UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

POST-GRADUATE EXAMS 2014 -2015.

1. BIO 5011 –Research statistical methods
2. BIO 5101 –Biosystematics of tropical plant taxation
3. BIO 5145 –Ecology and management of wildlife populations
4. BIO 5401 –Molecular Biology
5. CHE 5011 –General Chemical Techniques
6. CHE 5535 –Physical organic Chemistry
7. CSC 5011 –Data Structures and Algorithms
8. CSC 5021 –Programming Languages
9. CSC 5711 –Databases and information Systems
10. GES 5311 –Principles of environmental and natural resources
11. GES 5375 –Forests and wild life management
12. GES 5385 –Sustainable land management and food security
13. MAT 5055 –Finance and reporting
14. MAT 5611 –Statistical Engineering
15. MAT 5681 –Survival Models
16. MAT 5911 –Stochastic Process

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 5011: RESEARCH STATISTICAL METHODS
THEORY PAPER II

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **ALL** QUESTIONS. YOU ARE ALLOWED TO USE AUTHORIZED COMPUTERS, LAPTOPS AND THE SPSSWin©, STATISTIX© OR MSEXCEL©STATISTICAL ANALYSIS SOFTWARE PROVIDED, TO ANSWER THE QUESTIONS. USE STATISTICAL OUTPUT ILLUSTRATIONS WHERE NECESSARY.

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1. Table 1 contains data on bird species richness from three habitats during different sampling periods of an ecological monitoring programme in Sioma Ngwezi National Park (SNNP) in Sesheke District, Western Province, Zambia.

   Table 1. Bird species richness data from three habitats in Sioma Ngwezi National Park in Sesheke District.

Sampling period	Riverine woodland	Kalahari Sand woodland	Mkusi woodland
Baseline	24	27	25
1st spray	12	22	25
2nd spray	30	29	40
3rd spray	46	20	51
4th spray	41	31	33
5th spray	35	33	45
Post spray	41	34	47
Hot and dry season	62	49	57
Rainy season	65	43	69
Cool and dry season	66	45	63

   Determine whether there are significant differences in bird species richness:

   (a) Among different habitats.
   (b) During different sampling periods.

2. Table 2 below shows data obtained in a completely randomized experiment to test the enzymatic activity (μM/min) of acid phosphatase at four pH values 3, 5, 7, and 9. Conduct an analysis of variance of the data to test the null hypothesis that there are no significant differences among enzyme activity means at different pH values.

Table 2. Enzymatic activity of acid phosphatase at different pH values.

Number	Enzyme activity μM/min	Treatment
1	11.1	1
2	10.0	1
3	13.3	1
4	10.5	1
5	11.3	1
6	12.0	2
7	15.3	2
8	15.1	2
9	15.0	2
10	13.2	2
11	11.2	3
12	9.1	3
13	9.6	3
14	10.0	3
15	9.8	3
16	5.6	4
17	7.2	4
18	6.4	4
19	5.9	4
20	6.3	4

LEGEND
Treatment 1 = pH 3
Treatment 2 = pH 5
Treatment 3 = pH 7
Treatment 4 = pH 9

3. Four different plant densities A-D were included in an experiment on the growth of lettuce. The experiment used a randomized block design (RBD), and the same number of plants are harvested from each plot, giving the weights (kg) recorded in Table 3a below.

Table 3a. Growth of lettuce at different plant densities in a randomised block experimental design.

DENSITY	BLOCKS			
	I	II	III	IV
A	2.7	2.6	2.5	3.0
B	3.0	2.8	3.2	3.1
C	3.3	3.3	3.5	3.4
D	3.2	3.0	3.0	2.2

The computer spreadsheet version of the data above appears as in Table 3b below:

Table 3b. Lettuce crop yield spreadsheet data

Number	Yield	Block	Treatment
1	2.7	I	A
2	2.6	II	A
3	2.5	III	A
4	3.0	IV	A
5	3.0	I	B
6	2.8	II	B
7	3.2	III	B
8	3.1	IV	B
9	3.3	I	C
10	3.3	II	C
11	3.5	III	C
12	3.4	IV	C
13	3.2	I	D
14	3.0	II	D
15	3.0	III	D
16	2.2	IV	D

Conduct an ANOVA to test the differences among the yield means.

END OF EXAMINATION

3

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 5011: RESEARCH STATISTICAL METHODS
THEORY PAPER I

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS.

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1. A group of researchers wanted to determine how a species of flour beetle (*Tribolium confusum*) is affected by the relative humidity of their environment: specifically, they wanted to be able to predict how much loss in weight (mg) they might expect when the beetles are grown under a given relative humidity. The researchers set up an experiment in which cultures of beetles were grown under 9 different relative humidities, and recorded the weight loss of each culture after six days as indicated in Table 1 below:

   Table 1. Weight loss in the flour beetle, *Tribolium confusum* grown at different relative humidities.

Humidity (%)	Weight loss (mg)
0	8.98
12	8.14
30	6.67
43	6.08
53	5.90
63	5.83
75	4.68
85	4.20
93	3.72

   Analyse tabulated results and determine how much weight you would expect a culture of beetles to lose if they were maintained at 25% relative humidity.

2. Heights (m) of pine trees from three sites of Zambia Forestry Corporation (ZAFICO) Plantation in Ndola are presented in Table 2 below. Test the null hypothesis that the mean pine tree heights of the three sites are not significantly different from each other.

Table 2. Height (m) of pine trees from three ZAFICO sites in Ndola.

Number	Site A	Site B	Site C
1	3.4	4.5	5.6
2	4.6	3.9	5.1
3	2.7	5.7	4.6
4	3.8	4.7	3.9
5	3.1	4.2	4.8
6	2.9	3.8	5.3
7	4.8	3.6	3.9
8	4.5	4.6	5.9
9	2.1	4.1	5.3
10	3.7	2.9	4.8

3. Table 3 presents mean biomass (g) of grassland plants in each of 20 experimental units. Half of the experimental units were burnt, and the other half were not.

Table 3. Data on mean biomass (g) of grassland plants.

TREATMENT	
Burnt	**Unburnt**
10.56	8.85
11.97	8.01
9.01	7.13
10.33	7.50
9.53	9.10
12.10	7.87
8.88	6.80
8.50	9.50
10.20	8.88
11.55	6.56

Test the null hypothesis that there is no significant difference in mean biomass of the two types of experimental units.

4. The yields (Kg) of a crop in an experiment with three randomized blocks are shown in Table 4 below. The yield of crop variety D in block 1 was missing but using the appropriate formula for estimating missing values in RBDs , the value was estimated to be 26.0 Kg.

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Table 4. Crop yield in a RBD experiment involving different crop varieties.

Crop variety	BLOCK		
	1	2	3
A	34.0	34.3	35.0
B	33.0	36.3	35.8
C	34.3	35.3	32.3
D	-	29.8	28.0

Conduct an ANOVA and separate the mean yields using the Least Significant Range statistic.

5. A caterpillar population in a large field has a density of 51 caterpillars/m^2. We want to test whether a particular herbicide has an effect on caterpillar density. Two possible designs are:

(a) The field is divided into two parts, and a pre-application sampling of 20 quadrats in each part shows no significant difference between them. The herbicide is applied to one half of the field, and the other half is kept as a control. After 72 hours, 20 quadrats are sampled in each half to determine the final density of caterpillars.

(b) The field is partitioned into a grid of one thousand 4m x 4m plots. Twenty of these are selected at random and used as controls, and another 20 plots are selected at random and used as herbicide plots. A pre-application sampling is done on each plot, and no significant difference is found. The herbicide is applied to the appropriate plots, and 72 hours later each plot is sampled again to determine the final density of caterpillars.

(i) For each design, state what constitutes the experimental unit.

(ii) Critique each design in terms of whether it satisfies the basic requirements of a good experimental design, and its appropriateness both for conducting statistical analysis of the results and for drawing conclusions with respect to the question being asked.

(iii) Describe how you might want to modify the better of the two designs if you had noticed that a moist depression ran diagonally across the field, and found that caterpillar densities were higher in more moist areas.

6. A fertilizer trial on strawberries consists of 4 replicates of the 4 treatment combinations of nitrogen and phosphorus (Θ, *n*, *p*, *np*). The resulting crop yields per plot (in suitable units) are presented in Table 5 below:

Table 5. Crop yields of an experiment involving various combinations of nitrogen and phosphorus

Blocks	Treatment			
	Θ	*n*	*p*	*np*
I	13	24	16	27
II	12	25	14	34
III	18	24	15	32
IV	15	31	20	30

Carry out an analysis to determine the effects (if any) due to blocks, n, p and the interaction np.

7. In an automobile exhaust emission study, four cars and four drivers were used to test the possible differences among four petrol additives (A, B, C & D) in reducing the amount of oxides of nitrogen emitted in exhaust gases. A Latin Square Design (LSD) was employed in the experimental setup and Table 6 below gives the results of this study with one missing value:

Table 6. Results of an automobile exhaust emission study to compare the efficiency of four petrol additives in reducing the amount of oxides of nitrogen emitted in exhaust gases.

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

(i) Estimate the missing value.
(ii) Test the null hypothesis that there are no significant differences among the additives.

8. You are interested in whether the thickness of the leaves of a given species of plant affects the growth rate of leaf-mining insect larvae. (These larvae tunnel through the leaf after they hatch, feeding on mesophyll).

(a) Identify an appropriate experimental unit (i.e. the unit that should be replicated) for a manipulative study designed to address this question.

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(b) Describe a simple manipulative experiment that you could conduct to test the null hypothesis that leaf thickness has no effect on larval growth rates and that would generate results that would let you predict larval growth rates from measurements of leaf thickness. Briefly describe any treatments you would establish, what would you measure, how would you analyze your data, and how you would use the results of the analysis.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 5101: BIOSYSTEMATICS OF TROPICAL PLANT TAXA
PRACTICAL PAPER

TIME: TWO HOURS

INSTRUCTIONS: ANSWER **BOTH** QUESTIONS.

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1.   (a) Use the taxonomic Key provided to identify specimens **A to J.**
     (b) List diagnostic features of each specimen identified.

2.   Construct a taxonomic key for the identification of specimens **K to O.**

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 5101: BIOSYSTEMATICS OF TROPICAL PLANT TAXA
PRACTICAL PAPER

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UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 5101: BIOSYSTEMATICS OF TROPICAL PLANT TAXA
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BIO 5101: BIOSYSTEMATICS OF TROPICAL PLANT TAXA
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **QUESTION ONE** AND ANY OTHER **FOUR** QUESTIONS.

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1. Summarise any **four** of the following:
   (a) Syntype.
   (b) Leaf dimorphism in the aquatic Polypodiales.
   (c) Androecium in Malvaceae.
   (d) Biosystematic phase of systematic knowledge.
   (e) Principle of priority in taxonomy.

2. Discuss the concept of taxonomic characters in plant systematics.

3. Discuss typification and it's the significance in plant systematics.

4. Compare and contrast the characteristic floral features of the Araceae, Arecaceae and the Malvaceae.

5. Discuss the various floristic regions of Africa and the provincial composition for each of them.

6. Discuss the distribution, characteristic features and economic importance of the family Solanaceae.

7. (a) State the various categories of online botanical databases.
   (b) Describe five online databases and highlight their importance.

8. Discuss Arthur Cronquist's (1981, 1988) ordinal classification within the Magnolidae in the light of the Angiosperm phylogeny Groups (APG, 2009)'s classification system.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
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2014 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 5145: ECOLOGY AND MANAGEMENT OF WILDLIFE POPULATIONS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER QUESTIONS **ONE** AND **TWO** AND ANY OTHER
THREE QUESTIONS. ILLUSTRATE YOUR ANSWERS WHERE NECESSARY.

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1. (a) Describe the interaction by predation of Sp_1 (prey) and Sp_2 (predator) and
    (b) Discuss the functional and numerical responses of this relationship.

2. Lamont Cole (1954) noted that natural history of population of species could be
    summarised by parameters l_x and m_x,
    (a) Discuss parameters l_x and m_x in population growth as applied to a single
        population model.
    (b) Describe methods used in deriving these parameters in a vertebrate population.
    (c) State the assumptions associated with these parameters.

3. In the regulation of populations of species, discuss the theories expressed by:
    (a) Andrewartha and Birch (1954)
    (b) Wynne-Edwards (1964)
    (c) Christian and Davis (1964).
    (d) Pimentel *et al* (1965).

4. Compare and contrast the concepts of carrying capacity and stocking rate in the
    populations species as applied to a single population model in wildlife management.

5. Summarise each of the following concepts:
    (a) Limiting similarity.
    (b) $1 - e^{-H}$
    (c) Stocking rate.
    (d) Wildlife hunting quota.

6. Discuss features which would indicate that a wildlife species population was overexploited, and state measures you would consider as significant in reversing t he trend.

7. Discuss each of the following as used in wildlife population management studies :
   (a) $N_t = N_0 e^{rt}$
   (b) *Syncerus caffer*.
   (c) k- selection strategies in wildlife species.
   (d) Wildlife habitat.

8. Discuss the concept of Maximum Sustainable Yield and give reasons why this concept is regarded as an epitaph in harvesting wildlife species populations.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 5145: ECOLOGY AND MANAGEMENT OF WILDLIFE POPULATIONS
THEORY PAPER

TIME: THREE HOURS

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THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 5145: ECOLOGY AND MANAGEMENT OF WILDLIFE POPULATIONS
THEORY PAPER

TIME: THREE HOURS

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END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 5401: MOLECULAR BIOLOGY
THEORY PAPER

TIME: THREE HOURS

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

1. Discuss the regulation of gene expression by various *cis*-acting and *trans*-acting elements and factors in eukaryotes.

2. (a) Describe the structure of an aptamer.
   (b) Explain how aptamers regulate cellular gene expression using specific examples.

3. Explain the recruitment and roles of various nucleosome-modifying enzymes in gene expression and silencing in eukaryotes.

4. Discuss the structure and biogenesis of small interfering RNAs and micro RNAs (miRNAs) as well as their roles in gene expression regulation.

5. Discuss the interactions between miRNAs and p53 in cancer development and control.

6. Discuss the phenomenon of imprinting using the example of insulin-like growth factor 2 (*Igf2*) and the human *H19* gene expression regulation on maternal and paternal X chromosomes.

7. (a) Describe two properties of mouse embryonic stem cells (mESCs) and explain why so much research interest has been generated in mESCs and stem cells.
   (b) Discuss the molecular events in transforming growth factor beta (TGF-β) signaling in mESC maintenance including the roles played by various regulators of mESC maintenance in the embryonic stem cell signaling.

TURN OVER

8. Summarise each of the following topics:
   (a) The molecular mechanisms involved in X-chromosome inactivation and why all calico cats are female.
   (b) The control of the *HO* gene in the yeast *Saccharomyces cerevisiae* during budding.
   (c) Cooperative binding of activators in human β-interferon gene expression.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR MID – YEAR EXAMINATIONS

CHE 5011 GENERAL CHEMICAL TECHNIQUES

TIME: THREE HOURS

INSTRUCTIONS

1 There are **five** questions in this Examination Paper.

2 Answer **Question 1** and any other **three** questions.

3 Question 1 carries 30 marks and the remaining questions carry 24 marks each.

4 Each question should be answered in a separate answer booklet.

5 Essential information and data are provided for this paper

Question 1

(a) For a particular bond, the compound in the vapour state absorbs IR radiation at higher wave number as compared to that when it is in the solid state. Briefly explain.

(b) How will you verify that a particular nmr signal is arising from the proton on a hetero atom such as -OH or –NH or –SH group. Briefly explain.

(c) Name three vertical gel electrophoresis techniques for separation of analytes.

(d) Moving boundary electrophoresis is not a good technique for separation of proteins. Suggest three possible reasons to explain this observation.

(e) What are X-rays and how are they generated?

(f) Write a brief note on the relevance of X-ray powder diffraction in the pharmaceutical industry

(g) What are the salient features of SCOT columns

(h) For the following detectors, ELSD, MS, PDA, **explain** the principle, sample type detected and advantage or disadvantage.

Question 2

(a) Briefly describe the Craig Tube recrystallization procedure for a microscale solid sample. Illustrate your answer with appropriate diagrams of the apparatus.

(b) How would you determine the purity of the recrystallized sample?

(c) Draw a labelled diagram of a microscale distillation apparatus.

(d) The efficiency of separation (N) in capillary electrophoresis (CE) is given by the expression given below. However, application of very high potentials (>20-30 kV) in CE separations leads to loss of resolution. . :
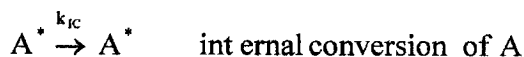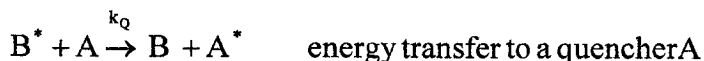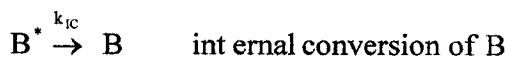
$$N = \frac{\mu V}{2D_m}$$

(i) Define the terms in the above equation.

(ii) Briefly explain how the use of high potentials leads to loss of resolution in CE.

(iii) Briefly discuss the applications and limitaions of the CE.

Question 3

(a) Describe the electron transition processes involved in x-ray generation.

(c) What is Bragg's Law and how can it be used to identify minerals?

(d) Briefly describe the X-ray absorption spectroscopy as one of the analytical techniques

(e) Powder X-ray diffraction (PXRD/XRPD) and single-crystal X-ray diffraction (SCXRD) make use of very similar instrumentation, with the primary differences being with the goniometer used in SCXRD to reorient the crystal. However, the chemical and analytical information that can be obtained from these techniques is very different. Describe this difference. In other words, what can one learn from SCXRD that cannot usually be learned from PXRD, and what can PXRD do that SCXRD cannot?

Question 4

Photolysis of benzene (B) in hexane solution in the presence of biacetyl (A) at a wavelength where biacetyl does not absorb, may be described by the following reaction scheme:

$$B + h\nu \xrightarrow{I_o} B^*$$ excitation of B

$$B^* \xrightarrow{k_f} B + h\nu_f$$ fluoresence of B

$$B^* \xrightarrow{k_{IC}} B$$ internal conversion of B

$$B^* + A \xrightarrow{k_Q} B + A^*$$ energy transfer to a quencher A

$$A^* \xrightarrow{k_{IC}} A^*$$ internal conversion of A

The A* and B* represents the S_1 vibrational excited states of A and B respectively in their S_0 ground states. Under conditions of continuous absorption of a laser beam by the sample, the dependence of the fluorescence intensity of benzene, I, on the concentration of biacetyl, A, is given below. I_0 is the fluorescence intensity of benzene in hexane in the absence of biacetyl.

[A]in mol/L	0.0001000	0.0002000	0.0003000	0.0004000
$(I/I_0)_f$	0.845	0.732	0.645	0.577

In a separate experiment, flash photolysis of benzene (B) in hexane solution resulted in fluorescence that decayed exponentially with a rate constant $k_f = 1.80 \times 10^8$ s^{-1}.

(a) Perform linear regression based on the data above and determine , a, b, and r

(b) Calculate the quenching rate constant, k_Q.

(c) (i) What is the role of a quencher.

(ii) Explain why doubling the concentration of biacetyl (A) does not necessarily double the fluorescence intensity of benzene (B).

Hint: Stern-Volmer equation is

$$\frac{1}{(I/I_o)_f} = \frac{1}{I_o f_a} + \frac{k_Q}{k_f I_o f_a}[A]$$

Question 5

(a) For your practical work, you were given three solvents, n-pentane, n-hexane, n-heptane. The boiling points for these are 36.1 $^\circ$C, 68 $^\circ$C and 98.42 $^\circ$C respectively. The GC-MS machine has a 25 $^\circ$C hold temperature with a gradient ramp 10 $^\circ$C per minute and maximum of 250 $^\circ$C.
Estimate how long each fraction will elute if a mixture of the solvents was injected.

(b) A soil sample from oil spillage along the Kitwe-Ndola road was collected by one of the technicians. Two volatile compounds labeled X and Y were separated on a 30m x 0.32mm I.D, 0.25μm pore size column. The observed retention times were 7 min 20 sec and 8 min 20 sec respectively. The base peak width for analyte Y was 10s. When a reference compound which was completely excluded from the stationary phase under the same conditions was studied, its retention time was 1 min 20s. In all cases temperature programming was used at 8 $^\circ$C/min with a hold temperature of 40°C and maximum temperature of 350 $^\circ$C.
Calculate
  (i)   The adjusted retention time for X and Y
  (ii)   The capacity factor for X and Y
  (iii) The selectivity factor for the two compounds
  (iv)   The number of theoretical plates in the column
  (v)   The resolution of the two compounds

(c) A zealous undergraduate ran a sample on an HPLC which was coupled to a UV-Vis detector and could not detect anything. What advise can you give this student? In your advice, **explain extensively** the means of achieving detection.

END OF EXAMINATION

Universal Statistical Tables:

1. Rejection Quotient, Q, at Different Confidence Limits.

Number of Observations	Confidence Level		
	Q_{90}	Q_{95}	Q_{99}
3	0.941	0.970	0.004
4	0.765	0.829	0.926
5	0.642	0.710	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568
15	0.338	0.384	0.475
20	0.300	0.342	0.425
25	0.277	0.317	0.393
30	0.260	0.298	0.372

2. Values of t for v Degrees of Freedom at Different Confidence Limits.

Number of Degrees of Freedom	Confidence Level			
	90%	95%	99%	99.5%
1	6.314	12.706	63.657	127.32
2	2.920	4.303	9.925	14.089
3	2.353	3.182	5.841	7.453
4	2.132	2.776	4.604	5.598
5	2.015	2.571	4.032	4.773
6	1.943	2.441	3.707	4.317
7	1.895	2.365	3.500	4.029
8	1.860	2.306	3.355	3.832
9	1.833	2.262	3.250	3.690
10	1.812	2.228	3.169	3.581
15	1.753	2.131	2.947	3.252
20	1.725	2.086	2.845	3.153
25	1.708	2.060	2.787	3.078
Infinite	1.645	1.960	2.576	2.807

3. Values of F at the 95% Confidence Level

$v_1 =$	2	3	4	5	6	7	8	9	10	15	20	30
$v_2 = $ 2	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.42	19.4	19.4	19.4	19.5
3	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.70	8.66	8.62
4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.86	5.80	5.75
5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.62	4.56	4.50
6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	3.94	3.87	3.81
7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.51	3.44	3.38
8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.22	3.15	3.08
9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.01	2.94	2.86
10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.85	2.77	2.70
15	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.40	2.33	2.25
20	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.20	2.12	2.04
30	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.01	1.93	1.84

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																1 H 1.01 Hydrogen	2 He 4.00 Helium
3 Li 6.94 Lithium	4 Be 9.01 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 23.00 Sodium	12 Mg 24.31 magnesium											13 Al 27.99 Aluminium	14 Si 28.09 Silicon	15 P 30.99 Phosphorus	16 S 32.07 Sulphur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.88 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.65 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 71.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 selenium	35 Br 79.96 Bromine	36 Kr 83.80 Kryptom
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 Iridium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 tellurium	53 I 126.90 Iodine	54 Xe 131.29 Xenon
55 Cs 132.91 Caesium	56 Ba 137.33 Barium	57 – 71	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantalum	74 W 183.84 Tungsten	75 Re 186.21 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.97 Gold	80 Hg 200.59 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po 208.98 Polonium	85 At 209.99 Astatine	86 Rn 222.02 Radon
87 Fr (223.02) Francium	88 Ra 226.03 Radium	89 – 103	104 Unq 261.11	105 Unp 262.11	106 unh 263.12	107 uns 262.12	108 Uno 265.00	109 Une 265									

KEY

Atomic number
X
Atomic mass
Name of the element X

Lanthanides (57–71)

57 La 138.91 Lanthanum	58 Ce 140.12 Cerium	59 Pr 140.91 Praseodymium	60 Nd 144.24 Neodymium	61 Pm 144.91 Promethium	62 Sm 150.36 Samarium	63 Eu 151.97 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.93 Terbium	66 Dy 162.50 Dysprosium	67 Ho 164.93 Holmium	68 Er 167.26 Erbium	69 Tm 168.93 Thulium	70 Yb 173.04 Ytterbium	71 Lu 174.97 Lutetium

Actinides (89–103)

89 Ac 227.03 Actinium	90 Th 232.04 Thorium	91 Pa 231.04 Protactinium	92 U 238.03 Uranium	93 Np 237.05 Neptunium	94 Pu 244.0 Plutonium	95 Am 243.86 Americium	96 Cm 247.07 Curium	97 Bk 247.07 Berkelium	98 Cf 251.08 Californium	99 Es 252.08 Einsteinium	100 Fm 257.10 Fermium	101 Md 260 Mendelevium	102 No 259.10 Nobelium	103 Lr 262.11 Lawrencium

Department of Chemistry-UNZA

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
MID YEAR EXAMINATIONS

CHE 5535: PHYSICAL ORGANIC CHEMISTRY

INSTRUCTIONS:

1. TIME: **THREE (3)** HOURS.
2. ANSWER <u>**ANY FOUR (4)**</u> QUESTIONS.
3. EACH QUESTION CARRIES **30 MARKS.**
4. PLEASE PRESENT YOUR ANSWERS IN A **LOGICAL** MANNER.
5. PLEASE BE NEAT AND TIDY
6. ENSURE THERE ARE **EIGHT (8)** PRINTED PAGES.

QUESTION ONE

(a) The table below shows the relative rates of alkaline hydrolysis of substituted benzamides in water at 100°C.

Substituent	Relative rate	σ-values
m-I	2.60	0.35
p-I	1.69	0.28
m-Br	2.97	0.39
p-Br	1.91	0.23
m-NO$_2$	5.60	0.71
H	**1.00**	**0.00**
m-CH$_3$	0.83	- 0.07
p-OCH$_3$	0.49	- 0.27
m-NH$_2$	0.93	- 0.16
p-NH$_2$	0.20	- 0.66

i) Demonstrate graphically the applicability (validity) of the Hammet equation to this reaction and determine its ρ–value.

(12 marks)

ii) Compare the magnitude of the determined ρ–value with that of the calculate one. Give your comment on the difference.

(2 marks)

(c) The effect of substituents on the log relative rates, *log k/k$_0$*, of phenyltrimethylsilanes in aqueous methanolic perchloric acid at 51^{0}C is given in the table below.

| Substituent	δ^+-values	log k/k$_0$,
p-N(CH$_3$)$_2$	-1.70	7.50
P-OCH$_3$	-0.78	3.18
P-CH$_3$	-0.31	1.32
m-CH$_3$	-0.07	0.36
H	**0.00**	**0.00**
P-Cl	0.11	-0.87
p-Br	0.15	-1.00

i) Demonstrate the correlation of the reaction with δ^+ values and provide the value of its constant, the *p*-value. *Note: A graph paper may be needed.*

(12 marks)

ii) Name the type of reaction in **(c) i)** above and show its mechanism.

(4 marks)

QUESTION TWO

(a) The calculated ρ-value for the dissociation of anilinium ions at 25^0C is 2.77. The reaction is shown below.
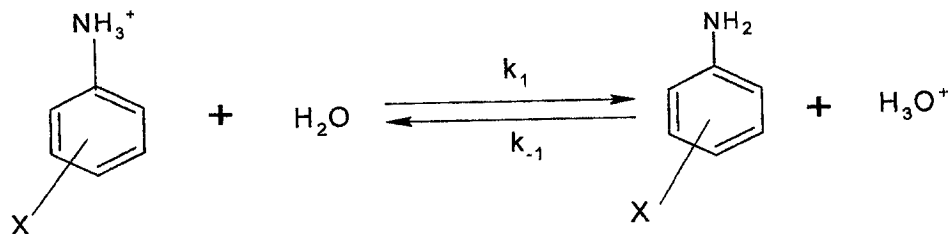
(i) Using the calculated ρ-value of the above reaction, calculate the log ratio of the ionisation constants of p-nitroanilinium and unsubstituted anilinium ions. *(3 marks)*

(ii) Laboratory experiments however, have shown that the observed ρ-value of the above reaction is in fact 3.52 and not 2.77, a discrepancy well outside experimental error, and implying an effective δ-value of 1.77 for p-NO_2 substituent. Explain briefly this observation and account for the discrepancy.

(10 marks)

(b) A Hammett plot for rate constants of the reaction shown below has a ρ-value of -5, 56 when substituent X is p-OCH_3, p-CH_3 m-CH_3, and H and using the σ-values of these substituents.
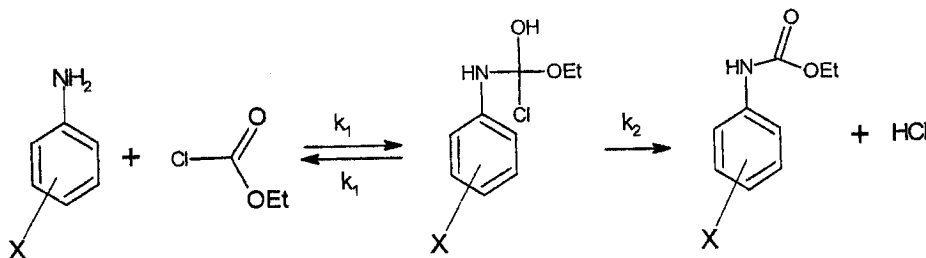
i) The same reaction has a ρ-value of -1.57 when the substituent X is p-Br, m-Cl, m-NO_2, p-NO_2 and p-COOEt and using σ-values of these substituents. Provide a mechanistic explanation to account for the difference in observed values of ρ for the above reaction.

(4 marks)

ii) Propose a mechanism for the transformation of the intermediate into the final product when the substituent X is p-OCH_3, p-CH_3 m-CH_3. Show your reasoning

(4 marks)

(c) The base-catalysed hydrolysis of ethyl m-nitrobenzoate is 63.5 times faster than the hydrolysis of ethyl benzoate under the same conditions. Calculate the comparable rate for the base-catalysed hydrolysis of ethyl p-methoxybenzoate under the same conditions. The m-NO_2 = 0.71 for the m-nitro group, and the p-OMe = – 0.27 for the p-methoxy group.

(6 marks)

3

(d) The values for the σ_m and σ_p for SOCH$_3$ are 0.52 and 0.49 respectively. The values for the σ_m and σ_p for SO$_2$CH$_3$ are 0.60 and 0.72 respectively. Comment on the differences in the σ_m- and σ_p-values for these substituents.
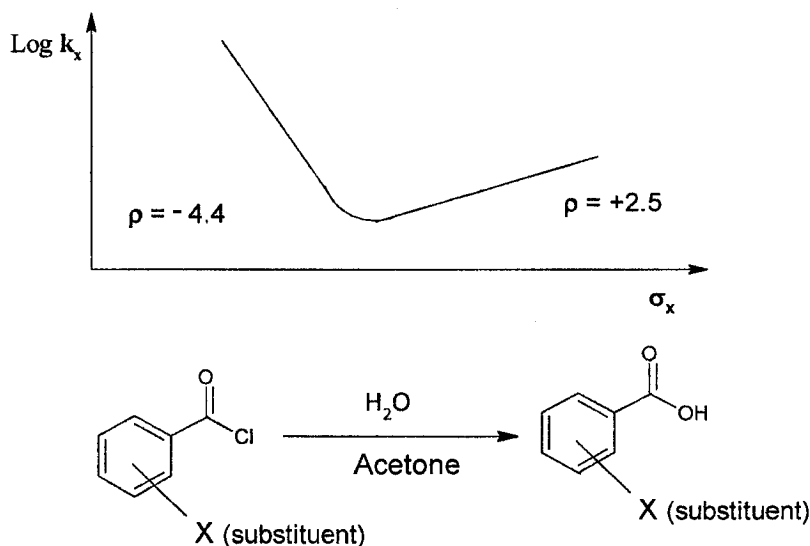
(3 marks)

QUESTION THREE

(a) Write the Yukawa-Tsuno equation applicable to compound **A** shown below and provide the meaning of each term in this equation. *(6 marks)*

$$O_2N\!\!-\!\!\langle\bigcirc\rangle\!\!-\!\!OSi(CH)_3 \qquad \text{Compound A}$$
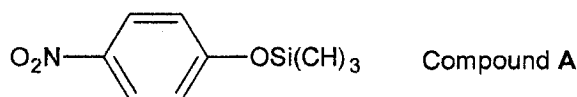
(b) The Hammett plot for hydrolysis of aromatic acyl chlorides is shown below. Comment briefly on the sensitivity of the reaction to the electronic environment.

$\rho = -4.4$ $\rho = +2.5$

(5 marks)

(c) i) Write the Hammett equation and briefly explain the significance of the terms in this equation. *(4 marks)*

ii) Hammett σ_m and σ_p constants fail to correlate certain reaction series. Explain why. *(3 marks)*

(d) The pKa of *p*-chlorobenzoic acid is 3.98 and the pKa of benzoic acid is 4.19. Calculate the σ-value for *p*-Cl substituent. *(4 marks)*
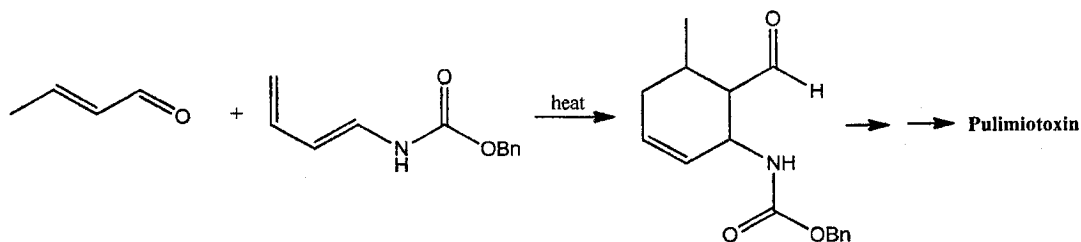
4

(e) The reaction of benzaldehyde with a hydroxylamine **A** gives a reactive intermediate **B**, which subsequently undergoes a concerted reaction with styrene to give the product **C**.

PhCHO + [structure A: Ph–CH₂–N(H)–OH] → **B** → [structure C: isoxazolidine ring with Ph groups]

A

C
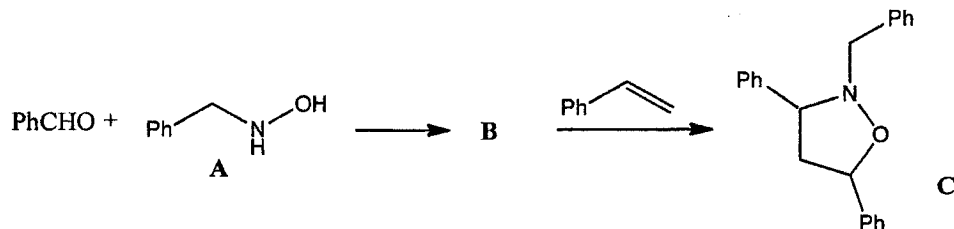
i)   Provide a structure for **B** and give a mechanism for its formation.   *(3 marks)*

ii) Propose a plausible mechanism to account for the product **C** from **B**. Briefly describe the type of reaction in less than two sentences.
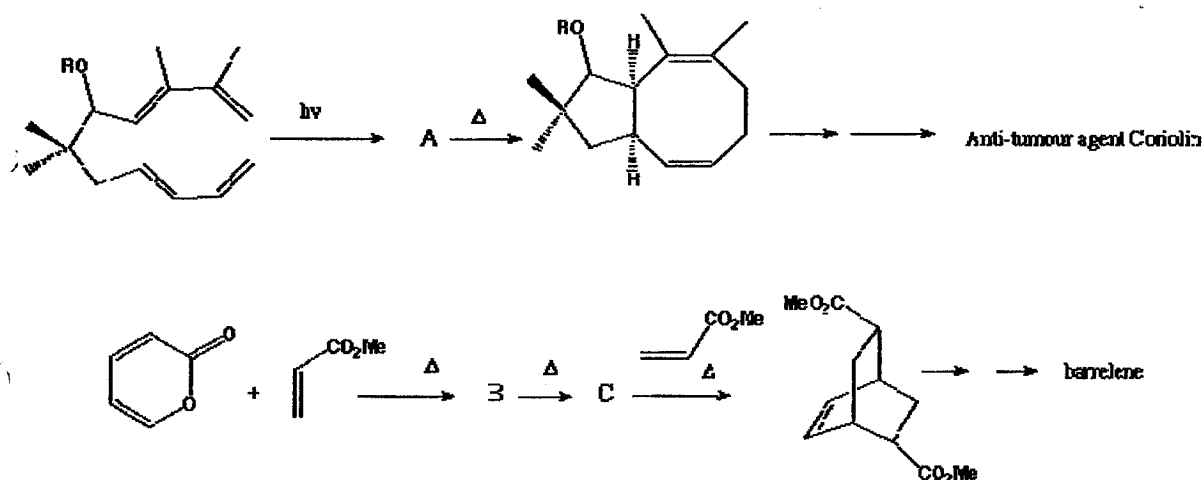
   (5 marks)

QUESTION FOUR

(a) A step in the synthesis of the alkaloid Pulimiotoxin is shown below.

[reaction scheme: crotonaldehyde + benzyl carbamate diene, heat → cyclohexene product] → → **Pulimiotoxin**

i)   With the aid of FMOs account for the control of the regiochemistry in this cycloaddition reaction.   *(5 marks)*

ii) Draw a transition state for the cycloaddition reaction, and predict the relative configurations of the three chiral centres in the product.   *(5 marks)*

iii) The use of a Lewis acid increases the rate of the cycloaddition reaction. With the aid of appropriate energy level diagrams, explain why?
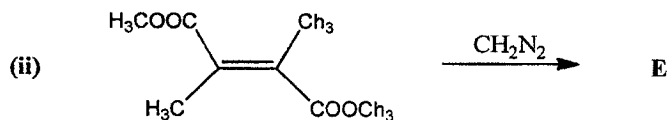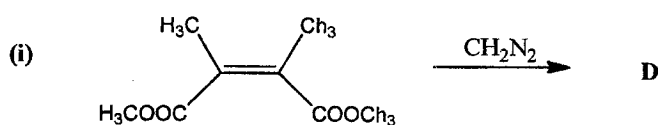
   (5 marks)

5

(b) Shown below are stages in the total syntheses of two interesting molecules. Describe the type of reaction occurring at each stage, including details of nomenclature and the number of electrons involved. Suggest structures for the intermediates **A**, **B** and **C**, and propose mechanisms for each stage.

(15 marks)

QUESTION FIVE

(a) Predict the product, including stereochemistry, of **ANY ONE** of the following reactions. Explain your answer using perturbation FMO theory.


(6 marks)

(b) With the aid of a suitable example illustrate how the FMO theory can explain the **endo** selectivity in thermal Diels-Alder reactions.

(5 marks)

6

(c) Predict the expected products and give mechanisms of the following reactions. For each reaction, show the transition state and briefly describe the reaction, in less than two sentences. *(5 marks each)*
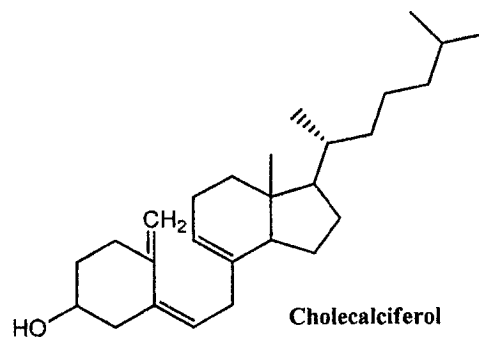
(i)

$$\xrightarrow[\text{Cope}]{120\ ^0C} \quad \mathbf{G}$$

(ii)

$$\xrightarrow[\text{(Claisen)}]{\text{heat}} \quad \mathbf{H}$$
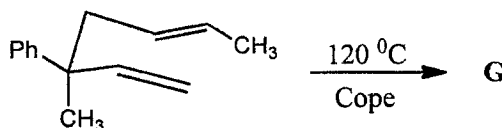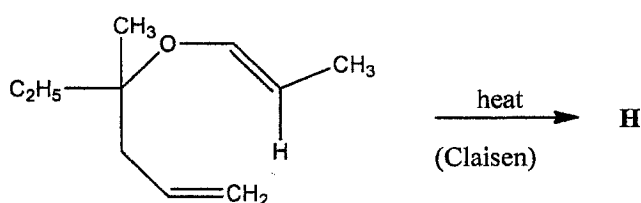
(d) When animals are exposed to sunlight, *7-dehydrocholesterol* found in their skin is converted into the hormone *cholecalciferol*, popularly called "*Vitamin D₃*", which plays a vital role in the development of bones.

7-Dehydrocholesterol
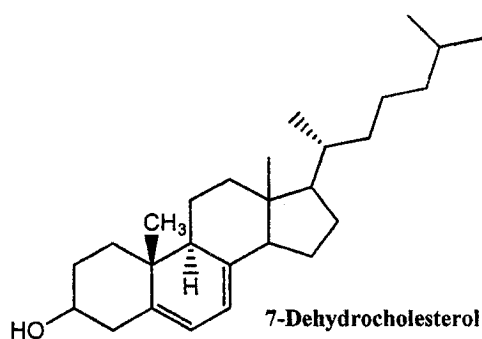
Cholecalciferol

Experimental evidence suggests that the conversion of 7-dehydrocholesterol into "Vitamin D₃" is a two step process. The photochemical irradiation results in a reactive intermediate (**2**), which subsequently rearranges to cholecalciferol (**3**) under thermal conditions, partial structures shown below:

7

(1)
7-Dehydrocholesterol

(2)

(3)
Cholecalciferol
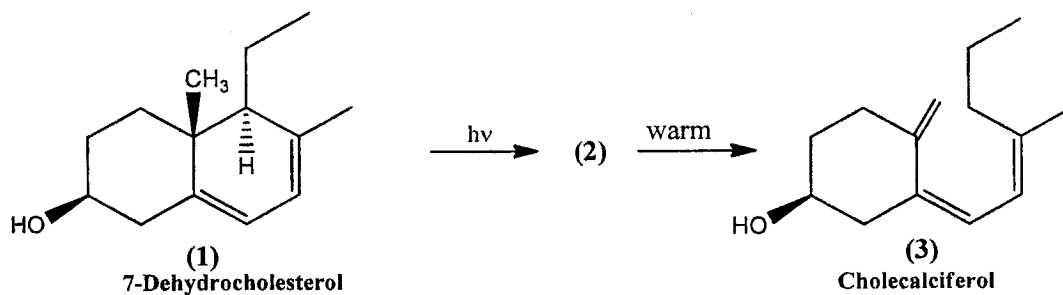
(i)   Identify the structure of the reactive intermediate **(2)**.

(ii)   Write a mechanism for each step of the reaction and briefly describe the type of pericyclic processes involved in each step (less than 2 sentences).

(10 marks)

END OF EXAM
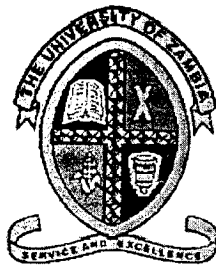
THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Studies

MID YEAR - FINAL EXAMINATION

DATA STRUCTURES AND ALGORITHMS
CSC 5011

Date: MONDAY, 23RD FEBRUARY 2015
Time: 09:00hrs – 12:00hrs
Duration: 3 Hours
Venue: HARDWARE LAB

Instructions

a) *There are SEVEN (7) questions in this paper and you are required to answer ANY FIVE (5) OF THEM IN ANY ORDER.*

b) *All questions have carry the weight of 20 marks each*

c) *Each question should start on its separate page or booklet*

1. Consider the following pseudocode

   Algorithm mystery(A, n)

   Input: Array A of integers and of size n > 1000

   for c ← 0 to n do

       s ← 0

       for d ← 0 to c do

           s ← s + A[d]

       A[c] ← s

   End.

   i.   What happens to the array a with the following call: mystery(a,5) where a = [12, 23, 25, 30, 20]

   ii. Give the best asymptotic (big-Oh) analysis of the following algorithm.

2. An algorithm processes N items in a time t_N.

   i.   If the algorithm is of logarithmic order, show that it requires

   $$t_N \left[1 + \frac{1}{\log N}\right]$$

   to process double the number of items.

   ii. How much time is required to process the same number of items if it is a linearly ordered algorithm?

3. Write the Java code to implement a linked list of integers. For all the operations insert, delete and size, give the asymptotic analysis.

4.
   i.   Explain the four features of a recursive function

   ii. Define a recursive function, which given the parameter n, it will print "I Love Algorithms" n times.

5. A recursive algorithm to convert a number to its binary equivalent leads to the following recurrence relation.

   $$T(1) = 1$$
   $$T(n) = T(^n/_2) + n$$

   i.   Solve this recurrence relationship and determine the order of this algorithm.

   ii. Does it perform better than a quadratic ordered algorithm? Explain.

6.
   i.   Describe what a Queue is

   ii. Give four applications of Queues

   iii. Devise a Java implementation of the Queue as an array.

7. Consider the following arithmetic expression

$(4 - 2 * 1 / 2 + 3) * 4 - (4 - 2 + 1)$

i. Show the order in which it is evaluated, taking into account the precedence and associatively of the operations.

ii. By showing the contents of the stack
   a) Convert it to postfix notation
   b) Evaluate the postfix expression

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

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
Department of Computer Studies

PROGRAMMING LANGUAGES
CSC 5021

2014-2015 FINAL EXAM

Date: 24th February 2015
Venue: Hardware Lab
Time: 14hrs
Duration: 3 Hours

Instructions

1. This exam contains six (6) questions. Answer **any** four (4) questions

2. Write your answers on a separate answer sheet

Chose any four (4) questions. Each question is worth 25 marks.

1. Write a program in Java to check if a number is even or odd. A number is called even if it is completely divisible by two and odd if it's not completely divisible by two. For example 4 is even number because 4/2 has remainder of 0 which means 4 is completely divisible by 2. On the other hand 5 is odd number because 5/2 will result in remainder as 1. Your program must prompt a user to enter a number, and then print out if the number is odd or even. [25 Marks]

2. Explain the following object-oriented concepts and give an example of how the concept is implemented in java either by writing code or using a diagram [25 Marks]
   a) Encapsulation (data hiding) [5 Marks]
   b) Object [5 Marks]
   c) Inheritance [5 Marks]
   d) Polymorphism [5 Marks]
   e) Method Overriding [5 marks]

3. Thorn Hill Secondary School wants to computerize its grading system. You have been hired to develop an application that will help them achieve their goal. The school wants your application to do the following tasks;
   Task one
   They want your application to allow the user to enter forty (40) grades. Thorn Hill allows grades to be in decimal. E.g. a pupil can have 55.7
   Task two
   They want your application to separate pupils who have failed from pupils who have passed. The pass mark at thorn hill is 40.
   Task three
   Your application should produce the following summary. It should print how many pupils have failed, the average mark of the failed pupils and display the failed grades. Your application should also print how many pupils have passed, the average mark of the passed pupils and display the passed grades.

   Write a java application to implement the three (3) tasks given above [25 Marks]

4. Analyze the following java code below and answer the questions that follows; [25 Marsk]

```java
public class Welcome{
    private int number;
    private String name;
    private double balance;

    public Welcome(int number, String name, double balance){
        this.number = number;
        this.name = name;
        this.balance = balance;
    }

    public void printName(){
        System.out.println(name);
    }

    public void printNumber(){
        System.out.println(number);
    }

    public void printBalance(){
        System.out.println(balance);
    }
}
```

a) Identify the name of the class in the code above [1 Mark]

b) State the convention used in naming java classes [1 Mark]

c) Identify all the java keywords in the code above and explain what each keyword means in java [6 Marks]

d) What is a java keyword? [1 Mark]

e) Identify all the identifiers in the above code [3 Marks]

f) What is an identifier? [1 Mark]

g) State the syntax for naming identifiers in java [1 mark]

h) State the convention used in naming java identifiers [1 Mark]

i) Identify all the attributes in the above code and state their visibility [3 marks]

j) What is a primitive data type? [1 mark]

k) What is a reference data type? [1 mark]

l) Identify all the methods in the above code and state their return types [3 marks]

m) Explain the use of a constructor in a java class [1 Mark]

n) When is the java constructor called in the execution of the program? [1 Mark]

5. In an effort to improve student health care, UNZA clinic has introduced a new vaccine against Typhoid. The new vaccine is called UNZABOMBA. All students will be vaccinated with UNZABOMBA upon arrival for second term. Different age groups will be receiving different amounts of the vaccination. The following table shows the age groups and the amount of vaccination to receive.

Age	Amount of vaccination in milliliters
15 - 20	500
21- 25	400
26 - 35	300
36 and above	100

Write a java code that prompts a user to enter the age of the student from the command line. Your code must then determine the amount of vaccine and print out to the user.

6.

    a) List down ten (10) java keywords and state their meaning in java. [10 Marks]

    b) Java comes with an API which is a collection of classes programmers can use to perform various tasks. List down five (5) classes from the java API [5 marks]

    c) Analyze the piece of java code given below;

```
for(int i=0; i <= 10 i++){
    if(i == 10){
    continue;
}
System.out.print(i);
```

      i. What syntax errors will the above code generate when compiled? [2]
      ii. Write the correct code [2]
      iii. Assuming you have corrected the error(s), what will be the output? [3]
      iv. Implement the above code using a while loop to give the same output. [3 marks]

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
Department of Computer Studies

FINAL EXAMINATION

DATABASES AND INFORMATION SYSTEMS
CSC 5711

Date: 26th FEBRUARY, 2015
Time: 14:00hrs – 17:00hrs
Duration: 3 Hours
Venue: HARDWARE LAB

Instructions

1. *Answer **all** the questions in **Section A** and choose **any two (2)** questions from **Section B**.*

SECTION A

ANSWER ALL QUESTIONS IN THIS SECTION

Marks

QUESTION 1   6

a) What does the acronym ACID means? Explain each of the conditions

QUESTION 2

a) In your own words, briefly describe the circumstances under which transactions would be a
desirable option when interacting with a MySQL database.   4

QUESTION 3

What are MySQL's main DML commands?   4

QUESTION 4

In regards to a RDBMS, what are super-types and sub-types?   4

QUESTION 5

a) Distinguish between data and information, and provide examples of each   5

b) Describe and give an example of how data becomes information   4

QUESTION 6

What is an Entity Relationship Model?   4

QUESTION 7

What is the main difference between CHAR and VARCHAR data types?   4

QUESTION 8

Write the **SQL CREATE TABLE** statement for the owns relation between
Skier and PairOfSkis. Make sure that your statement specifies the **PRIMARY KEY**
and any **FOREIGN KEYS**. Additionally, we would like to enforce the constraint that purchase price
be greater than zero.   5

Total 40 Marks

ANSWER ANY <u>TWO</u> QUESTIONS IN THIS SECTION

QUESTION 1   **Marks**

For this question use the tables given below:

Assignment table   **employee table**

client_no	employee_id
1	6
3	1
4	5
7	2
9	3

employee_id	fname	lname	mob	dob	sex	hiredate
1	John	Banks	0401230154	1970-07-21	M	1999-03-05
2	Julie	Connor		1980-12-12	F	2000-02-13
3	Trish	Williams	0407366987	1965-08-08	F	2001-09-16
4	Donald	Jones		1955-11-23	M	1990-12-19	no
5	Karen	Clayden	0411654789	1960-10-10	F	1995-10-01
6	Peter	Banks	0418950123	1975-06-12	M	1999-08-15
7	John	Connor	0415879789	1981-07-21	M	1997-05-14	no

Client table

client_no	client_name	client_add	client_phone	priority
1	ElectroZap	27 Spark Way, Perth	0893091754	High
2	CoffeKing	36 Jitters Road, Perth	0893097774	Medium
3	CompKids	97 Infant Street, Perth	0894441754	Low
4	PaperMan	55 Papercut Close, Perth	0892751754	High
5	SillySprings	21 Boing Rise, Perth	0892720000	Medium
6	MightyModems	12 Comms Way, Wanneroo	0892728888	Low
7	TrendyPaint	53 Brush Avenue, Booragoon	0892765454	High
8	BagsRUs	100 Handy Street, Mt Lawley	0894446000	Medium
9	TastyTea	99 Brew Court, Subiaco	0894506400	Low
10	FancyFillings	18 Sandwich Rise, Wembly	0893557854	High

a. Write a query that returns the name of the client to which employee Julie Connor has been assigned.   5

b. Write a query that uses a LEFT JOIN between the employees table and the assignment table that shows those employees not presently assigned to a client. Make sure employees that are assigned to a client do not appear in the list.

                                                                                                       5

c. Write a query that uses a LEFT JOIN between the client table and the assignment table that shows those clients not presently assigned an employee. Make sure clients that do have an employee assigned to them do not appear in the list.   5

d. Write a query that returns the names of employees working for 'high' priority clients, along with the names of those clients.   5

e. Write a query that returns the full name of any female employee assigned to a low or medium priority client.   5

f. Write a query that returns the names of employees in the employee table that have the same name, ordered alphabetically. (You are to assume that you do not know which employees have the same name).   5

Total 30 Marks

QUESTION 2

a) Create an ERD, using the following requirements:

- An INVOICE is written by a SALESREP. Each sales representative can write many invoices, but each invoice is written by a single sales representative.   **5**

- The INVOICE is written for a single CUSTOMER. However, each customer can have many invoices.   **5**

- An INVOICE may include many detail lines (LINE) which describe the products bought by the customer.   **5**

- The product information is stored in a PRODUCT entity.   **5**

- The product's vendor information is found in a VENDOR entity.   **5**

b) What is the difference between a logical E-R model and its corresponding physical one?

5

Total 30 Marks

- Each order is identified by a unique order number.
- Each detail line within an order is identified by a line number, unique within the order.

d) design a set of the tables in the third normal form (3NF) for the system.   **14**

Total 30 Marks

END OF PAPER

- Each order is identified by a unique order number.
- Each detail line within an order is identified by a line number, unique within the order.

d) design a set of the tables in the third normal form (3NF) for the system.   **14**

Total 30 Marks

END OF PAPER

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR FINAL EXAMINATIONS

GES 5311: PRINCIPLES OF ENVIRONMENTAL AND NATURAL RESOURCES MANAGEMENT

TIME: **Three hours**

INSTRUCTIONS: **Answer any FOUR questions**
                    All questions carry equal marks

---

1. 'Ester Boserup sees population growth as a positive factor in sustainable natural resources exploitation whilst Thomas Malthus sees it as a threat through extensification'. Discuss

2. Using the the paradox of plenty theory explain why Zambia a country with abundant natural resources still remains poor.

3. Discuss the major environmental effects of both dry and wet acid deposition.

4. Explain why the concept of sustainable development requires that we see our world as a system that connects space and time.

5. What could cause the factors of production to be of low quality or unavailable?

6. Explain the linkages between Desertification, Global Climate Change, and Biodiversity Loss.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR FINAL EXAMINATIONS
GES 5375: FORESTS AND WILDLIFE MANAGEMENT

TIME: Three Hours

INSTRUCTIONS: Answer **question one (1) and any three questions.**

Question 1 Carries 40 marks and all other questions carry equal marks.

Candidates are advised to make use of illustrations and examples wherever appropriate.

---

1. The Government of the Republic of Zambia is currently drafting a Country REDD+ strategy as part of its commitment towards climate change mitigation and forest protection. Assume you are a REDD+ consultant and have been hired to contribute to this process. In particular, the government would like you to address the following:
    (a) How REDD+ fits into the Payments for Ecosystem Services (PES) conservation
    (b) The appropriateness of REDD+ as a forest conservation strategy and;
    (c) The risks associated with implementing REDD+ in Zambia's rural areas.

    Write a report on these three issues for submission to the government.

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

    (a) Endangered species in Southern Africa
    (b) Importance of wildlife to humans
    (c) Community based wildlife conservation
    (d) Poaching
    (e) Habitat loss in relation to wildlife conservation
    (f) Forest conservation.

3. Explain the importance of energy flow and nutrient cycling in forest ecosystems and show how a good understanding of these processes is essential for conservation.

4. Critically examine the concept of ecological equilibrium and show how it has historically influenced forest conservation.

5. 'Southern Africa seems to have plenty of wildlife, but much of it is threatened'. Discuss.

6. 'Fortress Conservation has done more harm than good to Zambia's conservation efforts'. Discuss.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

2014 ACADEMIC YEAR FINAL EXAMINATIONS

GES 5385: SUSTAINABLE LAND MANAGEMENT AND FOOD SECURITY

TIME   : Three hours

INSTRUCTIONS   : Answer any four questions. Candidates are advised to make use of
                   illustrations and examples wherever appropriate

1. Define the concept of food security and explain its major dimensions.

2. Using examples, explain how sustainable land management practices can enhance rural household food security.

3. With the use of examples, show how food systems in Northern, Western, Eastern and Southern Zambia were able to demonstrate vulnerability, resilience and adaptation to the forces of modernisation during the colonial period.

4. Explain the land management responses of the farmers to population pressure in the Kano close settled zone in Northern Nigeria.

5. Discuss the main barriers to climate change adaptation affecting the efficient use of land resources in the developing world.

6. 'Land tenure policy is one of the key issues affecting land resource management'. Explain this assertion within the Zambian context.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC MID-YEAR EXAMINATIONS

MAT5055:   FINANCE AND FINANCIAL REPORTING

TIME: THREE (3) Hours

INSTRUCTIONS:

1. Answer ALL questions.

2. Show all your work to earn full marks.

Section A

1. Which of the following is NOT a fundamental concept underlying financial statements?
   a. Prudence
   b. Consistency
   c. Going Concern
   d. Independence

2. Cash from operating activities is most likely to be equivalent to:
   a. EBIT
   b. EBIT with depreciation and amortization added back
   c. EBIT with depreciation, amortization added back and adjustment for changes in working capital items
   d. EBIT less capital expenditure

3. Which of the following statements is TRUE?
   Cash is consumed by
   a. Increased inventory and increase payables
   b. Increase inventory and decreased payables
   c. Decreased inventory and decreased payables
   d. Decreased payables and decreased payables

4. An example of an intangible asset is:
   a. An amount owed by the customer
   b. A purchased patent
   c. A product guarantee
   d. Employee training

5. In statement of financial position for a company, total equity is equal to:
   a. Non Current assets less long term liabilities
   b. Total assets less total liabilities
   c. Total assets less current liabilities
   d. Current assets less current liabilities

6. As compared to equity, debt finance:
   a. Takes longer to raise
   b. Does not generate a tax benefit to the company
   c. Is harder to market
   d. Is easier to tailor to the needs of the company

7. Entries related to fixed assets during a single period are:

Opening net book value:	5000
Closing net book value:	3000
Depreciation Charge:	500

Net Book value of disposals: 2500
Sales value of disposals: 3000

Capital expenditure during this period is:
   a. Nil
   b. 500
   c. 1000
   d. 1500
   e. 2000

8. Financial risk includes:
   a. Operational risk, credit risk and liquidity risk
   b. Credit risk, commercial risk and liquidity risk
   c. Liquidity risk, commercial risk and financial market risk
   d. Interest rate risk, liquidity risk and credit risk

9. Maintaining a minimum of one week's supply of inventory is an example of risk response of :
   a. Avoid
   b. Accept and retain
   c. Accept and reduce
   d. Accept and transfer

10. What is the normal order of activity in a risk management framework?
   a. Identify, Assess, Evaluate, report, respond
   b. Identify, Assess, Evaluate, Respond, Report
   c. Identify, Assess, Respond, Report, Evaluate
   d. Identity, Respond, Evaluate, Report, Assess

11. What are the two criteria used in a risk map?
   a. Response to risk and likelihood or frequency
   b. Likelihood or frequency and severity of the risk
   c. Severity of the risk and response to risk
   d. Severity of the risk and manage and transfer or accept.

12. What does the description of a company as a "limited " mean?
   a. The liability of the company is limited by law
   b. The liability of shareholders is limited by law
   c. The number of shareholders is limited by law
   d. Shares can only be resold by shareholders to other existing shareholders

13. A project has the following cashflows:

Investment (Upfront): 100
Net Operating Cashflows:
Year 1 70
Year 2 80
Year 3 60

An internal rate of return has been calculated at 50%. It is true that:

a. The NPV of the project is positive at a 50% discount rate
b. There are many IRRs
c. The calculation is wrong
d. The IRR is consistent with a reinvestment rate of 50%

14. A project has an investment of 100 followed by net annual cash flows receipts of 20, and annual profits of 15 over a 10-year period. Depreciation is charged at 5 per annum straight line. The cost of capital is 10 %. The payback period is :

a. 5.0 years
b. 6.3 years
c. 6.7 years
d. 9.1 years
e. 10 years

15. A project involves investing 900 in a machine now, followed by positive net operating cash flow of 400, 600 and 500 at the end of each of the next three years. The weighted average cost of capital is 10%, the best NPV estimate of the project is:

a. (900)
b. (400)
c. (160)
d. 340
e. 900

16. When setting a dividend policy, management should consider:

Future Investments (1)
Capital Structure Covenants (2)
Accumulated Retained Profits (3)

a. 1, 2 and 3
b. 1 and 2
c. 1 and 3
d. None of the above

17. A company has a beta of 1.4 and debt: equity ratio of 1.4. The cost of debt is 5% pre tax. The Risk free rate is 2%, the market premium for risk is 4 % and corporation tax is 30%. The best estimate of the company's WACC is:

a. 4.9%
b. 6.8%
c. 7.1%
d. 7.6%

18. A potential investment with a beta equal to 1:
a. Has no risk
b. Has no unsystemic risk
c. Could be held instead of a diversified portfolio
d. Has the systemic risk similar to the market

19. Risk that cannot be diversified away is known as :
a. Systematic risk or specific risk
b. Systematic risk or market risk
c. Specific risk or unique risk
d. Systematic risk or specific risk or unique risk

20. Modigliani and Miller predicted that, when corporate tax is present, an increase in gearing would reduce the WACC because of :
a. Reduced agency costs
b. Relatively low pre-tax cost of debt
c. Tax relief on debt interest
d. Lower issue cost of debt

21. Myers Pecking order theory suggests that firms should finance business expansion in the following priority order:
1. Retained Earnings   2. Debt Issue   3. Equity

a. 1, 2 then 3
b. 1,3 then 2
c. 2,1 then 3
d. 2,3 then 1

22. Which of the following is the LEAST likely consequence of financial distress?
a. Suppliers insist on receiving payment on delivery
b. Good employees seek employment elsewhere

c. Tax authorities demand early settlement of liabilities

d. Customers worry about reliability and desert the company

23. Which of the following activities is NOT consistent with a belief in the weak form efficientmarket hypothesis?
    a. Chartism
    b. Fundamental analysis
    c. Reading annual reports

24. From the perspective of the company, the company's equity finance:
    a. Is less risky than debt finance
    b. Is more risky than debt finance
    c. Is of equal risk to debt finance

25. The acceptance of a bill of exchange usually creates a legal obligation on the:
    a. Payee to pay the drawer
    b. Drawer to pay the payee
    c. Drawee to pay the payee
    d. Drawer to pay the drawee

26. Risk Appetite can be affected by

	Nature of Business	Gearing Ration
a.	Yes	Yes
b.	Yes	No
c.	No	No
d.	No	Yes

27. The share price of a Zambian Airline fluctuates with changes in the price of fuel. This can be classified as an example of :
    a. Economic Risk
    b. Transaction risk
    c. Translation risk
    d. Pre-transaction risk

28. Which of the following is NOT true of the Internal Rate of Return (IRR) method of project appraisal?
    a. IRR can sometimes have multiple solutions.
    b. IRR is less popular than Net Present Value as a measure of project worth.
    c. IRR has the benefit of highlighting the return achieved by the project.
    d. IRR is the most reliable means of choosing between mutually exclusive projects.

29. You have a diversified portfolio. You are offered an opportunity to invest in an oil exploration venture in the South Atlantic. Which of the following risks associated with this project is a systematic risk?

   a. Bad weather might hamper operations until the cash runs out. □

   b. The geological surveys, which suggest the existence of oil, might be wrong. □

   c. The price of crude oil on the world markets might fall, making any finds uneconomic. □

   d. Interest rates might rise, pushing up the costs of borrowing for the enterprise. □

30. A company has a high return on capital employed but a low gross profit percentage. Which of the following is the best interpretation of these results? □

   a. The company is profitable because it prices its sales aggressively.

   b. The company should increase its selling prices. □

   c. The company is unprofitable despite a high return on capital employed

   d. Gross profit is a very straightforward measure, so the company should disregard the return on capital employed. □

Section B

Provide short answers to each of the following questions

1. Describe the difference between the Net Present Value and Internal rate of Return?
2. What is the significance of the cost of capital in an investment decision?
3. How does risk relates to returns on an investment?
4. What is the role of a finance manager in an organization?
5. How does dividend policy affect an organisation?
6. Explain the agency theory in management of company finance.
7. What is the importance of an audit opinion in the financial statements?

Section C

Question 1

You are a member of a team responsible for the evaluation of investment proposals in a large multinational company that is quoted on a major stock exchange. The directors of one of the company s largest subsidiaries has proposed a major investment that would double that subsidiary s manufacturing capacity and would enable it to export to several new markets. The proposed investment would require the company to raise a great deal of money, either by borrowing or by the issue of equity. The amount involved is large enough to justify either a share issue or the sale of loan stock, but not a combination of the two. The proposal has been backed by a detailed analysis of the cash flows that are expected to arise from this expansion. The Company has a policy of evaluating investment opportunities on the basis of the net present value (NPV) of estimated cash flows.

(i) (a) Identify the factors that the company may use to determine the rate at which this proposal might be discounted; and (b) Explain which of these factors would be most relevant to this project. [6]

(ii) Explain how the decision to raise finance using either loan stock or equity might affect the company s weighted average cost of capital (WACC). [8]

(iii) It has been suggested that ..political , or subjective, factors within companies are often more relevant to investment decisions than objective economic factors in deciding whether a project should proceed. Explain why this might be so. [6]
[Total 20]

Question 2

You have been asked to assist Holder, a manufacturing company, to prepare its annual accounts. The following information has been obtained from the company's bookkeeping records:

Balances as at 31 March 2013

	ZMW 000
Administrative salaries	3,600
Advertising	66,000
Bank overdraft	1,650
Buildings - depreciation	45,000
Buildings - valuation	450,000
Cost of inventory consumed	435,000
Delivery vehicle running costs	51,000
Delivery vehicles - cost	375,000
Delivery vehicles - depreciation	255,000

Dividend paid	150,000
Factory running costs	105,000
Interest	38,400
Inventory at 31 March 2013	36,000
Land - valuation	840,000
Loan (repayable 2018)	300,000
Machinery - cost	186,000
Machinery - depreciation	84,000
Manufacturing wages	195,000
Retained earnings	262,350
Revaluation reserve	240,000
Revenue	1,686,000
Sales salaries	84,000
Share capital	210,000
Trade payables	57,000
Trade receivables	126,000

The figures shown above do not include the following:

1. A revaluation exercise was conducted on 1 April 2012. Land was revalued at ZMW1,000,000,000 and buildings at ZMW 500,000,000.

2. Depreciation has still to be charged as follows:
   - Buildings - 2% of cost or valuation
   - Delivery vehicles - 25% reducing balance
   - Machinery - 20% of cost

   Prepare:

   (a)   an income statement
   (b)   a statement of changes in equity, and
   (c)   a statement of financial position

   for the year ended 31 March 2013.

   These statements should be in a form suitable for publication insofar as it is possible from the information provided.   [20]

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF MATHEMATICS AND STATISTICS

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

MAT5611   :   STATISTICAL INFERENCE

TIME ALLOWED: Three (3) Hours

INSTRUCTIONS: 1.   Answer any **Four** (4) Questions
                            2.   Show All Essential Working

---

1.   (a)   Define the following:
            (i)   minimal sufficient statistic.
            (ii)   location equivariant estimator.

    (b)   Suppose that $X_1, ..., X_n$ is random sample from a distribution with probability density function $f_\theta(x) = \dfrac{1}{\sigma} e^{-\left(\frac{x-\mu}{\sigma}\right)}$, $x > \mu$, $\sigma > 0$, where $\theta = (\mu, \sigma)$.

            (i)   Find a sufficient statistic for $\theta = (\mu, \sigma)$.
            (ii)   Show that the sufficient statistic in (i) is a minimal sufficient statistic.
            (iii)   Given that $\mu = 0$, show that X is a scale invariant family distribution.
            (iv)   Given that σ is known, show that X is a location family distribution.

    (c)   Suppose $X_1, ..., X_n$ is a random sample from a distribution with probability density function

$$f_\theta(x) = \frac{\beta^\alpha}{\Gamma(\alpha)} x^{\alpha-1} e^{-\beta x}$$, $x > 0$, $\alpha > 0$, $\beta > 0$ where $\theta = (\alpha, \beta)$.

            (i)   Show that $f_\theta(x)$ is a regular exponential family distribution.
            (ii)   Find a complete sufficient statistic for $\theta = (\alpha, \beta)$.
            (iii)   Find a U.M.V.U.E. for $\tau(\theta) = \dfrac{\alpha}{\beta}$.

2.   (a)   Define the following:
            (i)   a complete statistic T.
            (ii)   an exponential family distribution.

(b) Let $X_1, \ldots, X_n$ be a random sample from a distribution with p.d.f.
$$f_\theta(x) = \frac{3\theta^3}{x^4}, \quad x > \theta \;, \quad \theta > 0$$

(i) Find a maximum likelihood estimator $\hat{\theta}$ for θ.
(ii) Show that $\hat{\theta}$ is a consistent estimator.
(iii) Show that $T = X_{(1)}$ is a complete sufficient statistic for θ.
(iv) Find the U.M.V.U.E. of θ.

(c) Let $X_1, \ldots, X_n$ be a random sample from the model
$$f_\theta(x) = \theta e^{-\theta x} \;, \quad x > 0 \;, \quad \theta > 0.$$

(i) Show that $T = \sum_{i=1}^{n} X_i$ is a complete sufficient statistic.

(ii) Show that $T = \sum_{i=1}^{n} X_i$ and $\dfrac{X_1}{T}$ are independent.

(iii) Find $E\left(\dfrac{X_1}{T}\right)$.

3. (a) (i) State the Information Inequality.
   (ii) Prove the Information Inequality.

(b) Suppose $X_1, \ldots, X_n$ is a random sample from a distribution with p.d.f.
$$f_\theta(x) = \frac{\alpha \beta^\alpha}{(\beta + x)^{\alpha + 1}} \;, \quad x > 0 \;; \quad \alpha > 0, \;\; \beta > 0 \;.$$

(i) Find the maximum likelihood estimator of $\theta = (\alpha, \beta)$.
(ii) Find the Fisher information.

4. (a) Define the following:
   (i) an unbiased estimating function.
   (ii) a locally most powerful test.

(b) Let $X_1, \ldots, X_n$ be a random sample from a distribution with probability function
$$f_\theta(x) = \theta(1 - \theta)^x \;, \quad x = 0, 1, 2, \ldots; \; \theta > 0.$$

(i) Find the maximum likelihood estimator of θ.
(ii) Find the maximum likelihood estimator of $\tau(\theta) = \dfrac{1 - \theta}{\theta}$.
(iii) Determine whether the maximum likelihood estimator of $\tau(\theta)$ attains the Cramer-Rao lower bound.

(c) A random sample $X_1, \ldots, X_n$ is drawn from a distribution with $E(X_i^a) = \dfrac{1}{\theta}$ and

$Var(X_i^a) = \dfrac{1}{\theta^2}$, $i = 1, 2, \ldots, n$. Consider the estimating function

$\psi(\theta, X) = \sum (1 - \theta X_i^a)$, $a > 0$.

(i) Show that $\psi(\theta, X)$ is an unbiased estimating function.

(ii) Find an estimator $\hat{\theta}$ that satisfies $\psi(\hat{\theta}, X) = 0$.

(iii) Find an approximate 95% confidence interval for θ.

5. (a) State the following:
   (i) Lehman – Scheffé's Theorem.
   (ii) Basu's Theorem.

(b) A random sample of size n, $X_1, \ldots, X_n$, is drawn from the p.d.f. $f(x) = \alpha^2 x e^{-\alpha x}$ and an independent random sample of size m, $Y_1, \ldots, Y_m$, is drawn from the p.d.f. $f(y) = \beta^2 y e^{-\beta y}$, where $\alpha > 0$ and $\beta > 0$ are unknown parameters.

   (i) Show that the generalized likelihood ratio for testing $H_0 : \alpha = \beta$ against $H_1 : \alpha \neq \beta$ has critical region of the form

   $$\Lambda(x, y) = n \log\left\{\frac{n}{n+m}(1 + v)\right\} + m \log\left\{\frac{m}{n+m}\left(1 + \frac{1}{v}\right)\right\} > k$$

   for some constant k, where $v = \dfrac{\sum\limits_{i=1}^{m} y_i}{\sum\limits_{i=1}^{n} x_i}$.

   (ii) Find the asymptotic distribution of $\Lambda(X, Y)$ under H_0.

(c) Let $X = (X_1, \ldots, X_n)$ be a random sample from a regular model $\{ f_\theta(x) : \theta \in \Omega \}$ where $S(\theta, X)$ is the score function. Show that
   (i) $E_\theta[S(\theta, X)] = 0$
   (ii) $Var_\theta[S(\theta, X)] = E_\theta\{(S(\theta, X))^2\}$

END OF EXAMINATION

3

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC MID-YEAR EXAMINATIONS

MAT5681:   SURVIVAL MODELS

TIME:	THREE (3) Hours

INSTRUCTIONS:

    1.   Answer ALL questions.

    2.   You may use calculators where necessary.

    3.   Show <u>all your work</u> to earn full marks.

Question 1

(a)   Write down a formula for $_tq_x$ ($0 \leq t \leq 1$) under each of the following assumptions:

        (i)   Uniform distribution of deaths   **[2] Marks**

        (ii)   Constant force of mortality   **[3] Marks**

        (iii) Calculate $_{0.5}p_{60}$ to six decimal places <u>under each</u> assumption given

            $q_{60}= 0.05$.   **[6] Marks**

(b)   The mortality of a group of lives is assumed to follow Gompertz' law. You are given that μ_x is 0.0035 for a 60 year old and 0.012 for a 70 year old.

        (i)   Calculate μ_x for a 40 year old   **[4] Marks**

        (ii)   Calculate μ_x for an 80 year old.   **[4] Marks**

Question 2

(a)   Let ℓ_x denote the expected number of lives at age x and d_x denote the expected number of deaths between the ages of x and x +1.

        (i)   State the life table value of $_tp_x$ in terms of expected number of lives at age x and x+ t.   **[2] Marks**

        (ii)   Given that $\frac{1}{\ell_{x+t}}\frac{d\ell_{x+t}}{dx} = \mu_{x+t}$ for $0 \leq t \leq 1$, show that

            $\frac{d_tp_x}{dx} = {_tp_x}(\mu_{x+t} - \mu_x)$ **[5] Marks**

(b) (i) Define each of the following terms:

- Initial rate of mortality

- Non-informative censoring

- The curtate future lifetime K_X of a life age x. **[6] Marks**

(ii) If in a mortality table $e_{55} = 30.20$ and $e_{56} = 29.27$, calculate q_{55}.

[4] Marks

Question 3

(a) Assume that motor insurance companies in Zambia grant their customers either no discount or 15% discount or 30% discount or 45% discount or 60 or 65% discount. A claim-free year results in a transition to the next higher state the following year (or in the retention of the maximum discount); similarly, a year with one or more claims causes a transition to the next lower state (or in the retention of the zero discount state).

Further, assume that the probability of a claim-free year is 0.6

(i) Write down the transition matrix of this process. **[4] Marks**

(ii) Suppose that a policyholder is in the 15% state, calculate the probability that he/she will be in the 45% state in the next two years.

[4] Marks

(b) A group of N lives is observed for some finite period between the ages x and $x + 1$. Let v_i be the observed waiting time for life i.

(i) Assuming a constant force of mortality μ between ages x and $x+1$, derive the maximum likelihood estimator $\hat{\mu}$ of this constant force under the Poisson model. **[5] Marks**

(ii) Write down the expected value of $\hat{\mu}$. **[3] Marks**

(iii) Write down an approximate 95% confidence interval for the constant force, μ. **[7] Marks**

Question 4

(a) Let $_tq_x$ be the probability that a life now aged x dies within t years.

(i) State the Balducci assumption for integer ages x for $0 \leq t \leq 1$.

[2] Marks

(ii) Using the Balducci assumption show that

$$_tq_x = \frac{t \times q_x}{1-(1-t) \times q_x} \quad \text{for } 0 \leq t \leq 1.$$ **[5] Marks**

(iii) Calculate $_{0.5}p_{70}$ to six decimal places using (ii) above given

$q_{70} = 0.045$ **[3] Marks**

(b) Suppose that the lifetime T has a Weibull distribution given below:

$f(t) = \alpha \lambda t^{\alpha-1} e^{-\lambda t^{\alpha}}$ for $\alpha > 0, \lambda > 0$ and t >0.

(i) Obtain the survival function S(x). **[4] Marks**

(ii) Obtain the hazard function h(x). **[2] Marks**

(iii) Obtain an expression for $_{t}p_{x}$ if lifetime has a Weibull distribution.

[4] Marks

Question 5

(a) The table gives data for a small sample of workers in a certain company. It shows the time in months until the first absence from work. Observations marked "+" show the time of leaving for those employees who left employment without being absent from work:

Male worker	2+	4	8+	11+
Female worker	6+	7	10	

A Cox Proportional Hazard Model: $\lambda(t|z) = \lambda_0(t)e^{\beta z}$ is to be fitted to the data where t is the time until the first absence from work, $\lambda_0(t)$ is the baseline hazard and z = 0 for males and z = 1 for females.

(i) Obtain the partial log-likelihood. **[10] Marks**

(ii) Calculate the maximum partial likelihood estimate of β. **[4] Marks**

(b) You are investigating the survival times of patients who have just undergone heart surgery at one of the 3 city hospitals - A, B or C. You have recorded the following data for each patient:

$Z_1 = \begin{cases} 0 & for\ females \\ 1 & for\ males \end{cases}$

$Z_2 = \begin{cases} 1 & if\ patient\ attended\ hospital\ B \\ 0 & otherwise \end{cases}$

$Z_3 = \begin{cases} 1 & if\ patient\ attended\ hospital\ C \\ 0 & otherwise \end{cases}$

You have decided to model the force of mortality at time t (measured in days since the operation was performed) by an equation of the form

$\lambda(t|z) = \lambda_0(t)e^{\beta z^T}$, and you have estimated the parameter values to be:

$\hat{\beta}_1 = 0.031, \quad \hat{\beta}_2 = -0.025, \quad \hat{\beta}_3 = 0.011$

Compare the force of mortality for a female patient who attended Hospital A with that of:

(i)   a female patient who attended Hospital B   **[6] Marks**

(ii)   a male patient who attended Hospital C   **[6] Marks**

Question 6

The quality manager at a light-bulb manufacturer is investigating the reliability of a new bulb using the Kaplan-Meier method. His team simulates normal usage on ten identical bulbs and records the number of hours until each blows. Each experiment stops after 200 hours. The results of the experiment are shown below.

Bulb	Lifetime (hours)
1	70
2	200^{*}
3	190
4	200^{*}
5	30^{+}
6	150
7	90
8	70
9	140
10	190

Note that * indicates that the bulb survived the 200 hour test and + indicates that the bulb was accidentally dropped by the investigator during the investigation.

(a)   Calculate the Kaplan-Meier estimate for the <u>survival function</u>.   **[10] Marks**

(b)   (i)   Estimate the probability that the bulb fails before the end of 90 hours.   **[2] Marks**

         (ii)   Estimate the number of bulbs that would fail before the end of 90 hours if a total of 200 new bulbs are put to the test.   **[3] Marks**

END OF EXAM

The University of Zambia
School of Natural Sciences
Department of Mathematics and Statistics

2014 Academic Year
Mid Year Examinations

MAT5911-Stochastic Processes

Time allowed: Three (3) Hours
Instructions: There are five questions in this examination paper. Answer any four questions. All questions carry equal marks.

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1.   (a)   Define the following:

   (i)   Counting process
   (ii)   Poisson process of rate λ
   (iii) Interarrival times in a Poisson process

   (b)   Let S_n denote the time of occurrence of the nth event in a Poisson process of rate λ. Find the probability distribution of S_n

   (c)   The rain season in Zambia is classified as Normal season or Abnormal season depending on the total rainfall received during a season. It has been estimated that in a normal season, storms occur according to a Poisson process with rate 3 per month, while in an abnormal season, storms occur according to a Poisson process with rate 5 per month. Suppose next season will be a normal season with probability 0.3. Let N(t) denote the number of storms during the first t months of the next season.

   (i)   Find $P\{N(t) = n\}$.
   (ii)   Is N(t) a Poisson process?
   (iii) Does {N(t)} have stationary increments? Why or why not?
   (iv)   If next season starts off with three storms in the first month of the season, find he conditional probability that it is a normal season?

2.   (a)   (i)   Define the following:
                    Stochastic process
                    Discrete time Markov chain
                    Homogeneous Markov chain

          (ii)   State and prove the Chapman Kolmogorov equations

(b) A company has three machines. Each day, independent of each other, a machine breaks down with probability p. Each night, there is one repair person who can repair at most one machine. Let X_n be the number of machines available for use at the beginning of the nth day. Find the transition matrix for the Markov chain $\{X_n\}_{n=0, 1, 2...}$.

(c) Daily electrical usage in Lusaka during October can be classified as normal, high or low depending on weather conditions which often make this level of usage change daily according to the following transition matrix:

$$\begin{pmatrix} \frac{3}{4} & \frac{1}{6} & \frac{1}{12} \\ \frac{2}{5} & \frac{1}{3} & \frac{4}{15} \\ \frac{1}{2} & \frac{2}{5} & \frac{1}{10} \end{pmatrix}$$

Find the probability of low electrical usage day after tomorrow given that the usage is normal today.

3. (a) Consider a Markov chain $\{X_n\}_{n=1, 2, ...}$.

(i) Define a recurrent state.

(ii) Let P_{ii}^{n} denote the probability that the chain is in state i at the nth transition given that it started from state i. Prove that state i is

recurrent if $\sum_{n=1}^{\infty} P_{ii}^{n} = \infty$

(b) Consider a symmetric random walk in two dimensions where a particle at the point (x, y) has a probability of $\frac{1}{4}$ of moving at the next step to any one of its four neighbours $(x + 1, y)$, $(x - 1, y)$, $(x, y + 1)$ $(x, y - 1)$. Let U_n be the probability that the particle starting at the origin is again at the origin at the nth step. Show that $U_{2n} \sim \frac{1}{\Pi n}$.

You may use Sterling's formula: $n! \sim \sqrt{2\Pi}\ n^{n+\frac{1}{2}} e^{-n}$

(c) Let $\{ X_n, n = 0, 1, ...\}$ be a Markov chain with states E_1, E_2, E_3 and E_4 and the associated transition matrix

$$P = \begin{pmatrix} \cdot 2 & \cdot 8 & 0 & 0 \\ \cdot 1 & \cdot 9 & 0 & 0 \\ 0 & \cdot 5 & 0 & \cdot 5 \\ \cdot 3 & 0 & \cdot 7 & 0 \end{pmatrix}$$

Find the expected number of steps when the chain is in state E4 given that it started in state E3.

2

4. (a) (i) Consider a Branching process $\{X_n, n = 0, 1, ...\}$ in which X_n denotes the size of the nth generation and μ denotes the expected number of off-springs of an individual. Assuming that the off-springs of the $(n-1)^{th}$ generation constitutes the nth generation and $E(X_0) = 1$, show that $E(X_n) = \mu^n$.

(ii) Let π_0 denote the probability of extinction of the population. Show that $\pi_0 \rightarrow 1$ whenever $\mu < 1$.

(iii) Let the probability mass function of off-springs of an individual in a Branching process be $p_0 = \dfrac{3}{4}, \quad p_2 = \dfrac{1}{4}$

Find π_0 where π_0 satisfies the equation $\sum_{j=0}^{\infty} p_j \, \pi_0^{j} = \pi_0$

(b) Machines in a factory break down at a Poisson rate of six per hour. There is a single repairman who fixes machines at Poisson rate of 8 per hour. Let $X(t)$ denote the number of faulty machines to be repaired including the one being repaired if there is any in the system at time t.

(i) Find the stationary distribution of $X(t)$.
(ii) The cost incurred in lost production when machines are out of service is K 1,000.00 per hour per machine. Find the average cost per hour incurred due to failed machines.

(c) In a bacteria culture, each organism will generate a successor with probability $\lambda \Delta t$ in any small interval of length Δt and there are no deaths. Thus if there are K members in the population at time t, then the probability that there will be a successor in $(t, t+\Delta t)$ is $K\lambda\Delta t$. Show that the expected number of members in the population at time t is $Ke^{\lambda t}$ if at t=0, the population size is K.

5. (a) In a single server queue system, the probability that exactly one customer arrives in $(t, t + h)$ is $\lambda h + 0(h)$. If the there are j customers for the service at time t, the probability that exactly one customer will complete service in $(t, t + h)$ is $j\mu h + 0(h)$. Probability that more than one change (arrival and/or service completions) occurs in $(t, t + h)$ is $0(h)$. Derive the statistical equilibrium distribution of the queue system.

(b) Let $\{X(t), t \geq 0\}$ be a Brownian motion process with a variance parameter σ^2. State the following:
(i) Probability distribution of $X(t)$, $t > 0$.
(ii) Probability density function of $X(t_2) - X(t_1)$, $t_1 < t_2$.
(iii) Joint density function of $X(t_1)$ and $X(t_2)$, $t_1 < t_2$.

(c)   Let $\{X(t),\ 0 \le t \le 1\}$ be a Brownian motion process with variance parameter 4. Find the following using the fact that for a Standard Brownian motion $\{Y(t)\}$

$E[Y(t_1)\ |\ Y(t_2) = a] = \frac{t_1}{t_2}\,a$ and $V[Y(t_1)\ |\ Y(t_2) = a] = \frac{t_1}{t_2}\,(t_2 - t_1)$ where $t_1 < t_2$

(i) $P[X(1) > 0\ |\ X\left(\frac{1}{2}\right) = 2]$ (ii) $P[X\left(\frac{1}{2}\right) > 0\ |\ X(1) = 2]$