE frame format. **Describe** each of the fields shown below. [7]



i) Below is a diagram showing how Ethernet technology works. **Describe** each of the ***fourteen steps shown*** below [7]



b) **What** is Crosstalk? **Briefly** describe each of the following types of Crosstalk **[6]**

i) NEXT

ii) FEXT

iii) PSNEXT

Question Four

a) **Name** the ***three*** types of **IEEE 802.3 Frames** and give one examples for each **[3]**

b) Below is an example of the pin layout of a Rollover UTP Cat5 cable **[4]**

Pin 1 ---------- Pin 8
Pin 2 ---------- Pin 7
Pin 3 ---------- Pin 6
Pin 4 ---------- Pin 5
Pin 5 ---------- Pin 4
Pin 6 ---------- Pin 3
Pin 7 ---------- Pin 2
Pin 8 ---------- Pin 1

i) **Where** is this cable used?

ii) **Give** the ***pin layout*** of the Crossover Cable and the Straight-Through Cable in the format shown above. **Give an example** of where each cable is used.

c) **Briefly describe** each of the following technologies **[3]**

i) FDDI

ii) Token Ring

iii) Ethernet

d) **What** is Bandwidth? **What** units are used to measure bandwidth? **Give** any four reasons why bandwidth is important **[3]**

e) ***Physical Network Topologies*** can be classified into *6 groups* while ***Logical Topologies*** fall under *2 groups*. **Briefly** describe each of the groups above **[7]**

End of Examination

All the Best!!!!!

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

GEO 111: INTRODUCTION TO HUMAN GEOGRAPHY

TIME: Three Hours

INTRUCTIONS: Answer questions 1(compulsory) and any other three. Question 1 carries 40 marks (40%) and the other three 20 marks each (20%) each.

---

1 Determine and comment on the settlement pattern of Luapula Province (Figure 1) which covers a total of 30,600 square kilometers.

2 Discuss the statement, 'it is advantageous to use the regional and systematic approaches in studying geography.'

3 Does Weber's theory account for all the factors which determine the location of industries in Zambia?

4 Discuss the contributions of geographers in antiquity and at least any three explorers to the field of geography.

5 The main factors of Christaller's central place theory are not applicable to the Zambian situation.' Discuss.

6 Show how the three relaxed rules of the Hagerstrand Model provide a logical framework for more realistic versions of the diffusion process.

END OF EXAMINATION

GEO. 111

URBAN SETTLEMENTS IN LUAPULA PROVINCE

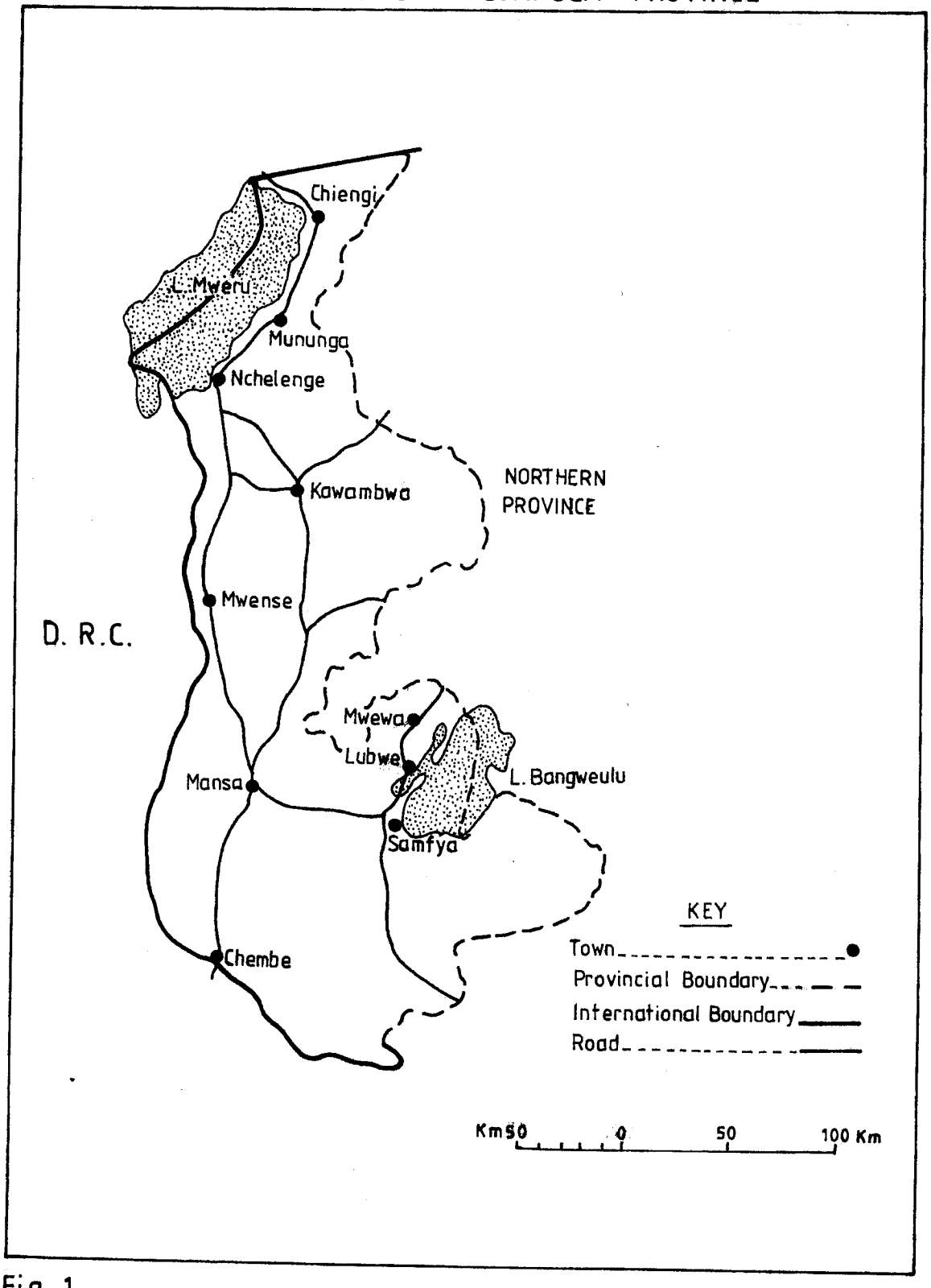


Fig. 1

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

GEO 155: INTRODUCTION TO PHYSICAL GEOGRAPHY

TIME: Three hours

INSTRUCTIONS: Answer any Four questions.

All questions carry equal marks. Candidates are advised to make use of illustrations and examples wherever appropriate.

---

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

   a) Relative humidity
   b) Solifluction
   c) Desert pavement
   d) Components of ecosystems
   e) B2 horizon

2. Explain the interactions between ocean currents and air masses with respect to El Niño and the Southern Oscillation.

3. Discuss the evolution and demise of the geomorphological cycle and two other alternative theories of landform development that were proposed against it.

4. Identify and describe three types of landforms resulting from exogenetic and endogenetic processes on earth.

5. Discuss the factors that influence the distribution of plants and animals in biomes.

6. The soils in high rainfall areas of Zambia are said to be acidic and have low fertility. Explain why this is so with respect to at least four soil forming processes.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 211 : THE GEOGRAPHY OF AFRICA

TIME: Three Hours

INSTRUCTIONS: Answer any four questions. The use of a Philips' University Atlas is allowed and candidates are advised to make use of illustrations and examples wherever appropriate.

---

1. In what ways is the physical environment in Africa a facilitator rather than an obstacle to agricultural development?

2. How can racial, ethnic and religious diversity contribute to socio-economic development in Africa?

3. Show how Africa's natural resource endowment can be the basis for sustainable socio-economic development.

4. Account for the regional imbalance in socio-economic development in Ghana and suggest ways to overcome it.

5. How does Ibrahim's (1983) model of Desertification explain the environmental crisis in the Sahel region?

6. Compare and contrast the strategies for socio-economic development that were followed by Kenya and Tanzania after independence?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINNATIONS

GEO 271: QUANTITATIVE TECHNIQUES IN GEOGRAPHY I

TIME: Three hours

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

---

1. Compare and contrast the scientific and non-scientific research methodologies.

2. Explain the characteristics of a well chosen geographical research problem.

3. What are the benefits and limitations of sampling?

4. 'Focus Group Discussion (FGD) is a research instrument that requires a skilled facilitator in solving any geographical problem'. Discuss.

5. Why is it important to review literature in research?

6. Discuss the quasi experimental design as a method of evaluating impacts of developmental projects.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 381: ENVIRONMENT AND DEVELOPMENT I

TIME: Three Hours

INSTRUCTIONS: Answer questions one (1) and any other three.
All questions carry equal marks.

---

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

   (a) Particle pollution
   (b) Social and economic effects of glacier retreat
   (c) Two principal functions of Environmental Impact Assessment (EIA)
   (d) Ozone depletion
   (e) The Key concepts of Environmental Planning

2. The type or level of water pollution in a city varies largely depending on the charactersitcis of the city. Discuss.

3. Without green house gases (GHGs) the world would be about 33 °C colder, so in this sense GHGs are life supporting. The issue is not their presence but the level of concentration. Explain.

4. Why does the sustainable development approach look at the issue of environment and development as an interlocking crisis?

5. Of the 6.4 billion global population, only 20% live in absolute wealth, while the majority live on less than a dollar per day. State the ecological implications of this scenario.

6. In what ways and to what extent are environmental problems caused by lack of adequate development.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 481: ENVIRONMENT AND DEVELOPMENT II

TIME: Three hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks.

---

1. Most of the anthropogenic emissions of carbon dioxide to the atmosphere during the last 20 years is due to burning of fossil fuels. The rest of the anthropogenic emissions are predominantly due to land-use change, especially deforestation. Analyse.

2. 'The irreversibility of an environmental impact is not a function of the type of impact.' Discuss.

3. Why is domestic sewage, fertilisers referred to as non-persistent water quality pollutants and what could be the likely hazard if the pollution load is high?

4. Evaluate the assertion that non-adoption of technology, especially of many environmental management strategies, by farmers is quite rational from their point of view.

5. 'The most pressing urban problems in the developed world are related to high levels of consumption while those in the cities of the developing world are related to unsustainable high population growth rates'. Use this assertion to evaluate the assumption that poverty causes environmental degradation.

6. The effectiveness of modern systems of environmental governance in achieving the transition to sustainability is explored in a variety of research projects, organized in four research clusters. Outline the four clusters.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 915: MEDICAL GEOGRAPHY

TIME: Three hours

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

---

1. Identify and explain the socio-cultural factors associated with the diffusion of diseases.

2. 'As human beings strive to improve their well-being through development, they create environments that make them vulnerable to diseases'. Discuss.

3. Elucidate how environmental factors affect the occurrence, spread and control of communicable diseases.

4. Discuss the assertion that 'Cardiovascular and Carcinomas illnesses are associated with the advancement in age'.

5. Explain the statement that 'the number of patients who obtain admission to a hospital is but a part of the total that is mentally ill' (Eberhardt and Krakower, 1960).

6. Nutrition has a cardinal role in one's good or ill health. Explain.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 931: RURAL GEOGRAPHY

TIME: Three Hours

INSTRUCTIONS: Answer any four questions. The use of a Philips' University Atlas is allowed and candidates are advised to make use of illustrations and examples wherever appropriate.

---

1. Show how land use has changed overtime from the simple to the complex in Africa.

2. Evaluate the view that peasants in sub- Saharan Africa are still in the making and are not captured by other social classes.

3. How should some female farmers be empowered in order to promote agricultural development in Africa?

4. With the aid of a diagram, describe Von Thünen's model of land use and show its applicability to Zambia.

5. Explain the factors account for the location of rural settlements in Africa?

6. 'Water is life'. Comment on this statement with respect to the provision of water and sanitation in rural Zambia.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 951: CLIMATOLOGY

TIME: Three hours

INSTRUCTIONS: Answer any Four questions.

All questions carry equal marks. Candidates are advised to make use of illustrations and examples wherever appropriate.

---

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

   a) Jet stream
   b) Conservation of absolute angular momentum
   c) Radiant energy
   d) Atmospheric 'window'
   e) Chlorofluorocarbons

2. With the aid of a labelled diagram, describe the Earth's radiation and energy balance.

3. Define boundary layer climates and discuss their spatial and temporal scales of measurement including areas of application of such knowledge.

4. Compare and contrast mid-latitude and tropical weather systems.

5. "Air pollution control must be a preventive rather than a remedial technology" (Oke, 1987: 306). Discuss.

6. Outline and describe the methods of assessing climate change and variability.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 961: SOILS GEOGRAPHY

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 advised to use illustrations and examples wherever appropriate.

---

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

   (a) Vertisols of the Kafue Flats
   (b) Types of soil horizons and their characteristics
   (c) Leaching and enrichment
   (d) Forms of soil moisture
   (e) Intrazonal soils

2. With the help of examples, explain how soil physical properties are the most important to a farmer.

3. With reference to Zambia, describe lithosols commenting on their characteristics, distribution and their value to humans.

4. 'Soils form as a result of complex interactions between a number of factors.' Discuss.

5. Demonstrate the ways in which soil profiles respond to different climates.

6. Outline and discuss what a geographer can learn about a soil from its colour.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 971: AERIAL PHOTOGRAPHY AND AIR PHOTO INTERPRETATION PAPER I

TIME: THREE HOURS

INSTRUCTIONS: ANSWER QUESTION ONE AND ANY OTHER THREE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

---

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

   (a) Central projection.
   (b) Ground control points.
   (c) Principal point.
   (d) Differential parallax.
   (e) Probabilistic interpretation.

2. Define the term 'effective area', and illustrate its significance in aerial photography.

3. Elucidate the assertion that aerial photography and aerial photo interpretation is a tool and not an application.

4. Using a dynamic environmental process, outline and explain at least five (5) advantages and disadvantages of using: (a) field observations; and, (b) conventional aerial photography.

5. What is flight planning, and why is it important in aerial photography?

6. Provide an illustrative algorithm showing how you would use aerial photointepretation to provide an explanation of vegetation cover.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 58001: THE HISTORY AND DEVELOPMENT OF GEOGRAPHY

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.

---

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

   (a) Universal Geography
   (b) German Geography during the Hitler period (1933- 1939)
   (c) Geography during the contemporary period
   (d) John Brunhe's contributions to the development of Geography
   (e) The highlights of Edrisi's book entitled 'Amusement for him who desires to travel around the world' published in 1154.

2. Pattison (1964) proposed four major traditions in geography. With the help of examples, outline and discuss each one of the four traditions.

3. 'Geographical thinking is older than the term 'Geography' which was first used by scholars at the museum in Alexandria at about 300 B.C.' Discuss.

4. 'The Second World War was a shattering experience for all those who were directly involved and the repercussions of that experience have changed the quality of life all over the world.' Discuss this statement in relation to world scholarship in Geography.

5. Outline and discuss the characteristics of post-modern British Geography.

6. Discuss the major characteristics of Soviet Geography from the 1930s to the 1960s.

END OF EXAMINATION

The University of Zambia

School of Natural Sciences

Department of Mathematics and Statistics

2007 Academic year

First Semester Examinations

M111 Mathematical Methods I

Time Allowed: Three (3) Hours **3rd September 2007**

Instructions:

1. You must write your **Computer Number**, Your **TG Number** on each answer booklet used.
2. Indicate the number of each question attempted in the first column on the main booklet
3. There are **six (6)** questions in this paper. Candidates must answer any **five (5)** questions only. All questions carry equal marks.
4. No **Calculators** to be used

1. (a) (i) Show that $2.5\overline{17}$ is a rational number

(ii) Given that $z = \frac{\sqrt{3}+i}{1-i}$, find $z^2 - \frac{1}{z^2}$ giving the answer in the form $a+ib$, where a and b are real numbers

(b) Let $f(x) = x^2 - 4x - 5$

(i) Is the function f, even or odd or neither?. Justify your answer.

(ii) Find the minimum or maximum value of f

(iii) Find the values of x for which $f(x) > 0$

(iv) Sketch the graph of f

(c) (i) Find the solution to the equation $2\sin^3 x - \sin x = 0$, $0 \le x < 2\pi$

(ii) Find $\frac{dy}{dx}$, given that $y = \sqrt{x^2-1}\sec x$

2. (a) Let $f(x) = \cos(2x - \pi)$, $0 \le x < 2\pi$

(i) Sketch the graph of f(x)

(ii) Find the values of x for which $f(x) = \frac{\sqrt{3}}{2}$

(b) Simplify the following as much as possible where A and B are any sets

(i) $(A \cup B) \cap (A \cup B')$

(ii) $[A' \cup (A \cap B)']'$

(c) (i) Find the derivative from first principles of $f(x) = \frac{1}{\sqrt{3x-1}}$

(ii) Prove that $\tan(x - \frac{\pi}{4}) = \frac{\tan x - 1}{\tan x + 1}$

3. (a) (i) Find the set of values of x for which $\frac{1+x}{1-x} > \frac{2-x}{2+x}$

(ii) Find the derivative from the first principles of $f(x) = \frac{1}{x-1}$

(b) (i) The complex numbers z_1 *and* z_2 are given by $z_1 = 2+3i$ and $z_2 = 3-2i$ $z_2 + (p+iq)z_1 = 1$ where p and q are real numbers, find the values of p a

(ii) Find $\frac{dy}{dx}$, if $y = x^{\frac{3}{2}} - 3x^{\frac{2}{3}}$

(c) Given the polynomial $p(x) = 2x^3 + x^2 - 5x + 2$

(i) Find all rational roots of the polynomial equation $p(x) = 0$

(ii) Find the range of values of x for which $p(x) \leq 0$

4. (a) Let f be given by $f(x) = \frac{25}{3x-2}$, find the following

(i) The domain and range of f

(ii) The inverse function of f

(iii) The solution of the equation $(fog)(x) = \frac{2}{x-1}$ where $g(x) = x+1$

(b) (i) Given that $y = \sec x + \tan x$, prove that $\frac{dy}{dx} - y\tan x = 1$

(ii) Given that $x-k$ is a factor of $p(x) = kx^3 - 3x^2 - 5kx - 9$, and $k \in R$, find possible values of k.

(c) (i) Given that $\sqrt{2}$ is an irrational number, prove that $\frac{1}{\sqrt{2}+1}$ is an irrational number.

(ii) Let $u = [-5,5]$ be the universal set, $A = (-2,1]$, B = [0 , 5] and C =(-3, 2). $A \cup (B' \cap C)$ and illustrate your answer on the number line.

(iii) On the same axis sketch the graphs of $f(x) = |3x+1|$ and $h(x) = |2-x| -$

5. (a) (i) Given that the roots to the equation $2x^2 - 3x + 2 = 0$ are denoted by α and β. Without solving for α and β, find the quadratic equation whose roots are $\frac{1}{\alpha\beta}$ and $\frac{1}{\alpha+\beta}$.

(ii) Find the derivative of $y = \frac{x^2 - 1}{x^2 + 1}$

(b) Let $f(x) = \frac{1}{x^2 - x - 2}$

(i) Find the domain and range of f

(ii) Find the vertical and horizontal asymptotes (if any)

(iii) Sketch the graph of f

(c) Let $f(x) = \begin{cases} 2x+1, & if\ x \le -1 \\ x^2 - 2 & if\ x > -1 \end{cases}$

(i) Is the function f(x) continuous at x = -1 ? Justify your answer,

(ii) Find $\lim_{x \to 2} f(x)$

(iii) Sketch the graph of $f(x)$

6. (a) Given $f(x) = (x - \alpha)(x - \beta)$, $\alpha > \beta > 0$. Sketch on separate diagrams; indicate the coordinates at which each curve meets the coordinate axes.

(i) $y = f(x)$

(ii) $y = -f(x + \alpha)$

(b) Let $f(x) = 2\sin(\pi - 2x)$

(i) Find the period, amplitude and phase shift of f(x)

(ii) Sketch the graph of f(x) , $0 \le x < 2\pi$

(c) Let an operator * on a set of real numbers be defined as follows $a * b = b^2 - a^2$, for any $a, b \in R$.

(i) Is * a binary operation on R ? Justify your answer

(ii) Compute 2*(3*(-2))

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

M231 : REAL ANALYSIS I
TIME : THREE HOURS
INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS

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1. (a). (i). Define a relation from a set A to a set B.
(ii). Define a function from a set A to a set B.

(b). Given the sequence $\{1, \frac{1}{2}, \frac{1}{3}, \frac{3}{4}, \frac{1}{5}, \frac{5}{6}, \frac{1}{7}, \frac{7}{8}, \frac{1}{9}, \frac{9}{10}, \ldots\ldots\}$
Determine two convergent subsequences and find their limits.

2 (a). Let $a, b, c \in \boldsymbol{R}$. Prove the following:
(i). If $a > b$ and $b > c$ the $a > c$.
(ii). Exactly one of the following holds:
$a > b;\ a = b;\ a < b$
(iii). $a \geq b$ and $b \geq a \Rightarrow a = b$

(b). Let $a, b \in \boldsymbol{R}$
(i). If $\forall \varepsilon > 0,\ a < b + \varepsilon$, prove that $a \leq b$
(ii). If $a > b$ show that $a > \frac{1}{2}(a+b) > b$

3. (a). Let $(\boldsymbol{F}, +, ., P)$ be a totally ordered field and $S \subset \boldsymbol{F}$

(i). Define a least upper bound of S.
(ii). If u is the least upper bound of S show that if
$x \in \boldsymbol{F}$ and $x < u$ then there exists $s \in S$ such that
$x < s \leq u$

(b). Prove that the subset of positive integers $\boldsymbol{N}$ has no upper bound in the field $(\boldsymbol{R}, +, ., P)$; i.e. prove that if $x \in \mathbf{R}$, $x > 0$ then there exists $n \in \boldsymbol{N}$ such that $n > x$.

4. (a). Define the following:

(i). a sequence in $\boldsymbol{R}$
(ii). a bounded sequence in $\boldsymbol{R}$
(iii). a convergent sequence in $\boldsymbol{R}$

(b). If $a \in \boldsymbol{R}$, and $|\ a\ | < 1$, prove that the sequence $\{a^n\}_{n=1}^{\infty}$ is convergent.

5. (a). Let $\{x_n\}_{n=1}^{\infty}$ be a sequence in $\boldsymbol{R}$

(i). When is the sequence said to be monotone increasing?
(ii). When is the sequence said to be monotone decreasing?
(iii). Suppose the sequence is monotone decreasing and bounded. Show that $\lim_{n\to\infty} x_n = g.l.b.\{x_n : n \in \mathbf{N}\}$

(b). Let $y_n = \left(1+\frac{1}{n}\right)^{n+1}$ for each $n \in \boldsymbol{N}$. Show that the sequence $\{y_n\}_{n=1}^{\infty}$ converges.

6. (a). Let $\{x_n\}_{n=1}^{\infty}$ be a sequence in $\boldsymbol{R}$.

(i). When is the sequence called a Cauchy sequence?
(ii). Suppose the sequence is a Cauchy sequence. Show that it is convergent.

(b). For each $n \in \mathbf{N}$, *Let* $x_n\ 1-\frac{1}{2}+\frac{1}{3}-\frac{1}{4}+\ .....+\frac{(-1)^{n+1}}{n}$
Prove that $\{x_n\}_{n=1}^{\infty}$ is a Cauchy sequence in $\boldsymbol{R}$.

7. (a). Suppose $|\ a\ | < 1$. Prove that the sequence $\{na^n\}_{n=1}^{\infty}$ converges to zero.

(b). If $\sigma > 0$, show that $\lim_{n\to\infty} \frac{\log n}{n^{\sigma}} = 0$

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

M 331 REAL ANALYSIS III

TIME ALLOWED: Three (3) hours

INSTRUCTIONS: 1. Answer Any **Five (5)** Questions.
2. All question carry equal marks.
3. Indicate the **Question Number** of the question answered on the main answer booklet.

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1. (a) Define the each of the following:
   (i) Neighborhood of a point;
   (ii) Interior point of a set;
   (iii) Exterior point;
   (iv) Open set;

   (b) Prove each of the following:

   (i) If E° is the interior of the set E and if $G \subset E$ and G is open then $G \subset E^\circ$.
   (ii) Every open set G is a union of open intervals.
   (iii) The set of boundary points of an open set is closed.

   (c) Give an example to show that the intersection of an arbitrary family of open sets is not open.

2. (a) What is meant by each of the following:
   (i) Limit point of a set
   (ii) A set which is dense in itself;
   (iii) Closed set.

   (b) Prove each of the following:
   (i) Every bounded infinite set of real numbers has at least one limit Point;
   (ii) For any set S, its derived set is a closed set.

   (c) Find the derived set for each of the following sets:

$$S_1 = \left\{1{,}1 + \frac{(-1)^n}{n} : n \in \mathbf{N}\right\}; \quad S_2 = \left\{1 - \frac{10}{n} : n \in \mathbf{N}\right\}; \; S_3 = \left\{\frac{m}{n} : m, n \in \mathbf{N}\right\}.$$

3. (a) What is meant by each of the following:

(i) Open cover of a set;
(ii) Compact set.

(b) Prove that every subset of a compact set is compact.

(c) Prove that the segment $(0,1)$ of $\mathbf{R}$ is not compact.

4. (a) Explain what is meant by the following:

(i) Two sets are separated;
(ii) A set is disconnected.

(b) Prove the each of the following:

(i) If the closed set F is the union of two separated sets A and B, then A and B are closed.
(ii) If two connected sets are not separated, then their union is connected.

(c) Prove that the real line is connected.

5. (a) (i) Define continuity of a function f at a point p of a metric space X.

(ii) When is a function f that maps a metric space X into a metric space Y said to be uniformly continuous on X.

(b) Prove that if f is a continuous mapping of a compact metric space X into metric space Y then $f(X)$ is compact.

(c) Prove that if f is a continuous function defined on a closed interval $[a,b]$, then f is uniformly continuous.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

M335: TOPOLOGY

TIME: Three (3) Hours

INSTRUCTIONS: Answer any four (4) questions out of five questions. Full credit will only be given when all necessary steps are shown.

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1. (a) Define the following:

   (i) Inverse image of a set.

   (ii) An equivalent relation.

   (iii) Metric space.

   (b) Prove the following:

   (i) The interior of a set in a topological space is an open set.

   (ii) If B and D are two subsets of a topological space $(X, £)$, then $\text{int}(B \cap D) = \text{int}(B) \cap \text{int}(D)$.

   (iii) A function $f : (X, £_x) \to (Y, £_y)$ is continuous if and only if for each $E \in £_y \Rightarrow f^{-1}(E) \in £_x$.

   (c) Let $f(x) = |2 - x| - 1$.

   (i) Find the domain and range of f.

   (ii) Find $f(A \cup B)$, where $A = (-2, 1]$ and $B = [-1, 3]$.

   (iii) Find $f^{-1}(D \cup H)$, where $D = (-1, 1)$ and $H = (1, 3)$.

(a) Define the following:

(i) An open sphere.
(ii) An open set in a metric space.
(iii) Limit point of a set in a metric space.

(b) Prove the following:

(i) The image of a compact set under a continuous function is compact.

(ii) If $f: [a,b] \to \mathbf{R}$ is a continuous function and $f(a) \neq f(b)$, then for each $y \in \mathbf{R}$ in between $f(a)$ and $f(b)$, $\exists\ x \in [a,b]$ such that $f(x) = y$.

(iii) If $f: (X, \pounds_x) \to (Y, \pounds_y)$ is one-one, onto and continuous function, when X is compact and $(Y, \pounds_y)$ is a Hausdorff space, then f is a homeomorphism.

(c) Let $A = \{1,2,3,4,5\}$ and $\pounds = \{ \phi, \{2\}, \{5\}, \{1,2\}, \{2,5\}, \{1,2,5\}, \{1,2,3,4\}, A \}$.

(i) Find interior of $B = \{1,2,3,5\}$.
(ii) Find closure of $D = \{2,3,4\}$
(iii) Find the boundary points of B, given in (i) above.
(iv) Find the derived set of B, given in (i) above.
(v) Is the topological space $(A, \pounds)$ connected? Justify your answer.

(a) Define the following:

(i) Neighbourhood in a metric space.
(ii) Topological space.
(iii) An interior point in a topological space.

(b) Prove the following:

(i) Each closed subset of a compact topological space is compact.

(ii) The image of a connected set under a continuous function is connected.

(iii) If topological spaces $(A, \pounds_1)$ and $(B, \pounds_2)$ are homeomorphic, then A is compact if and only if B is compact.

(c) (i) Given a non-empty set A and two metrices d_1 and d_2 on A, i.e. (A, d_1) and (A, d_2) are metric spaces. Is (A, d^*) a metric space if $d^*(a,b) = d_1(a,b)\, d_2(a,b)$ for any $a,b \in A$. Justify your answer.

(ii) If $\{A_\lambda : \lambda \in \Omega\}$ is an indexed collection of sets and B is any set, prove that

$$B \cap \left(\bigcap_{\lambda \in \Omega} A_\lambda \right)' = \bigcup_{\lambda \in \Omega} \left(B \cap A_\lambda' \right).$$

4. (a) Define the following:

(i) The closure of a set in a topological space.
(ii) A boundary point of a set.
(iii) Continuity of a function at a point.

(b) Prove the following:

(i) If (A,d) is a metric space, and x_0 is a limit point of $E \subset A$, then every neighbourhood of x_0 contains infinitely many points of E.

(ii) If $f: A \to B$ is a function, D_1 and D_2 subsets of B, then $f^{-1}(D_1 \cap D_2) = f^{-1}(D_1) \cap f^{-1}(D_2)$.

(iii) If $£_1$ and $£_2$ are topologies on a set A, then their intersection is a topology on

(c) (i) For any points $P_1(x_1, y_1)$ and $P_2(x_2, y_2)$ in $\mathbf{R}^2$ define $d(P_1, P_2) = ½ \max \{ |x_1 - x_2|, |y_1 - y_2| \}$. Sketch the graph of $S_r(P)$, where r and $P = (1, -2)$.

(ii) Let $A = \{a,b,c,d,e,f\}$
and $£ = \{ \phi, \{d\}, \{d,e\}, \{a,d,e\}, \{b,c,d\}, \{b,c,d,e\}, A \}$
if $D = \{a,b,c,e\}$ find the relative topology on D.

(iii) Is the relative topology in (ii) above connected? Justify your answer.

5. (a) Define the following:

(i) A homeomorphism.
(ii) Subspace of a topological space.
(iii) Compact topological space.

(b) Prove the following:

(i) The intersection of any finite number of open sets in a metric space is open.
(ii) An open sphere in a metric space is an open set.
(iii) The union of any finite number of closed sets in a topological space is closed.

(c) (i) If $(X, £_x) \sim (Y, £_y)$ means that $\exists$ a homeomorphism from $(X, £_x)$ to $(Y, £_y)$. Is $\sim$ an equivalence relation? Justify your answer.

(ii) If $A = \{1,2,3,4,5,6\}$, $B = \{a,b,c\}$.

$£_A = \{ \phi, \{1\}, \{5,6\}, \{1,5,6\}, \{2,3,4\}, \{1,2,3,4\}, \{2,3,4,5,6\}, A \}$.
$£_B = \{ \phi, \{a\}, \{b\}, \{a,b\}, \{b,c\}, B \}$. Let $f: (A, £_A) \to (B, £_B)$
where $f(1) = f(4) = c$, $f(2) = f(3) = b$, $f(5) = f(6) = a$.
Is f continuous? Justify your answer.

END OF EXAMINATION.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2007 ACADEMIC YEAR

FIRST SEMESTER EXAMINATIONS

M361 – MATHEMATICAL STATISTICS

INSRUCTIONS: (i) Answer any **Three (3)** questions.
(ii) All questions carry equal marks.
(iii) Show all essential steps to gain full marks.
(iv) Statistical tables will be provided and use of calculators is allowed.

TIME ALLOWED: **Three (3)** hours.

Q1. (a) Define the following terms:

(i) The cumulative distribution function $F_x(x)$ of a random variable X

(ii) Moment generating function (mgf) of a random variable X

(iii) Jacobian transformation $(x,y) \rightarrow (u,v)$

(b) (i) Consider a continuous random variable X, and let $Y = X^2$. Find $f_y(y)$

(ii) Suppose that $F_X(x) = 1 - e^{-2x}$, $0 < x < \infty$, and consider $Y = e^X$. Find $f_y(y)$

(c) (i) Let $X_1, X_2, X_3, ..., X_{10}$ be a random sample of size $n = 10$ from an exponential distribution with mean 2. Find the moment generating function of $Y = X_1 + X_2 + ... + X_{10}$ and state the probability distribution of Y.

(ii) Let 3.1, 0.2, 1.6, 5.2 and 2.1 be a random sample from a Uniformly distributed density over the unknown range (a, b). Find the estimates for a and b by the method of moments.

(iii) If the joint density function of X and Y is given by $f_{x,y}(x,y) = 2e^{-(x+y)}$, $0 < x < y < \infty$, Find the joint density function of X and $X + Y$.

Q2 (a) Define the following terms:

(i) The probability distribution function of the k*th* order statistic Y_k of the random sample $X_1, X_2, X_3, \ldots\ldots\ldots, X_n$.

(ii) Likelihood function of the random sample $X_1, X_2, X_3, \ldots\ldots\ldots, X_n$ from a density $f(x,\theta)$.

(iii) An estimator

(b) Prove the following

If $X_1, X_2, X_3, \ldots\ldots\ldots, X_n$ are independent and identically distributed random variables with common distribution function $F_x(.)$, then

$$f_{y_n}(y) = n\left[F_x(y)\right]^{n-1} f_x(y),$$

where $Y_n = \max(X_1, X_2, \ldots\ldots, X_n)$

(c) Consider a random sample of size n from a distribution with density

$$f(x) = \frac{1}{x^2}, \quad 1 \le x < \infty.$$

(i) Give the joint density of the order statistics.

(ii) Give the pdf of the smallest order statistic, Y_1.

(iii) Give the pdf of the largest order statistic, Y_n.

(iv) Derive the pdf of the sample range, $R = Y_n - Y_1$

(d) The n independent and identically distributed random variables $X_1, X_2, X_3, \ldots\ldots\ldots, X_n$ each have probability density function

$$f(x,\theta) = \frac{3x^2}{\theta}\exp\left\{-\frac{x^3}{\theta}\right\}$$ where $\theta > 0$ is unknown parameter.

(i) Find the sufficient statistics for θ

(ii) Find the maximum likelihood estimator $\hat{\theta}$, of θ

(iii) Show that $\hat{\theta}$ is a consistent estimator of θ.

(iv) Find the Cramer - Rao lower bound for $\hat{\theta}$.

(v) Show that the estimator $\hat{\theta}$ is UMVUE.

Q3. (a) Define the following terms:

(i) Sufficiency
(ii) The size of a test
(iii) Most powerful test.

(b) The n independent and identically distributed random variables $X_1, X_2, X_3, \ldots\ldots\ldots, X_n$ each have probability density function $f(x,\theta) = 3\theta x^2 \exp\{-\theta x^3\}$ where $\theta > 0$ is unknown parameter.

(i) Show that this pdf satisfies the factorization criterion.
(ii) Find the sufficient for this pdf.
(iii) Determine the likelihood ratio for two values of θ, θ_1 and θ_2.
(iv) Using (iii), show that the pdf has a monotone likelihood ratio
(v) Use the Neyman-Pearson lemma to derive the form of the most powerful test of $H_0 : \theta_0 = 1$ *Vs* $H_1 : \theta_1 = 2$.
(vi) Show that this test is also the most powerful against the composite alternative hypothesis $\theta_1 > 1$.
(vii) If the size of the test is 0.05 and n = 5, determine the corresponding critical region.

(c) Let X_1 and X_2 be independent normal random variables with mean μ and variance σ^2

(i) Find the mean square error of the two estimators

$$\hat{\mu}_1 = \frac{X_1 + X_2}{2} \quad \text{and} \quad \hat{\mu}_2 = \frac{X_1 + X_2}{k}$$

(ii) Show that $\text{var}(\hat{\mu}_2) < \text{var}(\hat{\mu}_1)$.
(iii) State which of the two is a better estimator. Support your answer statistically.

Q4. (a) (i) Define the following terms:

- Asymptotically unbiased
- Consistent estimator.

(ii) State without proof the theorem concerning the theoretical lower bound for the variance of an estimator $T(X_1, X_2, ..., X_n)$ for θ based on the sample of size n.

(b) $X_1, X_2, X_3, ..., X_n$ are independent and identically distributed random variables each have probability density function

$$f(x,\theta) = \left(\frac{2x}{\theta}\right)\exp\left\{-\frac{x^2}{\theta}\right\} \quad \text{where } \theta > 0 \text{ is unknown constant.}$$

(i) Find the maximum likelihood estimator, $\hat{\theta}$ of θ.
(ii) Show that the estimator $\hat{\theta}$, is an unbiased
(iii) Find the variance, $\text{var}(\hat{\theta})$ of the estimator.
(iv) Show also that this variance is the least possible for an unbiased estimator, $\hat{\theta}$ of θ.

(c) The random variable X is uniformly distributed over the interval $(0, a)$. If $X_1, X_2, ..., X_n$ is a random sample of size n, show that $T = \max(X_1, X_2, ..., X_n)$ is

(i) an unbiased estimator
(ii) asymptotically unbiased
(iii) a consistent estimator of the parameter a

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER
FINAL EXAMINATIONS

M411: THEORY OF FUNCTIONS OF A COMPLEX VARIABLE I

TIME: Three (3) Hours

INSTRUCTIONS: Attempt any five (5) questions.

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1. (a) Let $U(x, y) = 2x - x^3 + 3xy^2$.

   (i) Show that U is a harmonic function.
   (ii) Find the harmonic conjugate $V(x, y)$ and hence express $f(x,y) = U(x,y) + iV(x,y)$ in powers of Z.

   (b) Find the center and the radius of the circle $3|z + i| = |z + 2|$.

   (c) Calculate the cuberoots of $\frac{1}{8i}$.

2. (a) Show that $\sin(x + iy) = \sin x \cosh y + i\cos x \sinh y$.

   (b) Consider the transformation

   $w = f(z) = \sin z, \quad 0 \le x < \frac{\pi}{2}$,

   if $y \ge 0$, show that $f(z)$ is a one-to-one mapping.

   (c) Compute the integral $\int_\gamma \sin z\, dz$ where γ is the line segment from $\frac{-\pi}{2} + i$ to $\pi + i$.

3. (a) Let g be a complex valued continuous function defined on the interval $[a, b]$. Prove that $\left| \int_a^b g(t)\, dt \right| \le \int_a^b |g(t)|\, dt$.

   (b) Let γ_1 be the semicircle from 1 to -1 through i and γ_2 be the semicircle from 1 to -1 through $-i$. Compute the integrals

   $$\int_{\gamma_1} \bar{z}\, dz \quad \text{and} \quad \int_{\gamma_2} \bar{z}\, dz$$

   (c) Find the principal value of $(-2 + 2i)^{1+i}$

4. (a) Find the radius of convergence.

(i) $\sum_{n=o}^{\infty} 3^n z^{2n}$ (ii) $\sum_{n=o}^{\infty} \frac{z^n}{5^n}$

(b) Let $\sum_{n=o}^{\infty} a_n (z_\alpha - z_o)^n$ be a convergent series for some $z_\alpha \neq z_o$. Show that if z is a complex number such that $|z - z_o| < |z_\alpha - z_o|$ then the series $\sum_{n=o}^{\infty} a_n (z - z_o)^n$ is absolutely convergent.

(c) Find the power series of the function $f(z) = \frac{z^2}{(4-z)^2}$ $|z| < 4$ about the origin.

5. (a) Let D be an open set containing γ and Ω where γ is the positively oriented boundary of Ω, and let f be a function defined on D.

(i) State the complex form of Green's Theorem.

(ii) If further γ is a smooth simple closed curve and both f and f' are continuous on D, show that $\int_\gamma f(z)dz = 0$.

(b) Determine the analyticity of the function $f(z) = e^{\bar{z}}$.

(c) (i) Express $\frac{1}{(z-1)(z-2)}$ into partial fractions.

(ii) Evaluate $\int_{|z|=3} \frac{\sin \pi z^2 + \cos \pi z^2}{(z-1)(z-2)} dz$.

6. (a) (i) State Morera's Theorem.

(ii) Let Ω be a domain containing a disc $D = \{z: |z| < r\}, r > o$ and define $F(z) = \int_o^z f(w)\, dw$ where $f(z)$ is continuous on Ω. If further $\int_\gamma f(z)\, dz = 0$ for every triangle contained in Ω, show that $F'(z) = f(z)$.

(b) Evaluate the limit if it exists, if it does not exist explain why.

(i) $\lim_{n \to \infty} \left(\frac{1+i\sqrt{3}}{\sqrt{5}} \right)^n$ (ii) $\lim_{z \to 0} \frac{|z|^2}{z}$

(c) Evaluate $\int_{|z|=2} \frac{e^{2z}}{(z^2-2z-3)^2} \, dz$

7. (a) (i) Find the fixed points of the function $f(z) = \frac{2i - z}{2 + 3i\,z}$.

(ii) Find a linear fractional transformation which maps the points $z_1 = -1$, $z_2 = 0$ and $z_3 = 1$ onto the points $w_1 = -i$, $w_2 = 1$ and $w_3 = i$ respectively.

(b) Let $D = \{ z : |z| < 1 \}$ be the unit disc and define the linear fractional transformation T by $T(z) = \lambda \frac{a - z}{1 - \bar{a}\,z}$ where $|\lambda| = 1$, $|a| < 1$.

(i) Show that the image of D under T is contained in D i.e. $T(D) \subset D$.

(ii) Find the inverse of T.

(c) Show that the mapping $w = f(z) = e^z$ is a conformal mapping of the region $y_o \leq \text{Im}\, z < y_o + 2\pi$, $-\infty < \text{Re}z < \infty$ of the z – plane onto the w – plane with the origin removed.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

M421 – STRUCTURE AND REPRESENTATIONS OF GROUPS

TIME ALLOWED : THREE (3) HOURS
INSTRUCTIONS : ANSWER ANY FOUR (4) QUESTIONS

---

1. (a). Define each of the following terms:

   (i). a normal series of a finite group G
   (ii). a commutator subgroup G' of a group G

   (b). (i). Let G be a finite group with normal series

   $$G = G_n \supseteq G_{n-1} \supseteq \ldots \supseteq G_1 \supseteq G_0 = \{e\}$$

   Then prove that every subgroup of G possesses a normal series.

   (ii). Let H be a subgroup of a group G such that $x^2 \in H$ for every $x \in G$. Then show that G/H is abelian.

   (c). (i). Let N be a normal subgroup of a group G such that $N \cap G^1 = \{e\}$. The prove that $N \subset Z(G)$, where $Z(G)$ denote the centre of G.

   (ii). Determine a normal series for the symmetric group S_3 of order 6.

2. (a). Define each of the following terms:

   (i). a solvable group G
   (ii). a nilpotent group G

   (b). (i). Let G contain a normal subgroup H such that both H and G/H are solvable then prove that G is a solvable group.

   (ii). Prove that every subgroup and quotient group of a solvable group Is solvable.

(c). (i). Prove that if G is a nilpotent group, then each of its subgroups and each factor group of G is nilpotent.

(i). Given that the group G with a normal subgroup N such that G/N and N are both nilpotent, is G nilpotent? Justify by an example.

3. (a). Let G denote a permutation group on the set Ω
Then give the meaning of each of the following terms:

(i). the stabilizer G_α of $\alpha \in \Omega$ in G
(ii). G is a regular permutation group

(b). (i). Show that if G is transitive on Ω, then all the stabilizers G_α, $\alpha \in \Omega$ are conjugate in G.

(ii). Prove that G is a regular permutation group on Ω if and only if for any $\alpha, \beta \in \Omega$, there exists one and only one $\sigma \in G$ such that $\alpha^\sigma = \beta$.

(c). (i). Show that if a transitive permutation group G on imprimitive on Ω, then no stabilizer G_α is maximal in G for each $\alpha \in \Omega$.

(ii). Show that if G a primitive regular permutation group of finite degree, then it is of prime power order.

4. (a). Give the meaning of each of the following terms:

(i). a matrix representation T of a group G
(ii). a kG – module M

(b). (i). Show that there exists a bijection between representations of a kG-module M representations of a fine group G with representation space M.

(ii). Confirm that irreducible kG-module M_i give rise to irreducible representations T_i with representation space M_i.

(c). Obtain a left regular representation of the symmetric group of degree 3 with elements (1), (12), (13), (23), (123), (132).

5. (a). Define each of the following terms

(i). a reducible representation T of a group G
(ii). a representation T of G is completely reducible

(b). State and prove the Mascheke's theorem for reducibility of representations.

(c). Show that the map T given by

$$T_{(g)} = \begin{pmatrix} 0 & 1 \\ -1 & -1 \end{pmatrix}$$

Is an irreducible representation over $\boldsymbol{R}$

6. (a). Define each of the following terms:

(i). the character χ of a representation T of G
(ii). the character table of a group G

(b). (i). Prove that the character χ of T is a class function on G

(ii). State the first orthogonality relations for group characters.

(c). (i). Show that the sum of squares of the degrees of characters of a finite group G equals the order of the group G.

(ii). part of the character table for the symmetric group S_3 of degree 3 is

	C_1	C_2	C_3
χ_1	1	1	1
λ_2	1	-1	1
χ_3	2`	λ	β

Find the values of λ and β

The University of Zambia
School of Natural Sciences
Department of Physics
2007 Academic Year First Semester
Final Examinations
P-191 : Introductory Physics - I

All questions carry equal marks. The marks are shown in brackets. Question 1 is compulsory. Attempt four more questions. Clearly indicate on the answer script cover page which questions you have attempted.

Time: Three hours. **Maximum marks = 100.**

Do not forget to write your computer number clearly on the answer book as well as on the answer sheet for Question 1. Tie them together!!

==========

Wherever necessary use:

$g = 9.8 m/s^2$

$P_A = 1.01 \times 10^5 N/m^2$

1 cal. = 4.18 J

$\rho_{water} = 1000 kg/m^3$

1 hp = 746W

1 Pascal =1 N/m^2

$G = 6.67 \times 10^{-11} Nm^2/kg^2$

1 metric ton = 1000 kg

Question 1: Sample answers: F (a), G (d).... etc. **DO NOT guess** the answer. For each correct answer, **2 marks** are given. For each wrong answer, **0.67** will be deducted. For no answer, zero mark. The minimum total mark for Question 1 is zero. [10 × 2 = 20]

(A) In general, during a collision between two particles:

(a) Some mechanical energy is lost.
(b) Momentum is not conserved.
(c) No mechanical energy is dissipated.
(d) Conservation of energy is violated.

(B) Mass is a scalar quantity and:

(a) Is always constant.
(b) May vary in magnitude.
(c) Is the same as weight.
(d) Depends on the size of the body.

(C) Which of the following quantities is a vector quantity?

(a) Mass.
(b) Speed.
(c) Length.
(d) None of these

(D) A man pushes horizontally to hold a large mirror of mass 10 kg against a vertical wall to keep it from sliding. If the coefficient of static friction between the mirror and the wall is 0.5. What magnitude of the push must he exert?

(a) 196 N (b) 5 N (c) 49 N (d) 98 N

(E) A 5 kg rifle fires a 20 g bullet at 1000 m/s. What is the recoil velocity of the rifle?

(a) 4000 m/s
(b) 4 m/s
(c) 40 m/s
(d) 400 m/s

(F) In order for a flywheel to be effective in its job of maintaining a constant engine speed, it must have:

(a) A large radius of gyration.
(b) A large moment of inertia.
(c) A small moment of inertia.
(d) A small radius of gyration.

(G) A ladder standing on a smooth frictionless floor and leaning against wall:

(a) Can be in equilibrium.
(b) Exerts equal normal forces against the wall and the floor.
(c) Rests in equilibrium at some inclination angle less than 45°.
(d) The ladder will slide.

(H) Work is always done on a body when:

(a) A force is exerted on it.
(b) It moves through a certain distance.
(c) It experiences an increase in energy through a mechanical influence.
(d) It experiences a force while in motion.

(I) Hooke's law states that the elongation of an elastic body is:

(a) Proportional to the square of the tension.
(b) Inversely proportional to the tension.
(c) Directly proportional to the square root of the tension.
(d) Proportional to the tension.

(J) A ballet dancer spinning his toes extends his arms so that his moment of inertia about the vertical axis of rotation increases. As a result:

(a) His angular velocity increases.
(b) His angular velocity decreases.
(c) His momentum increases.
(d) His angular momentum decreases.

ATTEMPT ANY FOUR QUESTIONS FROM BELOW:

Q.2 (a) A man pushes a Toyota pick-up truck weighing 2 tonnes from rest along a horizontal road with a steady constant force of 100 N. The resistance offered by the truck to the motion amounts to 25 N per tonne. Find the velocity of the truck at the end of one minute. (1tonne = 1000 kg) [8]

(b) A body is projected vertically upwards with an initial velocity of 28m/s. Another body is projected vertically upward 2 s after the first body with an initial velocity of 21 m/s.

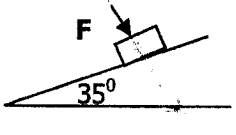
(i) Find the height to which the first body rises.

(ii) At what time after the first body is projected are the two bodies at the same height?

(iii) Find the velocity of each body at that instant in (ii). [12]

Q.3 (a) A bus travels 400 m between 2 points. It starts from rest, accelerates at 1.5 m/s^2 until it reaches a velocity of 9 m/s. It travels at this velocity for sometime. Then it decelerates at 2 m/s^2 until it comes to a stop. Find the total time of travel. [11]

(b) The coefficient of static friction between the 3.0 kg crate and the 35^0 incline in the figure below is 0.30. What minimum force **F** must be applied to the crate perpendicular to the incline to prevent the crate from sliding down the incline? [9]

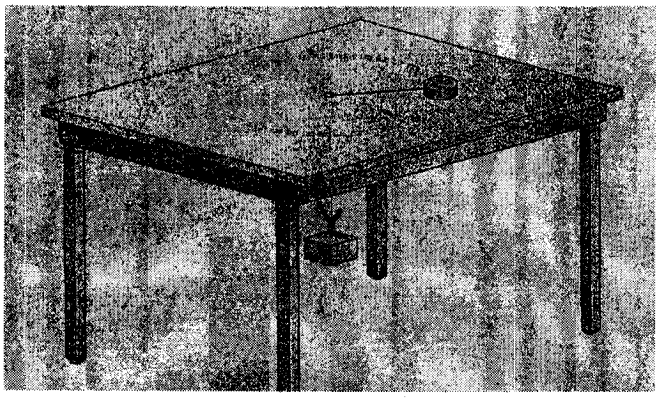


Q.4 (a) A cylindrical mass of 0.25 kg is tied to a string and allowed to revolve in a circle of radius 1.0 m on a frictionless horizontal table. The other end of the string passes through a hole in the centre of the table, and a mass of 1.0 kg is tied to it as shown below. The suspended mass remains in equilibrium while the cylindrical mass on the table top revolves.

i) What is the tension in the string?

ii) What is the horizontal force acting on it?

iii) What is the speed of the puck in m/s and in rads/s? [7]

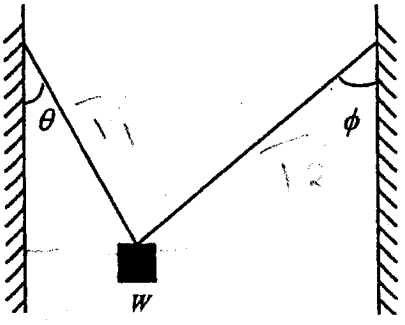


(b) A ~~0.03~~ 0.03kg bullet is fired vertically at 200 m/s into a 0.15 kg cricket ball that is initially at rest. How high does the combination rise after collision assuming the bullet embeds itself in the ball? [8]

(c) The coefficient of static friction is 0.800 between the soles of a sprinter's running shoes and the level track surface on which she is running. Determine the maximum acceleration she can achieve. Do you need to know her mass? [5]

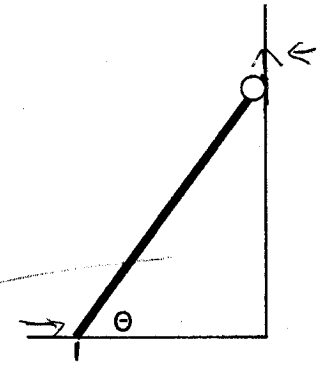
Q.5 (a) A solid sphere of moment of inertia 0.05 kg.m^2 rolls without slipping from the top of an inclined plane 3 m above ground level. Calculate the speed of the sphere at the bottom of the incline. [8]

(b) A metal block of weight W is suspended by two light strings as shown in the figure below. The block is at rest when $\theta = 36.9°$ and $\varphi = 53.1°$ with the vertical. Compute the tensions in terms of W for the left and right hand strings. [12]



Q.6 (a) An object is suspended from the ceiling of a train compartment by an inextensible wire. The object shifts through an angle of 20° when the train moves in a circular path of 200 m radius. Calculate the speed of the train. [5]

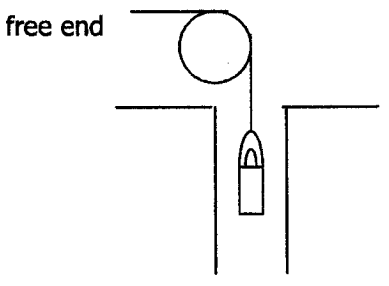
(b) A 25 kg ladder of length L leans against a vertical wall, as shown below. The upper end of the ladder has two rollers so that the wall exerts no friction in the vertical direction, but the force of friction that the ground exerts on the ladder holds the ladder in place. If the coefficient of friction between the ladder and the ground is 0.4, what is the minimum angle θ at which the ladder will remain in equilibrium? [12]



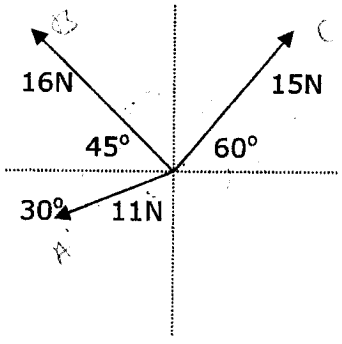
(c) A woman wearing high heeled shoes is invited to a home in which the kitchen has a vinyl floor covering (plastic mat). Why should the homeowner be concerned? [3]

Q.7.(a) A 3 kg mass slides on a frictionless surface at 40 cm/s and strikes a 4 kg mass at rest. The 3 kg mass moves off at 30 cm/s at an angle of 35° from the incident direction. Find:
i) the angle at which the 4 kg mass moves off,
ii) the speed of the 4 kg mass after impact. [11]

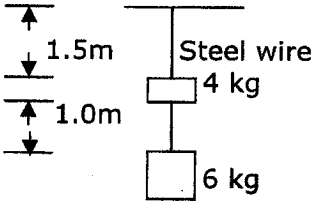
(b) A bucket of mass 8 kg is supported by a light rope wound round a solid wooden cylinder of mass 12 kg and radius 20 cm and is free to rotate about its axis. A man is holding the free end of the rope as shown below, with the bucket at rest initially, He lets go of the rope so that the bucket starts falling into a well 50 m deep as the rope unwinds. Neglecting friction, obtain the speed of the cylinder just before the bucket enters the water. [9]



Q.8 (a) Three forces in the same plane as shown in the figure act on an object. Find the magnitude and direction of the resultant. [12]



(b) Compute the elongation of the steel wire and brass wire shown in the figure below. The unloaded length of the steel wire is 1.5 m and that of the brass wire is 1.0 m. Both wires have a diameter of 0.25 cm. (Y_{steel}= 2.0 x 10^{11} N/m^2, Y_{brass}= 0.9 x 10^{11} N/m^2) [8]



END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

PHYSICS DEPARTMENT

FIRST SEMESTER UNIVERSITY EXAMINATION –SEPTEMBER, 2007

P231 (PROPERTIES OF MATTER AND THERMAL PHYSICS)

TIME : THREE HOURS **MAX. MARKS : 100**

ANSWER : ANY FIVE QUESTIONS

QUESTION 1

1. (a) Show that if a clean narrow-bore glass tube is placed vertically with one end below the surface of a liquid, the height h of the capillary ascent is given by the formula:

$$h = \frac{2T\cos\theta}{r\rho g}$$ (10 Marks)

where T is the surface tension of the liquid
g is acceleration due to gravity
r is the radius of the glass tube
θ is the angle of contact between the solid surface and the targent plane to the liquid measured through the liquid

(b) A large soap bubble of radius a contains inside it a smaller soap bubble of radius b. The smaller bubble bursts isothermally with no leakages of air from the system as a whole, and a new bubble of radius R is formed.

Show that $P(R^3 - a^3) + 4T(R^2 - a^2 - b^2) = 0$, where P is the atmospheric pressure, and T is the surface tension. (10 marks)

QUESTION 2

2. (a) Show that the bulk modulus of elasticity $K = \frac{Y}{3(1-2\sigma)}$ (10 Marks)

where Y is the Young's modulus for the material of the wire,
σ is the Poisson's ratio which in turn is defined as the ratio of lateral strain to targential strain i.e. $\sigma = \frac{\beta}{\alpha}$

(b). A wire of length 1m and diameter 10^{-3}m is stretched by 6×10^{-4}m by a load of 10kg. The wire is twisted by 70^0 by a force of 5×10^{-3} kg weight applied to each end of 0.2m length rod soldered at its mid points to the end of the wire.

(i) Calculate the Young's modulus of the material of the wire (5 Marks)
(ii) Calculate the modulus of rigidity of the material of the wire (5 Marks)

QUESTION 3

3. (a) Show that the deflection at the free end of the uniformly loaded cantilever of length l, clamped horizontally at one end, is given by $\frac{(w + \frac{3}{8}w_1)l^3}{3YIg}$ (10 Marks)

where w is the load
w_1 is the weight of the cantilever
l is the length of the cantilever
Y is the Young's modulus of the material of the cantilever
Ig is the geometrical moment of inertia of the material of the cantilever.

b) A bar of length 1m and cross section 5×10^{-3} m^2 is supported at its two ends and loaded in the middle. The depression observed in the middle is 1.96×10^{-3} m when a load of 0.1 Kg is placed. Calculate the Young's modulus of the material. $Ig = \frac{bd^3}{12}$ (5 Marks)

(c) A uniform rod of length 1 metre is clamped horizontally at one end. A weight of 0.1 kg is attached at the free end. Calculate the depression of the mid-point of the rod. (5 Marks)

The diameter of the rod is 0.02m, and $Y = 10^{10}$ N/m^2

QUESTION 4

4. (a) Explain the terms: stress, strain, Young's modulus, and bulk modulus. (5 Marks)

(b) Show that a small uniform volume strain, v, is equal to three strains each equal to $v/3$, in three perpendicular directions (along the edges of a cube). (5 Marks)

(c) Show that the bulk modulus for a gas at constant temperature (i.e. under isothermal conditions) is equal to its pressure . (10 Marks)

QUESTION 5

5. (a) Describe the statical method for determining the modulus of rigidity of a wire. (10 Marks)

(b) Show that the couple required per unit twist or the torsional rigidity of the material of a cylinder is given as: (10 Marks)

$$\tau = \frac{\pi \eta r^4}{2l}$$

where η is the modulus of the rigidity of the material of the cylinder, r is the radius of the cylinder, and l is the length of the cylinder.

QUESTION 6

6. (a) Describe the method for determining the modulus of rigidity of a wire using a torsion pendulum. (10 Marks)

(b) Show that the time period, T, of a body suspended from the wire which executes torsional vibrations about the wire as axis, i.e., of a torsional pendulum is given as:

$T = 2\pi\sqrt{\frac{I}{C}}$ where I is the moment of inertia of the body about the wire and τ the couple per unit (radian) twist of the wire. The couple per unit twist, τ, is given as :

$\tau = \frac{\pi \eta r^4}{2l}$ where η is the coefficient of rigidity of the material of the wire, r is the radius of the wire, l is the length. The angular displacement, θ, of the resulting

equation for simple harmonic motion is $\theta = \theta_o \sin\left(\frac{2\pi t}{T}\right)$ where θ_o is the amplitude and T is the period of the oscillation. (10 marks)

QUESTION 7

7. (a) Explain in details the determination of Young's modulus by Searle's method. Show that the time period of vibration of each bar is given by

$T = \sqrt{\frac{2lI}{\pi Y r^4}}$ from which $Y = \frac{8\pi l I}{T r^4}$ where I is the moment if inertia of the material of the wire, l is its length, r is the radius and geometrical moment of inertia, *Ig*, for the wire equals $\frac{\pi r^4}{4}$ (10 Marks)

(b) Show that Poisson's ratio of the material of the wire in terms of periods T_1 and T_2 is $\sigma = \frac{Y}{2\eta} - 1 = \frac{T_2^2 - 2T_1^2}{2T_1^2}$ (10 Marks)

== End of P-231 Examination ==

THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF PHYSICS

UNIVERSITY EXAMINATIONS, 2007

P261: Electricity and Magnetism

Answer five questions only. **Time allowed: Three (3) hours.**

Maximum marks: 100

Some constants and equations you may find useful:

1. electronic charge e = 1.6 X10^{-19} Coul.
2. molar mass for copper M =63.5 g/mol
3. Avogadro's number N_A = 6.02 X10^{23} /mol
4. $\int_{CS} \vec{E}.\vec{dS} = \frac{\int dq}{\varepsilon_o}$
5. $\int \vec{B}\vec{dl} = \mu_o i$
6. $\vec{B} = \frac{\mu_o i \vec{dl} \sin\theta}{4\pi r^2}$
7. $F = \frac{\mu_o I_1 I_2 l}{2\pi r}$
8. $\mu_o = 4\pi X10^{-7}$ T.m/A

Q1 (a) A circular coil of radius R is uniformly charged with a positive charge of magnitude Q, figure 1.

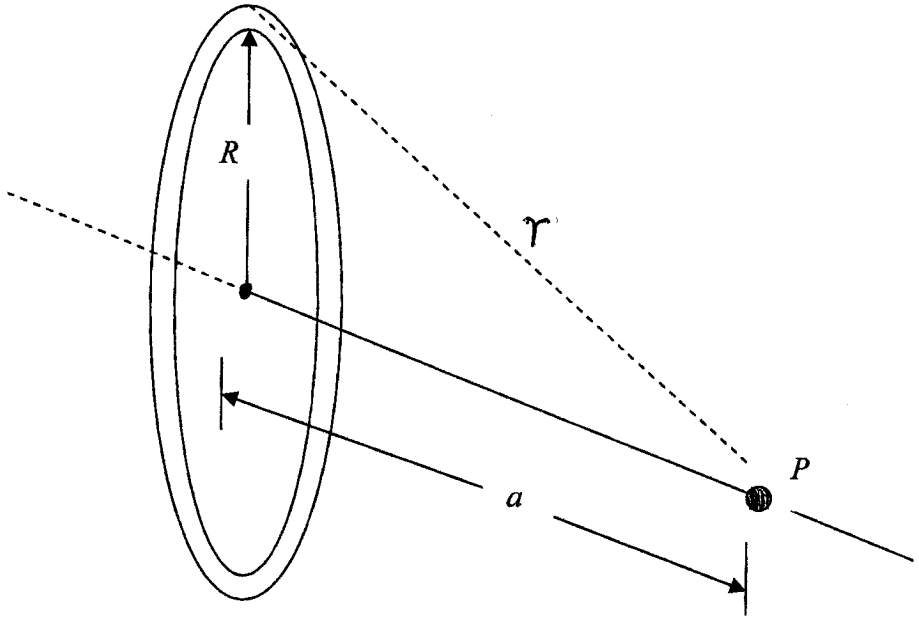


Figure 1

(i) Show that the electric field at any arbitrary point P situated a distance a from the center of the coil on the axis of the coil is given by $E = \frac{aQ}{4\pi\varepsilon_o} \frac{1}{(a^2 + R^2)^{3/2}}$ N/C

[6]

(ii) How does the field in part (a) behave in the event when $a \geq\geq R$ **[2]**

(b) A very thin disk of radius R is electrically charged with a surface charge density σ given by the expression $\sigma = Kr^2$ where K is a constant. Show that the total charge on the disk is $Q = \frac{\pi K R^4}{2}$ coul. **[4]**

A circular disk of radius R is uniformly charged and has a surface charge density σ.

i) Find the electric field intensity E at a point P situated a distance a on the central axis perpendicular to the plane of the disk. **[6]**

ii) Show that in the event when $R \geq\geq a$, the expression for the electric field assumes the form $E = \dfrac{\sigma}{2\varepsilon_o}$. **[2]**

a) A sphere of radius R in figure 2 carries a charge Q uniformly distributed in its volume V. Taking the symbol ρ for charge density, find the electric field function

(i) inside the sphere, that is when $r < R$ and

(ii) outside the sphere, that is when $r > R$ [Hint: use Gauss's law.]

[6]

) Draw a graphical plot (properly labeled) of the field variation derived in parts (a) (i) and (ii) in the intervals $0 < r < \infty$

[3]

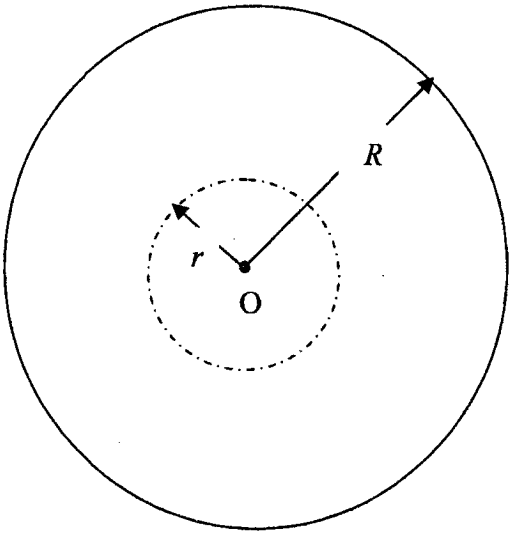


Figure 2

(c) Find the expression for the potential of the sphere in figure 2 on its surface as well as at its center. **[6]**

(d) (i) Define electric potential at a point P. [2]

(ii) If the net electric field E at a point is zero, can we conclude that the net electric potential is also zero? [2]

Q3 (a) Dielectrics are basically insulators that are used in capacitors to increase the value of their capacitance C. Describe how the capacitance increase comes about. (A diagram would be helpful here) [6]

(b) Figure 3 is a parallel plate capacitor of plate separation a. A rigid conducting slab of length b is inserted in the volume of the capacitor. The section can be moved vertically. Show that the equivalent capacitance of the whole assembly is independent of the position of the center section and is given by $C_{eq} = \frac{\varepsilon_o A}{a-b}$ [7]

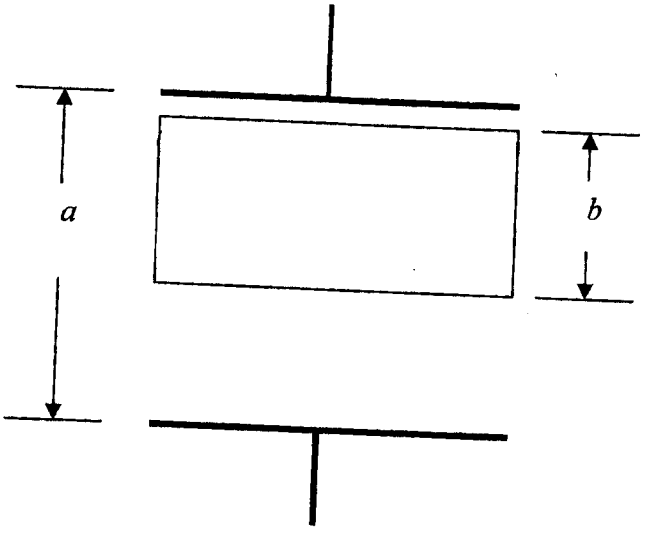


Figure 3

(c) Figure 4 is a capacitor assembly implemented with materials of dielectric constants k_1, k_2 and k_3. Show that the capacitance C of this assembly is given by $C = \frac{\varepsilon_o A}{d}\left[\frac{k_1}{2} + \frac{k_2 k_3}{k_2 + k_4}\right]$ [7]

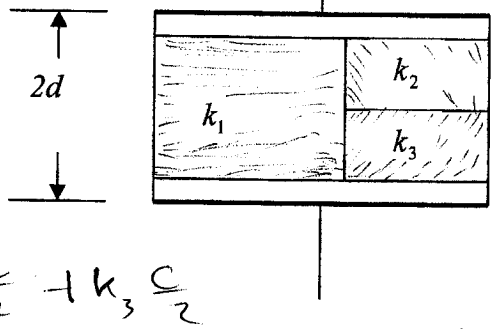


Figure 4

Q4 (a) A resistor is constructed by shaping a material of resistivity ρ into a hollow cylinder of length L with inner and outer radii r_a and r_b respectively, figure 5. When a potential difference is applied between the ends of the cylinder, a current I flows parallel to the axis.

(i) Find a general expression for the resistance R of this device in terms of R, ρ, r_a and r_b. [3]

(ii) Show that the material behaves like a solid cylinder of radius r_b when $r_b >> r_a$. [2]

(iii) Find a general expression for the resistance of the device in terms of R, ρ, r_a and r_b if the potential difference is applied between the inner and outer surfaces so that the resulting current flows radially outward. [7]

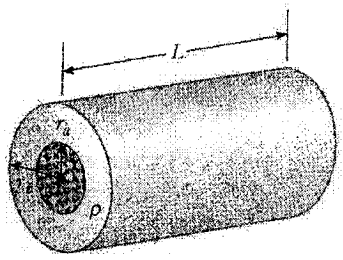


Figure 5

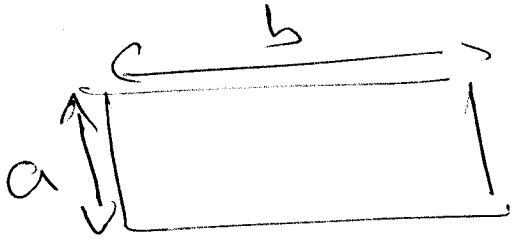
(b) (i) The drift velocity v_d of electric charge carriers in a conductor is very low, of the order of 10^{-4} m/s. However, the response of elements placed in a circuit, e.g., the electric filament lamp is almost instantaneous. Explain this paradox. **[3]**

(ii) The 12-gauge copper wire in a typical residential building has a cross-sectional area of 3.31 X10^{-6} m^2. If it carries a current of 10.0 A, what is the drift speed of the electrons in the wire? Assume that each copper atom contributes one free electron to the current. (The density of copper is 8.95 gcm^{-3}) **[5]**

Q5 (a) Discuss the significance of the equation $\int \vec{B}d\vec{S} = 0$ **[2]**

(b) (i) A rectangular loop of width a and length b is located parallel to a long wire carrying a current $I = 2$ A, figure 6. The distance between the wire and the near side of the loop is c. Find the total magnetic flux through the loop due to the current in the wire. There is no current in the loop. **[7]**

(Hint: Start with a differential flux $d\phi$ in a differential area element dA as shown in figure 6 and integrate the result).



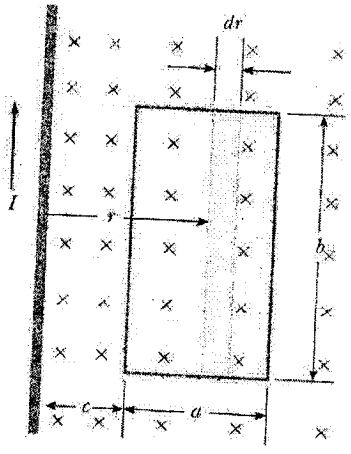


Figure 6

(ii) Supposing that the loop carries a current I_2 of 0.5 A, calculate the magnitude and direction of the resultant force on the loop given that $a = 30$ cm, $b = 50$ cm and $c = 10$ cm.

[6]

(a) Two parallel wires carry currents in opposite directions. Describe the resultant magnetic field vector created by the wires at points

$F = BIL$

(i) between the wires and

(ii) outside the wires in a plane containing them. (Hint: a diagram would be helpful here)

[3]

(iii) If a beam of electrons is not deflected in passing through a certain region of space, can we conclude that there is no magnetic field in that region?

[2]

$B \propto F$

Q6 (a) Consider a very long, thin straight wire carrying a constant current I placed along the y-axis, figure 7. Determine the **magnitude** and **direction** of the magnetic field at point P due to this current. [7]

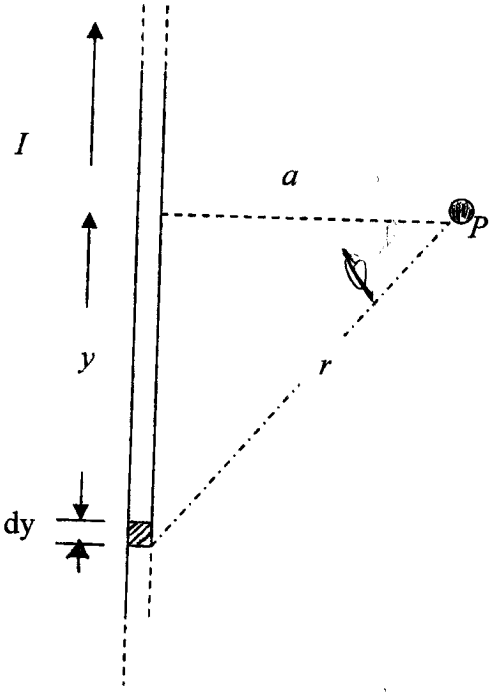


Figure 7

(b) Ampere's law in magnetic fields plays a similar role as that played by Gauss's law in electrostatics. State one similarity and one difference between the two laws. [3]

(c) A long co-axial cable consists of two concentric conductors with the dimensions shown, figure 8. There are equal and opposite currents of magnitude I in the conductors. Use Ampere's law to find

(i) The magnetic filed B at a radius $r < a$,

(ii) The magnetic field between the two conductors i.e. $a < r < b$,

(iii) The magnetic field within the outer conductor i.e. $b < r < c$ and

(iv) The magnetic field outside the cable i.e. $r > c$. [10]

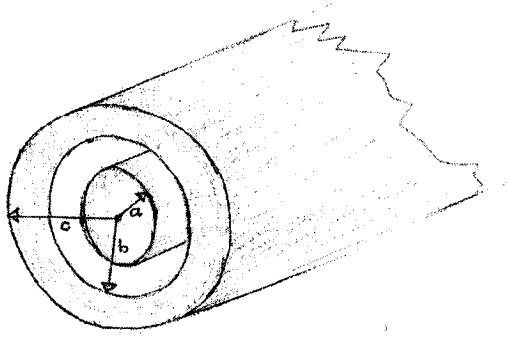


Figure 8

Q7 (a) One difference between electro-static and electro-dynamic fields is that the former are conservative while the latter are non-conservative.

(i) Explain the physical meaning of this statement. **[2]**

(ii) A 30 turn circular coil of radius 4.00 cm and resistance 2.00 Ω is placed in a magnetic field directed perpendicular to the plane of the coil. The magnitude of the magnetic field varies in time according to the expression $B = 0.010t + 0.04t^2$ tesla, where t is in seconds and B in tesla. Calculate the e.m.f induced at $t = 5.00$ secs. **[6]**

(b) Use Lenz's law to answer the following:

(i) What is the direction of the induced current in resistor R in figure 9 (a) when the magnet is moved away from the coil as shown.

(ii) What is the direction of the current induced R in figure 9(b) right after switch S is closed?

(iii) What is the direction of the induced current in R when the current I in figure 9(c) decreases rapidly to zero? **[7]**

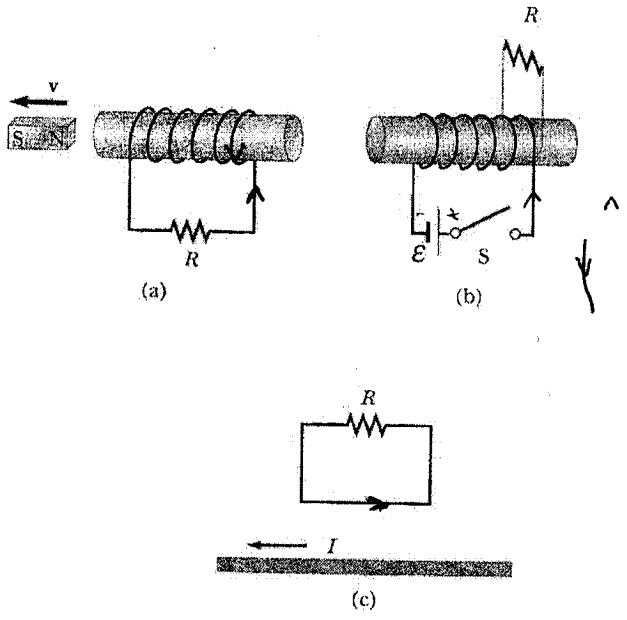


Figure 9

(c) In a 250 turn automobile alternator, the magnetic flux in each turn is $\Phi_B = (2.50X10^{-4})\cos\omega t$ T.m^2, where ω is the angular speed of the alternator. The alternator is geared to rotate three times for each engine rotation. When the engine is running at an angular speed of 1000 rev/min., determine

(i) the induced e.m.f in the alternator as a function of time;

(ii) the maximum e.m.f. in the alternator. **[5]**

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS
UNIVERSITY EXAMINATIONS
FIRST SEMESTER 2007
P351
INTRODUCTION TO QUANTUM MECHANICS

TIME: THREE HOURS

ANSWER ANY FOUR QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

TOTAL MARKS: 100

---

1. (a) A stream of particles of mass m moving from the left in a region where $V(x) = 0$ encounters a potential step at $x = 0$ of height V_0.

(i) Show that even if $E > V_0$ some particles will be reflected at the step. **[6 marks]**

(ii) Show that even if $E < V_0$, some particles will penetrate into the step. **[6 marks]**

(iii) For the case $E < V_0$ prove that the probability current density inside the barrier is zero and explain the meaning of this. **[2 marks]**

Recall that

$$j = \frac{\hbar}{2mi}[\psi^* \frac{\partial}{\partial x}\psi - \psi \frac{\partial}{\partial x}\psi^*]$$

(b) (i) The Hermitian conjugate B of an operator A is such that

$$\int \psi^* A \phi d\tau = \int (B\psi)^* \phi d\tau$$

Use this to explain what a Hermitian operator is. **[2 marks]**

(ii) Prove that the eigenvalues of a Hermitian operator are real and hence justify the importance of Hermitian operators in quantum mechanics. **[4 marks]**

(iii) Show that the Hamiltonian operator for the linear anharmonic oscillator

$$H = -\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + \frac{1}{2}kx^2 + bx^3 + cx^4$$

is Hermitian. Assume that the functions on which the operator acts vanish at $x = \pm\infty$. **[5 marks]**

2. A particle is confined in a potential of the form

$$V(x) = \begin{cases} \infty, & x \leq 0 \\ 0, & 0 < x < a \\ V_0, & x \geq a \end{cases}$$

Since the particle is confined, $E < V_0$.

(i) Sketch the potential. **[1 mark]**

(ii) Write down the boundary conditions at $x = -\infty$, $x = 0$, $x = a$ and $x = \infty$. **[2 marks]**

(iii) Show that the eigenfunctions of the particle are

$$\psi(x) = \begin{cases} 0, & x \leq 0 \\ A\sin kx, & 0 < x < a \\ D\exp(-qx), & x \geq a \end{cases}$$

and write down the expressions for k and q. **[10 marks]**

(iv) Show that the energy eigenvalues are obtained from

$$\tan ka = -\frac{k}{q}$$

[4 marks]

(v) Show that the normalized eigenfunction is

$$\psi(x) = \begin{cases} 0, & x \leq \infty \\ A\sin kx, & 0 < x < a \\ Ae^{qa}\sin ka\exp(-qx), & x \geq a \end{cases}$$

where

$$A = [\frac{a}{2} - \frac{1}{4k}\sin 2ka + \frac{1}{2q}e^{2qa}\sin^2 ka]^{-1/2}$$

[7 marks]

(vi) Calculate the probability that a position measurement finds the particle outside the well, i.e., in the region $x \geq a$. **[3 marks]**

3. (a) (i) Explain what is meant by degeneracy and justify the statement that there can be no degeneracy if a system has only one degree of freedom, i.e., only one independent variable. **[2 marks]**

(b) A system consists of three particles of masses m_1, m_2 and m_3 confined within a one dimensional box with walls at $x = 0$ and $x = L$. If the independent coordinates of the particles are x_1, x_2 and x_3 respectively,

(i) explain why inside the box the Hamiltonian of the system is

$$H = -\frac{\hbar^2}{2m_1}\frac{\partial^2}{\partial x_1^2} - \frac{\hbar^2}{2m_2}\frac{\partial^2}{\partial x_2^2} - \frac{\hbar^2}{2m_3}\frac{\partial^2}{\partial x_3^2}$$

[2 marks]

(ii) Starting from the time-independent Schroedinger equation for the system, show that the normalized eigenfunctions are

$$\psi_{n_1 n_2 n_3}(x_1, x_2, x_3) = \left(\frac{2}{L}\right)^{3/2} \sin\frac{n_1 \pi x_1}{L} \sin\frac{n_2 \pi x_2}{L} \sin\frac{n_3 \pi x_3}{L}, \quad n_1,\ n_2,\ n_3 = 1, 2, 3...$$

while the allowed energies are

$$E_{n_1 n_2 n_3} = \frac{\pi^2 \hbar^2}{2L^2}\left(\frac{n_1^2}{m_1} + \frac{n_2^2}{m_2} + \frac{n_3^2}{m_3}\right)$$

[15 marks]

(iii) Suppose that in fact $m_1 = m_2 = m_3 = m$. Deduce the degeneracies of the two lowest energy levels and give all the eigenfunctions corresponding to these energies. **[6 marks]**

4. **(a)** Explain why angular momentum is important in quantum mechanics. **[2 marks]**

(b) A system is in the angular momentum state corresponding to $l = 2$.

(i) Obtain the magnitude of the angular momentum and the possible values of its z component. **[3 marks]**

(ii) Find the angles which the angular momentum vector makes with the z axis for each of these cases. **[3 marks]**

(c) **(i)** Using Cartesian coordinates, obtain the components of the angular momentum operator

$$\mathbf{L} = -i\hbar \mathbf{r} \times \boldsymbol{\nabla}.$$

[2 marks]

(ii) Given that in spherical polar coordinates the operator for the z component of the angular momentum is

$$L_z = -i\hbar \frac{\partial}{\partial \phi}$$

show that the eigenfunctions of L_z are

$$\Phi_m(\phi) = \frac{1}{\sqrt{2\pi}} e^{im\phi}, \; m = 0, \pm 1, \pm 2, ...$$

[10 marks]

5. (a) Consider a hydrogen atom whose wave function at $t = 0$ is the following superposition of energy eigenfunctions $\psi_{nlm}(\mathbf{r}) = R_{nl}(r)Y_{lm}(\theta, \varphi)$,

$$\Psi(\mathbf{r}, t = 0) = A[2\psi_{100}(\mathbf{r}) - 3\psi_{200}(\mathbf{r}) + \psi_{322}(\mathbf{r})]$$

(i) Assuming that the parity of the spherical harmonic $Y_{lm}(\theta, \phi)$ is $(-1)^l$, what is the parity of $\Psi(\mathbf{r}, t = 0)$? **[2 marks]**

(ii) If $\Psi(\mathbf{r}, t = 0)$ is normalised, what is the value of A? **[4 marks]**

(iii) What is the probability of finding the system in the ground state $(n, l, m) = (1, 0, 0)$, in the state $(n, l, m) = (2, 0, 0)$ and in the state $(n, l, m) = (10, 5, -3)$? **[3 marks]**

(iv) In the state $\Psi(\mathbf{r}, t = 0)$, what are the expectation values of the energy E, of L^2 and of L_z? **[6 marks]**

Note that in eV, the energy of the hydrogen atom is $E_n = -13.6/n^2$.

(b) The ground state of the linear harmonic oscillator is

$$\psi_0(x) = \left(\frac{\alpha}{\sqrt{\pi}}\right)^{1/2} e^{-\alpha^2 x^2/2}$$

where $\alpha = \left(\frac{m\omega}{\hbar}\right)^{1/2}$.

(i) Given that the Hamiltonian of the harmonic oscillator is

$$H = -\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + \frac{1}{2}m\omega^2 x^2$$

show that the ground state energy is

$$E_0 = \frac{1}{2}\hbar\omega$$

[5 marks]

(ii) Show that the expectation value of the momentum vanishes. **[3 marks]**

6. (**a**) The radial function u_{El} for the hydrogenlike atom satisfies the differential equation

$$\left[\frac{d^2}{d\rho^2} - \frac{l(l+1)}{\rho^2} + \frac{\lambda}{\rho} - \frac{1}{4}\right] u_{El}(\rho) = 0,$$

where, as defined in class, $\lambda = \alpha\left(-\dfrac{\mu c^2}{2E}\right)^{1/2}$, μ is the reduced mass, $\alpha = \dfrac{e^2}{4\pi\epsilon_0\hbar c}$ and $\rho = \left(\dfrac{8\mu c^2}{\hbar^2}\right)^{1/2} r$.

(**i**) Show that the acceptable behaviour of the solution for large values of ρ is $e^{-\rho/2}$. **[5 marks]**

(**ii**) Show that the behaviour of the solution for small values of ρ goes as ρ^{l+1}. **[5 marks]**

(**iii**) Show that if we seek the solution in the form $u_{El}(\rho) = e^{-\rho/2} f(\rho)$, then $f(\rho)$ satisfies

$$\left[\frac{d^2}{d\rho^2} - \frac{d}{d\rho} - \frac{l(l+1)}{\rho^2} + \frac{\lambda}{\rho}\right] f(\rho) = 0,$$

[5 marks]

(**iv**) If we set

$$f(\rho) = \rho^{l+1} \sum_{k=0}^{\infty} c_k \rho^k,$$

we obtain the recursion relation

$$c_{k+1} = \frac{k + l + 1 - \lambda}{(k+1)(k+2l+2)} c_k.$$

Use this to prove that the energy eigenvalues are

$$E_n = -\frac{1}{2}\mu c^2 \frac{\alpha^2}{n^2}.$$

[5 marks]

(**b**) A hydrogen atom is in the state corresponding to the principle quantum number $n = 2$. Determine the degree of degeneracy of this state and enumerate, in terms of the quantum numbers, all the eigenfunctions that correspond to this value of n. You should ignore the electron spin. **[5 marks]**

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

THE UNIVERSITY OF ZAMBIA
PHYSICS DEPARTMENT
UNIVERSITY EXAMINATIONS
FIRST SEMESTER – 2007
P361 - ELECTROMAGNETISM

TIME: 3 HOURS MAX MARKS: 100

ATTEMPT ANY FOUR QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

You may use the following information:

$$\varepsilon_0 = 8.85 \times 10^{-12} \text{ farad/meter}$$
$$\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$$
$$N_a = 6.0 \times 10^{23} \text{ mol}^{-1}$$

$$\int \sec\theta \, d\theta = \ln(\sec\theta + \tan\theta)$$

The vector identities

$$\vec{\nabla} \times (\vec{\nabla} \times \vec{A}) = -\vec{\nabla}^2 A + \vec{\nabla}(\vec{\nabla} \cdot \vec{A})$$
$$\vec{\nabla} \cdot (f\vec{A}) = f\vec{\nabla} \cdot \vec{A} + \vec{A} \cdot \vec{\nabla} f$$
$$\vec{\nabla} \times (f\vec{A}) = \vec{\nabla} f \times \vec{A} + f(\vec{\nabla} \times \vec{A})$$
$$\vec{\nabla}(V\vec{\nabla}V) = (\vec{\nabla}V)^2 + V\vec{\nabla}^2 V$$

The vector $\vec{r}$ is directed from $P'(x', y', z')$ to $P(x, y, z)$. If P' is fixed and P is allowed to move, then the gradient under this condition is given by

$$\vec{\nabla}\left(\frac{1}{r}\right) = -\frac{\hat{r}}{r^2}$$

If P is fixed and P' is allowed to move, then the gradient is

$$\vec{\nabla}'\left(\frac{1}{r}\right) = \frac{\hat{r}}{r^2}$$

In spherical coordinates (r,θ,ϕ)

$$\vec{\nabla} f = \frac{\partial f}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial f}{\partial \theta}\hat{\theta} + \frac{1}{r\sin\theta}\frac{\partial f}{\partial \phi}\hat{\phi}$$

$$\vec{\nabla}^2 \equiv \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial}{\partial \theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2}{\partial \phi^2}$$

$$\vec{\nabla}.\vec{A} \equiv \frac{2}{r}A_r + \frac{\partial A_r}{\partial r} + \frac{A_\theta}{r}\cot\theta + \frac{1}{r}\frac{\partial A_\theta}{\partial \theta} + \frac{1}{r\sin\theta}\frac{\partial A_\phi}{\partial \phi}$$

$$\vec{\nabla}\times\vec{A} = \frac{\hat{r}}{r\sin\theta}\left[\frac{\partial}{\partial\theta}\left(\sin\theta\, A_\phi\right) - \frac{\partial A_\theta}{\partial \phi}\right] + \frac{\hat{\theta}}{r}\left[\frac{1}{\sin\theta}\frac{\partial A_r}{\partial \phi} - \frac{\partial}{\partial r}\left(rA_\phi\right)\right] + \frac{\hat{\phi}}{r}\left[\frac{\partial}{\partial r}\left(rA_\phi\right) - \frac{\partial A_r}{\partial \theta}\right]$$

In cylindrical coordinates (ρ,ϕ,z)

$$\vec{\nabla} f = \hat{\rho}\frac{\partial f}{\partial \rho} + \hat{\phi}\frac{1}{\rho}\frac{\partial f}{\partial \phi} + \hat{z}\frac{\partial f}{\partial z}$$

$$\vec{\nabla}\vec{A} = \frac{1}{\rho}\frac{\partial}{\partial \rho}\left(\rho A_\rho\right) + \frac{1}{\rho}\frac{\partial A_\phi}{\partial \phi} + \frac{\partial A_z}{\partial z}$$

$$\vec{\nabla}\times\vec{A} = \hat{\rho}\left(\frac{1}{\rho}\frac{\partial A_z}{\partial \phi} - \frac{\partial A_\phi}{\partial z}\right) + \hat{\phi}\left(\frac{\partial A_\rho}{\partial z} - \frac{\partial A_z}{\partial \rho}\right) + \hat{z}\left[\frac{1}{\rho}\frac{\partial}{\partial \rho}\left(\rho A_\phi\right) - \frac{1}{\rho}\frac{\partial A_\rho}{\partial \phi}\right]$$

$$\nabla^2 f = \frac{1}{\rho}\frac{\partial}{\partial \rho}\left(\rho\frac{\partial f}{\partial \rho}\right) + \frac{1}{\rho^2}\frac{\partial^2 f}{\partial \phi^2} + \frac{\partial^2 f}{\partial z^2}$$

For any arbitrary vector $\vec{A}$ and a surface S bounding a volume τ

$$\int_\tau \left(\vec{\nabla}\times\vec{A}\right)d\tau = -\int_s \vec{A}\times d\vec{s}$$

Poisson's Equation

$$\vec{\nabla}^2 V = -\frac{\rho}{\varepsilon_0}$$

For a long solenoid of length L, the magnetic induction is given by

$$B = \frac{\mu_0 NI}{L} \quad \text{inside}$$
$$= 0 \quad \text{outside}$$

The vector potential at a point due to a current carrying conductor

$$\vec{A} = \frac{\mu_0 I}{4\pi} \oint \frac{d\vec{l}}{r}$$

The magnetic induction

$$\vec{B} = \frac{\mu_0 I}{4\pi} \oint \frac{d\vec{l} \times \hat{r}}{r^2}$$

$$\vec{B} = \vec{\nabla} \times \vec{A}$$

Vector potential due to a magnetic dipole

$$\vec{A} = \frac{\mu_0}{4\pi} \frac{\vec{m} \times \hat{r}}{r^2}$$

The magnetic induction at a point on the axis of a circular current carrying loop is

$$B = \frac{\mu_0 I a^2}{2\left(a^2 + z^2\right)^{3/2}}$$

The Maxwell's Equations are

$$\vec{\nabla} \cdot \vec{D} = \rho_f$$
$$\vec{\nabla} \cdot \vec{B} = 0$$
$$\vec{\nabla} \times \vec{E} + \frac{\partial \vec{B}}{\partial t} = 0$$
$$\vec{\nabla} \times \vec{H} = \vec{J}_f + \frac{\partial \vec{D}}{\partial t}$$

Q.1 (a) The potential energy for a charge distribution is given by

$$W = \frac{1}{2}\int_{\tau} V\rho\, d\tau$$

Giving adequate reasoning, wherever necessary, use this equation to show that the energy density associated with an electric field in vacuum is given by

$$W = \frac{\varepsilon_0}{2}\int_{\tau} E^2 d\tau$$

[12 marks]

(b) A sphere of radius R has a total charge Q uniformly distributed over its volume.

(i) Obtain expressions for the electric field intensity at a point inside as well as outside the sphere. [4+2 marks]

(ii) Use the expression for the energy density derived in (a) above and the expressions for the electric field intensity obtained in (b) (i) above to show that the electric potential energy of the sphere is given by [7 marks]

$$W = \frac{3Q^2}{20\pi\varepsilon_0 R}$$

Q.2 (a) Define polarization. Briefly describe the physical mechanism underlying polarization. [2+2 marks]

(b) A block of dielectric material has a dipole moment of $\vec{P}$ per unit volume, which is a function of the position within the dielectric. Show that the electric potential due to the dielectric material at a point outside the material is the same as that due to a volume charge density and a surface charge density. Hence obtain expressions for the bound volume and surface charge densities in the dielectric. [10 marks]

(c) A long cylindrical shell has inner and outer radii of a and b respectively. The space between the two radii is filled with a class A dielectric of relative permittivity ε_r. A charge of uniform linear density λ Coulomb/meter is distributed along its axis. Using the generalized form of Gauss'law and explaining the physical concepts involved,

(i) obtain expression for $\vec{D}$ and $\vec{E}$ at a point within the dielectric.
(ii) Hence obtain an expression for $\vec{P}$ inside the dielectric.
(iii) Find the bound surface charge densities on the surfaces of the shell.

[4+3+4 marks]

Q.3. (a) State the uniqueness theorem in electrostatics and explain its significance. [5 marks]

(b) An infinite grounded metallic plate has a point charge Q placed at a distance D from it.

(i) Explain and use the method of images to obtain an expression for the electric potential V at a point due to this configuration. [6 marks]

(ii) Use the expression for V above to obtain the components E_r and E_θ of the electric field intensity. [4 marks]

(iii) Hence obtain an expression for the electric field intensity at a point on the plate. [3 marks]

(iv) Use the result in (iii) above to calculate the induced electric charge density on the plate. [2 marks]

(v) Hence show that the total charge induced on the plate is $-Q$. [5 marks]

Q.4 A conducting sphere of radius R is charged to a potential V and spun about a diameter at an angular velocity ω. Show that

(a) the surface current density is $\varepsilon_0 \omega V \sin\theta$, where θ is the spherical polar angle of a point on the surface if the axis of rotation is taken as the z-axis and the centre of the sphere as the origin. [8 marks]

(b) the magnetic induction at the centre is

$$B = \frac{2}{3}\mu_0 \varepsilon_0 \omega V .$$

[8 marks]

(c) the magnetic dipole moment is

$$\vec{m} = \frac{4}{3}\pi R^3 M \hat{k} \text{ where } M = \varepsilon_0 \omega V .$$

[9 marks]

Q.5 (a) Define self inductance and mutual inductance. [2+2 marks]

(b) Obtain an expression for the mutual inductance between two long coaxial overlapping solenoids of nearly the same radius R, lengths L_a and L_b ($L_a > L_b$) and total number of turns N_a and N_b, respectively. [8 marks]

(c) Two long rectangular loops are lying parallel to each other in the same plane. They have lengths L_1 and L_2 and widths w_1 and w_2, respectively. The loops do not overlap, and the distance between the near sides is s. Show that the mutual inductance between the loops is

$$M = \frac{\mu_0 L_2}{2\pi} \ln\left[\frac{s + w_2}{s\left(1 + \frac{w_2}{s + w_1}\right)}\right]$$

if $L_2 < L_1$ and if the loops have a single turn. Neglect end effects.

[13 marks]

Q.6 (a) Write down Maxwell's equations in vacuum in terms of the $\vec{E}$ and $\vec{H}$ vectors.

[4 marks]

(b) Show that in vacuum the electric field vector and the magnetic field vector satisfy the general wave equation. Deduce the velocity of these waves.

[6 marks]

(c) Show that plane polarized electromagnetic waves propagating in vacuum are transverse in nature.

[4 marks]

(d) Show that the $\vec{E}$ and $\vec{H}$ vectors are mutually perpendicular. [6 marks]

(e) Find the relative phases of the $\vec{E}$ and $\vec{H}$ vectors. [2 marks]

(f) Compare the energy densities associated with the electric and the magnetic fields.

[3 marks]

..... **END OF THE EXAMINATION** .....

UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS
2007 FIRST SEMESTER UNIVERSITY EXAMINATIONS

P421
SOLID STATE PHYSICS I

DURATION: Three (3) hours

INSTRUCTIONS: Answer only four (4) questions in total. *All questions carry equal marks indicated by summing up the* ***bold*** *numbers in parentheses next to problems.*

MAXIMUM MARKS: 100 %

Use, where necessary:

Electron mass, $m = 9.1 \times 10^{-31}$ kg
Electron charge, $e = 1.6 \times 10^{-19}$ C
Planck's constant, $h = 6.63 \times 10^{-34}$ J.s
Speed of light in vacuum, $c = 3.0 \times 10^{8}$ m/s
Permittivity of free space, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2.J^{-1}.m^{-1}$
Boltzmann's constant, $k_B = 1.38\ 07 \times 10^{-23}$ $J\,K^{-1}$
Atomic mass unit, a.m.u. $= 1.66 \times 10^{-27}$ kg

Reciprocal versus direct lattice vectors: $\mathbf{A} = 2\pi \dfrac{\mathbf{b}\times\mathbf{c}}{\mathbf{a}\cdot(\mathbf{b}\times\mathbf{c})}$; $\mathbf{B} = 2\pi \dfrac{\mathbf{c}\times\mathbf{a}}{\mathbf{a}\cdot(\mathbf{b}\times\mathbf{c})}$; $\mathbf{C} = 2\pi \dfrac{\mathbf{a}\times\mathbf{b}}{\mathbf{a}\cdot(\mathbf{b}\times\mathbf{c})}$

Maxwell-Boltzmann distribution law: $\langle E\rangle = \dfrac{\hbar\omega}{\exp(\hbar\omega / k_B T) - 1}$

$$\int_0^\infty \frac{x^2 dx}{e^x - 1} = \sum_{n=1}^{\infty} \frac{1}{n^2} = 1.51$$

Q1. (a). Draw two adjacent fcc unit cells and join the top and bottom face centres of each cell. Also join these four face centres to the nearest common corners. **(4)**

(i) What is the unit cell outlined by this procedure? **(2)**

(ii) Is it a Bravais lattice? **(1)**

(iii) If so, the fcc cell with a higher symmetry must be a special case of the outlined cell. Explain. **(2)**

(b). The unit cell of aluminium is fcc with lattice constant $a = 0.4049$ nm.

(i) How many unit cells are in an aluminium foil 0.005 cm thick and side 25 cm^2? **(2)**

(ii) If it weighs 8.44×10^{-3} kg, how many atoms are present? The atomic mass of Aluminium 27. **(2)**

(iii) How many atoms are there in each unit cell? **(1)**

(c). (i) Show that for a cubic lattice, the lattice constant a is given by

$$a = \left[\frac{nM_A}{N_A \rho}\right]^{1/3}$$

where n is the number of atms per unit cell, M_A is the atomic mass, N_A is the Avogadro number and ρ is the density of the crystal material. **(4)**

(ii) Zinc has hcp structure. The height of the unit cell is 0.494 nm. The nearest neighbo distance is 0.27 nm. The atomic weight of zinc is 65.37. Calculate the volume of the u cell and density of zinc. **(7)**

Q2. (a). Explain qualitatively, and if possible quantitatively, why the X-ray diffraction lin observed from small crystallites become broadened . Base the discussion on a on dimensional finite array of atoms. **(6)**

(b). (i) Set up the primitive translational vectors **a**, **b**, and **c** for a f.c.c. lattice in a convenie form and get the fundamental vectors **A**, **B**, and **C** of the reciprocal lattice. **(9)**

(ii) Show that formation of the planes bisecting the fourteen shortest reciprocal lattice vecto yields a Brillouin zone which is a trunctated octahedron. **(5)**

(iii) What is the symmetry of the reciprocal lattice so produced? **(3)**

(iv) Without making any further analysis, can you make a rapid deduction as to t reciprocal lattice of a b.c.c. lattice? **(2)**

Q3. (a). (i) Describe the salient features of covalent and metallic bonded crystals. **(6)**

(ii) Account for the difference in the physical properties of diamond and graphite in tern of the structural arrangements and bonds. **(6)**

(b). The potential energy U of NaCl can be described empirically by

$$U = -\frac{e^2}{4\pi\varepsilon_o R} + Ae^{-R/\rho}$$

where R is the internuclear separation. The equilibrium separation of the nuclei R_0 2.5 A and the dissociation energy is 3.6 eV.

(i) Calculate A and ρ/R_0, neglecting zero-point vibrations. **(8)**

(ii) Sketch U and each of the terms in U on one graph. **(3)**

(iii) Give the physical significance of A and ρ. **(2)**

Q4. (a). List six (6) salient features of the Einstein and Debye models, respectively, that make models differ from or similar to each other. **(6)**

(b). In a 3-D sample with one atom in the basis, we can approximate the dispersion relati by $\omega = vk$, where v is the speed of sound (which is the same for all directions of Assuming that all branches of the spectrum have angular frequency ω_m,

(i) show that the total number of phonons is given by

$$n_T = \frac{3V}{2\pi^2 v^3}\left[\frac{k_B T}{\hbar}\right]^3 \int_0^{x_m} \frac{x^2 dx}{e^x - 1} \quad , \quad \text{where } x_m = \frac{\hbar\omega_m}{k_B T}. \qquad \textbf{(12)}$$

(ii) Show that for $k_B T << \hbar\omega$, the total number of phonons is proportional to T^3. **(7)**

Q5. (a). What do you understand by the term **phonon**? How do you compare it with the term **photon**? **(4)**

(b). A sample contains N electrons, which behave as free particles with energy

$$E = \frac{\hbar^2 k^2}{2m^*}$$

where m^* is an effective mass. Derive formulae for the Fermi energy E_F in the following cases:

(i) The sample is one-dimensional (1-D) and is of length d. **(3)**

(ii) The sample is two-dimensional (2-D) and is of area A. **(3)**

(iii) The sample is three-dimensional (3-D) and is of volume V. **(3)**

In this problem, you may wish to note that in general, the number of k states in V_{rj} (a dimensional volume in r-space) and V_{kj} (a j-dimensional volume in k-space) is given by

$$n = \left(\frac{1}{2\pi}\right)^j V_{rj} V_{kj} \ .$$

(c). (i) In each case, show that the density of states at E_F is of the form

$$g(E_F) = \xi \frac{n}{E_F}$$

with ξ a number ~ 1 and $n = \begin{cases} N/d & (1-\text{D}) \\ N/A & (2-\text{D}) \\ N/V & (3-\text{D}) \end{cases}$ **(9)**

(ii) Hence show that irrespective of the number of dimensions, $g(E_F)$ is proportional to m^*.

Q6. (a). Describe what the Kronig-Penney model is and discuss its essential features. **(5)**

(b). Show that if, in the potential model used in connection with the Kronig-Penney calculations, V_o is allowed to become infinitely large and b is allowed to approach zero, such that the product

$$P = -\frac{\beta^2 ab}{2}$$

remains fixed, then the allowed energy values are given by the solution of equation

$$\frac{P}{\alpha a}\sin \alpha a + \cos \alpha a = \cos ka \quad . \qquad \textbf{(13)}$$

(c). Also show that this leads to allowed and forbidden energy bands. **(7)**

NB. $\alpha = \left(\frac{2m^* E}{\hbar^2}\right)^{1/2}$, $\beta = \left[\frac{2m^*(E - V_o)}{\hbar^2}\right]^{1/2}$, a and b are the widths of the quantum well and the barrier, respectively, and k the wavevector.

@@@@@@@@@@ **THE END** @@@@@@@@@@

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2007 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

P441 : Analogue Electronics II

Time : Three hours. **Maximum marks = 100.**

Attempt any four questions.
All questions carry equal marks.
The marks are shown in brackets.

Q1. **(a)** Draw the block diagram representation of a typical operational amplifier and explain the function of each block. [8]

(b) What are the characteristics of an ideal operational amplifier? [8]

(c) A Colpitt's oscillator used as the local oscillator in an AM radio receiver is to produce frequency 1MHz to 2 MHz.

(i) What must be the inductance of the coil if the minimum capacitance obtainable is 43pF? [3]

(ii) What must be the maximum value of C to produce the necessary frequencies? [3]

(iii) What frequency would be produced if this coil were used in the Hartley oscillator circuit with C=100pF? [3]

Q2. **(a)** Draw the schematic of a circuit whose output goes to $+V_{sat}$, when the input signal crosses +5V in the positive direction. Draw the corresponding input and output waveforms. [6]

(b) Draw the circuit diagram of a practical integrator and explain how it functions. [8]

(c) The frequency response of a certain operational amplifier is shown in figure 1.

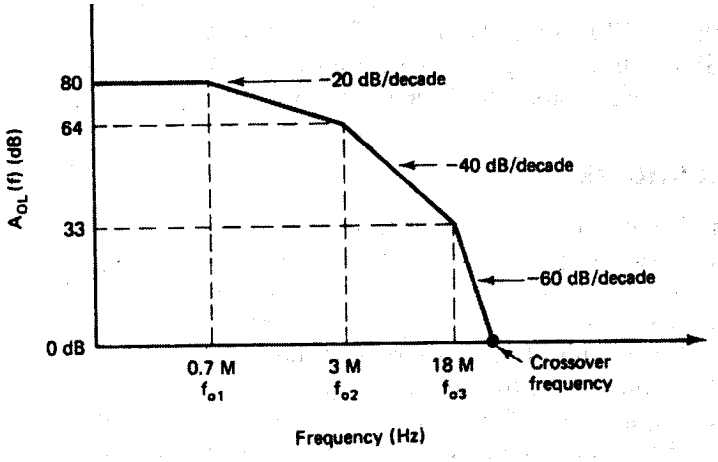


Figure 1

(i) Write the open loop gain equation for the operational amplifier as a function of break frequencies and dc gain A. Given $A=10^4$. [2]

(ii) Determine the magnitude of the open loop gain in decibels if the frequency of operation is 10MHz. [4]

(iii) What is meant by circuit stability? Explain the methods used to check the stability of a circuit. [5]

Q3. (a) Show that the bandwidth of a non-inverting amplifier with feedback is larger than that without feedback. [6]

(b) (i) With relevant circuit diagram, discuss the principle of operation of a Hartley oscillator. [11]

(ii) What is the frequency of a Hartley oscillator, if the total inductance is 100μH and the capacitance is 225 μF? [3]

(c) The following specifications are given for a certain wide band pass filter.

f_L=400Hz, f_H=1kHz and total pass band gain=1.

(i) Calculate the Q value of the filter. [2]

(ii) Calculate the magnitude of the gain in decibels at the centre frequency.[3]

Q4. (a) Explain Miller's Theorem. Show how this theorem is useful in deriving the input resistance of an inverting amplifier. [4+6]

(b) (i) What is a notch filter? Give two applications of notch filters. . [3]

(ii) Design a 400Hz notch filter with 741 operational amplifier. [7]

(c) Consider operational amplifier circuit shown in figure 2. The operational amplifier is MC1536 with the following specifications.

V_{io}= 7.5 mV (max) , I_{io}=50nA(max) and I_B=250nA (max).

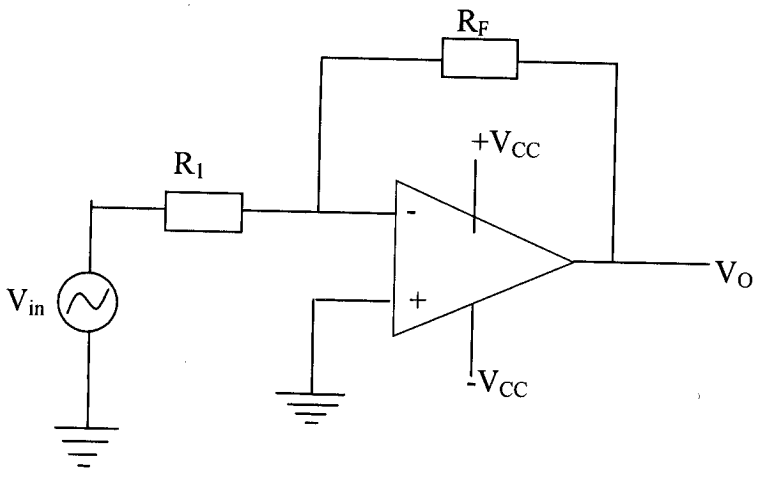


Figure 2

Compute the maximum possible total output offset voltage

(i) due to V_{io} and I_B and [2.50]

(ii) due to V_{io} and I_{io}. [2.50]

Q5 (a) Describe the working of a square wave generator with relevant diagrams. [10]

(b) (i) What is meant by slew rate of an operational amplifier? What are the causes of slew rate? [4]

(ii) Derive the slew rate equation for an operational amplifier. [5]

(c) Design a first order high pass Butterworth filter at a cut off frequency of 400Hz and a pass band gain of 3. [6]

Q6. (a) Design an input voltage compensating network for the μA 715 operational amplifier. The operational amplifier uses ±15V supply voltages and V_{io}=5mV maximum. Draw the complete circuit diagram for the operational amplifier to be used as an inverting amplifier with a gain of 4. [8]

(b) The 741C is used for the differential amplifier of figure 3 with R_1=R_2=1kΩ and R_F=R_3=10kΩ.

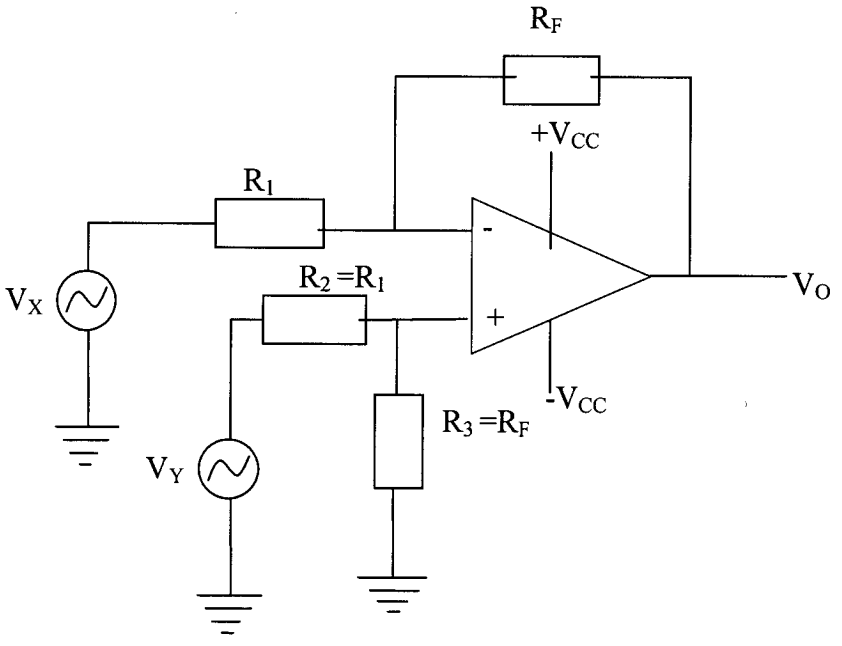


Figure 3

(i) Calculate the closed loop voltage gain. [1.50]

(ii) Calculate the input resistances assuming that the circuit is initially nulled. [2]

(iii)Compute the output voltage if V_x=-3.2V and V_y=-3V. [1.50]

Given that R_i=2MΩ, A=200,000.

(c) Write short notes on [12]

(i) Transient response
(ii) Voltage follower
(iii) Frequency scaling
(iv) CMRR

END OF P441 EXAMINATION

UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS
2007 FIRST SEMESTER UNIVERSITY EXAMINATIONS

PHY 5211
CONDENSED MATTER PHYSICS I

DURATION: Three (3) hours

INSTRUCTIONS: Answer only THREE (3) questions in total. *All questions carry equal marks as indicated by summing up the* ***bold*** *numbers in parentheses next to the problems.*

MAXIMUM MARKS: 100 %

Use, where necessary:

Reciprocal versus direct lattice vectors: $\mathbf{A} = 2\pi \dfrac{\mathbf{b}\times\mathbf{c}}{\mathbf{a}\cdot(\mathbf{b}\times\mathbf{c})}$; $\mathbf{B} = 2\pi \dfrac{\mathbf{c}\times\mathbf{a}}{\mathbf{a}\cdot(\mathbf{b}\times\mathbf{c})}$; $\mathbf{C} = 2\pi \dfrac{\mathbf{a}\times\mathbf{b}}{\mathbf{a}\cdot(\mathbf{b}\times\mathbf{c})}$

Structure factor: $S(\mathbf{k}) = \sum_j f_j(\mathbf{k}) \exp\left[i\mathbf{k}\cdot\mathbf{r}_j\right]$

Atomic form factor: $f(\mathbf{k}) = \int \rho(\mathbf{r}) \exp\left[i\mathbf{k}.\mathbf{r}\right] d^3\mathbf{r}$

Tensor transformations: $T'_{ij} = \sum_{kl} a_{ik} a_{jl} T_{kk} = \sum_k a_{ik} a_{jk} T_{kk}$

$T'_{ji} = \sum_{kl} a_{jk} a_{il} T_{kl} = \sum_k a_{jk} a_{ik} T_{kk}$

Q1. (a). There are two forms of graphite. The most common form is hexagonal graphite which has a stacking sequence A - B - A - B. The other form of graphite is rhombohedral graphite. This is based on a trigonal form which has a stacking sequence A - B - C - A - B - C.

(i) Describe the primitive unit cells for the two forms of graphite. **(8)**

(ii) How many atoms are in the primitive unit cells of graphite? **(4)**

(b). Consider the (1, 0, 0) and (0, 0, 1) planes of an f.c.c. lattice with axes described by the conventional unit cell. What are the indices of the planes when referred to the primitive axes? **(8)**

(c). The angles α_1 ($\angle \mathbf{a}_2, \mathbf{a}_3$), α_2 ($\angle \mathbf{a}_3, \mathbf{a}_1$), and α_3 ($\angle \mathbf{a}_1, \mathbf{a}_2$) between the three primitive lattice vectors of the direct lattice, $\mathbf{a}_i$, are related to the angles β_i between the three primitive lattice vectors of the reciprocal lattice, $\mathbf{b}_i$. The angles β_I are defined as β_1 ($\angle \mathbf{b}_2, \mathbf{b}_3$), β_2 ($\angle \mathbf{b}_3, \mathbf{b}_1$), and β_3 ($\angle \mathbf{b}_1, \mathbf{b}_2$) . Show that

$$\cos\alpha_1 = \frac{\cos\beta_2 \cos\beta_3 - \cos\beta_1}{|\sin\beta_2 \sin\beta_3|} \qquad \textbf{(13.3)}$$

and also the inverse relation. See figure 1 below.

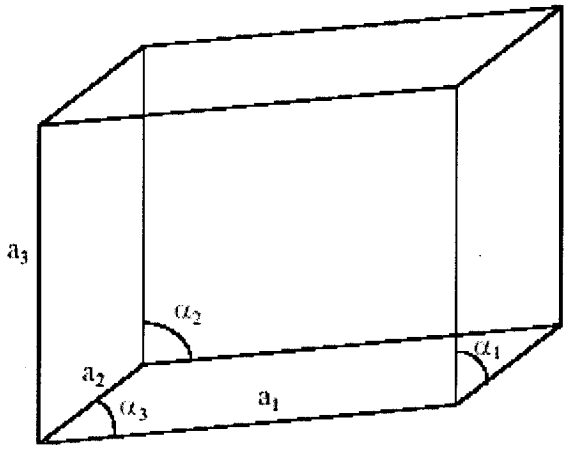


Figure 1: A primitive unit cell

Q2. (a). Calculate the structure factor for the Zinc Blende structure. The Zinc Blende structure is a face centered cubic lattice of side a, with a positively charged ion at the origin and a negatively charged ion at $\frac{a}{4}(\hat{\mathbf{x}} + \hat{\mathbf{y}} + \hat{\mathbf{z}})$. **(5)**

(b). Calculate the x-ray scattering intensities for the close-packed structures formed by stacking hexagonal layers in the following sequences:

(i) The sequence ABAB... (the h.c.p. sequence). **(6)**

(ii) The sequence ABCABC... (the f.c.c. sequence). **(6)**

(iii) The random sequence in which all the consecutive layers are di_erent, but given one layer (say A), there is an equal probability that it will be followed by either one of the two other layers. **(6)**

(c). Find the atomic form factor for the hydrogen atom using the electron density

$$\rho(r) = \frac{1}{\pi a^3} \exp\left[-\frac{2r}{a}\right]$$

where a is the Bohr radius. **(10.3)**

Q3. (a). Show that the transformation matrix

$$\mathbf{a} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & \sin\theta \\ 0 & -\sin\theta & \cos\theta \end{pmatrix}$$

has the condition $\mathbf{a}^{-1} = \mathbf{a}^{T}$. **(10)**

(b). The non-zero components of the piezoelectric tensor for a cubic crystal of point group $\bar{4}3m$ are $d_{14} = d_{25} = d_{36}$.

(i) deduce expressions for the components of the dielectric polarisation referred to the principal axes if a stress σ_3' is applied normal to the (111) plane. **(10)**

(ii) The cubic phase of ZnS (point group $\bar{4}3m$) has $d_{14} = 3.1 \times 10^{-12}$ CN^{-1}. Calculate the charges induced on a (111) plate of area 30 mm^2. **(13.3)**

Q4. (a). Consider a one-dimensional linear chain, with a unit cell composed of two atoms, one with mass M_1 and the other with mass M_2. The atoms interact with their nearest neighbors via a harmonic force, with force constant γ. Find the phonon dispersion relation. **(8)**

(b). Consider a one-dimensional line of ions, with equal masses but alternating charges, such that the charge on the n-th ion is $e_n = e\,(-1)^n$. Assume that the inter-atomic potential has two contributions:

(A) A short-ranged force between nearest neighbors with a force constant $C_1 = \gamma$.

(B) A Coulomb interaction between all the ions

$$C_n = 2(-1)^n \frac{e^2}{n^3 a^3}$$

where a is the atomic spacing.

(i) Show that

$$\frac{\omega(k)}{\omega(0)} = \sin^2\frac{ka}{2} + \sigma\sum_{n=1}^{\infty}\frac{(-1)^n}{n^3}(1-\cos kna)$$

where $\omega_0^2 = 4\frac{\gamma}{M}$ and $\sigma = \frac{e^2}{\gamma a^3}$. **(15.3)**

(i) Show that $\omega^2(k)$ becomes soft $\omega^2(k) = 0$ at $k = \tilde{\pi}/a$ if $\sigma > 4/7$. (

(ii) Show that the speed of sound becomes imaginary if $\sigma > 1/2\ln 2$ (

@@@@@@@@@ **THE END** @@@@@@@@@

UNIVERSITY OF ZAMBIA
DEPARTMENT OF PHYSICS
UNIVERSITY EXAMINATIONS
FIRST SEMESTER 2007
PHY5911
COMPUTATIONAL PHYSICS AND MODELLING

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

Useful formulas:

Inverse of a matrix

$$A^{-1} = \frac{1}{\det A} B^T,$$

where B is the matrix of the cofactors of A.

Norms of a matrix:

$$\|A\| = \sqrt{\sum_{j=1}^{n}\sum_{k=1}^{n} a_{jk}^2}$$

$$\|A\| = \max_k \sum_{j=1}^{n} |a_{jk}|$$

$$\|A\| = \max_j \sum_{k=1}^{n} |a_{jk}|$$

The trapezoidal rule:

$$\int_a^b f(x)dx \simeq \frac{h}{2}\left[f(a) + f(b) + 2\sum_{i=1}^{n-1} f(a+ih)\right]$$

Fourier coefficients:

$$\begin{aligned} a_0 &= \frac{1}{2L}\int_{-L}^{L} f(x)dx \\ a_n &= \frac{1}{L}\int_{-L}^{L} f(x)\cos\frac{n\pi x}{L}dx \\ b_n &= \frac{1}{L}\int_{-L}^{L} f(x)\sin\frac{n\pi x}{L}dx \end{aligned}$$

The QR algorithm uses:

$$C_j = \begin{bmatrix} 1 & 0 & .. & 0 & 0 & .. & 0 & 0 \\ 0 & 1 & .. & 0 & 0 & .. & 0 & 0 \\ : & : & : & : & : & : & : & : \\ 0 & 0 & : & c_j & s_j & : & 0 & 0 \\ 0 & 0 & : & -s_j & c_j & : & 0 & 0 \\ : & : & : & : & : & : & : & : \\ 0 & 0 & .. & 0 & 0 & .. & 1 & 0 \\ 0 & 0 & .. & 0 & 0 & .. & 0 & 1 \end{bmatrix}$$

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1. (a) Use Cholesky's method to solve the linear system

$$\begin{aligned} x_1 - x_2 + 3x_3 + 2x_4 &= 15 \\ -x_1 + 5x_2 - 5x_3 - 2x_4 &= -35 \\ 3x_1 - 5x_2 + 19x_3 + 3x_4 &= 94 \\ 2x_1 - 2x_2 + 3x_3 + 21x_4 &= 1 \end{aligned}$$

[25-marks]

2. (a) Show that the condition number

$$\kappa(A) = \|A\| \left\|A^{-1}\right\|$$

is a measure of the ill- or well-conditioning of a linear system. [10-marks]

(**b**) Determine whether the system with the coefficient matrix

$$A = \begin{pmatrix} 10 & 1 & 1 \\ 1 & 10 & 1 \\ 1 & 1 & 10 \end{pmatrix}$$

is well-conditioned and explain the implications of your findings. [15-marks]

3. (**a**) Locate the regions in which the eigenvalues of the matrix

$$A = \begin{pmatrix} 5 & -2 & 2 \\ 2 & 0 & 4 \\ 4 & 2 & 7 \end{pmatrix}$$

lie. [5-marks]

(**b**) (**i**) Derive the integration formula

$$I = \frac{4}{3}I_2 - \frac{1}{3}I_1$$

using the fact that the truncation error in the multiple-application trapezoidal rule is

$$E(h) = -\frac{(b-a)}{12}h^2\overline{f}''$$

where $\overline{f}''$ is the second derivative of the function to be integrated evaluated at a certain point in the interval of integration $[a, b]$. [10-marks]

(**ii**) Hence use the trapezoidal rule with $n = 2$ and $n = 4$ to obtain an estimate of the value of

$$I = \int_0^1 e^{-x^2} dx$$

[10-marks]

4.(**a**) A periodic function defined over the interval $-2 \leq x \leq 2$ is given by $f(x) = |x|$ so that

$$f(x) = \begin{cases} -x, & -2 \leq x \leq 0 \\ x, & 0 \leq x \leq 2 \end{cases} \quad \text{period } p = 2L = 4$$

(i) Show that the Fourier series representation of the function is

$$f(x) = 1 - \frac{8}{\pi^2}\left(\cos\frac{\pi x}{2} + \frac{1}{9}\cos\frac{3\pi x}{2} + \frac{1}{25}\cos\frac{5\pi x}{2} + ...\right)$$

[15-marks]

(ii) Hence prove that π can be calculated from the series

$$\pi^2 = 8(1 + \frac{1}{9} + \frac{1}{25} + \frac{1}{49} + ...)$$

[2-marks]

(b) A certain function has the following values at the indicated data points:

x_i	0	1.	1.571
$f(x_i)$	0	0.707	1

(i) Estimate the value of the function at $x = 0.6$. [5-marks]
(ii) Estimate the value of the derivative at $x = 1.2$. [3-marks]

5. (a) Give two advantages of Gauss-Legendre integration over, say, Simpson's rule. [2-marks]

(b) The two-point Gauss-Legendre quadrature formula can be derived by assuming that

$$\int_{-1}^{+1} f(x)dx = c_0 f(x_0) + c_1 f(x_1)$$

with c_0, x_0, c_1 and x_1 to be determined from the condition that the integrals of

$$f(x) = 1,\ f(x) = x,\ f(x) = x^2 \text{ and } f(x) = x^3$$

between the limits ± 1 should be given exactly by the formula.

(i) Show that the condition to be satisfied leads to the equations

$$\begin{aligned} c_0 + c_1 &= 2 \\ c_0 x_0 + c_1 x_1 &= 0 \\ c_0 x_0^2 + c_1 x_1^2 &= 2/3 \\ c_0 x_0^3 + c_1 x_1^3 &= 0 \end{aligned}$$

[6-marks]

(**ii**) Show that the solutions

$$\begin{aligned} c_0 &= c_1 = 1 \\ x_0 &= -\frac{1}{\sqrt{3}} \end{aligned}$$

and

$$x_1 = \frac{1}{\sqrt{3}}$$

satisfy these equations. [4-marks]

(**c**) (**i**) Use two-point Gauss quadrature to obtain the integral

$$I = \int_0^{\pi/2} \frac{\sin x}{x} dx$$

[13-marks]

6. (**a**) (**i**) Show that the eigenvalues of a diagonal matrix are the diagonal elements. [4-marks]

(**ii**) Show that a similarity transformation leaves the eigenvalues of a matrix unchanged. [6-marks]

(**iii**) Show that the sequence of steps in the QR algorithm corresponds to a similarity transformation. [6-marks]

(**b**) A certain matrix has been tridiagonalized to the form

$$B = \begin{pmatrix} 9 & 1 & 0 \\ 1 & 4 & 1 \\ 0 & 1 & 1 \end{pmatrix}$$

. Show how to eliminate the element b_{21} as the first step to generating the upper triangular matrix R_0. [9-marks]

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