

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS –2001/2002

FIRST SEMESTER EXAM PAPERS
SCHOOL OF NATURAL SCIENCE

1. BS 111 - Cell molecular biology and genetics
2. BS 221 - Form, function and diversity of plants
3. BS 319 - Biostatistics (Theory paper)
4. BS 321 - Evolution and Ethnology
5. BS 331 - Plant physiology (practical paper)
6. BS 351 - Entomology (Theory paper)
7. BS 361 - Molecular Biology (Theory paper)
8. BS 375 - Invertebrate Zoology (Theory paper)
9. BS 411 - Insect behaviour and ecology I (Theory)
10. BS 425 - Immunology (Theory paper)
11. BS 475 - Population ecology I
12. BS 491 - Freshwater Biology (Practical paper)
13. BS 491 - Freshwater Biology (Theory paper)
14. BS 915 - Biology of seed plants (practical paper)
15. BS 935 - Plant pathology (Theory paper)
16. C. 101 - Introduction chemistry
17. C 205 - Analytical – Inorganic chemistry
18. C 225 - Analytical Chemistry
19. C 245 - Inorganic chemistry I
20. C 251 - Organic chemistry I
21. C 311 - Biochemistry I

- 22. C 321 - Spectral analytical method
- 23. C 341 - Inorganic Chemistry II
- 24. C 351 - Organic Chemistry III
- 25. C 361 - Chemical, Kinetics and nuclear chemistry
- 26. C 411 - Advanced Biochemistry
- 27. C 421 - Applied Analytical Chemistry
- 28. C 441 - Advanced Inorganic Chemistry I
- 29. C 481 - Inorganic Industrial Chemistry
- 30. C 491 - Organic Industrial Chemistry
- 31. CAV 251 - Analytical, physical, organic chemistry
- 32. CS 3021 - Introduction to database and file systems
- 33. GEO 111 - Introduction to Human geography I
- 34. GEO 175 - Introduction to mapping techniques in Geography Paper II
- 35. GEO 211 - The Geography of Africa
- 36. GEO 271 - Quantitative techniques in Geography I
- 37. GEO 381 - Environment and development I
- 38. GEO 481 - Environmental and development II
- 39. GEO 911 - Population Geography
- 40. GEO 921 - Economic geography
- 41. GEO 951 - Climatology
- 42. GEO 955 - Geomorphology
- 43. GEO 961 - Soils Geography
- 44. GEO 971 - Aerial photography and photo interpretation (paper I)
- 45. M III - Mathematical methods I
- 46. M 161 - Introduction to probability and statistics I
- 47. M 211 - Mathematical methods III

- 48. M 221 - Linear algebra
- 49. M 225 - Introduction to mathematics Logic
- 50. M 231 - Real Analysis I
- 51. M 261 - Introduction to statistics
- 52. M 325 - Groups and Ring Theory
- 53. M 331 - Real analysis III
- 54. M 421 - Structure and representation of groups
- 55. M 431 - Real analysis V
- 56. M 461 - Multivariate analysis
- 57. M 911 - Mathematical methods V
- 58. P 191 - Introduction to physics I
- 59. P 251 - Classical mechanics I
- 60. P 261 - Electricity and magnetism
- 61. P 341 - Introduction to Electronics
- 62. P 351 - Introduction to Quantum mechanics
- 63. P 361 - Electromagnetism
- 64. P 401 - Computation Physics II
- 65. P 421 - Solid state Physics I
- 66. P 231 - Properties of Matter and Thermal Physics

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS—APRIL, 2002.

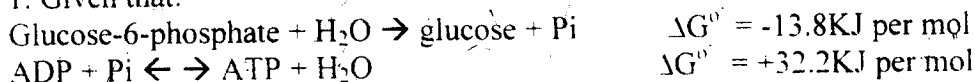
BS 211
CELL MOLECULAR BIOLOGY AND GENETICS

PRACTICAL PAPER

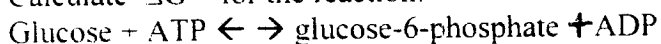
TIME: 3 HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS.

1. Given that:



Calculate ΔG° for the reaction:



Comment upon the physiological feasibility of the enzyme catalysed reaction and its mechanism.

2. For an enzyme-catalysed reaction, the $K_M = 1 \mu\text{mol per litre}$ and $V_{\text{max}} = 100 \mu\text{mol per minute}$. Given the following substrate concentrations:

	Substrate concentration ($\mu\text{mol per litre}$)
A	0.1
B	0.2
C	1.0
D	2.0
E	10.0
F	100.0

$\frac{1}{V_{\text{max}}}$

- Plot the Michaelis-Menten graph for this enzyme-catalysed reaction.
- If the enzyme has a low K_M , will it bind the substrate at low or high concentrations? Has it got low or high affinity?
- If the enzyme has a high K_M , will it bind the substrate at low or high concentrations? Has it got low or high affinity?
- Consider the fate of a glucose molecule in the bloodstream. All cells obtaining glucose from the bloodstream possess the enzyme hexokinase: this enzyme phosphorylates glucose that is trapped inside cells. But liver cells possess glucokinase: this enzyme phosphorylates glucose that is stored as glycogen. Thus there are two alternate enzymes for the same reaction: one enzyme leading to energy generation, the other enzyme leading to energy storage. Which of the two enzymes has a lower K_M ? Comment on the metabolic significance of your answer.

3. Calculate K_M and V_{max} for an enzyme, for which the following data are provided:

	Substrate conc. (mmoles per litre)	Initial velocity (μmol per minute)
A	0.6	1.14
B	1.0	1.70
C	1.5	2.36
D	3.0	3.64
E	6.0	5.0
F	15.0	6.46

4. A compound is known to inhibit an enzyme. However, the type of inhibition is not known. Enzyme assays were conducted in the presence and absence of a fixed concentration of an inhibitor at various substrate concentrations. The following data were obtained:

Substrate concentration (mmoles per litre)	Initial velocity (μmol per minute)	
	A (minus inhibitor)	B (plus inhibitor)
0.02	31.3	16.1
0.03	41.7	22.2
0.04	47.6	27.8
0.06	57.1	35.7
0.12	71.4	52.6

Using whatever procedure you consider to be most appropriate, determine the type of inhibition involved. Briefly outline how will you experimentally confirm your conclusions?

5. Suppose that you have a homozygous stock carrying the autosomal recessive genes a, b, and c linked in that order. You cross females of this stock with males of a homozygous wildtype. You then cross the F1 heterozygote males with their heterozygote sisters and obtain the following F2 phenotypes and frequencies:

+++	1,364
a++	47
a+c	5
---c	84
+bc	44
+b+	4
ab+	87
abc	365

Total = 2,000

Construct a genetic map for the linked genes. What is the coefficient of coincidence? Is there any interference?

-END OF EXAMINATION-

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAMINATIONS - APRIL 2002

BS 221
FORM, FUNCTION AND DIVERSITY OF PLANTS
Theory Paper

TIME: *Three Hours*

ANSWER: FIVE questions, ONE from SECTION A, TWO from SECTION B and TWO from SECTION C.

Use a SEPERATE Answer Book for EACH Section.

SECTION A

1. Describe the different growth forms exhibited by members of the Bryophyta.
2.
 - a) Illustrate the position of the bryophytes in the Plant Kingdom.
 - b) Briefly describe the main structural differences between the 3 major groups of the bryophytes.
3.
 - a) Explain the phenomenon of 'alternation of generations' among the bryophytes.
 - b) Describe the general structure of a typical moss plant, explaining which parts represent the different generations.

SECTION B

4. Compare thallus and cell structure in *Ulothrix* and *Oedogonium* and describe their asexual and sexual reproduction.
5. Describe structure and reproduction in bacteria and explain their economic importance.
6. Describe vegetative and reproductive structures of *Peronospora* and explain its importance in agriculture.
7. Write detailed notes on any FOUR of the following:
 - i. Virus structure
 - ii. Akinete
 - iii. Zygosporium
 - iv. Oogamy in *Fucus*
 - v. Auxospore
 - vi. Heterocyst

SECTION C

8. Give an illustrated account of the life cycle exhibited by species of *Selaginella* and explain how the concepts of either homospory or heterospory could be extended to the biology of seed plants.
9. Describe, with examples, the diversity of sori arrangement in homosporous ferns and relate their significance to the taxonomy of pteridophytes.
10. Outline features of the vegetative and reproductive organs known to be unique to members of the genus *Pinus*.

11. Describe some of the peculiar vegetative and reproductive features characteristic to the genus *Equisetum*.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – APRIL 2002

BS319

BIOSTATISTICS

THEORY PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS. ANSWER TWO QUESTIONS FROM **SECTION A** AND TWO QUESTIONS FROM **SECTION B** AND ANY ONE FROM EITHER **SECTION A** OR **SECTION B**. USE A SEPARATE ANSWER BOOK FOR EACH SECTION

SECTION A

1. In a study to determine the effectiveness of inoculation against cholera, a sample of 111 volunteers was divided into two groups. 57 volunteers received a standard dose of pathogenic bacteria followed by an antiserum and a control group of 54 that received the bacteria but no antiserum. After a sufficient time had elapsed for an incubation period and for the disease to run its course, 38 dead people and 73 survivors were counted. Of those that died, 13 had received bacteria and antiserum while 25 has received bacteria only. Is inoculation effective?

2. The effect of DDT on the fecundity (number of eggs laid per female per day) of the fruit fly *Drosophila Melanogaster* yielded the following results:

DDT treated insects	20.9	11.6	22.3	30.2	33.4	26.7	39.0	12.8	14.6	12.2
Control insects	20.3	37.6	36.9	37.3	28.2	23.4	33.7	29.2	41.7	51.8

Is there a significant difference in the fecundity of the insects when you assume that the variance of the two samples is (a) equal (b)unequal?

3. Measurements were made of the length of "buttons" in micro units (μm) of different specimens of the sea cucumber *Stichopus* sp in order to determine the mean length of

a "button" in the species. The measurements made were not normally distributed. Log transform the data given below and (a) calculate the mean and standard deviation of the measurements (b) the confidence limits of the mean at 95% CL.

Measurements (μm) 115. 88. 100. 96. 88. 91. 84. 98. 87. 91. 102. 80. 77. 91. 85. 89

4. The outcome of a dihybrid cross between tall, potato leaf tomatoes and dwarf, cut leaf tomatoes yielded the following results: Tall, cut leaf 926: Tall, potato leaf 288: Dwarf, cut leaf 293: and Dwarf, potato leaf 104. If the expected ratio of phenotypes is 9:3:3:1, test the results for goodness of fit.

SECTION B

1. A limnologist obtained eight containers of water from each of four ponds. The pH of each water sample was measured. The following table shows the pH recorded.

Pond 1	Pond 2	Pond 3	Pond 4
7.68	7.71	7.74	7.71
7.69	7.73	7.75	7.71
7.70	7.74	7.77	7.74
7.70	7.74	7.78	7.79
7.72	7.78	7.80	7.81
7.73	7.78	7.81	7.85
7.73	7.80	7.84	7.87
7.76	7.81		7.91

- 1.1. Test first whether the variance of the pH is the same for all ponds (significance level $\alpha = 0.05$):
- 1.2. Upon the conclusion drawn from 1.1 above, apply the appropriate test for the equality of pH in all four ponds ($\alpha = 0.05$).

2. A researcher has compiled the following pairs of data for each specimen of three fish species, where total length (TL) is the predictor variable.

Fish species 1: TL (cm) and age, t (years):

Fish species 2: TL (cm) and standard length, SL (cm):

Fish species 3: TL (cm) and proportion of mature fish (P)

The following table summarizes the data obtained.

Fish species 1		Fish species 2		Fish species 3	
TL (cm)	t (years)	TL (cm)	SL (cm)	TL (cm)	P
15.5	1	15.0	13.5	16	0
31.0	2	18.2	16.3	18	0.19
36.0	3	22.8	20.0	20	0.38
45.0	4	19.0	17.2	22	0.61
53.0	5	25.0	23.0	24	0.67
60.0	6	27.5	26.4	26	0.76
64.0	7	30.3	29.1	28	0.77
				30	0.94
				32	0.96
				34	0.96
				36	1.00
				38	1.00
				40	1.00

2.1. Plot the scatter diagrams of the dependent variables against TL. Draw your preliminary conclusions:

2.2. For the plot suggesting a clear linear association between the dependent variable and TL.

- Determine the equation of the regression line and superimpose the fitted line on the corresponding scatter diagram plotted on 2.1 above:
- Calculate the coefficient of correlation and the coefficient of determination:

- c. Use the ANOVA procedure to test the strength of the relationship between the predictor variable and TL.
3. The following information provides the results of a 2^3 factorial design laid out in five blocs. to determine the effect of different kinds of fertilizers (K, N, P and their combinations) on potato crop yield.
- 3.1. Determine the main effects and interactions (performing the ANOVA test is not necessary here):
- 3.2. Test the significance of the factorial effects ($\alpha = 0.05$) and try to interpret the interactions observed.

BLOCK 1

kn	·1·	kp	K
284	98	372	257
n	Knp	p	np
111	446	302	361

BLOCK 2

kp	knp	p	·1·
385	429	317	105
k	n	np	kn
283	95	328	311

BLOCK 3

p	kn	·1·	n
305	320	85	133
np	k	kp	knp
335	267	399	464

BLOCK 4

np	kp	k	knp
351	422	298	452
n	·1·	kn	p
97	126	277	313

BLOCK 5

k	p	knp	n
281	300	420	122
kp	np	·1·	kn
420	320	110	290

4. Six greenhouse benches were set up as blocks. Within each block, one of each of four varieties of houseplants was planted. The plant heights (cm) obtained are tabulated as follows:

VARIETIES				
Blocks	1	2	3	4
1	19.8	21.9	16.4	14.7
2	16.7	19.8	15.4	13.5
3	17.7	21.0	14.8	12.8
4	18.2	21.4	15.6	13.7
5	20.3	22.1	16.4	14.6
6	15.5	20.8	14.6	12.9

Non-parametrically test the hypothesis that all four varieties of plants reach the same maximum height.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – APRIL 2002

BS321

EVOLUTION AND ETHOLOGY

THEORY PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS. ANSWER TWO QUESTIONS FROM **SECTION A** AND TWO QUESTIONS FROM **SECTION B** AND ANY ONE FROM EITHER **SECTION A** OR **SECTION B**. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY. USE A SEPARATE ANSWER BOOK FOR EACH SECTION.

Section A

1. (a) Describe the process of speciation
(b) What are the properties of a species and how are they achieved?
2. How could the evolution of Giraffes from short-necked ancestors be explained in terms of (a) Lamarckism and (b) Darwinism.
3. (a) State the Hardy Weinberg (H-W) Law
(b) If a population consists of 49% *AA*, 42% *Aa* and 9% of *aa* individuals. show by calculation how the law applies
(c) If the H-W equilibrium exists in the population what are the rates and amounts of evolution.
(d) What factors disturb the H-W equilibrium?
4. (a) How does narrow specialisation and broad adaptability contribute to either survival or extinction of species
(b) Distinguish between delayed and immediate replacement and between evolutionary divergence and evolutionary convergence

Section B

1. (a) What are the two types of mating systems found in natural populations
(b) What factors determine the evolution of a particular mating system in a species?

2. Compare and contrast
 - (a) Anisogamy and Isogamy
 - (b) Epigamic selection and Intrasexual selection
 - (c) Irrelevant activities and Redirection activities
 - (d) Sexual reproduction and Parthenogenesis
 - (e) Altruism and Selfishness

3. Aggression forms the basis of most social behaviours found in animals. What are the different types of aggressive behaviours and what is their significance?

4. Defence behaviour is an important form of egocentric behaviour in animals. How does an animal react to or defend itself against its enemies

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER UNIVERSITY EXAMINATIONS – APRIL 2002.

BS 331 PLANT PHYSIOLOGY

PRACTICAL PAPER

TIME: THREE HOURS

INSTRUCTIONS:

ANSWER: ALL QUESTIONS

1. Prepare a stock of several strips of the lower epidermis of *Rhoeo* sp provided and float them in distilled water contained in a petri dish. Mount a strip of the epidermis on a microscope slide in a few drops of each of the substances A, B, and C, one at a time, cover with a cover glass and observe the cells under the low power of the microscope over a period of 20 to 30 minutes.

Note the time it took for the cells to show signs of plasmolysis and when the cells appeared to have recovered from plasmolysis. Record your results in table form.

- (a) Discuss the results.
(b) Suggest the order of permeability of the cell membranes of *Rhoeo* to substances A, B and C.
2. The effect of CO₂ on the rate of photosynthesis in a water plant was studied by varying the amount of CO₂ supplied as NaHCO₃ in the bathing medium and measuring the volume of O₂ evolved during a period of five minutes.

In every case the plant was illuminated with a 200W incandescent light bulb placed at a distance of 36 cm from the plant. The following results were obtained:

NaHCO ₃ in bathing medium %	O ₂ evolved Micro litre
0.5	29.0
1.0	43.0
1.5	47.5
2.0	49.0

- (a) Plot these results on a graph presenting O_2 output as a function of carbon dioxide supply.
- (b) Explain why O_2 output was not linear.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS

APRIL, 2002

BS 351 : ENTOMOLOGY

THEORY PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS. TWO QUESTIONS FROM SECTION A AND TWO QUESTIONS FROM SECTION B. THE LAST QUESTION CAN BE SELECTED FROM EITHER SECTION.

SECTION A

INSECT MORPHOLOGY, ANATOMY AND ORDERS

1. Insects are the most successful organisms on earth today, numbering more than nine hundred thousand described species. Discuss characteristics that insects share in common with other Arthropods and those that set them apart from the other Arthropods.
2. All the different forms of gnathal appendages found among insects at present are believed to have evolved from the biting-and-chewing type, such as those of a grasshopper. Discuss what modifications were necessary to these generalized gnathal appendages to give rise to those of a (i). Mosquito, (ii). House fly and, (iii). Honeybee.
3. Discuss structural modifications of insect legs that are related to habits and habitats insects are adapted to and explain what specialized structures occur on the hind legs of the honeybee and the front legs of crickets and katydids.
4. Describe the different types of ovarioles found in insects and indicate which types are exhibited by the (i). Honeybee, (ii). Termite and, (iii) members of the Coleoptera-Polyphaga group.

SECTION B**INSECT PHYSIOLOGY AND BIOCHEMISTRY**

5. Discuss hormonal regulation of moulting in insects and explain why insect cuticle shows different colours, some of which are very beautiful to the human eye.
6. One Lecturer in the Department of Biological Sciences of the University of Zambia was heard telling his students that, "In Zambia, diapause in insects is a period of arrested development caused by freezing temperatures around the month of June". Argue for or against this statement.
7. Unlike the vertebrate blood, which is red in colour, insect haemolymph is generally yellowish or greenish. Explain why insect haemolymph is not red and discuss its functions in the insect body.
8. Describe the structure of the insect body wall and indicate which of its features are important in thermo- and osmo-regulation.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER UNIVERSITY EXAMINATIONS—2002
BS361 Molecular Biology
Theory Exam paper 1

Instructions:

Time: 3 (three) hours

Answer All questions *Answers must be precise and to the point.*

Q1. Define each of the following terms:

- a) Nucleotide
- b) Linking number ✓
- c) Operon
- d) Holoenzyme
- e) Coding strand of DNA

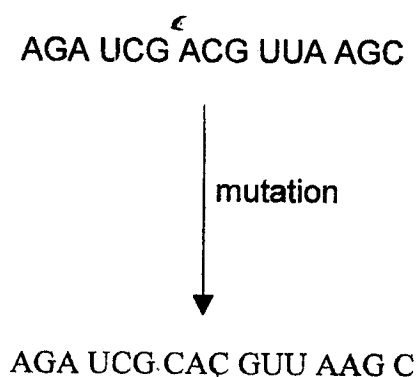
Q1. Write short notes on any four of the following:

- a) Gene cloning
- b) Gene therapy for cancer
- c) Application of genetic engineering to environmental clean up
- d) Homeodomain
- e) Mutagens
- f) Leucine zippers

Q3. The protein EF-Tu delivers aa-tRNAs to the empty A sites on ribosomes. It is then re-used for delivery of more aa-tRNAs to the ribosome.

- a) briefly explain the steps in the EF-Tu cycle (in prokaryotes) which makes this process possible.
- b) What is the significance of this process in the efficacy of the antibiotic Kirromycin?

Q4. The illustration below shows the effect of a mutation on a coding DNA sequence.



- a) Using the genetic code provided, translate both the original sequence and the resulting sequence after the mutation.
- b) What type of mutation does this represent?
- c) What (is) are the implication(s) of such a mutation?

The Genetic Code

Amino acid	Three-letter code	Genetic code
Alanine	Ala	GC*
Cysteine	Cys	UGU, UGC
Aspartic Acid	Asp	GAU, GAC
Glutamic Acid	Glu	GAA, GAG
Phenylalanine	Phe	UUU, UUC
Glycine	Gly	GG*
Histidine	His	CAU, CAC
Isoleucine	Ile	AUU, AUC, AUA
Lysine	Lys	AAA, AAG
Leucine	Leu	UUA, UUG, CU*
Methionine	Met	AUG
Asparagine	Asn	AAU, AAC
Proline	Pro	CC*
Glutamine	Gln	CAA, CAG
Arginine	Arg	CG*, AGA, AGG
Serine	Ser	UC*, AGU, AGC
Threonine	Thr	AC*
Valine	Val	GU*
Tryptophan	Trp	UGG
Tyrosine	Tyr	UAU, UAC

Q5.

- a) Explain the meaning of DNA denaturation and renaturation.
- c) What is nucleic acid hybridisation?
- d) Describe two common ways of performing the nucleic acid hybridisation reaction.
- e) Which of the two methods in 'd' is better than the other and why?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER UNIVERSITY EXAMINATIONS – APRIL, 2002.

BS 375 Invertebrate Zoology

Theory Paper

TIME: THREE HOURS

INSTRUCTIONS:

ANSWER: Answer Question One(1) and Three other Questions.
Question one carries 31-marks while other questions carry equal marks.

- Q1. (a) The classification of the members of the metazoan sub-kingdom of the Animal Kingdom has followed a number of schemes, including the one that breaks down this sub-kingdom into the Diploblastic and Triploblastic Divisions. What is the basis of this classification?
- (b) A. The following Orders belong to the same class: on what basis are they separated into distinct orders:
- i. Scorpionida
 ii. Araneae
 iii. Acarina
 iv. Name the class and phylum to which they belong.
- B. The following classes belong to one phylum. Summarise the taxonomic features used to separate them into differences classes.
- i. Gastropoda
 ii. Rolecypoda
 iii. Cephalopoda
 iv. Name the class and phylum to which they belong.
- C. The following orders belong to the same class. Indicate the features used in their classification into separate orders:
- i. Plesiopora
 ii. Prosopora
 iii. Opistropora
 iv. Name the class and phylum to which they belong.

D. The following orders belong to one class. Indicate the features used in their separation into orders.

- i. Cryptomonadina
- ii. Protomonadina
- iii. Trichomonadina
- iv. Name the class and phylum to which they belong.

E. The following orders belong to one class. Indicate the features used in their separation into orders:

- i. Coccidia
- ii. Haemosporidia
- iii. Gregarinida
- iv. Name the class and phylum to which they belong.

F. The following orders belong to one class. What taxonomic features are used to separate them into orders.

- i. Siphonoptera
- ii. Anoplura
- iii. Mallophaga
- iv. Name the class and phylum to which they belong.

Q2. (a) What are the functions of blood?

(b) Review the circulatory systems of invertebrates.

Q3. Write brief notes on the following topics:

(a) Reproduction in coelenterates

(b) Sense organs in the invertebrates

(c) Evolution of the blood sucking habit in invertebrates.

Q4. (a) Give illustrated descriptions of the life histories of *Taenia saginata* and *Fasciola hepatica*.

(b) What are the major adaptations to parasitism seen in these and other invertebrates.

Q5. (a) What is respiration?

(b) Review respiratory structures seen in terrestrial and aquatic invertebrates.

Q6. (a) Define and briefly describe the processes of Osmo-regulation and Homeostasis in invertebrates.

(b) What are the various excretory mechanisms seen in aquatic and terrestrial invertebrates.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS

APRIL, 2002

BS 411 : INSECT BEHAVIOUR AND ECOLOGY

THEORY : PAPER I.

TIME: THREE (3) HOURS

**INSTRUCTIONS: ANSWER FIVE QUESTIONS. ALL QUESTIONS CARRY
EQUAL MARKS.**

1. One Entomologist was heard saying, "One invention by insects that will remain unsurpassed for a long time to come by whatever man has made is, cold light production". Argue for or against this statement and explain how light is produced by insects.
2. Distinguish between innate and learned insect behaviour and explain how for example, an insect that is reared in isolation from an egg to the imago stage in a laboratory is able to construct a species-specific nest when it comes to breeding time.
3. Describe two kinds of transverse orientation exhibited by named insect groups and explain the biological significance of these kinds of innate behaviour in insects?
4. Discuss periodicity in cockroach behaviour and explain how cockroaches deal with changes in the photoperiod during the year in relation to their activities.
5. Discuss the mechanisms of dispersal in insects and explain what prompts some insects such as locusts to travel long distances from their native lands.
6. What is a pheromone? Using specific examples, discuss the roles pheromones play in the lives of named insect species or insect groups.

7. **Distinguish between habituation and conditioning learning in insects. Under what circumstances does each occur and how do they both differ from latent learning in insects.**
8. **What is an insect society and in terms of organization and maintenance, what are the differences between termite and ant insect societies?**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS—APRIL 2002

BS 425

IMMUNOLOGY

THEORY PAPER

TIME: THREE (3) HOURS

INSTRUCTIONS:

ANSWER ALL QUESTIONS FROM SECTION A

ANSWER TWO (2) QUESTIONS FROM SECTION B

SECTION A:

1. Identification of herpesvirus-like DNA sequences in AIDS-associated Kaposi's sarcoma (KS) was done by Chang *et al* in 1996. A major controversy then ensued as to whether KS-associated herpesvirus was a ubiquitous pathogen or not in humans. However, the epidemiology of African KS has changed in the wake HIV/AIDS. It has been postulated that the Th1/Th2 cytokine balance plays a role in the clinical manifestation of African KS. Reveal the experimental insights that elucidated whether KS was caused by a herpesvirus or not. Discuss the link between KS and HIV/AIDS, and the immunological basis of the clinical spectrum of KS.

2. A certain population of Chinese people is known to drink their own urine, ostensibly to boost the immune system. Discuss the immunological relevance or non-relevance of this indigenous practice. Suggest a mechanism as to how (or how not) urine can boost the immune system.

3. (a) Chinsebu *et al* (2001) found that in about 10% of couples having unprotected sex, either the husband is HIV positive or the spouse is negative, or vice-versa. Suggest the cyto-immunological basis of this discordancy.

(b) Aspirin is believed to reduce the HIV load. Suggest a mechanism of action of Aspirin on HIV.

SECTION B:

1. Microbes use various strategies to evade the immune system. Using four named examples, discuss this phenomenon.

2. (a) Tolerance and immunity are linked. Discuss.

(b) Discuss the immunological basis of food allergies.

3. How is the immune system able to cope with the myriad of pathogens?
4. Explain the principles involved in the following techniques:
 - (a) agglutination
 - (b) immunodiffusion
 - (c) radioimmunoassay
 - (d) immunofluorescence
 - (e) immunoprecipitation
 - (f) immunoelectrophoresis
 - (g) ELISA
5. Discuss immunity to cancer. two named bacteria and one named fungus.
6. Discuss immuno-supression and immuno-boosters. Propose a mechanism for the reported efficacy of the 'african potato'.
7. Starting with the hybridoma technology. describe three other methods used in antibody engineering. Comment on the production of 'plantibodies'.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – APRIL 2002

BS475

POPULATION ECOLOGY

(PAPER I)

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS AND USE
ILLUSTRATIONS WHEREVER POSSIBLE.

-
1. A cohort of 200 seedlings of *Lapeirousia rivularis* had a juvenile mortality rate of 0.5 per annum during the first two years and an adult mortality rate of 0.1 per annum for the remainder of its life. Discuss the survivorship of the species.
 2. Calculate and discuss reproductive allocation in a plant with the following characteristics:
 - i. Vegetative biomass per flowering plant of 10.0g.
 - ii. Seed mass per plant of 4.0g.
 - iii. Nitrogen content in vegetative biomass of 0.5%
 - iv. Nitrogen content in seed of 5.0%
 - v. Phosphorus content in vegetative biomass of 0.2%
 - vi. Phosphorus content in seed of 1.0%.
 3. Discuss the fate of seed banks in an ecosystem.
 4. The quadrat is the foundation of plant demography. Discuss this statement.
 5. Contrast and discuss the life cycles of annual and perennial plants.
 6. Under what conditions are perennial plants more competitive than annual plants.
 7. Why are weed plants better adapted to habitats with ephemeral environmental conditions.
 8. Why is the dormancy strategy favoured in seasonal habitats with predictable or unpredictable environmental conditions.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGICAL SCIENCES

BS 491 Freshwater Biology

Practical Paper

First Semester Examinations

April 2002

Instructions

Attempt **all** the questions in this paper. At the end of the examination, please hand in all the answer booklets and question papers.

1. A Limnologist assigned to study the ecology of a lake has completed one year of temperature data collection. The Table 1 below shows temperature measurements recorded during each month from July 1978 to June 1979 at different depths.

Table 1 Temperature data °C from the lake at different depths for one annual cycle

Depth (m)	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0	16	16	18	20	23	25	27	27	27	25	21	19
2	16	16	18	20	23	25	26	27	27	25	21	19
4	16	16	17	20	22	24	25	26	27	25	21	18
6	16	16	17	18	22	24	24	25	26	25	20	18
8	16	16	17	18	20	23	24	24	25	24	20	18
10	16	16	17	17	20	23	23	24	25	24	18	16
15	16	16	16	17	18	20	20	23	24	23	18	16
20	16	16	16	16	18	19	19	20	23	22	16	16
25	16	16	16	16	18	18	18	18	20	20	16	16
30	16	16	16	16	16	18	17	17	18	18	16	16
35	16	16	16	16	16	16	17	17	18	17	16	16
40	16	16	16	16	16	16	16	17	17	16	16	16
45	16	16	16	16	16	16	16	17	16	16	16	16
50	16	16	16	16	16	16	16	16	16	16	16	16
55	16	16	16	16	16	16	16	16	16	16	16	16
60	16	16	16	16	16	16	16	16	16	16	16	16

- i) Construct an appropriate Depth- time diagram designed to aid in describing the thermal regime of the lake.
- ii) Briefly describe the thermal regime for the lake based on the diagram constructed in i. above.
- iii) What is the appropriate category for the lake being investigated and
- iv) In which part of the world would such a lake be found.

2. Two small lakes with morphometric parameters described below are reported to occur within the same catchment area:

Lake A		Lake B	
Depth(m)	Area(m ²)	Depth(m)	Area (m ²)
0m	550	0	1,500
20	350	10	800
40	240	20	80
60	160	30	50
80	60	50	10
100	20		
120	5		

i) Applying the formula:

$$V = \frac{h}{3} \{ A_1 + A_2 + (A_1 \times A_2)^{1/2} \}$$

Estimate the volume of water that is in lake A and in lake B

ii) Construct hypsographic depth area and depth volume curves for both lakes.

iii) Based on the graphs constructed in ii above compare both lakes.

3. i) A sample of water was collected from Lake A from a depth of 8 m for the determination of phyto-plankton concentration and the Utermoh's method was used. In this procedure, a 50 cm³ sedimentation chamber was used and the counting chamber had radius of 1.5 cm. The diameter of the transect under the microscope was estimated at 0.02 cm. A transect across the entire diameter of the counting chamber recorded a mean value of 70 cells of *Cymbella ventricosa*.

Estimate the number of *Cymbella ventricosa* cells in a cm³ at this depth. Explain the various stages of your calculations.

- ii) From Lake B a sample was collected for the analysis of zooplankton. This sample was collected using a plankton net which was raised from a depth of 20 metres to the surface. The diameter of the plankton net used was 80 cm and the volume of the bottle attached to the net was 200cm³. From this collection bottle a small sample of 1 cm³ was collected for microscopic examination. Twenty (20) *Daphnia* individuals were enumerated in the 1 cm³ put on the glass slide.

Estimate the number of *Daphnia* organisms per cubic meter above the depth of 20m.

4. Morphometric parameters of water bodies have been used to estimate potential fish yields of reservoirs, floodplains and rivers. The Table below provides surface areas of selected common water bodies in Zambia

Table Mean surface areas of selected water bodies.

Water Body	Mean Surface Area
Lake Itzhi-tezhi	360km ²
Kafue Floodplains	3.600 km ²
Lake Kariba	5.360 km ²
Zambezi River (Part of Zambezi now flooded by Lake Kariba)	300 km ²

- i) Based on the relationships

$$Y = 4.32 \times A^{1.005} \text{ for Floodplains}$$

$$\log_e Y = 3.57 + \log_e A \text{ for lakes and}$$

$$Y = \frac{L^2}{300} \text{ for rivers}$$

Compute potential fish yields for the water bodies listed above.

- ii) Fish stock Assessments conducted after the formation of the Lake Kariba and Itzhi-tezhi indicated maximum sustainable yields as follows:

Lake Kariba	2000 tonnes of fish per year
Lake Itzhi-tezhi	800 tonnes of fish per year

Give reasons for the differences between the predicted yields from morphometric parameters and those obtained from results of fish stock assessment studies.

- iii) Briefly explain why reservoirs have different potential fish yields in comparison to natural lakes, and what can be done to improve the performance of man made lakes.

END OF PRACTICAL EXAMINATION

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGICAL SCIENCES

BS 491 Freshwater Biology

Theory Paper

First Semester Examinations

April 2002

Instructions

Attempt all the **three** questions in **Section A** and **three** questions in **Section B**. At the end of the examination, please hand in all the answer booklets and question papers.

SECTION A

- Q1 Round 1971 is reported to have identified four critical points in the seasonal succession of phytoplankton in warm temperate monomictic lakes.
- i) Name and describe the four critical points in seasonal succession of phytoplankton?
 - ii) What are the factors controlling growth and development of phytoplankton populations during each critical phase?
- Q2 Define the following terms and concepts as applied in limnology and describe how each of term relates or influences productivity of aquatic ecosystems
- i) Mean depth
 - ii) Shore line development
 - iii) Water turbidity
 - iv) Isothermy
 - v) Size of catchment area
- Q3 A well known freshwater biologist is reported to have suggested that 'a perceptive limnologist can assess the relative productivity of a lake simply by measuring the oxygen concentration throughout the depth profile during summer stratification.'

Assess the validity and accuracy of this statement and explain in detail the rationale for such a deduction.

SECTION B

- Q4 Dissolved carbon dioxide in the hypolimnion is sometimes used to determine the productivity of a water body. Explain the rationale and the shortcomings for using this method for determining the productivity of aquatic ecosystems?
- Q5 Describe a classification of lakes based on the annual thermal regimes.
- Q6 Discuss the dynamics of Silicates compounds in freshwater ecosystems and evaluate the role of contribution of silicon compounds in the seasonal succession of the phytoplankton in monomictic lakes of temperate regions.
- Q7 Discuss in detail, dynamics and circulation of carbon compounds in freshwater ecosystems.

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER EXAMINATIONS

APRIL 2002

Cina

BS 915

BIOLOGY OF SEED PLANTS

Practical Paper

TIME *Three Hours*

ANSWER: ALL Questions

1. Examine specimens A, B, C, D, E, F, G, H, I and J and describe in each case:
 - i. the category of the herb, condiment, spice or beverage to which it belongs;
 - ii. the part of the plant from which it is obtained;
 - iii. the purpose for which it is used;
 - iv. the botanical name of each specimen.

2. Use the following data to construct a floral diagram, floral formula and identify the family name.

'A plant collected in the open space of the miombo woodland is characterised by the possession of trifoliolate leaves. The flowers are bisexual, borne solitary on a raceme. Each flower exhibits a zygomorphic symmetry; the calyx is comprised of 5 sepals that are fused into a tube. Corolla consists of 5 yellow petals, the larger adaxial petal located externally and overlapping 2 side (lateral) petals called wings; the 2 abaxial petals fused to form a boat-like keel. Stamens 10, of which 9 are united at the base and 1 free. The ovary is comprised of one carpel and is superior.'

3. Draw and label features of botanical interest displayed in specimen K. Name the organ.

4. Use the apparatus and reagents provided to carry out the "Maule Test" on plant specimens labelled **L**, **M**, and **N**. Identify each specimen to its major taxonomic group.

5. You are provided with lists of woody species recorded in two vegetation types encoded as **Woodland Type A** and **Woodland Type B**. Assuming that such vegetation types occur on two adjacent islands or biomes, use the data given on Data Sheet 1 to calculate the 'Demarcation Knot' between the two vegetation types. Comment on your findings.

END OF EXAMINATION

Dataset 1: Species lists compiled from woodland *Types A* and *Type B*.

Woodland Type A

①	<i>Acacia</i>	<i>oboloba</i>	* 26	<i>Markhamia</i>	<i>obtusifolia</i>	26
* ②	<i>Albizia</i>	<i>malunnesiana</i>	* 27	<i>Monotes</i>	<i>glaber</i>	
③	<i>Amblyocarpus</i>	<i>andongensis</i>	* 28	<i>Ochna</i>	<i>pulchra</i>	
④	<i>Baikia</i>	<i>plurijuga</i>		* 29	} <i>Parinari capensis</i> <i>Parinari curatellifolia</i>	
⑤	<i>Baphia</i>	<i>equaertii</i>				
	<i>Baphia</i>	<i>massaiensis</i>	* 30	<i>Pavetta</i>	<i>schumanniana</i>	
* 6	<i>Bauhinia</i>	<i>macrantha</i>	* 31	<i>Peltophorum</i>	<i>africanum</i>	
* 7	<i>Bobsonia</i>	<i>madagascariensis</i>	* 32	<i>Pseudolachnostylis</i>	<i>maprouneifolia</i>	
* 8	} <i>Brachyegia</i>	<i>bakerana</i>	33	<i>Pygmaeothamnus</i>	<i>zeyheri</i>	
		<i>floribunda</i>	34	<i>Schinziophyton</i>	<i>rautanenii</i>	
		<i>longifolia</i>	35	<i>Strophanthus</i>	<i>welwitschii</i>	
		<i>spiciformis</i>	36	<i>Terminalia</i>	<i>sericea</i>	
9	<i>Burkea</i>	<i>africana</i>	* 37	<i>Tricalysia</i>	<i>suffruticosa</i>	
* 10	<i>Combretum</i>	<i>mechowianum</i>	* 38	<i>Thunbergia</i>	<i>crispa</i>	
11	<i>Copaifera</i>	<i>baumiana</i>	39	* } <i>Uapaca kirkiana</i> <i>Uapaca nitida</i>		
12	<i>Cryptocarpus</i>	<i>pseudotaxus</i>	* 40		<i>Xylopi</i>	<i>odoratissima</i>
* 13	<i>Dalbergia</i>	<i>nyassae</i>	* 41	<i>Zanha</i>	<i>africana</i>	
* 14	<i>Dialium</i>	<i>anglerianum</i>				
* 15	<i>Dichrochys</i>	<i>cinerea</i>				
* 16	<i>Diospyros</i>	<i>batocana</i>				
* 17	<i>Diplolobium</i>	<i>zambeianum</i>				
* 18	<i>Diplorhynchus</i>	<i>condylocarpon</i>				
* 19	<i>Erythraeum</i>	<i>africanum</i>				
20	<i>Guiboria</i>	<i>coleosperma</i>				
21	<i>Hanna</i>	<i>chlorantha</i>				
* 22	<i>Isobertia</i>	<i>angolensis</i>				
* 23	} <i>Julberdia</i>	<i>globiflora</i>				
		<i>paniculata</i>				
* 24	<i>Landolphia</i>	<i>camptoloba</i>				
* 25	<i>Lannea</i>	<i>cululis</i>				

Woodland Type B

- | | | | | | | |
|----|-------------------------|---------------------|-----------------------------|-----------------------|-----------------------------------|-----------------------|
| 1 | Abrus pulchellus | * | 24 | Landolphia kirkii | | |
| 2 | Adenolobos punctatus | * | 25 | Lannea edulis | | |
| * | 3 | Albizia antunesiana | 26 | Maranthes polyandra | | |
| 4 | Anisopyllea pomifera | * | 27 | Markhamia obtusifolia | | |
| 5 | Azanza garckeana | 28 | Monopetalanthus richardsiae | | | |
| * | 6 | Bauhinia petersiana | * | 29 | | |
| 7 | Becium obovatum | } | | | | |
| * | 8 | | | | 30 | Ochna schweinfurthii |
| } | | 31 | Olax obtusifolia | | | |
| | | 9 | 32 | P | | |
| | | 10 | } | | | |
| | | 11 | | | | 33 |
| | | * | 12 | * | 34 | Peltophorum africanum |
| | | } | | 35 | Pericopsis angolensis | |
| 13 | * | | | 36 | Pseudolachnostylis maprouneifolia | |
| * | 14 | 57 | Pterocarpus angolensis | | | |
| * | 15 | 38 | Rothmannia englerana | | | |
| * | 16 | 39 | Smilax krausiana | | | |
| } | | 40 | Strychnos cocculoides | | | |
| | | 17 | * | 41 | Tricalysia suffruticosa | |
| * | 18 | * | 42 | Thunbergia crispa | | |
| } | | 43 | } | | | |
| | | 19 | | | 44 | Uapaca kirkiana |
| | | 20 | | | 45 | Xeromphis obovata |
| * | 21 | * | 46 | Xylopia odoratissima | | |
| } | | 47 | Zanha africana | | | |
| | | 22 | Isoberlinia angolensis | | | |
| * | 23 | } | | | | |
| } | | | | | 48 | Uapaca nitida |
| | | } | | 49 | Uapaca sansibarica | |
| 24 | Julbernardia globiflora | | | | | |
| } | | 50 | Uvariastrum hexaloboides | | | |
| | | 25 | Julbernardia paniculata | | | |



THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER I EXAMINATIONS – APRIL 2002

INTRODUCTORY CHEMISTRY - C101

INSTRUCTIONS TO THE CANDIDATES

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

The paper consists of two (2) sections: **A** and **B**

Answer each section in a separate answer booklets.

- Section **A** has ten (10) questions. **ANSWER ALL QUESTIONS.**
Each question carries equal marks. (Total marks = **40**).
- Section **B** has five (5) questions. **ANSWER ANY FOUR QUESTIONS (4)**
Each question carries equal marks. (Total marks = **60**).

DURATION: Three (3) hours

YOU ARE REMINDED OF THE NEED TO ORGANIZE AND PRESENT YOUR WORKING CLEARLY AND LOGICALLY.

DATA SHEET

PYHSICAL CONSTANTS

Avogadro's number	= $6.02 \times 10^{23} \text{ mol}^{-1}$
Planck's constant, h	= $6.63 \times 10^{-34} \text{ J.s}$
Faradays constant, F	= $96\,487 \text{ C mol}^{-1}$
Speed of light, c	= $2.998 \times 10^8 \text{ m s}^{-1}$
Mass of an electron	= $9.11 \times 10^{-31} \text{ kg}$
Rydberg constant	= $2.18 \times 10^{-18} \text{ J}$ or 109678 cm^{-1}
Universal gas constant, R	= $8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ = $0.0821 \text{ dm}^3 \text{ atm K}^{-1} \text{ mol}^{-1}$ = $8.314 \text{ kPa dm}^3 \text{ K}^{-1} \text{ mol}^{-1}$
Heat capacity of water	= $4.18 \text{ J g}^{-1} \text{ K}^{-1}$
	= $\text{kg m}^2 \text{ s}^{-2} \text{ K}^{-1}$
$\ln x$	= $2.303 \log_{10} x$

STANDARD ELECTRODE POTENTIALS

<u>Electrode</u>	<u>E° (Volts)</u>
$\text{Mg}^{2+} \text{Mg}$	-2.36
$\text{Zn}^{2+} \text{Zn}$	-0.76
$\text{Cu}^{2+} \text{Cu}$	+0.34
$\text{I}_2 \text{I}^-$	+0.54
$\text{AuCl}_4^- \text{Cl}^-$	+0.99
$\text{Cl}_2 \text{Cl}^-$	+1.36
$\text{Au}^{3+} \text{Au}$	+1.50

THE PERIODIC TABLE IS PRINTED AT THE BACK OF THIS PAGE.

THE PERIODIC TABLE

Group 1 2 3 4 5 6 7 0

Period

1	H Hydrogen
---	---------------

Atomic Number	Symbol	Name	Relative atomic mass
---------------	--------	------	----------------------

2	He Helium
---	--------------

2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
1	Li Lithium	Be Beryllium											B Boron	C Carbon	N Nitrogen	O Oxygen	F Fluorine	Ne Neon
2	Na Sodium	Mg Magnesium											Al Aluminium	Si Silicon	P Phosphorus	S Sulphur	Cl Chlorine	Ar Argon
3	K Potassium	Ca Calcium	Sc Scandium	Ti Titanium	V Vanadium	Cr Chromium	Mn Manganese	Fe Iron	Co Cobalt	Ni Nickel	Cu Copper	Zn Zinc	Ga Gallium	Ge Germanium	As Arsenic	Se Selenium	Br Bromine	Kr Krypton
4	Rb Rubidium	Sr Strontium	Y Yttrium	Zr Zirconium	Nb Niobium	Mo Molybdenum	Tc Technetium	Ru Ruthenium	Rh Rhodium	Pd Palladium	Ag Silver	Cd Cadmium	In Indium	Sn Tin	Sb Antimony	Te Tellurium	I Iodine	Xe Xenon
5	Cs Caesium	Ba Barium	La Lanthanum	Hf Hafnium	Ta Tantalum	W Tungsten	Re Rhenium	Os Osmium	Ir Iridium	Pt Platinum	Au Gold	Hg Mercury	Tl Thallium	Pb Lead	Bi Bismuth	Po Polonium	At Astatine	Rn Radon
6	Fr Francium	Ra Radium	Ac Actinium															
7	Unk Unknown elements																	

Lanthanoid elements

Actinoid elements

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce Cerium	Pr Praseodymium	Nd Neodymium	Pm Promethium	Sm Samarium	Eu Europium	Gd Gadolinium	Tb Terbium	Dy Dysprosium	Ho Holmium	Er Erbium	Tm Thulium	Yb Ytterbium	Lu Lutetium	
89	90	91	92	93	94	95	96	97	98	99	100	101	102	
Th Thorium	Pa Protactinium	U Uranium	Np Neptunium	Pu Plutonium	Am Americium	Cm Curium	Bk Berkelium	Cf Californium	Es Einsteinium	Fm Fermium	Md Mendelevium	No Nobelium	Lr Lawrencium	

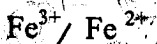
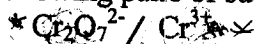
SECTION A

ANSWER ALL

- A1. State whether each of the following is an **Intensive** or **Extensive** property of a substance
- (a) Change in Gibb's free energy, G ~~EX~~
 - (b) Enthalpy change of a reaction, H
 - (c) Electron affinity, E_a .
 - (d) The electrode potential, E° , of a cell.

A2. A sample of a phosphorus fertilizer contains 60% CaHPO_4 and 40% $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$. Calculate the mass percent of phosphorus (%P) in this fertilizer.

A3. From the following pairs of substances

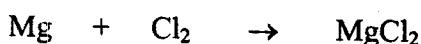


Which ones are

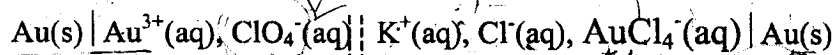
- (i) oxidants?
- (ii) reductants?

- A4. (a) Write down the equation that expresses the deviation of real gases from ideal gases. Explain the meaning of each term in the equation.
- (b) A liter of methane gas (CH_4), at STP contains more atoms of hydrogen than does a liter of pure hydrogen gas, H_2 , at STP. What gas law can be used to explain this and use it to explain why?

- A5. (a) A chemist desires to electrodeposit on a platinum cathode all of the copper (II) ions present in 500 cm^3 of a 1.5 M solution of copper (II) chloride. What is the theoretical time required if a constant current of 0.5 amperes is passed through the solution?
- (b) Calculate the standard voltage for a cell whose overall reaction in aqueous solution is:



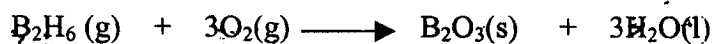
A6. Consider the cell:



- Is the cell written in the conventional manner? Briefly explain your answer.
- What is the cell reaction as the current flows?
- Calculate E° for the cell reaction in part (b).

A7. (a) Define the term *Internal Energy* of the system.

(b) For the reaction, at 25°C ,



ΔE is -2143.2 kJ kJ°

- Calculate ΔH° for the reaction.
- Determine the value of $\Delta H_f^{\circ}(\text{B}_2\text{H}_6, \text{g})$, given that

$$\Delta H_f^{\circ}(\text{B}_2\text{O}_3, \text{s}) = -1264.0 \text{ kJ mol}^{-1} \text{ and}$$

$$\Delta H_f^{\circ}(\text{H}_2\text{O}, \text{l}) = -285.9 \text{ kJ mol}^{-1}.$$

$$\Delta H^{\circ} = (\Delta H_f^{\circ} \text{ prod} - \Delta H_f^{\circ} \text{ reactant})$$

A8. The *enthalpy of solution*, $\Delta H_{\text{sol}}^{\circ}$, is the enthalpy change that accompanies the dissolution of 1.00 mol of a solid in a large excess of water. In an experiment 8.00 g of ammonium nitrate (NH_4NO_3) was dissolved in 50.0 g of water in a simple polystyrene calorimeter. The temperature fell by 10.1°C .

- Is the reaction endothermic or exothermic? Explain.
- Calculate the enthalpy of solution for the process:

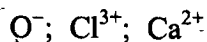


A9. (a) (i) Identify the sub shell associated with the following quantum numbers.

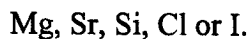
$$n = 1, l = 0 \text{ and } n = 3, l = 2$$

- Draw the shapes of the orbitals in (i) above
- What is the maximum number of electrons contained in these orbitals?

-
- A10. (a) Write the ground state electron configuration of the following atoms and ions, determine their magnetic behaviour.



- (b) On the basis of their position on the periodic table, predict which one has the smallest atomic radius.



SECTION B

ANSWER ANY FOUR QUESTIONS

- B1. The label on a nitric acid bottle reads as follows;

Relative Molecular Mass = 63.01 70% $\frac{m}{m}$ HNO_3 S.G. = 1.42.

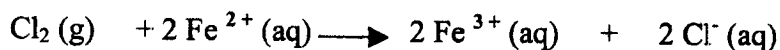
- (a) Define S.G. of a liquid.
- (b) What is the concentration of the acid in mol/dm^3 ?
- (c) 25 cm^3 of this acid is diluted to 750 cm^3 . If 24.8 cm^3 of NaOH was required for titration with 20 cm^3 of the diluted acid, calculate the molarity of the NaOH

-
- B2. (a) One method of analyzing amino acids is the van Slyke method. The characteristic amino group ($-\text{NH}_2$) in protein material is allowed to react with nitrous acid, HNO_2 to form N_2 gas. From the volume of the gas, the amount of amino acid can be determined. A 0.0604 g sample of a biological sample containing glycine, $\text{CH}_2(\text{NH}_2)\text{CO}_2\text{H}$, was analyzed by the van Slyke method and yielded 3.70 mL of N_2 collected at 735 torr and 29°C . What was the percentage of glycine in the sample?



- (b) Very briefly, describe the factors responsible for the deviation of the behavior of real gases from that of an ideal gas.
- (c) Show how Boyle's, Charles's and Dalton laws follow from the assumptions of the kinetic-molecular theory.
- (d) When two cotton plugs are moistened with different solutions and placed simultaneously at the ends of a glass tube, a white ring forms 61.2 cm from the ammonia-moistened ($\text{NH}_3(\text{aq})$) plug. If the total length of the tube is 103 cm, what is the molecular mass of the gas being released from the other plug?

B3. Given the reaction



- (a) Write the two balanced half reactions.
- (b) Sketch a clear diagram of a galvanic cell in which the above reaction is used to obtain an electric current. A salt bridge containing KCl electrolyte is used to prevent reaction of $\text{Fe}^{2+}(\text{aq})$ with $\text{Cl}_2(\text{g})$ directly. On the diagram
- Label the anode and the cathode;
 - Label the positive (+) and negative (-) electrode;
 - Indicate the direction of flow of electrons and the current in the external circuit; and
 - Indicate the direction of flow of all cations and anions.
- (c) If the Gibbs free energy ΔG° of the reaction as written is - 113.85 k J, calculate the potential E° for the reaction.
- (d) What would be the potential for the conversion of Fe^{3+} to Fe^{2+} ?
- (e) What would be the cell potential of the reaction at 25 °C if the concentrations of all the reactants and products were 0.10 M and the cell was operating at 101325 Pa?

- B4. (a) (i) Define the term *enthalpy change of vaporization*.
 (ii) Calculate the enthalpy change of formation of ethanol, C_2H_6O , using the following information

$$\Delta H_{\text{vap}}^{\circ}(C_2H_6O, (l)) = + 43 \text{ kJ mol}^{-1}, \Delta H_{\text{atm}}^{\circ}(C (s)) = + 715 \text{ kJ mol}^{-1}$$

$$BE (O_2) = + 496 \text{ kJ mol}^{-1}, BE (H_2) = + 436 \text{ kJ mol}^{-1} \text{ and}$$

$$\text{Total BE } (C_2H_6O) = + 3220 \text{ kJ mol}^{-1}.$$

- (b) The major natural source of fluoride is the mineral fluorspar, which is mainly calcium fluoride, CaF_2 . Using the following information:

	kJ/mol
$\Delta H_{\text{at.}}^{\circ} (Ca)$	+ 178
$\Delta H_f^{\circ} (CaF_2)$	- 1220
BE (F_2)	+ 158
$\Delta H_{\text{I.E}_1}^{\circ} (Ca)$	+ 590
$\Delta H_{\text{I.E}_2}^{\circ} (Ca)$	+ 1150
$\Delta H_{\text{L.E}}^{\circ} (CaF_2)$	- 2640

- (i) Construct a Born-Haber cycle for the formation of CaF_2 from its elements.
 (ii) Use the cycle to calculate the electron affinity of $F (g)$.

- B5. (a) (i) Define the term *iso-electronic species*.
 (ii) Select the iso-electronic species from the following atoms and ions. Br^+ , Se , As^- and Cl^- .
- (b) (i) Find the total number of orbitals associated with the principal quantum number, $n = 4$
 (ii) Write the reaction $SO_3^{2-} + S \longrightarrow S_2O_3^{2-}$ using Lewis structures of the reactants and product. Indicate the coordinate covalent bond (or bonds) in the product.

- (c) (i) Define the terms *electron affinity* and *resonance*.
- (ii) Calculate the formal charges on each atom in nitric acid and write its resonance forms showing the non-bonding electrons, if any.
- (d) Use Valence Shell Electron-Pair Repulsion (VSEPR) approach to predict and draw the shape of SO_2 and AlCl_4^- . ✓
-

THE END

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS – APRIL 2001

Analytical/Inorganic Chemistry C205

ANSWER ALL QUESTIONS

TIME: 3 HOURS

1. (a) A solution with a final volume of 500.0 mL was prepared by dissolving 25.00 mL of methanol (CH_3OH , density 0.7914 g/mL) in chloroform.

(i) Calculate the molarity of methanol in the solution. [5]

(ii) If the solution has a density of 1.454 g/mL, find the molality of methanol. [5]

(b) Find the absolute and percent relative uncertainty and express the answer with a reasonable number of significant figures in the following:

$$9.23 \pm (0.03) + 4.21 (\pm 0.02) - 3.26 (\pm 0.06) \quad [2]$$

(c) The Ti content (wt%) of five different ore samples (each with a different Ti content) was measured by each of the two methods.

Sample	% Composition by Method 1	% Composition by method 2
A	0.0134	0.0135
B	0.0144	0.0156
C	0.0126	0.0137
D	0.0125	0.0137
E	0.0137	0.0136

Do the two analytical techniques give results that are significantly different at the 95% confidence level? [8]

(d) Standard solutions containing 35, 40 and 45 $\mu\text{g per cm}^3$ of α - methyl dopa gave absorbance values of 0.301, 0.360 and 0.396 respectively. Use linear regression to calculate the best straight line for the calibration. If a sample solution gives an absorbance of 0.445, calculate the concentration of α - methyl dopa in the sample. [5]

2. (a) Write the mass balance equations for K^+ and for phosphate in a solution prepared by mixing 0.0250 mol KH_2PO_4 plus 0.0300 mol of KOH and diluting to 1.00L. [5]

(b) Write the charge balance equation for the above solution. [2]

(c) The acid HA has $\text{pK}_a = 4.00$. Use α values to calculate the fraction in the form HA and fraction in the form A^- at $\text{pH} = 5.00$. Does your answer agree with what you expect for the quotient $[\text{A}^-]/[\text{HA}]$ at $\text{pH} = 5.00$? [6]

- (d) What fraction of ethane-1,2-dithiol ($\text{HSCH}_2\text{CH}_2\text{SH}$) is in each form (H_2A , HA^- , A^{2-}) at pH 8.00? ($K_{a1} = 1.4 \times 10^{-9}$ and $K_{a2} = 3.7 \times 10^{-11}$)[6]
3. (a) Calculate pCa for the titration of 25.00 mL of 0.0200 M EDTA with 0.0100 M CaSO_4 at pH 10.00 at the following volumes: 20.0, 50.0, 55.0 mL. ($K_f \text{CaY}^{2-} = 1.0 \times 10^{12}$ and $\alpha_Y^{4-} = 0.054$)[6]
- (b) Distinguish between end point and equivalence point. With reference to your answer, what does the term titration error mean?[6]
- (c) Write the de Broglie equation and define all parameters. [5]
- (d) Calculate the wavelength of an electron whose mass is 9.11×10^{-31} kg and moving at 2.998×10^7 m, given Planck's constant (h) = 6.626×10^{-34} J.s[5]
- (e) Draw the shapes of all orbitals with $l = 2$. [5]
4. (a) Use Slater's rules to calculate the effective nuclear charge for the 6s electron in cesium (Cs) atomic number = 55. What is the energy of the electron in (j)? $1 \text{ eV} = 1.602 \times 10^{-19}$ J.[4]
- (b) Use the formation of SF_4 , SF_6 but not OF_4 or OF_6 to explain the concept of expanded octets.[2]
- (c) Distinguish between Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT). Use the formation of the H_2 molecule to help you explain the distinction.[3]
- (d) A Lewis base is defined as a species that is capable of donating electrons to an electron deficient species. Draw the molecular orbital diagrams for CO and N_2 . From the two diagrams calculate
- the bond orders for each species.[2]
 - Explain why CO is a stronger Lewis base than N_2 . [4]
 - Why does CO form M-CO rather than M-OC bonds in transition metal complexes? (M = Metal)[2]
- (e) Calculate the D_{qs} i.e. Ligand Field Stabilization Energies (LSFEs) for octahedral complexes of the following metal ions. Assume that both low and high spin complexes are possible i.e. each metal ion will assume two answers. (i) V^{2+} (ii) Rh^{3+} (iii) Au^{3+} [6]
- (f) With the aid of the spectrochemical series, predict whether the following are high or low spin complexes and based on your prediction, calculate the Ligand Field Stabilization Energy for each. State whether each of the complexes obeys the 18-electron rule.
- FeF_6^{4-}
 - $[\text{Ni}(\text{en})_3]^{2+}$ [6]

Table A.1. The *t*-distribution

Value of <i>t</i> for a confidence interval of Critical value of $ t $ for <i>P</i> values of Number of degrees of freedom	90%	95%	98%	99%
	0.10	0.05	0.02	0.01
1	6.31	12.71	31.82	63.66
2	2.92	4.30	6.96	9.92
3	2.35	3.18	4.54	5.84
4	2.13	2.78	3.75	4.60
5	2.02	2.57	3.36	4.03
6	1.94	2.45	3.14	3.71
7	1.89	2.36	3.00	3.50
8	1.86	2.31	2.90	3.36
9	1.83	2.26	2.82	3.25
10	1.81	2.23	2.76	3.17
12	1.78	2.18	2.68	3.05
14	1.76	2.14	2.62	2.98
16	1.75	2.12	2.58	2.92
18	1.73	2.10	2.55	2.88
20	1.72	2.09	2.53	2.85
30	1.70	2.04	2.46	2.75
50	1.68	2.01	2.40	2.68
∞	1.64	1.96	2.33	2.58

Table A.2. Critical values of *F* for a one-tailed test (*P* = 0.05)

ν_1	1	2	3	4	5	6	7	8	9	10	12	15	20
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.9	245.9	248.0
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45
3	10.13	9.552	9.277	9.117	9.013	8.941	8.887	8.845	8.812	8.786	8.745	8.703	8.660
4	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999	5.964	5.912	5.858	5.803
5	6.608	5.786	5.409	5.192	5.050	4.950	4.876	4.818	4.772	4.735	4.678	4.619	4.558
6	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147	4.099	4.060	4.000	3.938	3.874
7	5.591	4.737	4.347	4.120	3.972	3.866	3.787	3.726	3.677	3.637	3.575	3.511	3.445
8	5.318	4.459	4.066	3.838	3.687	3.581	3.500	3.438	3.388	3.347	3.284	3.218	3.150
9	5.117	4.256	3.863	3.633	3.482	3.374	3.293	3.230	3.179	3.137	3.073	3.006	2.936
10	4.965	4.103	3.708	3.478	3.326	3.217	3.135	3.072	3.020	2.978	2.913	2.845	2.774
11	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.896	2.854	2.788	2.719	2.646
12	4.747	3.885	3.490	3.259	3.106	2.996	2.913	2.849	2.796	2.753	2.687	2.617	2.544
13	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.714	2.671	2.604	2.533	2.459
14	4.600	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.646	2.602	2.534	2.463	2.388
15	4.543	3.682	3.287	3.056	2.901	2.790	2.707	2.641	2.588	2.544	2.475	2.403	2.328
16	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.538	2.494	2.425	2.352	2.276
17	4.451	3.592	3.197	2.965	2.810	2.699	2.614	2.548	2.494	2.450	2.381	2.308	2.230
18	4.414	3.555	3.160	2.928	2.773	2.661	2.577	2.510	2.456	2.412	2.342	2.269	2.191
19	4.381	3.522	3.127	2.895	2.740	2.628	2.544	2.477	2.423	2.378	2.308	2.234	2.155
20	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447	2.393	2.348	2.278	2.203	2.124

ν_1 = number of degrees of freedom of the numerator and ν_2 = number of degrees of freedom of the denominator.

THE PERIODIC TABLE

Group 1 2 3 4 5 6 7 0

Period

1	H Hydrogen
2	He Helium

Atomic Number
Symbol
Name
Relative atomic mass

1	He Helium
2	H Hydrogen

1	2	3	4	5	6	7	8	9	10
1	Li Lithium	Be Beryllium	B Boron	C Carbon	N Nitrogen	O Oxygen	F Fluorine	Ne Neon	
2	Na Sodium	Mg Magnesium	Al Aluminum	Si Silicon	P Phosphorus	S Sulfur	Cl Chlorine	Ar Argon	
3	K Potassium	Ca Calcium	Sc Scandium	Ti Titanium	V Vanadium	Cr Chromium	Mn Manganese	Fe Iron	Cobalt
4	Rb Rubidium	Sr Strontium	Y Yttrium	Zr Zirconium	Nb Niobium	Mo Molybdenum	Tc Technetium	Ru Ruthenium	Rh Rhodium
5	Cs Cesium	Ba Barium	La Lanthanum	Hf Hafnium	Ta Tantalum	W Tungsten	Re Rhenium	Os Osmium	Ir Iridium
6	Fr Francium	Ra Radium	Ac Actinium	Rf Rutherfordium	Hg Mercury	Tl Thallium	Pb Lead	Bi Bismuth	Po Polonium
7				Uuq Ununquadium	Uup Ununpentium	Uuh Ununhexium			

Lanthanoid elements

Actinoid elements

58	Ce Cerium	59	Pr Praseodymium	60	Nd Neodymium	61	Pm Promethium	62	Sm Samarium	63	Eu Europium	64	Gd Gadolinium	65	Tb Terbium	66	Dy Dysprosium	67	Ho Holmium	68	Er Erbium	69	Tm Thulium	70	Yb Ytterbium	71	Lu Lutetium
90	Th Thorium	91	Pa Protactinium	92	U Uranium	93	Np Neptunium	94	Pu Plutonium	95	Am Americium	96	Cm Curium	97	Bk Berkelium	98	Cf Californium	99	Es Einsteinium	100	Fm Fermium	101	Md Mendelevium	102	No Nobelium	103	Lr Lawrencium

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS – APRIL 2001

Analytical Chemistry C225

ANSWER ALL QUESTIONS

TIME: 3 HOURS

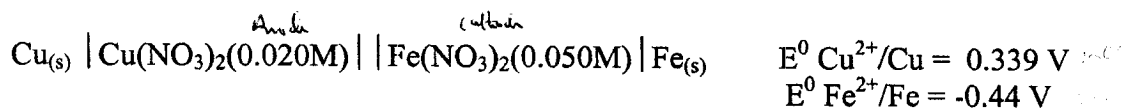
1. (a) A solution with a final volume of 500.0 mL was prepared by dissolving 25.00 mL of methanol (CH_3OH , density 0.7914 g/mL) in chloroform.
- (i) Calculate the molarity of methanol in the solution. [5]
(ii) If the solution has a density of 1.454 g/mL, find the molality of methanol. [5]
- (b) Find the absolute and percent relative uncertainty and express the answer with a reasonable number of significant figures in the following:
 $9.23 \pm (0.03) + 4.21 (\pm 0.02) - 3.26 (\pm 0.06)$ [2]
- (c) The Ti content (wt%) of five different ore samples (each with a different Ti content) was measured by each of the two methods.

Sample	% Composition by Method 1	% Composition by method 2
A	0.0134	0.0135
B	0.0144	0.0156
C	0.0126	0.0137
D	0.0125	0.0137
E	0.0137	0.0136

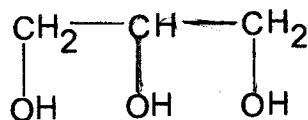
Do the two analytical techniques give results that are significantly different at the 95% confidence level? [8]

- (d) Standard solutions containing 35, 40 and 45 $\mu\text{g per cm}^3$ of α - methyl dopa gave absorbance values of 0.301, 0.360 and 0.396 respectively. Use linear regression to calculate the best straight line for the calibration. If a sample solution gives an absorbance of 0.445, calculate the concentration of α - methyl dopa in the sample. [5]
2. (a) Write the mass balance equations for K^+ and for phosphate in a solution prepared by mixing 0.0250 mol KH_2PO_4 plus 0.0300 mol of KOH and diluting to 1.00L. [5]
- (b) Write the charge balance equation for the above solution. [5]

- (c) A 0.0450 M solution of HA is 0.60% dissociated. Calculate pKa for this acid. [5]
- (c) The acid HA has pKa = 4.00. Use α values to calculate the fraction in the form HA and fraction in the form A⁻ at pH = 5.00. Does your answer agree with what you expect for the quotient [A⁻]/[HA] at pH = 5.00? [5]
- (e) What fraction of ethane-1,2-dithiol (HSCH₂CH₂SH) is in each form (H₂A, HA⁻, A²⁻) at pH 8.00? (K_{a1} = 1.4 × 10⁻⁹ and K_{a2} = 3.7 × 10⁻¹¹) [5]
3. (a) Calculate the pH at the following points for the titration of 50.00 mL of 0.0500 M formic acid (K_a = 1.80 × 10⁻⁴) with 0.0500 M KOH: 10.0, 25.0, 50.0, 55.0 mL. Sketch a graph of pH Vs V_b. [5]
- (b) Calculate pCa for the titration of 25.00 mL of 0.0200 M EDTA with 0.0100 M CaSO₄ at pH 10.00 at the following volumes: 20.0, 50.0, 55.0 mL. (K_f CaY²⁻ = 1.0 × 10¹² and α_Y^{4-} = 0.054) [5]
- (c) Distinguish between end point and equivalence point. With reference to your answer, what does the term titration error mean? [5]
- (d) Calculate the cell potential for the following cell: [5]



- (e) An aqueous glycerol solution weighing 100.0 mg was treated with 50.0 mL of 0.0837 M Ce⁴⁺ in 4 M HClO₄ at 60 °C for 15 min to oxidize glycerol to formic acid



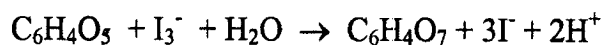
Glycerol

Mw 92.095

Formic acid

The excess Ce⁴⁺ required 12.11 mL of 0.0448 M Fe²⁺ to reach a ferroin end point. What is the weight percent of glycerol in the unknown? [5]

4. (a) Ascorbic acid (Vitamin C) reacts with I₃⁻ according to the reaction equation:



Ascorbic
acid

Starch is used as an indicator in the reaction. The end point is marked by an appearance of a deep blue starch-iodine complex when the first fraction of a drop of unreacted I₃⁻ remains in the solution.

- (i) If 29.41 mL of I_3^- solution is required to react with 0.1970 g of pure ascorbic acid, what is the molarity of the I_3^- solution? [5]
- (ii) A vitamin C tablet containing ascorbic acid plus an inert binder was ground to a powder, and 0.4242 g was titrated by 31.63 mL of I_3^- . Find the weight percent of ascorbic acid in the tablet. [5]
- (b) State four desirable properties of a gravimetric precipitate. [4]
- (c) Very briefly, discuss the phrase "Crystal Growth" in gravimetric analysis. [5]
- (d) A 0.05020-g sample of impure piperazine contains 71.29 wt% piperazine (MW 86.137). How many grams of product (MW 206.243) will be formed when this sample is analyzed by the following reaction? $(CH_2)_4(NH)_2 + 2CH_3CO_2H \rightarrow (CH_2)_4(NH_2)_2^{2+}(CH_3CO_2^-)_2$ [6]

Table A.1. The t -distribution

Value of t for a confidence interval of Critical value of $ t $ for P values of Number of degrees of freedom	90% 0.10	95% 0.05	98% 0.02	99% 0.01
1	6.31	12.71	31.82	63.66
2	2.92	4.30	6.96	9.92
3	2.35	3.18	4.54	5.84
4	2.13	2.78	3.75	4.60
5	2.02	2.57	3.36	4.03
6	1.94	2.45	3.14	3.71
7	1.89	2.36	3.00	3.50
8	1.86	2.31	2.90	3.36
9	1.83	2.26	2.82	3.25
10	1.81	2.23	2.76	3.17
12	1.78	2.18	2.68	3.05
14	1.76	2.14	2.62	2.98
16	1.75	2.12	2.58	2.92
18	1.73	2.10	2.55	2.88
20	1.72	2.09	2.53	2.85
30	1.70	2.04	2.46	2.75
50	1.68	2.01	2.40	2.68
∞	1.64	1.96	2.33	2.58

Table A.2. Critical values of F for a one-tailed test ($P = 0.05$)

ν_1	1	2	3	4	5	6	7	8	9	10	12	15	20
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.9	245.9	248.0
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45
3	10.13	9.552	9.277	9.117	9.013	8.941	8.887	8.845	8.812	8.786	8.745	8.703	8.660
4	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999	5.964	5.912	5.858	5.803
5	6.608	5.786	5.409	5.192	5.050	4.950	4.876	4.818	4.772	4.735	4.678	4.619	4.558
6	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147	4.099	4.060	4.000	3.938	3.874
7	5.591	4.737	4.347	4.120	3.972	3.866	3.787	3.726	3.677	3.637	3.575	3.511	3.445
8	5.318	4.459	4.066	3.838	3.687	3.581	3.500	3.438	3.388	3.347	3.284	3.218	3.150
9	5.117	4.256	3.863	3.633	3.482	3.374	3.293	3.230	3.179	3.137	3.073	3.006	2.936
10	4.965	4.103	3.708	3.478	3.326	3.217	3.135	3.072	3.020	2.978	2.913	2.845	2.774
11	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.896	2.854	2.788	2.719	2.646
12	4.747	3.885	3.490	3.259	3.106	2.996	2.913	2.849	2.796	2.753	2.687	2.617	2.544
13	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.714	2.671	2.604	2.533	2.459
14	4.600	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.646	2.602	2.534	2.463	2.388
15	4.543	3.682	3.287	3.056	2.901	2.790	2.707	2.641	2.588	2.544	2.475	2.403	2.328
16	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.538	2.494	2.425	2.352	2.276
17	4.451	3.592	3.197	2.965	2.810	2.699	2.614	2.548	2.494	2.450	2.381	2.308	2.230
18	4.414	3.555	3.160	2.928	2.773	2.661	2.577	2.510	2.456	2.412	2.342	2.269	2.191
19	4.381	3.522	3.127	2.895	2.740	2.628	2.544	2.477	2.423	2.378	2.308	2.234	2.155
20	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447	2.393	2.348	2.278	2.203	2.124

ν_1 = number of degrees of freedom of the numerator and ν_2 = number of degrees of freedom of the denominator.

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER I EXAMINATIONS, APRIL 2002

C245

INORGANIC CHEMISTRY I

TIME : THREE HOURS

INSTRUCTIONS

1. THIS EXAMINATION HAS SIX (6) QUESTIONS.
 2. ANSWER ANY FOUR (4) QUESTIONS.
 3. EACH QUESTION CARRIES TWENTY FIVE (25) MARKS.
 4. A TIDY AND ORDERLY PRESENTATION IS A MUST.
-

1(a) Use Molecular Orbital Theory (MOT) to predict which of the following species is diamagnetic.



[Atomic Number : H = 1 ; O = 8]

(b) Draw a clearly labelled energy level molecular orbital diagram for nitrogen molecule. Using the diagram deduce the bond order in the nitrogen molecule.

[Atomic number : N = 7]

(c) What is meant by the term diagonal relationship between the two elements of different groups in the periodic table. Discuss this relationship of beryllium (Group IIA) with aluminium (Group III A)

(d) Write the structures of the following species.



2(a) In a photoelectric experiment, when the light with a wavelength of 425 nm falls on the surface of potassium metal electrons with kinetic energy of $2.00 \times 10^5 \text{ J mol}^{-1}$ are emitted. Calculate

- (i) the minimum energy that is needed to eject an electron from potassium.
- (ii) the maximum wavelength of light that will cause a photoelectron to be ejected.

- (b) Write three commercial uses of each of the following.
- (i) Sodium thiosulphate (ii) Sodium tetraborate
- (c) List the differences between an orbit and orbital.
- (d) Write the balance chemical reactions, when
- (i) Carbon disulphide reacts with sodium azide.
- (ii) Powdered colemanite mineral of boron is boiled with sodium carbonate solution.
- (iii) Steam is passed over red hot alumina.
- 3(a) Discuss the method of extraction of beryllium metal in which its ore beryl is fused with potassium carbonate at $1500 - 1600^{\circ}\text{C}$ in an electric furnace. Write all chemical reactions involved in the method.
- (b) Explain two methods for the preparation of sodium thiosulphate. Write balanced chemical reactions, when it reacts with
- (i) Silver chloride (ii) Iodine
- (c) The work function of a certain metal is 1.8 eV. Calculate the maximum velocity of the emitted photoelectrons at the metal surface, if the metal is subjected to irradiation of photon of wavelength 4000 Å.
- (d) Derive the following expression apply to calculate the radius of the n^{th} orbit of hydrogen and hydrogen like species.
- $$r_n = \frac{n^2 h^2 \epsilon}{Z e \pi m}, \text{ where the symbols have their usual meaning.}$$
- Hence calculate the radius of the second orbit of the hydrogen atom.
- 4(a) Compare the general properties of the elements of groups IA and IIA of the periodic table.
- (b) Write two methods for the preparation of diboron. Explain the reactions when it reacts with
- (i) aqueous potassium hydroxide
- (ii) ammonia at high temperature.

(c) Write clearly the formula used to apply the Slater's rules to calculate the shielding constant (σ) and the effective nuclear charge (Z_{eff}) in the following cases.

- (i) Valence electron in Mn.
- (ii) 3d electron in copper.

[Atomic number : Mn = 25 ; Cu = 29]

(d) Give formula equations of Allred and Rochow's scale and Mulliken's approach to calculate the electronegativity of elements. Define each term in the formula.

5(a) Calculate the Lattice energy for the reaction $2\text{Al}(\text{s}) + 3/2 \text{O}_2(\text{g}) \rightarrow \text{Al}_2\text{O}_3(\text{s})$ by using the following data

	kJ mol^{-1}
Enthalpy of formation of $\text{Al}_2\text{O}_3(\text{s})$	- 1675.7
Enthalpy of sublimation	324.3
First ionization energy	578.0
Second ionization energy	1817.0
Third ionization energy	2745.0
	} for Al
Enthalpy of dissociation of oxygen molecule	498.4
First electron affinity of oxygen	- 141.4
Second electron affinity of oxygen	790.0

(b) Deduce the angular wave functions and draw the shapes of the atomic orbital with $l = 0, 1$ and 2 .

(c) Discuss the position of Hydrogen in the periodic table.

(d) Explain Borax Bead test for the qualitative analysis of Cr, Co and Ni ions.

6(a) Use Valance Bond Theory (VBT) to determine the type of hybridization for the central atom in AlCl_3 and hence decide its geometrical shape.

[Atomic number ; Al = 13 ; Cl = 17]

- (b) Write a short account on the following
- (i) Exchange pairs of electrons.
 - (ii) The relationship of complete wave function with radial and angular wave functions.
- (c) What happens when,
- (i) Sodium hydroxide solution reacts with aluminium sulphate solution.
 - (ii) Born is fused with caustic soda .
 - (iii) A mixture of boron trioxide , ammonium fluoborate is heated with sulphuric acid.
- (d) Complete and balance the following chemical equations.
- (i) $\text{Na}_2\text{B}_4\text{O}_7 + \text{HCl} + 5 \text{H}_2\text{O} \longrightarrow$
 - (ii) $\text{KOH} + \text{Sn} + \text{H}_2\text{O} \longrightarrow$
 - (iii) $\text{Be} + \text{HNO}_3 \text{ (hot \& conc)} \longrightarrow$

PHYSICAL CONSTANTS

Avogador's constant	$6.022 \times 10^{23} \text{ mol}^{-1}$
Planck's constant	$6.626 \times 10^{-34} \text{ J.s}$
Speed of light	$3.00 \times 10^8 \text{ m s}^{-1}$
Mass of electron	$9.11 \times 10^{-31} \text{ kg}$
Permittivity of the medium, ϵ	$8.854 \times 10^{-12} \text{ J}^{-1} \text{ C}^2 \text{ m}^{-1}$
Charge on the electron	$1.602 \times 10^{-19} \text{ C}$
1 J	$= \text{kg m}^2 \text{ s}^{-2}$
1 Å	$= 10^{-10} \text{ m}$
1 e V	$= 1.6 \times 10^{-19} \text{ J}$

END OF C245 EXAMINATIONS

THE PERIODIC TABLE

Group 1 2 3 4 5 6 7 0

Period

1	H Hydrogen
2	He Helium

Atomic Number	Symbol	Name	Relative atomic mass
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2	He Helium
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3	Li Lithium	4	Be Beryllium	5	B Boron	6	C Carbon	7	N Nitrogen	8	O Oxygen	9	F Fluorine	10	Ne Neon
11	Na Sodium	12	Mg Magnesium	13	Al Aluminum	14	Si Silicon	15	P Phosphorus	16	S Sulfur	17	Cl Chlorine	18	Ar Argon
19	K Potassium	20	Ca Calcium	21	Sc Scandium	22	Ti Titanium	23	V Vanadium	24	Cr Chromium	25	Mn Manganese	26	Fe Iron
27	Rb Rubidium	28	Sr Strontium	29	Zn Zinc	30	Ga Gallium	31	Ge Germanium	32	As Arsenic	33	Se Selenium	34	Br Bromine
37	Cs Cesium	38	Ba Barium	39	Y Yttrium	40	Zr Zirconium	41	Nb Niobium	42	Mo Molybdenum	43	Tc Technetium	44	Ru Ruthenium
55	Fr Francium	56	Ra Radium	57	La Lanthanum	58	Ce Cerium	59	Pr Praseodymium	60	Nd Neodymium	61	Pm Promethium	62	Sm Samarium
87	Fr Francium	88	Ra Radium	89	Ac Actinium	90	Th Thorium	91	Pa Protactinium	92	U Uranium	93	Np Neptunium	94	Pu Plutonium
103	Lr Lawrencium	104	Rf Rutherfordium	105	Db Dubnium	106	Sg Seaborgium	107	Bh Bohrium	108	Hs Hassium	109	Mt Meitnerium	110	Ds Darmstadtium
111	Rg Roentgenium	112	Cn Copernicium	113	Nh Nihonium	114	Fl Flerovium	115	Mc Moscovium	116	Lv Livermorium	117	Ts Tennessine	118	Og Oganesson

58	Ce Cerium	59	Pr Praseodymium	60	Nd Neodymium	61	Pm Promethium	62	Sm Samarium	63	Eu Europium	64	Gd Gadolinium	65	Tb Terbium	66	Dy Dysprosium	67	Ho Holmium	68	Er Erbium	69	Tm Thulium	70	Yb Ytterbium	71	Lu Lutetium
140	Ce	141	Pr	144	Nd	(147)	Pm	150	Sm	152	Eu	157	Gd	159	Tb	163	Dy	165	Ho	167	Er	169	Tm	173	Yb	175	Lu
232	Th Thorium	231	Pa Protactinium	238	U Uranium	237	Np Neptunium	242	Pu Plutonium	243	Am Americium	247	Cm Curium	249	Bk Berkelium	251	Cf Californium	254	Es Einsteinium	253	Fm Fermium	256	Md Mendelevium	259	No Nobelium	261	Lr Lawrencium

▶▶ Actinoid elements

▶ Lanthanoid elements

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SEMESTER I EXAMINATIONS - APRIL 2002.

ORGANIC CHEMISTRY I - C251

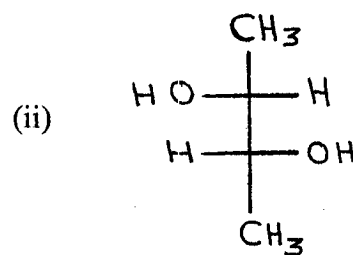
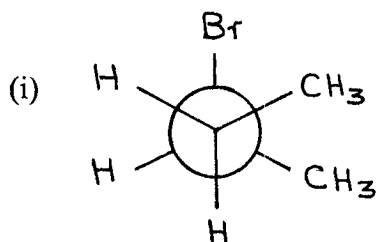
Time: Three (03) Hours

Instructions:

1. Answer any FOUR questions.
2. All questions carry equal marks.
3. Marks allocation for each question is shown.
4. Maximum marks = 100

QUESTION - ONE

- a) Name the following compounds by the R/S system of nomenclature. State whether they are optically active and give your reason.



(08 marks)

- b) The S_N2 reaction sometimes occurs intramolecularly, (that is - within the same molecule), Using this notion write the molecular structure of the product you would expect to obtain from treatment of 4-bromo-1-butanol with a base, EtO^- . Write a mechanism for this reaction and give the IUPAC name for the product.

(06 marks)

- c) If the product obtained in 1(b) above were treated with methylmagnesium bromide in ether followed by acidic hydrolysis what product would you expect to obtain?

(06 marks)

d) Arrange the compounds of each set in order of increasing reactivity towards indicated reactions.

(i) Bromocyclohexanol, 1-bromo-1-methylcyclohexanol, bromomethylcyclohexanol toward S_N2 displacement.

(ii) 1-Iodobutane, 1-iodo-2,2-dimethylpropane, 1-iodo-2-methylbutane, 1-bromo-3-methylbutane toward S_N1 displacement.

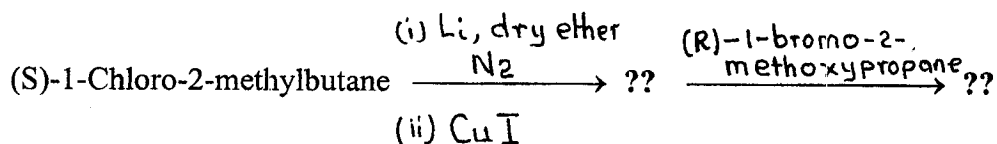
(05 marks)

QUESTION TWO

a) Outline a synthesis of (R)-2-azidobutane from (R)-2-bromobutane. Show clearly all the reagents and reaction conditions for each step. Mechanisms of the reactions are NOT required. [Note: Azido group is $-N_3^-$ meaning $^-N=N\equiv N$]

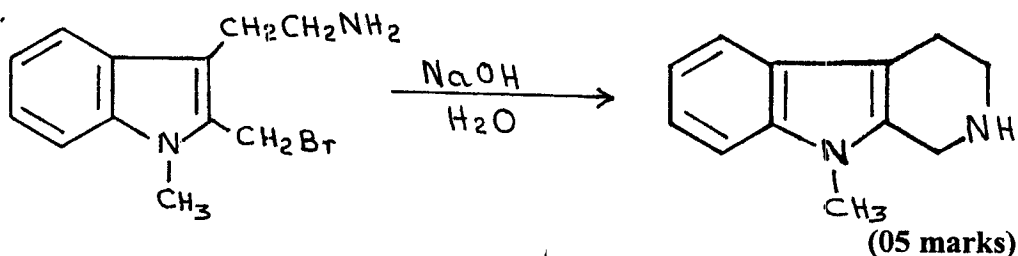
(09 marks)

b) Give stereochemical structures of the expected major products of the following reactions.

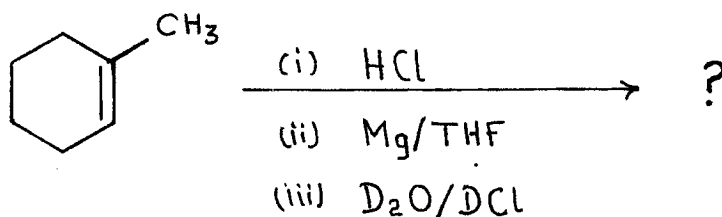


(06 marks)

c) Propose a plausible reaction mechanism to account for the indicated product of the following reaction.



- d) Predict the products and give mechanisms of the following reactions.



(05 marks)

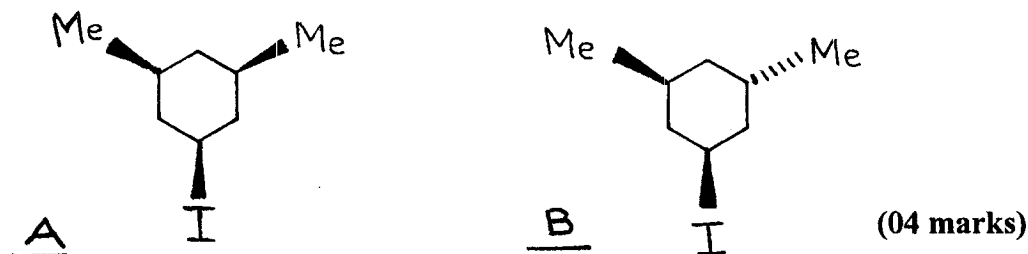
QUESTION THREE

- (a) Solvolysis of 1-iodo-2-methylbutane in aqueous propanone [$\text{H}_2\text{O} + \text{CH}_3\text{COCH}_3$], at 25°C gave a number of products including 2-methyl-2-butanol, 3-pentanol and 2-pentanone in 52%, 20% and 10% yield respectively. Provide a mechanism to account for the formation of the observed products of this reaction.

(12 marks)

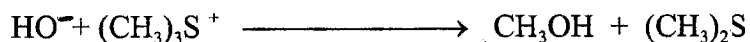
- b) Suggest an explanation for each of the following observations.

- (i) Compound A reacts faster by $\text{S}_{\text{N}}2$ mechanism than compound B.



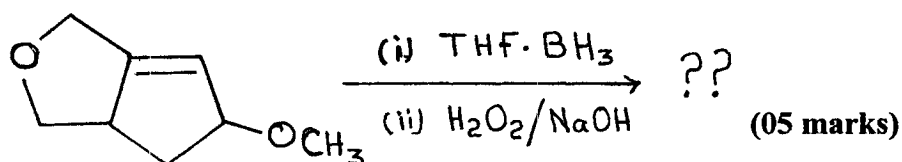
(04 marks)

- (ii) Increasing solvent polarity causes a large decrease in the rate of the $\text{S}_{\text{N}}2$ attack by hydroxide ion on trimethylsulfonium ion, $(\text{CH}_3)_3\text{S}^+$.



(04 marks)

- c) Predict the major organic product of the following reactions and show the mechanism of the first reaction ONLY.



(05 marks)

QUESTION FOUR

- a) An unknown compound **C** was reacted with one mole equivalent of hydrogen over palladium catalyst and gave a compound **D**, which upon ozonolysis yielded hexanal as the only organic compound. Write the reactions involved clearly showing intermediates for each reaction and provide molecular structures and names for compounds **C** and **D**.

(08 marks)

- b) Provide an explanation to account for each of the following observations.

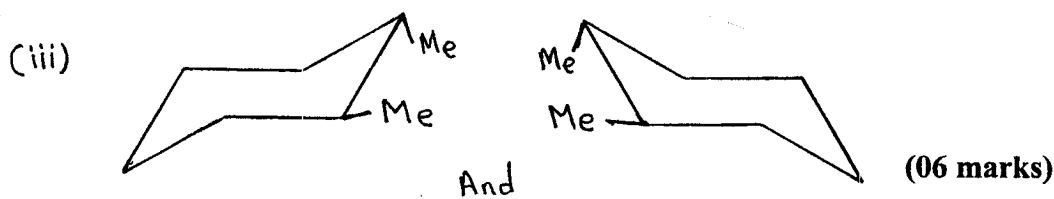
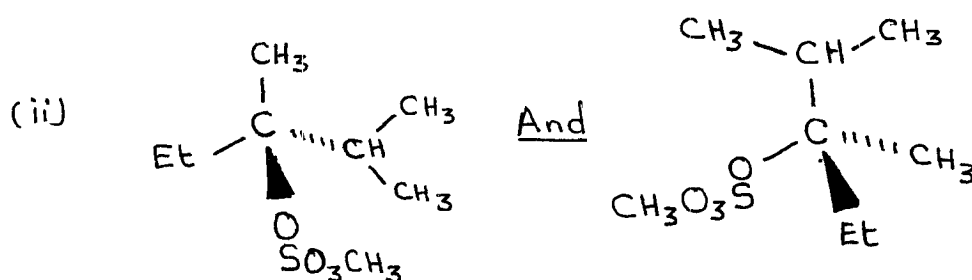
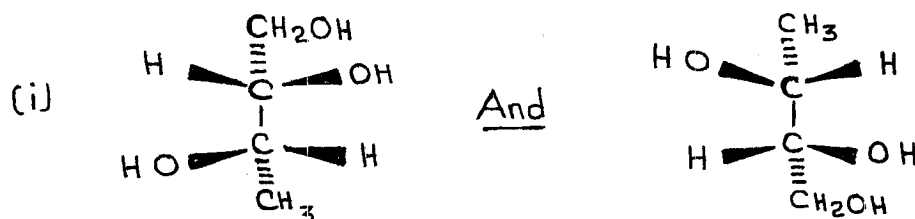
- (i) 1,3-Cis-disubstituted cyclohexanes are more stable than 1,3-trans-disubstituted cyclohexanes.

(07 marks)

- (ii) Acetate (CH_3COO^-) ion and hydroxyl (HO^-) ion react at the same rate with 2-bromo-2-methylpropane at room temperature.

(04 marks)

- c) What is the stereochemical relationship between the following pairs of compounds?

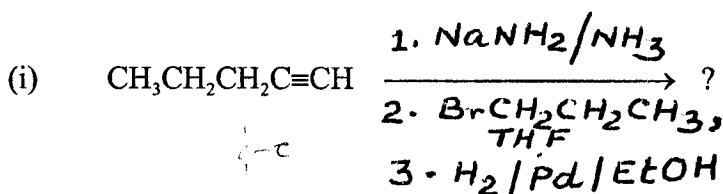


QUESTION FIVE

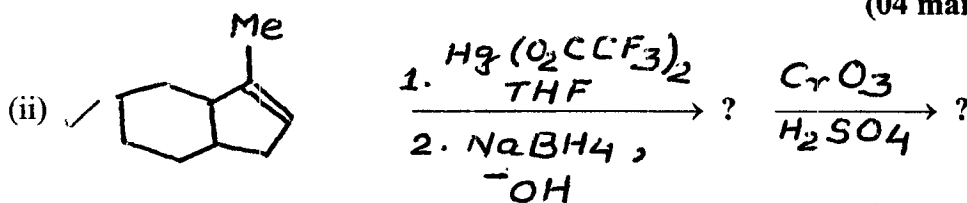
- a) When 4-pentene-1-ol is reacted with aqueous bromine ($\text{H}_2\text{O} + \text{Br}_2$), a cyclic bromoether is obtained rather than the expected bromohydrin. Suggest a plausible mechanism for this transformation.

(06 marks)

- b) Write the mechanism for the following reactions.

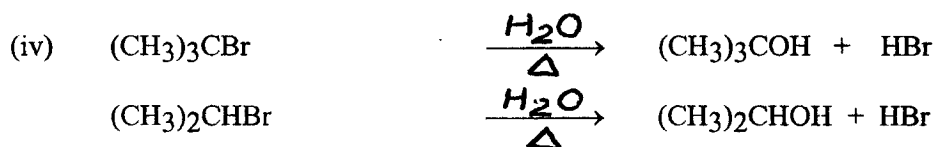
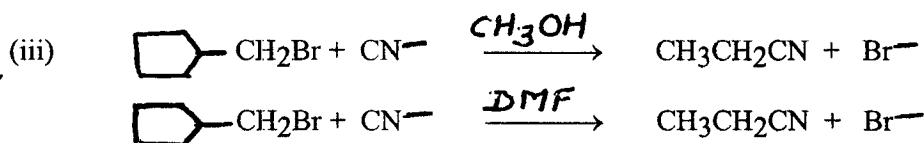
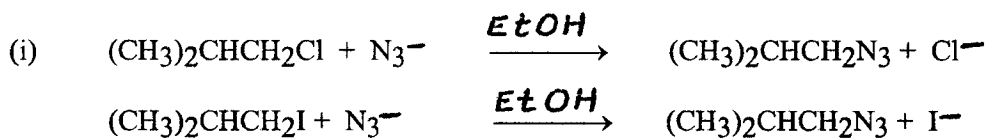


(04 marks)



(07 marks)

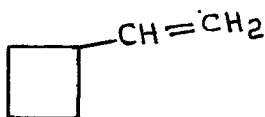
- c) Which of the following reactions would you expect to occur at a faster rate? Briefly explain your choice.



(08 marks)

QUESTION SIX

- a) Write the steps involved in the hydration of cyclobutylethene, structure shown below, in presence of dilute sulfuric acid and show clearly the stereochemistry of the product.



Cyclobutylethene

(06 marks)

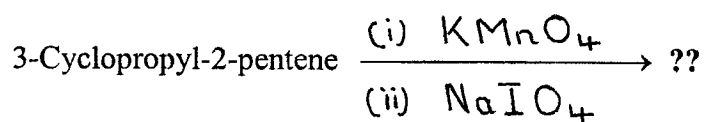
- b) Write four (04) limitations of the Grignard reactions.

(04 marks)

- c) Making use of $(\text{CH}_3)_3\text{SiCl}$, CH_2O and any other needed reagents, show how you would synthesize butane-1,4-diol from 3-bromo-1-propanol.

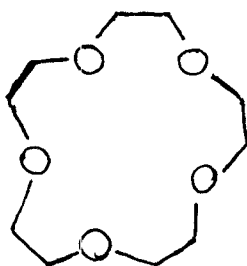
(07 marks)

- d) ✓ Draw the structures of the major organic products of the following reactions.



(06 marks)

- e) Name the compound shown below.



(02 marks)

END OF EXAM - GOOD LUCK !