THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

EXAM PAPERS 2019/2020

1. CHE 1000 – Introduction to Chemistry
2. CHE 2001 – Agricultural and Veterinary Chemistry
3. CHE 2015 – General Analytical and Inorganic Chemistry
4. CHE 2112 – Introductory Biochemistry
5. CHE 2219 – Chemical Analysis
6. CHE 2415 – Basic Inorganic Chemistry
7. CHE 2511 – Basic Organic Chemistry
8. CHE 2522 – Functional Group and Arene Chemistry
9. CHE 3211 – Spectroscopic Methods of Analysis
10. CHE 3222 – Instrumental Methods of Chemical Analysis
11. CHE 3422 – Organometallics and Reactions mechanisms
12. CHE 3611 – Chemical Kinetics and Nuclear Chemistry
13. CHE 3622 – Colloids and Electrochemistry
14. CHE 4211 – Analysis of Inorganic Compounds

15. CHE 4222 – Food, Drugs, Pesticides and Detergent Analysis

16. CHE 4522 – Physical Organic Chemistry and Natural Products Chemistry

17. CHE 4715 – Essentials of Medicinal Chemistry

18. CHE 5011 – General Chemical Techniques

19. CHE 5122 – Physiological Chemistry

20. CHE 5535 – Physical Organic Chemistry

21. CSC 2000 – Computer Programming

22. CSC 2101 – Introduction to Computer Systems

23. CSC 2202 – Operating Systems

24. CSC 2702 – Databases and Information Management Systems

25. CSC 2901 – Discrete Structures

26. CSC 2912 – Numerical Analysis

27. CSC 3011 – Algorithm and Complexity

28. CSC 3120 – Digital Electronics

29. CSC 3301 - Programming Language Design and Implementation

30. CSC 3311 – Structure and Interpretation of Computer Programs

31. CSC 3402 – Artificial Intelligence

32. CSC 3600 - Software Engineering

33. CSC 3612 – IT Project Management

34. CSC 3712 – Advanced Databases

35. CSC 3750 – Management Information Systems

36. CSC 3801 – Computer Network and Data Communication

37. CSC 4035 – Web Programming and Technologies

38. CSC 4130 – Advanced Hardware Design and Implementation

39. CSC 4505 – Computer Graphics

40. CSC 4630 – Advanced Software Engineering

41. CSC 4631 – Software Testing and Maintenance

42. CSC 4642 – Software Quality Assurance

43. CSC 4722 – Distributed Systems

44. CSC 4765 – IT Audit and Controls

45. CSC 4792 – Data Mining and Warehousing

46. CSC 4812 – Cloud and High Performance Computing

47. CSC 4835 – Wireless and Mobile Networks

48. CSC 4845 – Fundamentals of Cluster and High-Performance Computing

DPE 2111 – Fundamental Concepts of Mathematics

49. GES 1310 – Introduction to Geography

50. GES 2122 – Elements of Cultural Geography

51. GES 2130 – The Geography of Africa with Special Reference to Zambia

52. GES 2210 – Fundamentals of Physical Geography

53. GES 2322 – Fundamentals of Natural Resources Economics

54. GES 2411 – Mapping and Field Techniques in Geography

55. GES 3151 – Regional Planning and Development

56. GES 3241 – Climatology

57. GES 3271 – Soils and Soil Resources
GES 3342 – Environmental Management and Planning
58. GES 4172 – Rural Land use and Landscapes

59. GES 4342 – Environment and Natural Resources Management

60. GES 4372 – Tourism, Environment and Development

61. GES 4385 – Environmental Hazards and Disasters

62. GES 4451 – Cartography
GES 4461 – Land Resource Survey
63. ICT 1110 – Computer Systems and Architecture

64. MAT 1100 – Foundation Mathematics

65. MAT 2001 – Principles of Financial Mathematics

66. MAT 2100 – Analytic Geometry and Calculus

67. MAT 2200 – Linear Algebra
MAT 2300 – Introduction to Real Analysis
68. MAT 2602 – Introduction to Statistics

69. MAT 3001 – Insurance and Alternative Risk Transfer

70. MAT 3011 – Principles of Finance and Financial Reporting

71. MAT 3022 – Investment and Portfolio Management

72. MAT 3100 – Multivariable Calculus

73. MAT 3110 – Engineering Mathematics II

74. MAT 3601 – Mathematical Statistics

75. MAT 4001 – Life and Health Insurance Mathematics

76. MAT 4011 – Operational Risk Management

77. MAT 4022 – Pension Design and Valuation

78. MAT 4032 – Financial Engineering

79. MAT 4119 – Engineering Mathematics III

80. MAT 4201 – Structure and Representation of Groups

81. MAT 4212 – Module and Field Theory

82. MAT 4300 – Elements of Functional Analysis

83. MAT 4600 – Multivariate Statistical Analysis

84. MAT 4615 – Nonparametric Methods

85. MAT 4645 – Time Series Analysis

86. MSE 9030 – Advanced Mathematics Education

87. MSE 9060 – Advanced Chemistry Teaching Methods

88. PHY 1010 – Introductory Physics

89. PHY 2112 – Atomic and Modern Physics

90. PHY 2231 – Thermodynamics and Properties of Matter

91. PHY 2511 – Classical Mechanics

92. PHY 2522 – Analytical Mechanics and Special Theory of Relativity

93. PHY 2611 – Electricity and Magnetism

94. PHY 2712 – Optics

95. PHY 3032 – Computational Physics

96. PHY 3621 – Electromagnetic Theory

97. PHY 4031 – Computational Physics II

98. PHY 3411 – Analogue Electronics I

99. PHY 3422 – Digital Electronics I

100. PHY 3531 – Introduction to Quantum

101. PHY 4021 – Mathematical Methods for Physics

102. PHY 4121 – Nuclear Experimental Techniques

103. PHY 4221 – Solid State Physics I

104. PHY 4242 – Fundamentals of medical Physics

105. PHY 4535 – Quantum Mechanics II

106. PHY 4815 – Physics of Reference Energy Resources

107. Acturial Economics

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019/2020 ACADEMIC YEAR
FINAL EXAMINATIONS

CHE1000: INTRODUCTION TO CHEMISTRY

TIME: THREE (3) HOURS

INSTRUCTIONS TO THE CANDIDATES

1. Indicate your **student ID number** and **TG number** on **ALL** your answer booklets.
2. This examination paper consists of two (2) sections: **A** and **B**
3. Section **A** has ten **(10)** short answer questions. Questions carry equal marks. (Total marks = **40**).

   ANSWER ALL QUESTIONS IN SECTION A IN THE MAIN ANSWER BOOKLET
4. Section **B** has five **(5)** long answer questions. Questions carry equal marks. (Total marks = **60**).

   ANSWER QUESTION B1 AND ANY ~~FOUR~~ 3 QUESTIONS, EACH QUESTION IN A SEPARATE ANSWER BOOKLET.
6. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.**
7. Please be reminded that it is your responsibility to **ENSURE** that you have Ten (10) printed pages containing questions A1 to A10 and B1 to B5.

ADDITIONAL INFORMATION TO THE CANDIDATES:

Useful data is provided on page 11.
Periodic Table of Elements is on last page.

SECTION A

ANSWER ALL QUESTIONS IN THIS SECTION IN THE MAIN BOOKLET

Question A1

A 2.00 g sample of a compound gave 4.86 g CO_2 and 2.03 g H_2O upon combustion in oxygen. Find its empirical formula, if it only contained Carbon, Hydrogen and Oxygen.

[4 Marks]

Question A2

A sample of sodium azide (NaN_3), a compound used in automobile air bags, was thermally decomposed, and 15.3 mL nitrogen gas was collected over water at 25°C and 755 torr. Given the vapour pressure of water at 25°C is 23.6 torr, how many grams of nitrogen were collected?

[4 Marks]

Question A3

Ozone molecules in the upper atmosphere absorb radiation. If the radiation has a wavelength between 240 nm and 310 nm, the ozone molecules will decompose into oxygen molecules and oxygen atoms. The oxygen atoms then recombine with the oxygen molecules to make more ozone, releasing heat. This converts light energy into heat energy and insulates the Earth.

$O_3(g) \rightarrow O_2(g) + O_(g)$	light energy absorbed
$O_2(g) + O(g) \rightarrow O_3(g)$	heat energy released

a) What kind of electromagnetic radiation has a wavelength between 240 and 310 nm?

b) Which wavelength represents the minimum amount of energy required for this reaction to proceed: 240 nm or 310 nm?

c) Calculate the minimum amount of light energy that must be absorbed to convert 1 mole of ozone into oxygen molecules and atoms.
Report your answer in kJ/mol.

[4 Marks]

Question A4

The atoms of N_2O (nitrous oxide, laughing gas) are connected: N—N—O.

a) Draw all resonance structures for N_2O that have minimum formal charges. Explicitly show (using curved arrows) the electron movements that transform one resonance structure into the other. You must explicitly show all non-zero formal charges.

b) Predict the geometry of this molecule and draw its structure.

[4 Marks]

Question A5

Under standard conditions at 25 °C, Zn(*s*) reacts with $Co^{2+}(aq)$ to produce Co(*s*)

Co^{2+} (aq)	+ 2 e^-	⇌ Co(s)	- 0.28 V
Zn^{2+} (aq)	+ 2 e^-	⇌ Zn(s)	- 0.76 V

a) Write the balanced equation for the oxidation half reaction.

b) Write the balanced net-ionic equation for the overall reaction.

c) Calculate the standard potential, $E°$, for the overall reaction at 25 °C.

[4 Marks]

Question A6

Use the following data to answer the questions about this reaction A (g) + 3B (g) → 2C (g), which is carried out in a 1.0 L container at 25°C

Run	[A] (M)	[B] (M)	Initial Rate of formation of C (M/min)
1	0.1	0.1	0.25
2	0.2	0.2	2.0
3	0.1	0.2	2.0

a) For experiment 1, give the initial rate of disappearance of A and B.

b) Determine the orders of reaction with respect to A and B.

[4 Marks]

Question A7

Given the following equations and their $\Delta H°$ values:

$2\ CH_3OH\ (l) + 3\ O_2\ (g) \rightarrow 2CO_2\ (g) + 4\ H_2O\ (g)$ $\quad \Delta H° = -305.4$ kJ

$HCO_2H\ (l) + \frac{1}{2}\ O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (g)$ $\quad \Delta H° = -65.2$ kJ

Calculate $\Delta H°$ for the reaction:

$CH_3OH\ (l) + O_2\ (g) \rightarrow HCO_2H\ (l) + H_2O\ (g).$

[4 Marks]

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Question A8

A recent analysis has shown that a certain variety of grapes contains 28 % sugar by mass. Assuming that sugar (formula $C_6H_{12}O_6$) is the only solute present and that water is the solvent, at what temperature will the grapes freeze? [Note: H_2O $K_f = 1.86\ °C \cdot kg/mol$]

[4 Marks]

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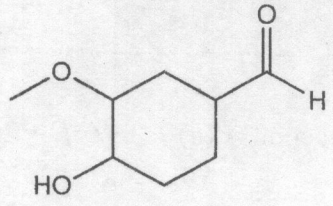
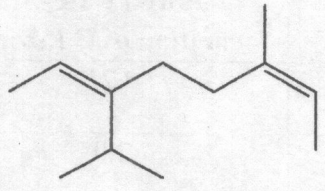
Question A9

Provide the IUPAC name for each of the molecules shown below:

(a)



(b)



[4 Marks]

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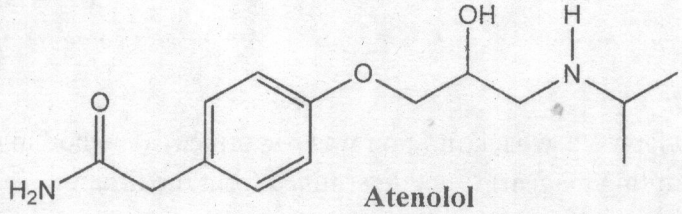
Question A10

a) Write the bond line formulae corresponding to IUPAC names:
Ethyl 4-aminobutanoate

b) Consider the molecular structure of the drug Atenolol, used for treatment of hypertension (high blood pressure).



Atenolol

Redraw the structure of Atenolol molecule, **circle** all functional groups and **name** them.
[4 Marks]

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SECTION B

ANSWER QUESTION B1 AND ANY THREE QUESTIONS EACH IN A SEPARATE BOOKLET

Question B1

a) In one of the CHE1000 laboratory back titration was performed, a method in which the analyte (which is the limiting reagent) is not determined from the titration reaction with a primary standard, but by working back to the original reaction.

(i) In titration, what is meant by the term Primary standard? **[1 Mark]**

(ii) In three (3) lines or less, explain the principle involved in a back titration. **[2 Marks]**

(iii) An acid and a base were titrated, state the suitable indicator used and the end-point color expected. **[2 Marks]**

(iv) The mass of magnesium hydroxide, $Mg(OH)_2$, in an indigestion tablet was determined as follows:

Step 1 The tablet was crushed and dissolved in exactly 40.00 cm^3 of dilute Hydrochloric acid (an excess).

$$Mg(OH)_2(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + 2H_2O(l)$$

Step 2 The amount of hydrochloric acid remaining was measured by titration with 0.250 mol dm^{-3} sodium hydroxide solution.

22.80 cm^3 of this sodium hydroxide solution was required.

Calculate the mass of magnesium hydroxide in the tablet. **[4 Marks]**

b) In the redox titration, the weed killer solution was prepared by dissolving hydrated iron(II) sulphate, $FeSO_4.7H_2O$, in water. This was then titrated with 0.0200 mol dm^{-3} potassium manganate(VII) which had average titre of 25.60 cm^{-3}. The half-equations for the redox reactions occurring in the reaction between iron(II) and potassium manganate(VII) in acidic solution are shown below.

$$Fe^{2+} \rightarrow Fe^{3+} + e^-$$
$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

(i) Give a reason why this titration does not need an indicator **[1 Mark]**

(ii) Deduce an overall equation for the reaction between iron(II) and manganate(VII) ions in acidic solution. **[2 Marks]**

(iii) Calculate the concentration, in g dm^{-3}, of hydrated iron(II) sulphate in the weed killer solution. **[3 Marks]**

[Total: 15 Marks]

Question B3

a) Due to COVID-19 coupled with erratic power supply from ZESCO, you decide to play around with galvanic cells and you construct a zinc–copper battery operating at a zero resistant small light emitting diode (L.E.D) at 25°C as follows:

$$Zn \mid Zn^{2+}(0.10\ M) \parallel Cu^{2+}\ (2.5\ M) \mid Cu$$

The mass of each solid electrode is 2.00 g.

The electrode potentials for the half reactions are:

$$Cu^{2+} + 2e^{-} \rightarrow Cu \qquad E^{o} = +0.3419\ V$$

$$Zn^{2+} + 2e^{-} \rightarrow Zn \qquad E^{o} = -0.7618\ V$$

(i) Which of the two is a reducing agent? **[1 Marks]**

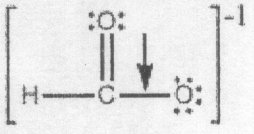
(ii) Calculate the cell potential when this battery is first connected. **[3 Marks]**

(iii) Calculate the cell potential after 10.0 A of current has flowed for 10.0 hours. (Assume each half-cell contains 1.00 L of solution.) **[3 Marks]**

(iv) Calculate the mass of each electrode after 10.0 hours. **[3 Marks]**

(v) What will cause the battery to die after some time? **[2 Marks]**

b) Using the table of mean bond enthalpies provided, predict the bond enthalpy (in kJ/mol) for the CO bond marked with an arrow in the molecule below. **[3 Marks]**



Bond	Mean Bond Enthalpy (in kJ/mol)
C-H	412
C-C	348
C=C	612
C-O	360
C=O	743

[Total: 15 Marks]

Question B4

a) Consider the following reaction in solution which was studied and gave the following data. Determine the rate law. **[5 Marks]**

$$2I^-(aq) + S_2O_8^{2-}(aq) \rightarrow I_2(aq) + 2SO_4^{2-}(aq)$$

$[I^-]_o$ (M)	$[S_2O_8^{2-}]_o$ (M)	Initial rates (mol. L^{-1}. s^{-1})
0.080	0.040	12.5×10^{-6}
0.040	0.040	6.25×10^{-6}
0.080	0.020	6.25×10^{-6}
0.032	0.040	5.00×10^{-6}
0.060	0.030	7.00×10^{-6}

b) At a particular temperature, 12 mol $SO_3(g)$ is placed into a 3.0 L rigid container, and the SO_3 dissociates by the reaction:

$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$$

At equilibrium 3.0 mol SO_2 is present. Calculate the equilibrium constant, K for this reaction. **[3 Marks]**

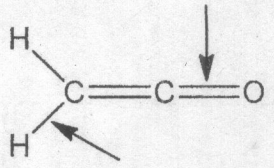
c) The activation energy for the decomposition of HI(g) to H_2 (g) and I_2(g) is 186 kJ/mol, and the rate constant at 555K is 3.52×10^{-7} L/mol. s.
What is the rate constant at 645 K? **[4 Marks]**

d) Calculate K_{sp} for $Pb_3(PO_4)_2(s)$ with a solubility of 6.2×10^{-12} mol/L. **[3 Marks]**

[Total: 15 Marks]

Question B5

a) Consider the ketene molecule shown below:



Identify the indicated bonds in terms of the types of bonds (**σ, π**) and the orbital overlaps Involved in bond formation. **[2 Marks]**

Bond	Bond description (σ, π)	orbital overlaps involved
C=O		
C-H		

b) Several constitutional (structural) isomers can be written for the molecular formula $C_4H_8O_2$.

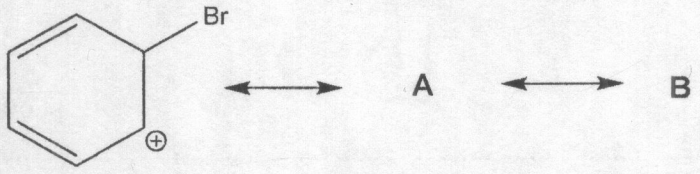
(i) Calculate the IHD and state all possible interpretations. **[3 Marks]**

(ii) One of the isomers, **B**, decolorizes bromine water. Does this isomer has a ring? Give a reason. **[2 Marks]**

(iii) Give the line (bond-line) formula and IUPAC name for another isomer **C**, a branched chain molecule, pH = 5.2. **[3 Marks]**

c) The compound with the molecular formula of C_4H_8 contains three structural isomers and two E/Z isomers. Draw the E isomers of C_4H_8, and give its IUPAC names. **[2 Marks]**

d) Draw two additional resonance structures A and B for the structure shown below, showing the movement of all electrons: **[3 Marks]**



[Total: 15 Marks]

USEFUL DATA

Physical contants

Avogadro constant, N_A	6.022×10^{23} mol^{-1}
Acceleration due to gravity	9.8 m s^{-2}
Faraday's constant, F	96485 C mol^{-1}
Mass of electron, m_e	9.11×10^{-31} kg
Planck's constant, h	6.626×10^{-34} J s
Rydberg constant, R_H	1.097×10^{7} m^{-1}
Speed of light, c	3.00×10^{8} m s^{-1}
Universal gas constant, R	8.3145 J mol^{-1} K^{-1}
	0.083145 L bar mol^{-1} K^{-1}
	0.08206 L atm mol^{-1} K^{-1}
	62.364 L torr mol^{-1} K^{-1}
	62.364 L mmHg mol^{-1} K^{-1}

Pressure conversions

1 atm = 1.01325×10^5 Pa = 1.01325×10^5 N m^{-2} = 760 torr = 760 mmHg = 1.01325 bar

1 bar = 1.00000×10^5 Pa
= 1.00000×10^5 N m^{-2}

Other conversion factors

V= J C^{-1} 1 eV = 1.602×10^{-19} J
I Joule = 1 J = 1 kg m^2 s^{-2} = 1 Pa m^3

Standard Reduction potentials

$ClO^-(aq) + H_2O(l) + 2e^- \leftrightharpoons Cl^-(aq) + 2OH^-$	$\varepsilon^o = +0.89$ V
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	$\varepsilon^o = -0.76$ V
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	$\varepsilon^o = +0.80$ V
$Cl_{2(g)} + 2e^- \rightleftharpoons 2Cl^-_{(aq)}$	$\varepsilon^o = 1.36$ V
$2ClO_{2(g)} + 2e^- \rightleftharpoons 2\,ClO_2^-{}_{(aq)}$	$\varepsilon^o = 0.954$ V
$H^+(aq) + e^- \rightleftharpoons \frac{1}{2} H_2(g)$	$\varepsilon^o = 0.00$ V
$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$	$\varepsilon^o = -2.37$ V

PERIODIC TABLE OF ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
hydrogen 1 **H** 1.00794																	helium 2 **He** 4.002602
lithium 3 **Li** 6.941	beryllium 4 **Be** 9.012182											boron 5 **B** 10.811	carbon 6 **C** 12.0107	nitrogen 7 **N** 14.00674	oxygen 8 **O** 15.9994	fluorine 9 **F** 18.9984	neon 10 **Ne** 20.1797
sodium 11 **Na** 22.98977	magnesium 12 **Mg** 24.3050											aluminium 13 **Al** 26.981538	silicon 14 **Si** 28.0855	phosphorus 15 **P** 30.97376	sulphur 16 **S** 32.065	chlorine 17 **Cl** 35.453	argon 18 **Ar** 39.984
potassium 19 **K** 39.0983	calcium 20 **Ca** 40.078	scandium 21 **Sc** 44.95591	titanium 22 **Ti** 47.867	vanadium 23 **V** 50.9415	chromium 24 **Cr** 51.9961	manganese 25 **Mn** 54.93805	iron 26 **Fe** 55.845	cobalt 27 **Co** 58.9332	nickel 28 **Ni** 58.6934	copper 29 **Cu** 63.546	zinc 30 **Zn** 65.409	gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.64	arsenic 33 **As** 74.9216	selenium 34 **Se** 78.96	bromine 35 **Br** 79.904	krypton 36 **Kr** 83.798
rubidium 37 **Rb** 85.4678	strontium 38 **Sr** 87.62	yttrium 39 **Y** 88.90585	zirconium 40 **Zr** 91.225	niobium 41 **Nb** 92.90638	molybdenum 42 **Mo** 95.94	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.9055	palladium 46 **Pd** 106.42	silver 47 **Ag** 107.8682	cadmium 48 **Cd** 112.411	indium 49 **In** 114.818	tin 50 **Sn** 118.710	antimony 51 **Sb** 121.760	tellurium 52 **Te** 127.60	iodine 53 **I** 126.9045	xenon 54 **Xe** 131.293
caesium 55 **Cs** 132.90545	barium 56 **Ba** 137.327	lutetium 71 **Lu** 174.967	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.9479	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.207	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.217	platinum 78 **Pt** 195.078	gold 79 **Au** 196.96655	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.3833	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.980	polonium 84 **Po** [209]	astatine 85 **At** [210]	radon 86 **Rn** [222]
francium 87 **Fr** [223]	radium 88 **Ra** [226]	lawrencium 103 **Lr** [262]	rutherfordium 104 **Rf** [261]	dubnium 105 **Db** [262]	seaborgium 106 **Sg** [266]	bohrium 107 **Bh** [264]	hassium 108 **Hs** [269]	meitnerium 109 **Mt** [268]	darmstadtium 110 **Ds** [271]	roentgenium 111 **Rg** [272]	ununbium 112 **Uub** [285]		ununquadium 114 **Uuq** [289]				

key

element name
atomic number
symbol
atomic mass

lanthanum 57 **La** 138.9055	cerium 58 **Ce** 140.116	praseodymium 59 **Pr** 140.90765	neodymium 60 **Nd** 144.24	promethium 61 **Pm** [145]	samarium 62 **Sm** 150.36	europium 63 **Eu** 151.964	gadolinium 64 **Gd** 157.25	terbium 65 **Tb** 158.9253	dysprosium 66 **Dy** 162.50	holmium 67 **Ho** 164.930	erbium 68 **Er** 167.259	thulium 69 **Tm** 168.934	ytterbium 70 **Yb** 173.04
actinium 89 **Ac** [227]	thorium 90 **Th** 232.038	protactinium 91 **Pa** 231.0359	uranium 92 **U** 238.0289	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2019/20 ACADEMIC YEAR
MID-YEAR EXAMINATIONS

CHE 2001: AGRICULTURAL AND VETERINARY CHEMISTRY

INSTRUCTIONS TO THE CANDIDATES

TIME ALLOWED: THREE (3) HOURS

All questions carry equal marks (**20 marks** EACH)

Answer **Any Five (5)** questions

Write your computer number on all Answer booklets

Please be reminded to present your answers in logical manner and be on point.

This examination consists of six (6) questions and **SIX** (6) printed pages and a Periodic Table.

QUESTION ONE

The unique properties of water make life possible on Earth. Approximately three-quarters of the Earth's surface is covered by water. Cells are made up of around 70-95% water. Water comprises roughly 70% of the human body.

(a) Describe the major physical and chemical properties of water that make it unique from other liquids. **[10 marks]**

(b) Explain the properties of water that enable it to travel up through the roots and stems of plants to reach the leaves. **[10 marks]**

QUESTION TWO

(a) A 0.40 M solution of the lactate ion ($C_3H_5O_3^-$) (a weak base), has a pH of 8.728.

(i) Calculate the K_b of the lactate ion ($C_3H_5O_3^-$). **[4 marks]**

(ii) Using the information from (2a), calculate the K_a for lactic acid ($HC_3H_5O_3$). **[1 mark]**

(b) The weak base ethylamine ($C_2H_5NH_2$) has a K_b of 6.4×10^{-4}.

(i) Write the equilibrium equation for the ionization of ethylamine. **[1 mark]**

(ii) What $[C_2H_5NH_2]$ is required to produce an ethylamine solution with a pH = 12.102? **[4 marks]**

(c) The pH in a 0.25 M solution of the acid HBrO is 4.65.

(i) Using this data above, calculate the value of K_a for the acid, HBrO. **[4 marks]**

(ii) Calculate the pH of a 0.22M solution of the salt $NaNO_2$, where K_a for HNO_2 is 7.2×10^{-4} **[3 marks]**

(iii) The value of K_b for the weak base methylamine (CH_3NH_2) is 4.4×10^{-4}. Calculate the value of K_a for the acid $CH_3NH_3^+$. **[3 marks]**

QUESTION THREE

(a) Given that a phase reaction A + B → C has a reaction rate which is experimentally observed to follow the relationship Rate = $k[A]^2[B]$. What factors would affect the value of the specific rate constant, k? **[4 marks]**

(b) The rate constant for a particular reaction is 1.3 x$10^{-4}M^{-1}s^{-1}$ at 100 °C, and 1.1 x $10^{-4}M^{-1}s^{-1}$ at 150 °C. What is the overall order of the reaction? **[4 marks]**

(c) Consider the following hypothetical data for the reaction Experimental kinetics dealing with one chemical species:

$$2NO_2 \rightarrow 2NO + O_2$$

$[NO_2]$ (M)	0.30	0.15	0.075	0.038
Time(min)	0	2.0	4.0	6.0

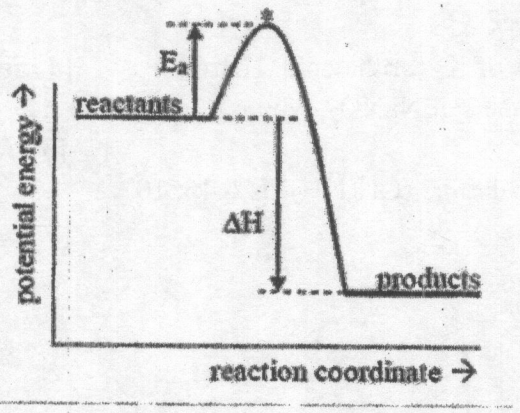
(i) Calculate the order of this reaction and write the complete rate law. **[4 marks]**

(ii) Calculate the half-life for this reaction? **[4 marks]**

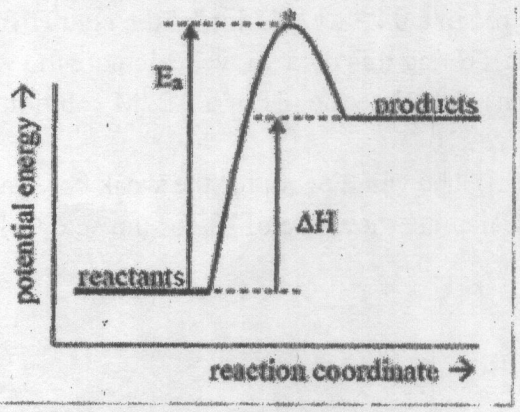
(iii) Calculate the rate constant for this reaction? **[4 marks]**

QUESTION FOUR

(a) Answer the questions below for each of the following reaction coordinate diagrams:



A.



B.

[8 marks]

(i) What type of chemical reaction is **A** and **B**?

(ii) What is the sign of **ΔH** for reaction **A** and **B**? Is heat absorbed or released?

(iii) Explain briefly what happens to the temperature of the surroundings?

(b) Given the equation below, determine how many grams of methane (CH_4) must be combusted in a Bunsen burner to bring a beaker with 325.7 g of water at 24.3 °C up to the normal boiling point? Assume that all of the heat generated by the burner is absorbed by the water. (Specific heat capacity of water: 4.182 $J\,g^{-1}\,C^{-1}$).

$$\mathbf{CH_{4(g)} + 2\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(g)} + 891\ kJ}$$

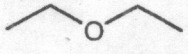
[6 marks]

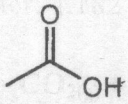
(c) A 28.5 g piece of metal at 99.8°C is placed in a calorimeter containing 50.0 g of water at 22.3 °C. The calorimeter itself has a heat capacity of 3.40 J/g°C, and the temperature rises to 26.1 °C. Calculate the specific heat capacity of the metal (J/g°C).

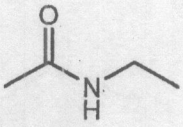
[6 marks]

QUESTION FIVE

(a) What functional group is present in each of the following molecules? **[6 marks]**

(i) 

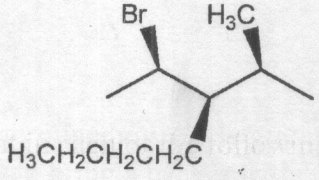
(ii) 

(iii) 

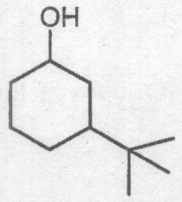
(b) Provide a molecule that contains the indicated functional group. Do not include multiple functional groups in the molecules you draw. **[4 marks]**

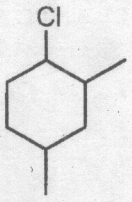
(i) Alkene
(ii) ketone

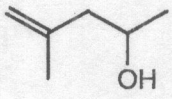
(c) Determine the absolute configuration of any stereogenic centres in the following molecule. Show your reasoning for full credit. **[4 marks]**



(d) Name the following compounds: **[2 marks]**

(i) 

(ii) 

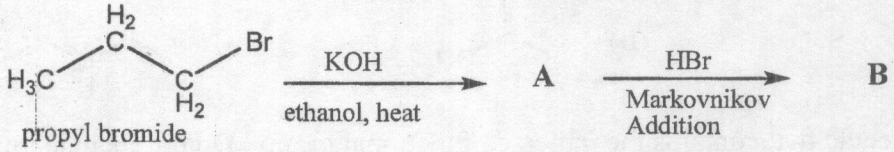
(iii) 

(e) Draw bond line formulas for the following compounds: **[4 marks]**

(i) Ethyl-2-methylbutanoate
(ii) 3-bromopentanal
(iii) 4-hydroxy-2-methylpentantoic acid

QUESTION SIX

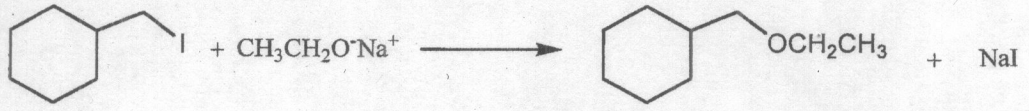
(a) Consider the following reaction of propyl bromide (1-bromopropane) with hot ethanolic potassium hydroxide shown below. An elimination reaction takes place instead of a nucleophilic substitution reaction.

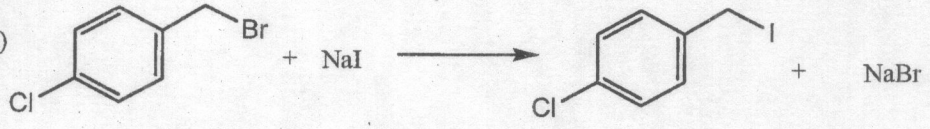


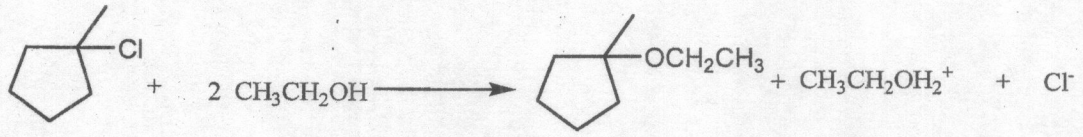
(i) Provide the structures of compound, **A** and **B.** **[2 marks]**
(ii) Write a detailed mechanism for conversion of propyl bromide to **A** and **B.** **[3 marks]**
(iii) Is this an E2 or E1 mechanism? **[1 mark]**
(iv) Name product **A** and **B** according to **IUPAC system.** **[2 marks]**

(b) Write the following net ionic equations and designate the nucleophile, substrate and leaving group in each reaction. **[6 marks]**

(i) $CH_3Br + NaCN \longrightarrow CH_3CN + NaBr$

(ii) 

(iii) 

(iv) 

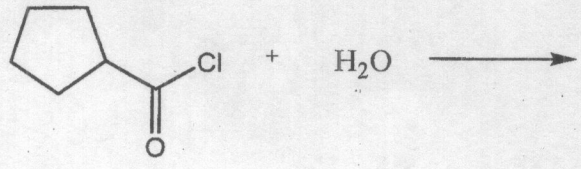
(c) Draw the general structure of an alpha amino acid. **[1 mark]**

(d) Give a known example of an alpha amino acid. **[1 mark]**

(e) Predict the product of the following reactions: **[4 marks]**

(i) $CH_3CH_2Br + NaSH \xrightarrow[DMF]{} ?$

(ii) $CH_3CH_2CH_2COOH + CH_3OH \xrightarrow{H_2SO_4} ?$

(iii)  ?

END OF EXAMINATION

Periodic Table of the Elements

1																	18
1 H Hydrogen 1.008	2											13	14	15	16	17	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305	3	4	5	6	7	8	9	10	11	12	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 84.798
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.249
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71 Lanthanides	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 Actinides	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Nh Nihonium unknown	114 Fl Flerovium [289]	115 Mc Moscovium unknown	116 Lv Livermorium [298]	117 Ts Tennessine unknown	118 Og Oganesson unknown

57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.243	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]

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THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

CHEMISTRY DEPARTMENT

2019/20 ACADEMIC YEAR FIRST HALF FINAL EXAMINATION

CHE 2015: General Analytical and Inorganic Chemistry

TIME: 3 HRS **December 2020**

INSTRUCTIONS TO THE CANDIDATES:

1. Indicate your **student ID number** on the provided answer scripts.
2. There are five questions in this paper; **you must answer question one (1) and any other three (3). Answer four in total.**
3. All questions carry equal marks.
4. Copies of the periodic table and statistical table data sheet are attached at the end of the exam paper.
5. **Kindly indicate the attempted questions on the front page of your examination main answer booklet. Use only the first column of the two columns titled "FOR USE BY EXAMINER".**
6. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.**

ANSWER QUESTION ONE AND ANY OTHER THREE

QUESTION ONE (COMPULSORY QUESTION!!)

(a) Among the alkali metals caesium is the most reactive. Explain based on periodic trends.

(b) Mention some points of similarities between Lithium and Magnesium owning to its diagonal relationship.

(c) Explain inert pair effect exhibited by group III elements. Arrange Al, Ga and In in the order of increasing trend of exhibiting inert pair effect.

(d) Predict the number of unpaired electron in square planar $[Pt(CN)_4]^{2-}$ ion. Show your working.

(e) The molecule BF_3 and NF_3 both are covalent compounds, but BF_3 is non-polar and NF_3 is polar. Comment on its symmetry and dipole moment.

QUESTION TWO

(a) From the following standard potentials, arrange the metals in the order of their **increasing** reducing power.

$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$: $E° = -0.76$ V
$Ca^{2+}(aq) + 2e^- \rightarrow Ca(s)$: $E° = -2.87$ V
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$: $E° = -2.36$ V
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$: $E° = -0.25$ V
$Ni(s) \rightarrow Ni2^{+}(aq) + 2e^-$: $E° = +0.25$ V

(b) The concentration of Cl^- in a 100.0-mL sample of water drawn from a fresh water acquifer suffering from encroachment of sea water, was determined by titrating with 0.0516 M $Hg(NO_3)_2$. The sample was acidified and titrated to the diphenylcarbazone end point, requiring 6.18 mL of the titrant. Report the concentration of Cl^- in parts per million.

(c) In brief, differentiate grab sample from a composite sample.

(d) Describe the steps in a sampling operation.

(e) In a redox titration, 20 ml of $Fe(II)SO_4$ was completely oxidised by 12.5 ml of 0.02 $mol.L^{-1}$ **acidified** dichromate solution. The unbalanced redox equation for the reaction is given below:

(i) Balance the equation above.

(ii) Calculate the concentration of the $Fe(II)SO_4$.

QUESTION THREE

(a) (i) Describe the mechanism of formation of a precipitate in gravimetric analysis.

(ii) Briefly discuss the different types of co precipitation that exist and state how each of them can be minimized.

(b) What is co precipitation? Briefly describe the three types of co precipitation that can occur during gravimetric analysis. In each case, give one step that can be taken to minimize it.

(c) A 0.4960 gm sample of a $CaCO_3$ is dissolved in an acidic solution. The calcium is precipitated as $CaC_2O_4.H_2O$ and the dry precipitate is found to weight 0.6186 gm. What is the percentage of CaO in the sample? (FW CaO = 56.08; FW $CaC_2O_4.H_2O$ = 146.2)

(d) Using diagram discuss the two impurity formation process of 'occlusion' and 'adsorption' in gravimetric analysis. [4 marks]

QUESTION FOUR

(a) A 0.005-g sample of a rock is to be analyzed, and iron is to be determined at the ppm level. Determine the type of analysis and type of constituent.

(b) Consider the following set of replicate measurements:

9.5, 8.5, 9.1, 9.3 and 9.1

calculate the (i) mean; (ii) median; (iii) spread, or range; (iv) standard deviation; and (v) coefficient of variation.

(c) Distinguish between

(i) the sample standard deviation and the population standard deviation.

(ii) random and systematic error.

(d) Describe the preparation of 750 mL of 6.00 M H_3PO_4 from the commercial reagent that is 86% H_3PO_4 (w/w) and has a specific gravity of 1.71.

QUESTION FIVE

(a) The OH^- ion concentration of a blood sample is 2.5×10^{-7} *M*. What is the pH of the blood?

(b) 315 mL of a 0.525 M solution of NaCl (molar mass=58.4 g/mole) is mixed with 188 mL of a 0.295 M solution of NaCl, then an additional 166 mL of water is added. Assuming the volumes are additive, what is the final molarity of solution?

(c) What volume of a 30.% (w/v) hydrogen peroxide solution is required to prepare 425 mL of a 6.0% (w/v) solution?

(d) Calculate the pH of the 0.30 M NH_3/0.36 M NH_4Cl buffer system. What is the pH after the addition of 20.0 mL of 0.050 M NaOH to 80.0 mL of the buffer solution?

(e) During sample preparation, some samples will easily dissolve in a suitable solvent simply by swirling and heating gently while others will not. If this occurs, digestion with a suitable solvent or solution is preferred.

(i) How do you understand sample digestion in this context?

(ii) Aqua regia is one solution made up two components. Name these components of aqua regia and the ratio of composition.

|>>>>>>>>>>END OF EXAM<<<<<<<<<<<<<|

USEFUL DATA

Avogadro's constant, N_A	6.022×10^{23} mol^{-1}
Molar volume of gas at S.T.P	22.4 dm^3 mol^{-1}
Planck Constant, h	6.626×10^{-34} Js
Rydberg constant, R_H	1.097×10^{7} m^{-1}
Speed of light in vacuum, c	3.00×10^{8} ms^{-1}
Mass of an electron	9.11×10^{-31} kg
1 electron volt (1 eV)	1.602×10^{-19} J

I Joule = 1 J = 1 kg m^2 s^{-2} = 1 Pa m^3

Standard Reduction Potentials at 25 °C

	Reduction Half-Reaction		E° (V)	
Stronger oxidizing agent	$F_2(g) + 2e^-$	$\longrightarrow 2F^-(aq)$	2.87	Weaker reducing agent
	$H_2O_2(aq) + 2H^+(aq) + 2e^-$	$\longrightarrow 2H_2O(l)$	1.78	
	$MnO_4^-(aq) + 8H^+(aq) + 5e^-$	$\longrightarrow Mn^{2+}(aq) + 4H_2O(l)$	1.51	
	$Cl_2(g) + 2e^-$	$\longrightarrow 2Cl^-(aq)$	1.36	
	$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^-$	$\longrightarrow 2Cr^{3+}(aq) + 7H_2O(l)$	1.33	
	$O_2(g) + 4H^+(aq) + 4e^-$	$\longrightarrow 2H_2O(l)$	1.23	
	$Br_2(aq) + 2e^-$	$\longrightarrow 2Br^-(aq)$	1.09	
	$Ag^+(aq) + e^-$	$\longrightarrow Ag(s)$	0.80	
	$Fe^{3+}(aq) + e^-$	$\longrightarrow Fe^{2+}(aq)$	0.77	
	$O_2(g) + 2H^+(aq) + 2e^-$	$\longrightarrow H_2O_2(aq)$	0.70	
	$I_2(s) + 2e^-$	$\longrightarrow 2I^-(aq)$	0.54	
	$O_2(g) + 2H_2O(l) + 4e^-$	$\longrightarrow 4OH^-(aq)$	0.40	
	$Cu^{2+}(aq) + 2e^-$	$\longrightarrow Cu(s)$	0.34	
	$Sn^{4+}(aq) + 2e^-$	$\longrightarrow Sn^{2+}(aq)$	0.15	
	$2H^+(aq) + 2e^-$	$\longrightarrow H_2(g)$	0	
	$Pb^{2+}(aq) + 2e^-$	$\longrightarrow Pb(s)$	-0.13	
	$Ni^{2+}(aq) + 2e^-$	$\longrightarrow Ni(s)$	-0.26	
	$Cd^{2+}(aq) + 2e^-$	$\longrightarrow Cd(s)$	-0.40	
	$Fe^{2+}(aq) + 2e^-$	$\longrightarrow Fe(s)$	-0.45	
	$Zn^{2+}(aq) + 2e^-$	$\longrightarrow Zn(s)$	-0.76	
	$2H_2O(l) + 2e^-$	$\longrightarrow H_2(g) + 2OH^-(aq)$	-0.83	
	$Al^{3+}(aq) + 3e^-$	$\longrightarrow Al(s)$	-1.66	
Weaker oxidizing agent	$Mg^{2+}(aq) + 2e^-$	$\longrightarrow Mg(s)$	-2.37	Stronger reducing agent
	$Na^+(aq) + e^-$	$\longrightarrow Na(s)$	-2.71	
	$Li^+(aq) + e^-$	$\longrightarrow Li(s)$	-3.04	

Table 17-1 Chemistry, 5/e
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Values of t for ν Degrees of Freedom for Various Confidence Levels[a]

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

[a] $\nu = N - 1$ = degrees of freedom.

Values of F at the 95% Confidence Level

	$\nu_1 = 2$	3	4	5	6	7	8	9	10	15	20	30
$\nu_2 = 2$	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.5
3	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.70	8.66	8.62
4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.86	5.80	5.75
5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.62	4.56	4.50
6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	3.94	3.87	3.81
7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.51	3.44	3.38
8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.22	3.15	3.08
9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.01	2.94	2.86
10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.85	2.77	2.70
15	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.40	2.33	2.25
20	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.20	2.12	2.04
30	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.01	1.93	1.84

Rejection Quotient, Q, at Different Confidence Limits[a]

No. of Observations	Confidence Level		
	Q_{90}	Q_{95}	Q_{99}
3	0.941	0.970	0.994
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

[a] Adapted from D. B. Rorabacher, *Anal. Chem.*, 63 (1991) 139.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF CHEMISTRY

2020 ACADEMIC YEAR FINAL EXAMINATIONS

CHE 2112: INTRODUCTORY BIOCHEMISTRY

NOVEMBER 2020

INSTRUCTIONS TO CANDIDATES:

Time: three (3) hours

All questions carry **equal marks** (20 marks each)

Answer **any Five (5)** questions

Write your computer number on all answer booklets

This examination consists of **SIX (6)** questions and **SIX (6)** printed pages

QUESTION 1

A weak acid may be represented by the term HA.

a) **Write** an equation for its equilibrium constant for the dissociation of such a weak acid. **[3 marks]**

b) Use your answer in question 1(a) to **derive** the Henderson-Hasselbalch equation. **[4 marks]**

c) (i) **Define** the term buffer capacity. **[2 marks]**

(ii) **Calculate** the pH of a buffer whose mixture is 6 mL of 0.1 mol/L sodium acetate and 4 mL of 0.1 mol/L acetic acid. (pKa for acetic acid is 4.76). **[4 marks]**

(iii) **Calculate** the pH after adding 1 mL of 0.01 mol/L sodium hydroxide to this buffer mixture. **[4 marks]**

(iv) **What** is the change in pH from pH in (ii) to pH in (iii) and comment on the effectiveness of this buffer. **[3 marks].**

QUESTION 2

a) **Define** the following:

i) Zwitterion
ii) pI **[2 marks]**

b) The amino acid, aspartate was titrated with 0.1N NaOH. **Draw** on a graph paper supplied a neat titration curve and clearly **label** on the curve the following:

i) pKa 1,2, 3
ii) pI
iii) pHm and
iv) the regions having the highest buffering capacity. **[4 marks]**

[Useful information: pKa_1 (α-carboxyl)= 2.1 pKa_2= 9.8 (α-amino) pKa_3=3.9 (β-carboxyl-side chain)]

P.T.O.

c) **Explain** the salient features of the following:

i) α-helix

ii) collagen helix

iii) β-pleated sheets. **[6 marks]**

d) You isolate a muscle protein (Mol. wt. 70 kD). It is a two stranded α-helical coiled coil. **Estimate** the length of the molecule. **[4 marks]**

e) Suppose that a 40 amino acid residue segment of a protein folds into a two stranded antiparallel β structure with a 4 residue hairpin turn. **What** is the longest dimension of this motif? **[4 marks]**

QUESTION 3

a) Draw the structure of Dipalmitoyl phosphatidyl choline. **[5 marks]**

b) (i) **What** is the use of this chemical in the lungs?**[2 marks]**

(ii) **What** condition arise to due lack of this lipid? ?**[3 marks].**

c) Figure 1 below shows a structure of a lipid molecule

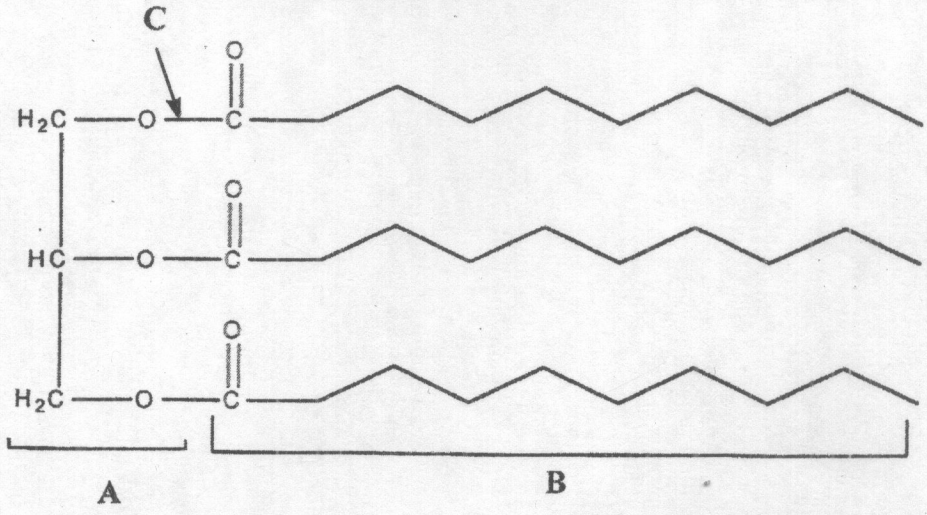


Figure 1: Structure of a lipid molecule

P.T.O.

i) **What** type of a chemical compound is the lipid in figure 1 and select which labelled letter A,B or C repsresents functional group in the lipid. **[3marks]**

ii) **What** is the importance of alkaline hydrolysis of this lipid?**[2 marks]**

iii) **Name** the chemical reaction used to form the bonds labelled C and the catalyst required for this reaction. **[2 marks]**

iv) **State** three functions of lipids in living organisms. **[3 marks]**

QUESTION 4

a) An unknown disaccharide was purified from bacteria. Equal amounts of D-glucose and D-galactose were obtained after acid hydrolysis of the disaccharide and the two sugars were found to be linked by an α linkage. Exhaustive methylation of the disaccharide produced equal amounts of 2,3,4,6-tetramethylgalactose and 2,4,6-trimethylglucose. Using Haworth formulas **draw** the structure of the disaccharide suggested by the above information and **show** clearly the link between the sugars. **[10 marks]**

b) **Explain** mutarotation using glucose as an example. **[5 marks]**

c) **Give** a brief description of how can you distinguish a furanose from a pyranose ring structure. **[5 marks]**

QUESTION 5

a) **What** is meant by the following expressions?

(i) *Michaelis* constant

(ii) Induced fit

(iii)$\Delta G^{\ddagger}$ **[3 marks]**

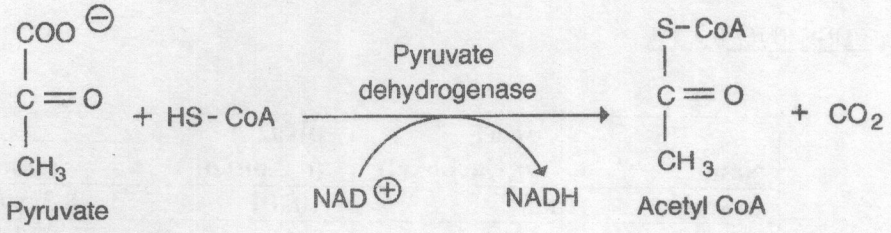
b) In an enzyme experiment the following data was obtained:

[S] μM	V_0 μmol/min
0.82	217
2.1	325
3.8	433
5.9	488
1000	647

Without plotting any graph or doing linear regression, **calculate** the K_m for this enzyme. **Show** your reasoning (steps) clearly.

[9 marks]

c) Consider the following reaction:



$\Delta G^{0'} = -33{,}400$ kcal/mol

(i) **Yes or No:** Is this a fast reaction? Briefly **explain.**

(ii) **Identify** the reducing agent.

(iii)**What** roles do NAD^+ and HS-CoA play in this reaction?

(iv)**What** class of enzyme is pyruvate dehydrogenase?

[8 marks]

QUESTION 6

a) **State** the Chargaff's Rules. **[2 Marks]**

b) **What** are salient features of β-DNA structure. **[4 Marks]**

c) **Draw** the chemical structure of any cytidine nucleoside analogue used in treatment of HIV. **[3 Marks]**

d) A sample of double stranded DNA was found to have guanylate as 29% of the nucleotide residues.

(i) **What** is the %AT of this DNA? **[5 Marks]**

(ii) **Draw** a structure showing hydrogen bonds between adenine and thymine. **[6 Marks]**

END OF EXAMINATION

USEFUL DATA

Name	pKa1 (α Carboxyl)	pKa2 (α Amino)	pKa3 (side chain)
Cysteine	1.7	10.8	8.3(Sulfhydryl)
Aspartate	2.1	9.8	3.9 (β-Carboxyl)
Lysine	2.2	9.0	10.5 (ε-Amino)

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

CHEMISTRY DEPARTMENT

2019/20 ACADEMIC YEAR FIRST HALF FINAL EXAMINATION

CHE 2219: Chemical Analysis

TIME: 3 HRS **December 2020**

INSTRUCTIONS TO THE CANDIDATES:

1. Indicate your **student ID number** on the provided answer scripts.
2. There are five questions in this paper; **answer any four (4) questions.**
3. All questions carry equal marks.
4. Copies of the periodic table and statistical table data sheet are attached at the end of the exam paper.
5. **Kindly indicate the attempted questions on the front page of your examination main answer booklet. Use only the first column of the two columns titled "FOR USE BY EXAMINER".**
6. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.**

ANSWER ANY FOUR QUESTIONS

QUESTION ONE

(a) From the following standard potentials, arrange the metals in the order of their **increasing** reducing power.

$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$: $E° = -0.76$ V
$Ca^{2+}(aq) + 2e^- \rightarrow Ca(s)$: $E° = -2.87$ V
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$: $E° = -2.36$ V
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$: $E° = -0.25$ V
$Ni(s) \rightarrow Ni2^+(aq) + 2e^-$: $E° = +0.25$ V

(b) The concentration of Cl^- in a 100.0-mL sample of water drawn from a fresh water acquifer suffering from encroachment of sea water, was determined by titrating with 0.0516 M $Hg(NO_3)_2$. The sample was acidified and titrated to the diphenylcarbazone end point, requiring 6.18 mL of the titrant. Report the concentration of Cl^- in parts per million.

(c) In brief, differentiate grab sample from a composite sample.

(d) Describe the steps in a sampling operation.

(e) In a redox titration, 20 ml of $Fe(II)SO_4$ was completely oxidised by 12.5 ml of 0.02 $mol.L^{-1}$ **acidified** dichromate solution. The unbalanced redox equation for the reaction is given below:

(i) Balance the equation above.

(ii) Calculate the concentration of the $Fe(II)SO_4$.

QUESTION TWO

(a) (i) Describe the mechanism of formation of a precipitate in gravimetric analysis.

(ii) Briefly discuss the different types of co precipitation that exist and state how each of them can be minimized.

(b) What is co precipitation? Briefly describe the three types of co precipitation that can occur during gravimetric analysis. In each case, give one step that can be taken to minimize it.

(c) A 0.4960 gm sample of a $CaCO_3$ is dissolved in an acidic solution. The calcium is precipitated as $CaC_2O_4.H_2O$ and the dry precipitate is found to weight 0.6186 gm. What is the percentage of CaO in the sample? (FW CaO = 56.08; FW $CaC_2O_4.H_2O$ = 146.2)

(d) Using diagram discuss the two impurity formation process of 'occlusion' and 'adsorption' in gravimetric analysis.

QUESTION THREE

(a) A 0.005-g sample of a rock is to be analyzed, and iron is to be determined at the ppm level. Determine the type of analysis and type of constituent.

(b) Consider the following set of replicate measurements:

9.5, 8.5, 9.1, 9.3 and 9.1

calculate the (i) mean; (ii) median; (iii) spread, or range; (iv) standard deviation; and (v) coefficient of variation.

(c) Distinguish between

(i) the sample standard deviation and the population standard deviation.

(ii) random and systematic error.

(d) Describe the preparation of 750 mL of 6.00 M H_3PO_4 from the commercial reagent that is 86% H_3PO_4 (w/w) and has a specific gravity of 1.71.

QUESTION FOUR

(a) The OH^- ion concentration of a blood sample is 2.5×10^{-7} M. What is the pH of the blood?

(b) 315 mL of a 0.525 M solution of NaCl (molar mass=58.4 g/mole) is mixed with 188 mL of a 0.295 M solution of NaCl, then an additional 166 mL of water is added. Assuming the volumes are additive, what is the final molarity of solution?

(c) What volume of a 30.% (w/v) hydrogen peroxide solution is required to prepare 425 mL of a 6.0% (w/v) solution?

(d) Calculate the pH of the 0.30 M NH_3/0.36 M NH_4Cl buffer system. What is the pH after the addition of 20.0 mL of 0.050 M NaOH to 80.0 mL of the buffer solution?

(e) During sample preparation, some samples will easily dissolve in a suitable solvent simply by swirling and heating gently while others will not. If this occurs, digestion with a suitable solvent or solution is preferred.

(i) How do you understand sample digestion in this context?

(ii) Aqua regia is one solution made up two components. Name these components of aqua regia and the ratio of composition.

QUESTION FIVE

(a) The alkalinity of a freshwater sample is a measure of its acid neutralizing ability and is primarily due to the presence of hydrogen carbonate ion (HCO_3^-). The Total Alkalinity is determined by titrating a water sample with a standardized acid to a methyl orange endpoint (pH ~ 4.5). What volume of 0.0280 N H_2SO_4 titrant is required to titrate a 25.0 mL water sample with a known alkalinity of 120 ppm of $CaCO_3$? Does your result suggest a problem with the methodology? If so, how could you modify the procedure to reduce the relative uncertainty in your analytical result?

(b) The analysis of a Reference Material for lead in blood samples with a certified concentration of 12.6 ng/mL was analyzed by graphite furnace atomic absorption (GFAA) spectroscopy. The results of six replicate analysis are listed below. Check for potential outliers using the Grubb's test at the 95% confidence level. Incorporating the removal of outliers (if any), quantify the precision and accuracy of the GFAA method to analyze lead in blood samples.

12.9 11.2 10.6 12.1 13.0 11.5 ng/mL

(c) Determine the mass of primary standards ($NaNO_3$ and $KH_2PO_4 \cdot 3H_2O$) required to prepare 250.0 mL of a combined standard solution containing 100.0 µg/L of NO_3^--N and 10.00 µg/L of PO_4^{3-}-P. Are there any practical challenges that limit the precision of the reported concentrations of your combined standard solution? If so, how might you suggest modifying your procedure?

|>>>>>>>>END OF EXAM; COMPLIMENTS OF THE SEASON<<<<<<<<<|

USEFUL DATA

Avogadro's constant, N_A	6.022×10^{23} mol^{-1}
Molar volume of gas at S.T.P	22.4 dm^3 mol^{-1}
Planck Constant, h	6.626×10^{-34} Js
Rydberg constant, R_H	1.097×10^7 m^{-1}
Speed of light in vacuum, c	3.00×10^8 ms^{-1}
Mass of an electron	9.11×10^{-31} kg
1 electron volt (1 eV)	1.602×10^{-19} J

I Joule = 1 J = 1 kg m^2 s^{-2} = 1 Pa m^3

Standard Reduction Potentials at 25 °C

Reduction Half-Reaction		$E°$ (V)	
Stronger oxidizing agent			Weaker reducing agent
$F_2(g) + 2e^-$	$\longrightarrow 2F^-(aq)$	2.87	
$H_2O_2(aq) + 2H^+(aq) + 2e^-$	$\longrightarrow 2H_2O(l)$	1.78	
$MnO_4^-(aq) + 8H^+(aq) + 5e^-$	$\longrightarrow Mn^{2+}(aq) + 4H_2O(l)$	1.51	
$Cl_2(g) + 2e^-$	$\longrightarrow 2Cl^-(aq)$	1.36	
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^-$	$\longrightarrow 2Cr^{3+}(aq) + 7H_2O(l)$	1.33	
$O_2(g) + 4H^+(aq) + 4e^-$	$\longrightarrow 2H_2O(l)$	1.23	
$Br_2(aq) + 2e^-$	$\longrightarrow 2Br^-(aq)$	1.09	
$Ag^+(aq) + e^-$	$\longrightarrow Ag(s)$	0.80	
$Fe^{3+}(aq) + e^-$	$\longrightarrow Fe^{2+}(aq)$	0.77	
$O_2(g) + 2H^+(aq) + 2e^-$	$\longrightarrow H_2O_2(aq)$	0.70	
$I_2(s) + 2e^-$	$\longrightarrow 2I^-(aq)$	0.54	
$O_2(g) + 2H_2O(l) + 4e^-$	$\longrightarrow 4OH^-(aq)$	0.40	
$Cu^{2+}(aq) + 2e^-$	$\longrightarrow Cu(s)$	0.34	
$Sn^{4+}(aq) + 2e^-$	$\longrightarrow Sn^{2+}(aq)$	0.15	
$2H^+(aq) + 2e^-$	$\longrightarrow H_2(g)$	0.00	
$Pb^{2+}(aq) + 2e^-$	$\longrightarrow Pb(s)$	−0.13	
$Ni^{2+}(aq) + 2e^-$	$\longrightarrow Ni(s)$	−0.26	
$Cd^{2+}(aq) + 2e^-$	$\longrightarrow Cd(s)$	−0.40	
$Fe^{2+}(aq) + 2e^-$	$\longrightarrow Fe(s)$	−0.45	
$Zn^{2+}(aq) + 2e^-$	$\longrightarrow Zn(s)$	−0.76	
$2H_2O(l) + 2e^-$	$\longrightarrow H_2(g) + 2OH^-(aq)$	−0.83	
$Al^{3+}(aq) + 3e^-$	$\longrightarrow Al(s)$	−1.66	
$Mg^{2+}(aq) + 2e^-$	$\longrightarrow Mg(s)$	−2.37	
$Na^+(aq) + e^-$	$\longrightarrow Na(s)$	−2.71	
$Li^+(aq) + e^-$	$\longrightarrow Li(s)$	−3.04	
Weaker oxidizing agent			Stronger reducing agent

Table 17.1 Chemistry, The
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Values of t for ν Degrees of Freedom for Various Confidence Levels[a]

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

[a] $\nu = N - 1$ = degrees of freedom.

Values of F at the 95% Confidence Level

	$\nu_1 = 2$	3	4	5	6	7	8	9	10	15	20	30
$\nu_2 = 2$	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.5
3	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.70	8.66	8.62
4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.86	5.80	5.75
5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.62	4.56	4.50
6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	3.94	3.87	3.81
7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.51	3.44	3.38
8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.22	3.15	3.08
9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.01	2.94	2.86
10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.85	2.77	2.70
15	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.40	2.33	2.25
20	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.20	2.12	2.04
30	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.01	1.93	1.84

Rejection Quotient, Q, at Different Confidence Limits[a]

No. of Observations	Confidence Level		
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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

[a] Adapted from D. B. Rorabacher, *Anal. Chem.*, 63 (1991) 139.

PERIODIC TABLE OF ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

hydrogen 1 **H** 1.00794																	helium 2 **He** 4.002602
lithium 3 **Li** 6.941	beryllium 4 **Be** 9.012182											boron 5. **B** 10.811	carbon 6 **C** 12.0107	nitrogen 7 **N** 14.00674	oxygen 8 **O** 15.9994	fluorine 9 **F** 18.9984	neon 10 **Ne** 20.1797
sodium 11 **Na** 22.98977	magnesium 12 **Mg** 24.3050											aluminium 13 **Al** 26.981538	silicon 14 **Si** 28.0855	phosphorus 15 **P** 30.97376	sulphur 16 **S** 32.065	chlorine 17 **Cl** 35.453	argon 18 **Ar** 39.984
potassium 19 **K** 39.0983	calcium 20 **Ca** 40.078	scandium 21 **Sc** 44.95591	titanium 22 **Ti** 47.867	vanadium 23 **V** 50.9415	chromium 24 **Cr** 51.9961	manganese 25 **Mn** 54.93805	iron 26 **Fe** 55.845	cobalt 27 **Co** 58.9332	nickel 28 **Ni** 58.6934	copper 29 **Cu** 63.546	zinc 30 **Zn** 65.409	gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.64	arsenic 33 **As** 74.9216	selenium 34 **Se** 78.96	bromine 35 **Br** 79.904	krypton 36 **Kr** 83.798
rubidium 37 **Rb** 85.4678	strontium 38 **Sr** 87.62	yttrium 39 **Y** 88.90585	zirconium 40 **Zr** 91.225	niobium 41 **Nb** 92.90638	molybdenum 42 **Mo** 95.94	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.9055	palladium 46 **Pd** 106.42	silver 47 **Ag** 107.8682	cadmium 48 **Cd** 112.411	indium 49 **In** 114.818	tin 50 **Sn** 118.710	antimony 51 **Sb** 121.760	tellurium 52 **Te** 127.60	iodine 53 **I** 126.9045	xenon 54 **Xe** 131.293
caesium 55 **Cs** 132.90545	barium 56 **Ba** 137.327	lutetium 71 **Lu** 174.967	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.9479	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.207	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.217	platinum 78 **Pt** 195.078	gold 79 **Au** 196.96655	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.3833	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.980	polonium 84 **Po** [209]	astatine 85 **At** [210]	radon 86 **Rn** [222]
francium 87 **Fr** [223]	radium 88 **Ra** [226]	lawrencium 103 **Lr** [262]	rutherfordium 104 **Rf** [261]	dubnium 105 **Db** [262]	seaborgium 106 **Sg** [266]	bohrium 107 **Bh** [264]	hassium 108 **Hs** [269]	meitnerium 109 **Mt** [268]	damstadtium 110 **Ds** [271]	roentgenium 111 **Rg** [272]	ununbium 112 **Uub** [285]		ununquadium 114 **Uuq** [289]				

key

element name
atomic number
symbol
atomic mass

lanthanum 57 **La** 138.9055	cerium 58 **Ce** 140.116	praseodymium 59 **Pr** 140.90765	neodymium 60 **Nd** 144.24	promethium 61 **Pm** [145]	samarium 62 **Sm** 150.36	europium 63 **Eu** 151.964	gadolinium 64 **Gd** 157.25	terbium 65 **Tb** 158.9253	dysprosium 66 **Dy** 162.50	holmium 67 **Ho** 164.930	erbium 68 **Er** 167.259	thulium 69 **Tm** 168.934	ytterbium 70 **Yb** 173.04
actinium 89 **Ac** [227]	thorium 90 **Th** 232.038	protactinium 91 **Pa** 231.0359	uranium 92 **U** 238.0289	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

CHEMISTRY DEPARTMENT

MID YEAR EXAMINATION

CHE 2415 BASIC INORGANIC CHEMISTRY

Answer any FOUR questions.
Each question carries 15 marks

Question 1

(a) An iron metal bar is being heated. As its temperature rises, it begins to glow—first dull red, then bright red, then orange, and then yellow. Use the blackbody radiation curve to explain these changes in the colour of the glow.

(b) Calcium metal has a work function 4.34×10^{-19}J. What is the minimum frequency, ν, of light that's required for the photoelectric effect of calcium to occur? Calculate the kinetic energy of the ejected electron if light of frequency 1.00×10^{15} s^{-1} is used to irradiate the calcium metal.

(c) (i) Give the n, *l*, and all of the m_l quantum numbers for the 4f orbital. How many radial and angular nodes are found in this orbital?

(ii) Compare the wavelength of a photon produced from a transition from n=3 to n=1 with that of a photon produced from a transition n=2 to n=1. Would $\lambda_{31} < \lambda_{21}$; $\lambda_{31} = \lambda_{21}$; $\lambda_{31} > \lambda_{21}$?. Justify your answer.

(d) (i) A scientist wants to eject electrons from a metal by shining a light on it, but none are coming out. To eject electrons, should the scientist decrease frequency, increase intensity, increase frequency or increase wavelength of incident light? Justify your answer.

(ii) Which orbital is defined by n = 4 and *l* = 1? How many orbitals are there in this set?

(e) A neutron has almost 2000 times the rest mass of an electron. Suppose they both have 1eV of energy. How would their wavelengths compare? neutron λ = electron λ; neutron λ < electron λ; neutron λ > electron λ. Justify your answer.

Useful Constants: $h = 6.626 \times 10^{-34}$J.s; $c = 3 \times 10^{8}$m/s; $N_A = 6.022 \times 10^{23}$mol^{-1}

Question 2

(a) (i) From an aqueous solution of a complex with the composition $CoClSO_4(NH_3)_5$,a precipitate is obtained with $BaCl_2$ but not with $AgNO_3$. What is the correct formula and the structure of the complex?

(ii) Which of the ions $[Fe(H_2O)_6]^{2+}$ and $[Fe(CN)_6]^{4-}$ will build a low spin complex? Explain why.

(b) $[Fe(H_2O)_6]^{3+}$ is strongly paramagnetic whereas $[Fe(CN)_6]^{3-}$ is weakly paramagnetic. Explain.

(c) The hexaquo manganese(II) ion contains five unpaired electrons, while the hexacyanoion of manganese(II)contains only one unpaired electron. Explain using Crystal Field Theory.

(d) What will be the correct order for the wavelengths of absorption in the visible region for the following: $[Ni(NO_2)_6]^{4-}$, $[Ni(NH_3)_6]^{2+}$, $[Ni(H_2O)_6]^{2+}$? Justify your answer.

(e) According to the crystal field model, what is the origin of the splitting of metal d orbitals into two sets in an octahedral complex?

Question 3

(a) Though there is a steady increase in atomic radius as we go down a group, the radii of atoms of fifth and sixth periods of a given subgroup are approximately equal. Why?

(b) What is the significance of large increase in third ionization energy of calcium and fifth ionisation energy of silicon?

(c) Arrange the following ions in the increasing (i) hydration energy (ii) ionic mobility: Na^+, Mg^{2+}, Al^{3+}. Justify your answer.

Question 4

(a) Theoretical and experimental lattice enthalpies of AgI are -808 and -889 kJ/mol respectively. Account for the discrepancy.

(b) In gravimetric analysis you are asked to precipitate SO_4^{2-}ions. You are provided with Mg^{2+}, Ca^{2+}, Ba^{2+} and Sr^{2+} ions. Which ion do you prefer? Why?

(c) A solid compound contains X, Y and Z atoms in a cubic lattice with X atoms occupying the corners, Y atoms in the body centred position and Z atoms at the centres of faces of unit cell. What is the empirical formula of the compound?

Question 5

(a) Consider the molecules NO, NO^+, and NO^-

(i) Prepare a molecular orbital energy level diagram for NO, showing clearly how the atomic orbitals interact to form MOs.

(ii) How does your diagram illustrate the difference in electronegativity between N & O?

(iii) Predict the bond order and number of unpaired electrons.

(iv) NO^+ and NO^- are also known. Compare the bond orders of these ions with the bond order of NO. Which of the three would you predict to have the shortest bond? Why?

(b) Boron is an intrinsic semiconductor, while aluminium is a metal.

(i) Sketch the band diagrams implied by this information. Clearly label each band.

(ii) Briefly discuss the feature(s) of these diagrams that cause the different electrical properties of boron and aluminium.

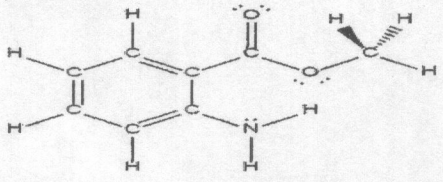
(c) A diode is composed of an n-type and a p-type semiconductor connected to each other

(i) Draw the band diagrams for a p-type and an n-type semiconductor, labeling all the relevant bands.

(ii) Explain how this diode device restricts the flow of electrons in one direction. Your answer should include a diagram.

Question 6

(a) The following is a graphic of methyl anthranilate, a compound that occurs naturally in grapes and gives them some of the characteristic grape aroma and flavour. It is the main flavouring agent in grape Kool-Aid



The following questions are to be answered using valence-bond theory.

(i) What is the hybridization of the nitrogen atom and the carbon atoms in the ring?

(ii) How would valence-bond theory describe the bonding in the C=O group of this molecule? Make sure to provide the description of both the sigma (σ) and pi (π) bonds.

(iii) Briefly explain what hybridization is and why it is necessary in valence bond theory.

(iv) Describe two key differences between molecular orbital theory and valence bond theory.

(b) What is unusual about the bonding in diborane (B_2H_6)? Include a diagram in your answer.

(c) Elements of s- block are largely found in biological fluids. By giving an example of one such element, explain its biological importance.

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.01 Hydrogen				KEY Atomic number X Atomic mass Name of the element X												1 H 1.01 Hydrogen	2 He 4.00 Helium
3 Li 6.94 Lithium	4 Be 9.01 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 23.00 Sodium	12 Mg 24.31 magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.99 Phosphorus	16 S 32.07 Sulphur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.88 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 71.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc 97.91 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 Tellurium	53 I 126.90 Iodine	54 Xe 131.29 Xenon
55 Cs 132.91 Caesium	56 Ba 137.33 Barium	57 – 71	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantalum	74 W 183.84 Tungsten	75 Re 186.21 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.97 Gold	80 Hg 200.59 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po 208.98 Polonium	85 At 209.99 Astatine	86 Rn 222.02 Radon
87 Fr (223.02) Francium	88 Ra 226.03 Radium	89 - 103	104 Unq 261.11	105 Unp 262.11	106 Unh 263.12	107 Uns 262.12	108 Uno 265.00	109 Une 265									

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019/2020 ACADEMIC YEAR
MID YEAR EXAMINATIONS

CHE 2511: BASIC ORGANIC CHEMISTRY

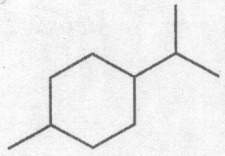
TIME ALLOWED: THREE (3) HOURS

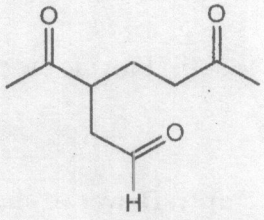
INSTRUCTIONS:

1. This paper contains five (5) questions and has seven (7) printed pages. Please ensure that you have seven printed pages.
2. Answer any **four (4)** questions.
3. Questions carry equal marks, (25).
4. Write your TG number (example: TG 10) on the cover page of each answer booklet.
5. Please be reminded of the need to present your answers in a logical manner and try to be on point.
6. Table of useful data is attached.

QUESTION ONE

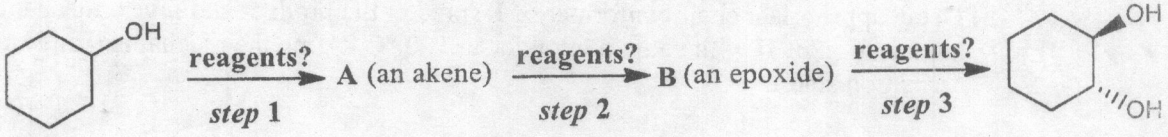
(a) Limonene, a major component of the oil extracted from lemon and orange peel, is used as flavouring agent in food and pharmaceutical industry. It also has chemo-preventive and antitumor activities. Upon treatment with excess hydrogen in presence of a platinum catalyst, limonene gives 1-isopropyl-4-methylcyclohexane. When limonene is treated with ozone and then with zinc and acetic acid, formaldehyde (HCHO) and a compound (**I**), structure shown below, are obtained.

1-isopropyl-4-methylcyclohexane: 

(I): 

Deduce the structure of limonene. Show your reasoning. **(5 marks)**

(b) A synthetic scheme for *anti*-cyclohexane-1.2-diol is shown below. Provide the reagents for the ***steps* 1, 2** and **3** and structures of the intermediates **A** and **B**. **(5 marks)**



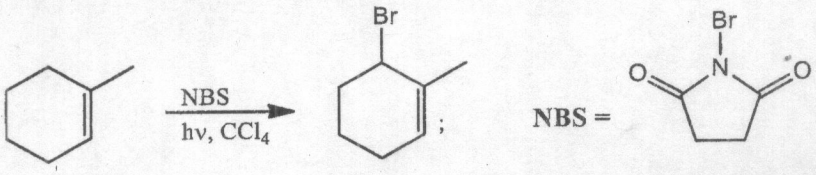
(c) Consider 2-methylbutane (*iso*pentane). Sighting along the C2–C3 bond:

(i) Draw all Newman projections of *iso*pentane and indicate the dihedral angles for each projection. **(6 marks)**

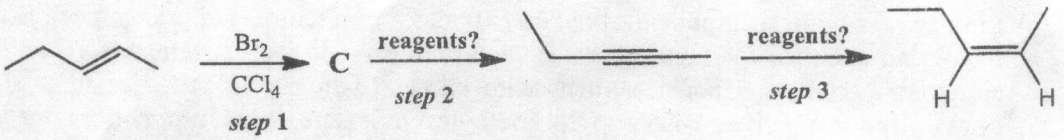
(ii) Plot a labeled quantitative graph; potential energy *versus* rotation for the C2-C3 bond in *iso*pentane. (See useful data attached) **(9 marks)**

QUESTION TWO

(a) Provide a plausible mechanism for the following reaction: **(6 marks)**



(b) A synthetic protocol for conversion of a *trans*-alkene to a *cis*-alkene is outlined below:

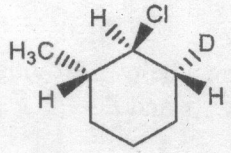


(i) Identify the intermediate **C**, including pertinent stereochemistry. **(2 marks)**

(ii) Provide the missing reagents for ***steps* 2** and **3**. **(4 marks)**

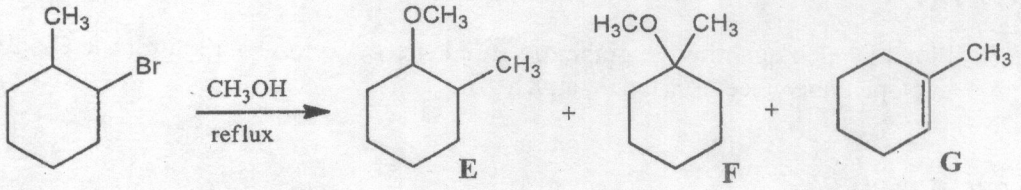
(c) (i) Draw two chair conformers for the molecule **D**, shown below. **(2 marks)**

D:



(ii) Using appropriate chair conformer of **D**, predict the product and give a mechanism for the reaction of **D** with sodium ethoxide at 100 °C. Name the mechanism and show the transition state. **(5 marks)**

(d) Solvolysis of 1-bromo-2-methylcyclohexane in methanol gives a complex mixture of products, including **E**, **F** and **G**, shown below:

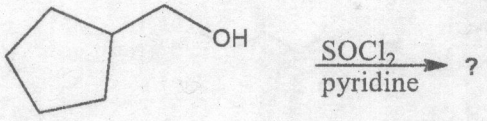


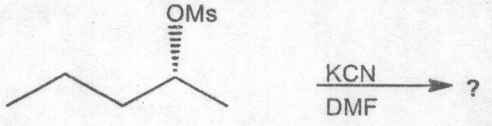
Provide a mechanistic explanation to account for the products **E-G**. **(6 marks)**

QUESTION THREE

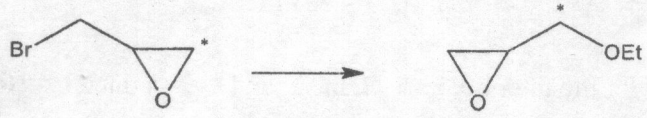
(a) Predict the major products of the following reactions and show stereochemistry where possible. *No reaction mechanism is required.* **(7 marks)**

(i)

(ii) 

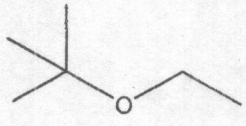
(iii) 

(b) When sodium ethoxide reacts with 1-(bromomethyl)oxirane labelled with ^{14}C as shown by the asterisk in **I**, the major product is **II**. Provide a mechanistic explanation for this result. **(4 marks)**



I **II**

(c) (i) 2-Ethoxy-2-methylpropane, shown below, can be synthesized by an S_N2 reaction between an alkoxide and an alkyl halide via a Williamson ether synthesis. Using this combination (an alkoxide and an alkyl halide), propose two probable routes through which 2-ethoxy-2-methylpropane can be synthesised. **(4 marks)**



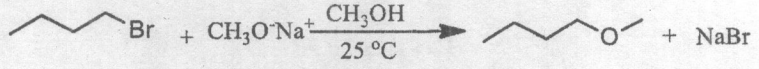
2-ethoxy-2-methylpropane

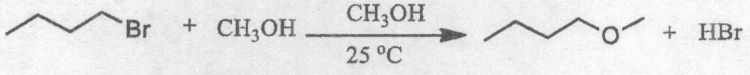
(ii) Which of your synthetic route would be expected to give a high yield of 2-ethoxy-2-methylpropane. Briefly explain. **(2 marks)**

(d) Reaction of cyclohexene with bromine in an aqueous solution of sodium chloride gives three products; *trans*-1, 2-dibromocyclohexane, *trans*-2-bromocyclohexanol and *trans*-1-bromo-2-chlorocyclohexane. Provide a plausible mechanism to explain the formation of *trans*-1-bromo-2-chlorocyclohexane. **(4 marks)**

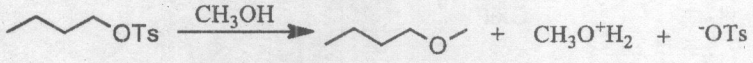
(e) Which reaction in each of the following pairs of reactions is faster? Briefly explain (*not more than* 4 *lines*). **(4 marks)**

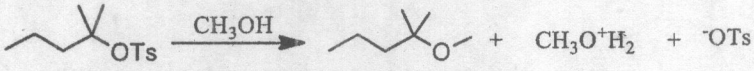
Reaction Pair 1

(i) 

(ii) 

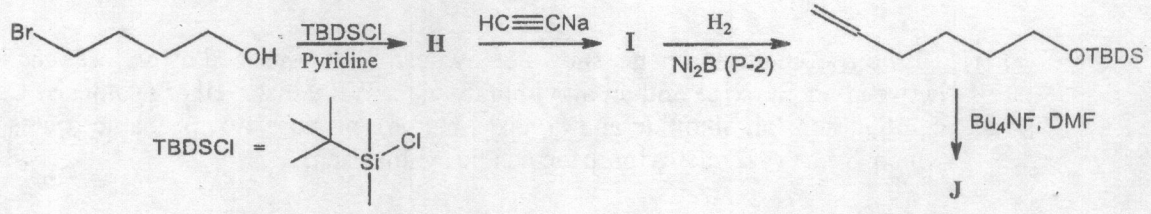
Reaction Pair 2

(i) 

(ii) 

QUESTION FOUR

(a) Write the missing structures for the intermediates **H** and **I**, and the product **J**. **(6 marks)**

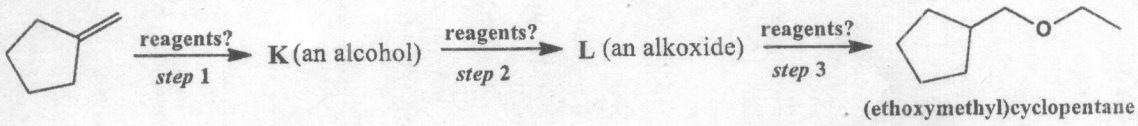


(b) Briefly explain why:

(i) Alcohols of low molecular mass are more soluble in water than the hydrocarbons of comparable molecular mass. **(2 marks)**

(ii) Phenol is more acidic than ethanol. **(3 marks)**

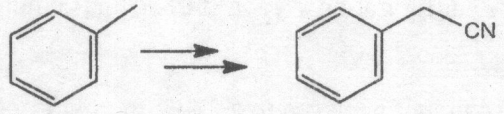
(c) A synthetic scheme for (ethoxymethyl)cyclopentane is shown below. Provide the reagents for the ***steps*** **1, 2** and **3** and structures of the intermediates **K** and **L**. **(6 marks)**



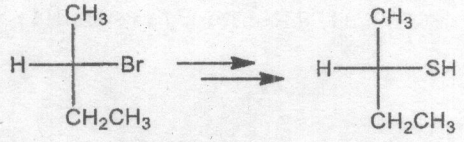
(ethoxymethyl)cyclopentane

(d) Show clearly how each of the following transformations can be achieved in good yield. **(8 marks)**

(i)



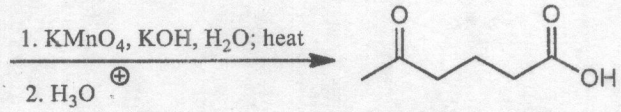
(ii)



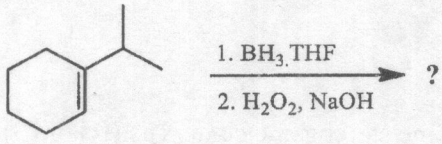
QUESTION FIVE

(a) Provide the missing starting material/product for the following reactions. *Please do not write reaction equations and mechanisms.* **(4 marks)**

(i) **M**

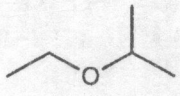


(ii)

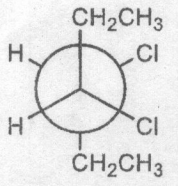


(b) When propene is treated with hydrogen chloride in ethanol, one of the products is ethyl isopropyl ether. Write a plausible mechanism to account for the formation of this product. **(4 marks)**

Ethyl isopropyl ether:



(c) Shown below is a Newman projection for 3, 4-dichlorohexane.



3,4-dichlorohexane

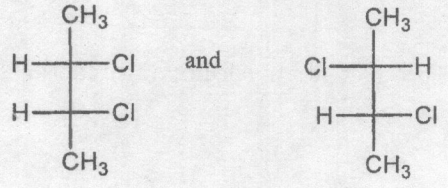
(i) Assign the absolute configuration to each of the two stereogenic centers. Show how you arrived at your answer. **(3 marks)**

(ii) Rewrite its name, indicating the configuration at each stereogenic center. **(1 mark)**

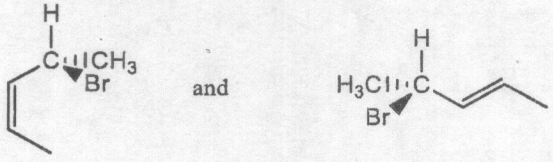
(d) When an aqueous solution of (-)-2-butanol is placed in a 200 mm polarimeter cell, the observed rotation is -4.05°. The solution was prepared by diluting 6 grams of (-)-2-butanol to a total volume of 40 mL with deionized water. Determine the specific rotation of (-)-2-butanol. **(5 marks)**

(e) Consider the following pairs of molecules:

(i)



(ii)



For each pair of molecules, designate the stereogenic centers as (**R**) or (**S**) and identify the relationship between them as enantiomers, diastereomers, constitutional isomers or two molecules of the same compound. Show how you arrived at your answer. **(8 marks)**

END OF EXAMINATION
GOOD LUCK!

CHE 2511 BASIC ORGANIC CHEMISTRY

USEFUL DATA

Table 1: Energy Costs for Interactions in Alkanes

Interaction	Energy Cost ($kJmol^{-1}$)	Interaction	Energy Cost ($kJmol^{-1}$)
H-H eclipsed	4.0	H-H gauche	0.0
H-CH_3 eclipsed	6.0	H-CH_3 gauche	1.8
CH_3-CH_3 eclipsed	11.0	CH_3-CH_3 gauche	4.0

Table 2: Energy Costs for 1,3-Diaxial Interactions in Cycloalkane Conformers

1,3-Diaxial interaction	Energy Cost ($kJmol^{-1}$)	1,3-Diaxial interaction	Energy Cost ($kJmol^{-1}$)
H-F	0.5	H-CH_3	3.7
H-Cl	1.4	H-CH_2CH_3	3.9
H-Br	1.4	H-$CH(CH_3)_2$	4.6
H-OH	2.1	H-$C(CH_3)_3$	11.3
H-COOH	2.9	H-C_6H_5	6.3
H-CN	0.4	H-$CH_2C(CH_3)_2$	4.2

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019/2020 ACADEMIC YEAR
FINAL EXAMINATIONS

CHE 2522: FUNCTIONAL GROUP AND ARENE CHEMISTRY

TIME ALLOWED: THREE (3) HOURS

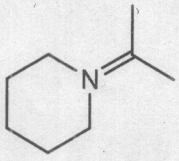
INSTRUCTIONS:

1. Answer any **FOUR (4)** questions.
2. Present your answers in a logical manner.
3. Write your TG number (example: TG 10) on the cover page of each answer booklet.
4. Begin each new question on a new page.
5. Ensure you have seven ~~(7)~~ 6 printed pages containing five (5) questions.

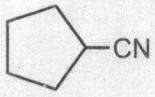
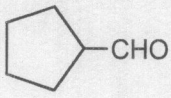
QUESTION ONE

(a) Provide the missing starting materials/products/ reagents/conditions for the following reactions. **(10 marks)**

(i) $2\ CH_3COCH_3 \xrightarrow{H_2SO_4} \mathbf{A}$ **(2 marks)**

(ii) **B** + **C** $\xrightarrow[conditions]{reagents,\ solvent}$  **(4 marks)**

(iii) $CH_3OCOCl \xrightarrow{NH_3} \mathbf{D}$ **(2 marks)**

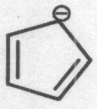
(iv)  $\xrightarrow[conditions]{reagents,\ solvent}$  **(2 marks)**

(b) Suggest a synthesis of the following compounds from indicated starting materials. Show all steps clearly, including the intermediates for each step. *Do not write mechanisms*. **(4 marks each)**

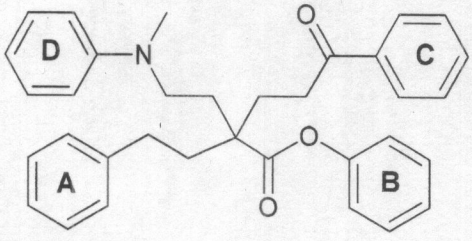
(i) 2-ethylhexanal from any alcohol containing not more than five carbon atoms.

(ii) Propanamide from propanol

(c) Determine whether each of the following is aromatic, non-aromatic, or anti-aromatic. Show your working. **(4 marks)**

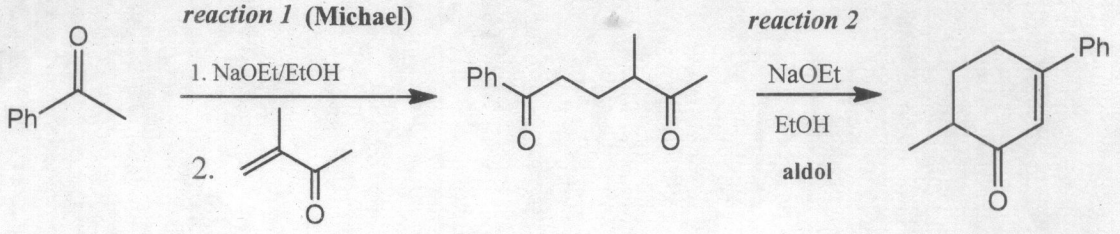
(i) (ii) 

(d) The following compound has four aromatic rings, **A** – **D**. Rank them in terms of increasing reactivity toward electrophilic aromatic substitution. **(3 marks)**



QUESTION TWO

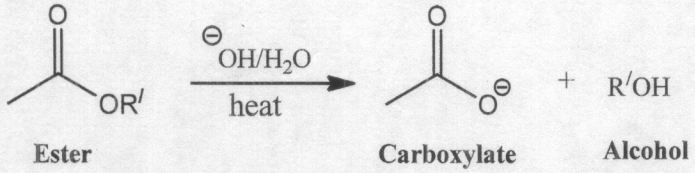
(a) A general procedure, called Robinson Annulation, for synthesis of 2-cyclohexenones important intermediates in organic synthesis, from acyclic starting materials is shown below:



Provide the mechanisms of **reactions 1** and **2.** **(11 marks)**

(b) Predict the product and give mechanism of *mono*-nitration of toluene ($C_6H_5CH_3$) with a mixture of concentrated nitric acid and sulphuric acid. **(6 marks)**

(c) Carboxylic acid group is often protected as tert.-butyl ester in organic synthesis. Unlike methyl and ethyl esters, which are easily hydrolysed by aqueous bases, tert.-butyl esters, $RCOOC(CH_3)_3$, are resistant to alkaline hydrolysis.



(i) Write the mechanism for alkaline hydrolysis of esters, $RCOOR'$, indicating the rate determining step. **(4 marks)**

(ii) Based on the hydrolysis mechanism you wrote, briefly explain why tert.-butyl esters are resistant to alkaline hydrolysis. **(2 marks)**

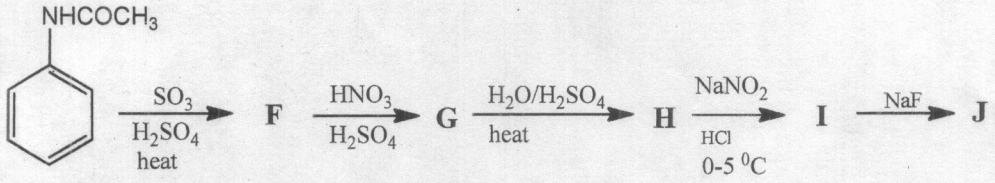
(d) Arrange dimethylamine, methylamine and triethylamine in the order of increasing basicity. **(2 marks)**

QUESTION THREE

(a) Aniline is more reactive than phenol towards electrophilic aromatic substitution reactions. Briefly explain this observation. **(3 marks)**

(b) Propose a synthesis of 1-aminobutane by the Gabriel method. Clearly show the starting material(s), all reagents required and the intermediates for each step. required. *Do not write mechanisms.* **(5 marks)**

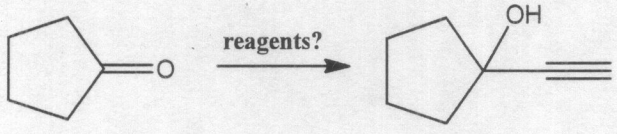
(c) Provide the structures for the following molecules, **F-J.** **(7 marks)**



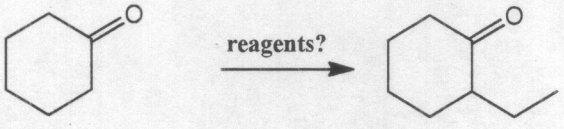
(d) Given that ketones are reduced faster than esters, propose a synthesis of 4-hydroxybutanone, $CH_3COCH_2CH_2OH$, from acetoacetic ester, $CH_3COCH_2COOC_2H_5$, in three steps. Show all steps clearly, including the intermediates. *Do not write mechanisms.* **(6 marks)**

(e) Provide all the reagents needed for the following transformations. **(4 marks)**

(i)



(ii)

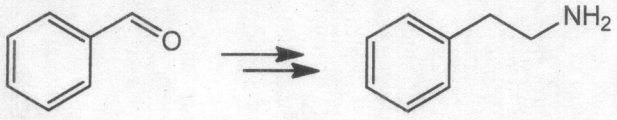


QUESTION FOUR

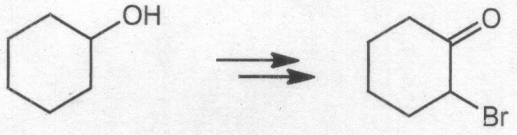
(a) Briefly explain why bromobenzene is *ortho/para* directing and yet it deactivates the ring towards electrophilic aromatic substitution. **(3 marks)**

(b) Propose a shortest synthetic protocol for each of the following transformations. Assume that all needed reagents are available. Show all steps of your proposed scheme clearly, including the reagents and intermediates for each step. *Please do not write mechanisms*. **(8 marks)**

(i)



(ii)



(c) Suggest a synthetic sequence for each or the following transformations. Show all steps clearly. *Do not write reaction mechanisms*. **(10 marks)**

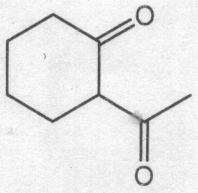
(i) Pentanoic acid from Butanoic acid
(ii) Ethylamine from 1-propanol

(d) Suggest a reaction sequence for the preparation of 4-aminobenzoic acid from toluene. **(4 marks)**

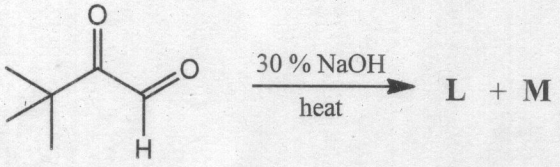
QUESTION FIVE

(a) Suggest a synthesis of the compound **K**, shown below, starting from cyclohexanol and acetic acid via an Stork enamine reaction. Show all steps, including the intermediates clearly. *Please do not write reaction mechanisms.* **(7 marks)**

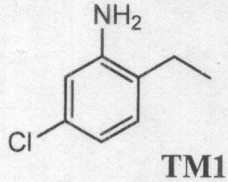
K:



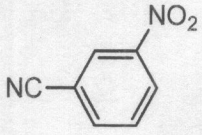
(b) Predict the products and give mechanism of the following Cannizzaro reaction: **(6 marks)**



(c) Suggest a synthesis for the following target molecules from benzene: **(12 marks)**



TM1



TM2

END OF EXAMINATION
GOOD LUCK!

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

CHEMISTRY DEPARTMENT

2019/20 ACADEMIC YEAR

CHE3211: SPECTROSCOPIC METHODS OF ANALYSIS
FINAL EXAM
DURATION: 3 HRS **NOV 2020**

INSTRUCTIONS TO THE CANDIDATES

1. Indicate your **student ID number** on the answer scripts provided.
2. There are a total of **FIVE** questions in this paper. **Answer any FOUR**
3. All questions carry 15 marks each.
4. **The periodic table copy attached to this exam paper.**
5. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.**

QUESTION ONE

(a) Sources of electromagnetic radiation are classified as either continuum or line sources. How do the two differ?

(b) In mass spectroscopy, why are fragments often produced with electron impact ionization?

(c) The determination of Fe in an industrial waste stream was carried out by the o-phenanthroline method. Using the data shown in the following table, determine the concentration of Fe in the waste stream. (Hint: Use *linear regression* to answer this question)

ppm Fe	Absorbance
0.00	0.000
1.00	0.183
2.00	0.364
3.00	0.546
4.00	0.727
unknown	0.269

(d) Why is a molecular absorption spectrum called a molecular "fingerprint?"

(e) Why is it that with atoms, only certain specific wavelengths get absorbed (resulting in a line spectra), whereas with molecules, broad bands of wavelengths get absorbed (resulting in continuous spectra)?

QUESTION TWO

(a) The hollow cathode lamp must contain the metal to be analyzed in the cathode. Explain.

(b) The transmittance of a solution is found to be 85.0% when measured in a cell whose path length is 1.00 cm. What is the percent transmittance if the path length is increased to 10.00 cm?

(c) Why is atomic emission more sensitive to flame instability than atomic absorption?

(d) The mass spectroscopy (MS) machine is operated under high vacuum.

(i) State the reason why it is operated under high vacuum.

(ii) Mention the main components of the MS machine that should be operated under high vacuum.

(e) State any two important information an NMR spectrum can provide you with and explain in brief, how that information can be of used for the purposes of molecular structural elucidation.

QUESTION THREE

(a) (i) Explain what is meant by the Raman Effect.

(ii) Draw a block diagram of a Raman Spectrometer.

(b) What term describes the incident radiation that is reemitted without a change in frequency?

(c)

(i) Compare and contrast Raman spectra with IR spectra.

(ii) Describe advantages of Raman Spectroscopy.

(iii)List the upper and lower limit of the IR region in wavenumbers (cm^{-1})

(d) Briefly explain the theory involved in Nephelometry and Turbidimetry.

QUESTION FOUR

(a) (i) Define absorbance and transmittance in absorption spectroscopy

(ii) Obtain an expression that relates the two terms in **(a)(i)**

(b) A substance with a molar absorptivity of 850 M^{-1} cm^{-1} at 500 nm is found in a solution of unknown concentration. A cell with a path length of 1.00 cm is used in a spectrometer and the %transmittance found for the solution at 500 nm is 30%. What is the concentration of this compound in the solution?

(c) State three factors that would cause a positive or negative deviation from Beer's law.

(d) IR spectroscopy is a technique mostly used for qualitative analysis of organic compounds.

(i) Explain the two criteria required for a molecule to absorb IR radiation.

(ii) Which of the molecules oxygen and hydrogen chloride is IR active and why?

QUESTION FIVE

(a) An organic reagent forms a complex with Fe^{2+} present in a food sample. Outline how you would choose the working wavelength.

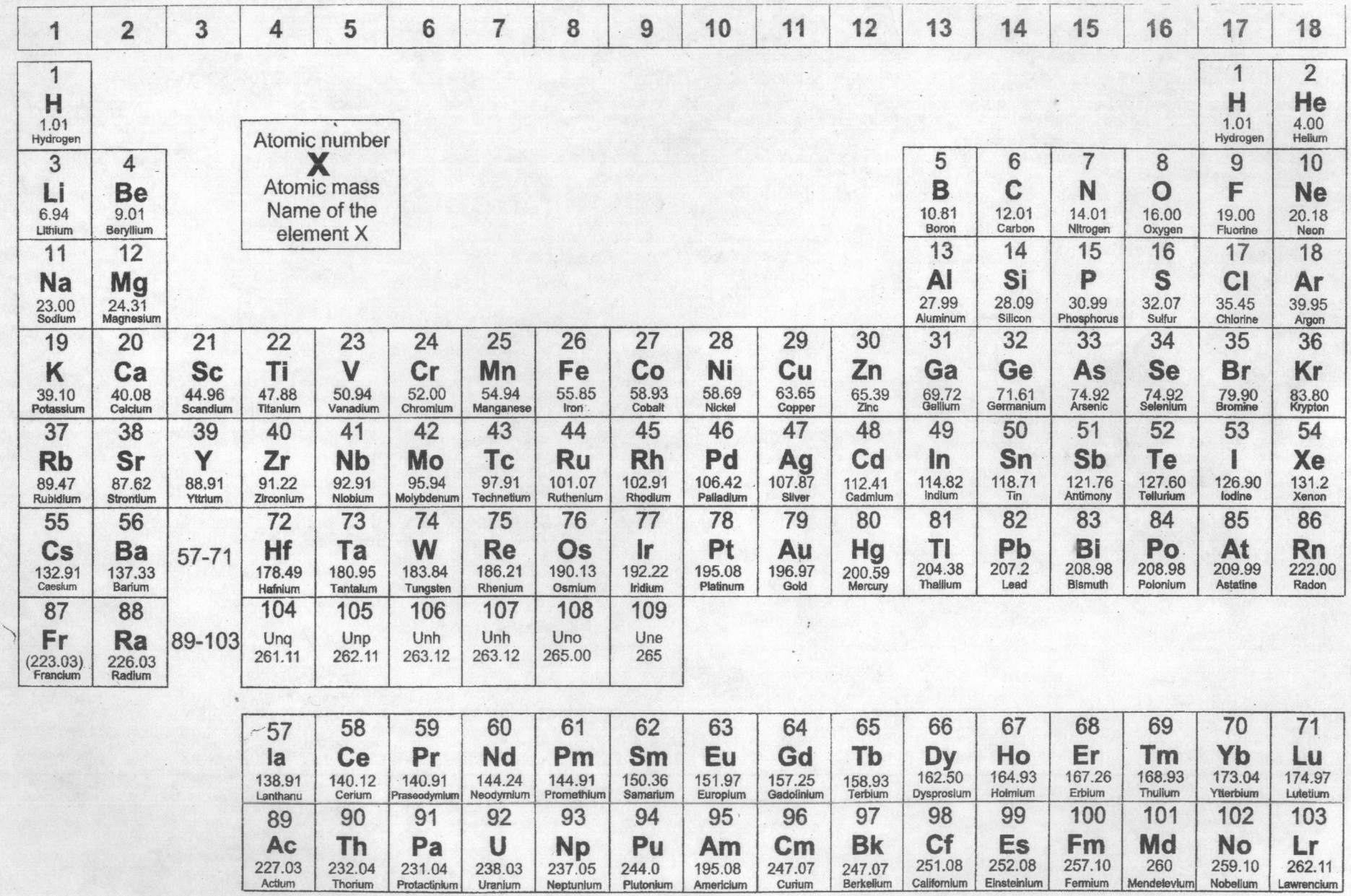
(b) Describe the molar ratio method and explain how it is used to determine stoichiometry.

(c) Describe the typical components of a UV/Visible spectrophotometer, explaining the function of each part. Include a sketch in your answer

(d) Explain the difference between fluorescence and phosphorescence

>>>End of Exam<<<

ALL THE BEST


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Atomic number
X
Atomic mass
Name of the element X
1 H 1.01 Hydrogen
2 He 4.00 Helium
3 Li 6.94 Lithium
4 Be 9.01 Beryllium
5 B 10.81 Boron
6 C 12.01 Carbon
7 N 14.01 Nitrogen
8 O 16.00 Oxygen
9 F 19.00 Fluorine
10 Ne 20.18 Neon
11 Na 23.00 Sodium
12 Mg 24.31 Magnesium
13 Al 27.99 Aluminum
14 Si 28.09 Silicon
15 P 30.99 Phosphorus
16 S 32.07 Sulfur
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 74.92 Selenium
35 Br 79.90 Bromine
36 Kr 83.80 Krypton
37 Rb 89.47 Rubidium
38 Sr 87.62 Strontium
39 Y 88.91 Yttrium
40 Zr 91.22 Zirconium
41 Nb 92.91 Niobium
42 Mo 95.94 Molybdenum
43 Tc 97.91 Technetium
44 Ru 101.07 Ruthenium
45 Rh 102.91 Rhodium
46 Pd 106.42 Palladium
47 Ag 107.87 Silver
48 Cd 112.41 Cadmium
49 In 114.82 Indium
50 Sn 118.71 Tin
51 Sb 121.76 Antimony
52 Te 127.60 Tellurium
53 I 126.90 Iodine
54 Xe 131.2 Xenon
55 Cs 132.91 Caesium
56 Ba 137.33 Barium
57-71
72 Hf 178.49 Hafnium
73 Ta 180.95 Tantalum
74 W 183.84 Tungsten
75 Re 186.21 Rhenium
76 Os 190.13 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 222.00 Radon
87 Fr (223.03) Francium
88 Ra 226.03 Radium
89-103
104 Unq 261.11
105 Unp 262.11
106 Unh 263.12
107 Unh 263.12
108 Uno 265.00
109 Une 265
57 la 138.91 Lanthanu
58 Ce 140.12 Cerium
59 Pr 140.91 Praseodymium
60 Nd 144.24 Neodymium
61 Pm 144.91 Promethium
62 Sm 150.36 Samarium
63 Eu 151.97 Europium
64 Gd 157.25 Gadolinium
65 Tb 158.93 Terbium
66 Dy 162.50 Dysprosium
67 Ho 164.93 Holmium
68 Er 167.26 Erbium
69 Tm 168.93 Thulium
70 Yb 173.04 Ytterbium
71 Lu 174.97 Lutetium
89 Ac 227.03 Actium
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 195.08 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

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

CHEMISTRY DEPARTMENT

2019/20 ACADEMIC YEAR

CHE 3222: INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS

FINAL EXAM

DURATION: 3 HRS **NOV 2020**

INSTRUCTIONS TO THE CANDIDATES

1. Indicate your **student ID number** on the answer scripts provided.
2. There are a total of **FOUR** questions in this paper. **Answer any THREE.**
3. All questions carry 20 marks each.
4. **The periodic table and standard electrode potential value table are attached to this exam paper.**
5. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.**

QUESTION ONE

(a) What is solvent extraction?

(b) Define the distribution coefficient (K_D) and the distribution ratio (D). State any differences between them.

(c) A solute, X, which weighs 1.200 g is dissolved in 300 mL of water in a separatory funnel. If D = 2.00 for A and assuming there is no dimerization and no pH dependence, calculate the amount of X that would remain after;

(i) One extraction with 300 mL of an organic solvent

(ii) Three extractions with 100 mL of the organic solvent each time.

(iii)Four extractions with 75 mL of the organic solvent each time.

(iv)Compare and comment on the results obtained in (c) (i) – (iii)

(d) For the gas liquid chromatography;

(i) Draw and label its schematic diagram.

(ii) What is the basic requirement for a mobile phase material? Give four commonly employed examples.

QUESTION TWO

(a) Why is the injection port of a GC at a higher temperature than the oven temperature?

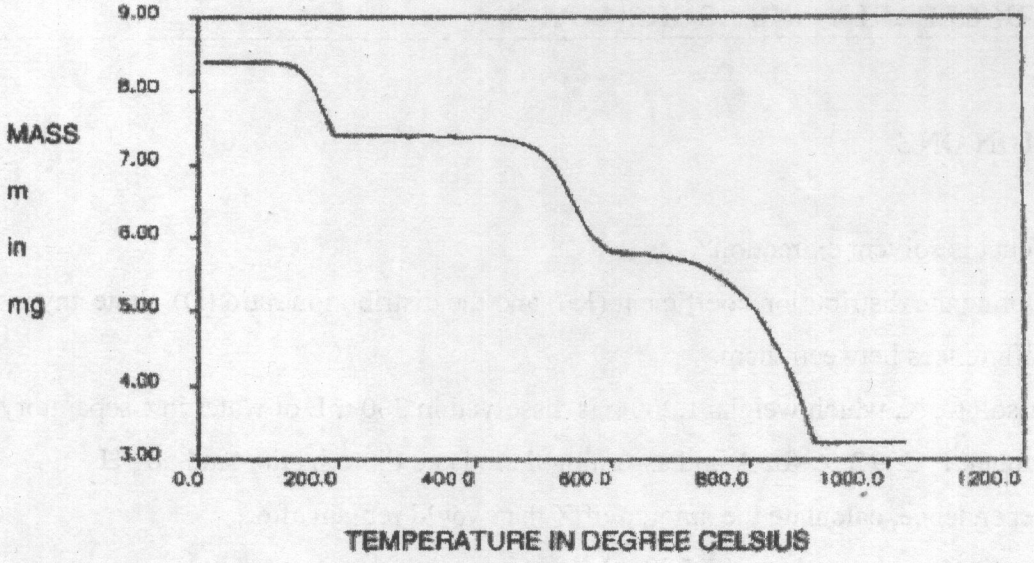
(b) In gas chromatography,

(i) What is column efficiency?

(ii) How is column efficiency value affected by the number of theoretical plates (N) and the plate height (H)?

(iii) What other factors affect it?

(c) The thermogram below is for the stepwise decomposition of a sample of calcium oxalate monohydrate powder ($Ca(COO)_2.H_2O$) as a function of temperature to yield CaO at temperatures above 900°C. From the thermogram, suggest a mechanism for each step in the decomposition.



(d) Given the following sets of terms, explain/define the terms in each set and give an expression that relates them.

(i) Retention time, tR, adjusted retention time, t'R and dead time, tm

(ii) Capacity factor, k, retention time, tR and dead time, tm.

QUESTION THREE

(a) Name the two variants of XRF instruments.

(b) What role does an analyser crystal play in x-ray fluorescence, XRF spectroscopy? What are the advantages and disadvantages to using an analyzer crystal in an XRF instrument? Mention one each.

(c) State two strengths and two limitations of X-Ray Fluorescence Spectroscopy.

(d) Define Kα emission, Lβ emission, and Kα2 emission.

(e) Define the term Fluorescence.

QUESTION FOUR

(a) A certain voltaic cell is composed of a Ce^{4+}/Ce^{3+} half-cell and a Sn^{4+}/Sn^{2+} half-cell. The overall cell reaction is

$$Ce^{4+} + Sn^{2+} \rightleftharpoons Sn^{4+} + Ce^{3+}$$

(i) What is E°cell?

(ii) Is the reaction spontaneous as written, left to right? Briefly explain your answer.

(b) Mention two common reference electrodes other than the Standard Hydrogen Electrode that come close to behaving ideally.

(c) This question is about potentiometric titrations.

(i) Mention two advantages and two disadvantages associated with the Potentiometric Titrations.

(ii) Mention any three basic apparatus required for all potentiometric titrations and explain what purpose each apparatus serves.

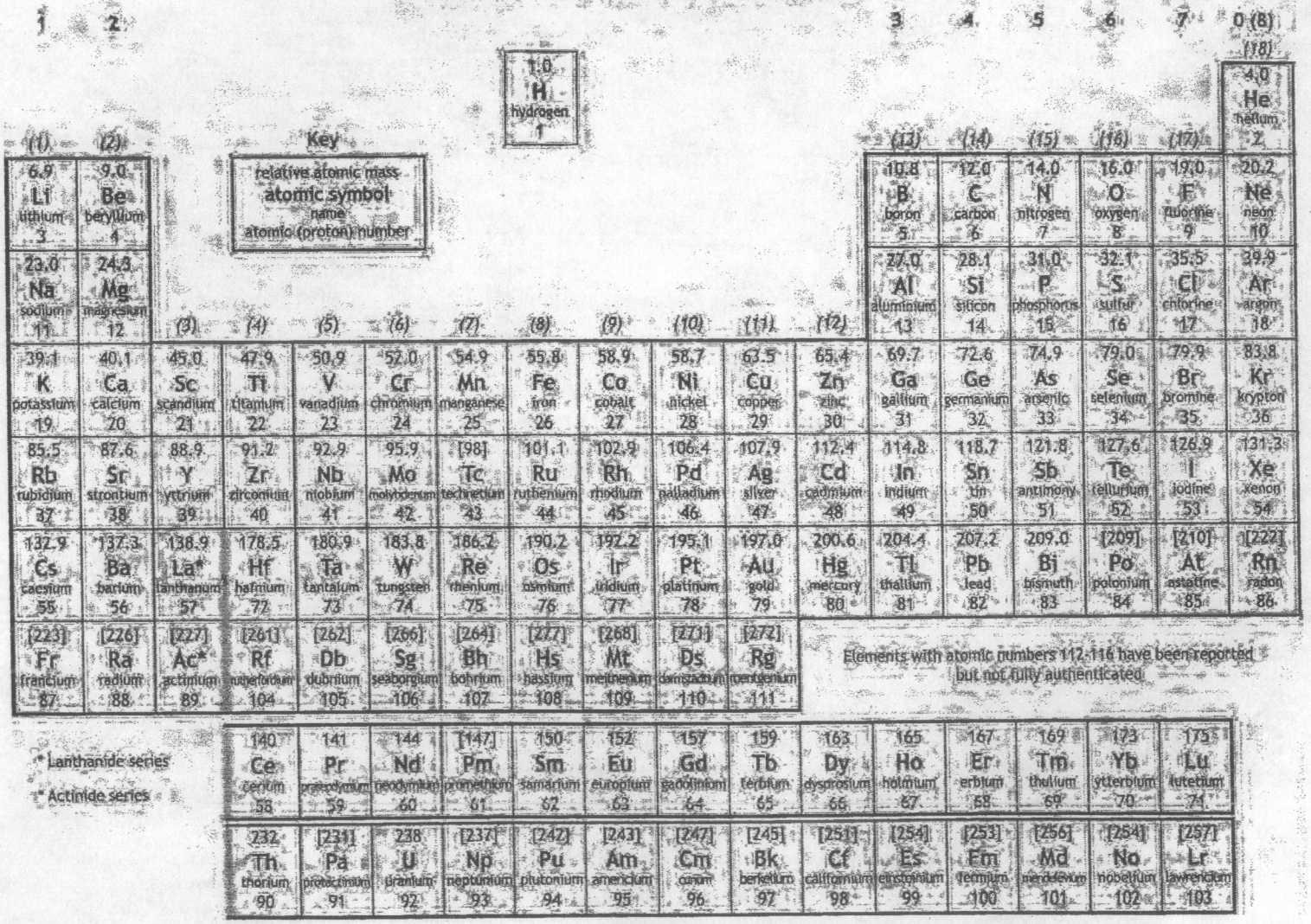
>>>End of Exam<<<

ALL THE BEST

STANDARD REDUCTION POTENTIALS IN AQUEOUS SOLUTION AT 25°C

Half-reaction			E^0(V)
$F_2(g) + 2e^-$	→	$2F^-$	2.87
$Co^{3+} + e^-$	→	Co^{2+}	1.82
$Au^{3+} + 3e^-$	→	$Au(s)$	1.50
$Cl_2(g) + 2e^-$	→	$2Cl^-$	1.36
$O_2(g) + 4H^+ + 4e^-$	→	$2H_2O(l)$	1.23
$Br_2(l) + 2e^-$	→	$2Br^-$	1.07
$2Hg^{2+} + 2e^-$	→	Hg_2^{2+}	0.92
$Hg^{2+} + 2e^-$	→	$Hg(l)$	0.85
$Ag^+ + e^-$	→	$Ag(s)$	0.80
$Hg_2^{2+} + 2e^-$	→	$2Hg(l)$	0.79
$Fe^{3+} + e^-$	→	Fe^{2+}	0.77
$I_2(s) + 2e^-$	→	$2I^-$	0.53
$Cu^+ + e^-$	→	$Cu(s)$	0.52
$Cu^{2+} + 2e^-$	→	$Cu(s)$	0.34
$Cu^{2+} + e^-$	→	Cu^+	0.15
$Sn^{4+} + 2e^-$	→	Sn^{2+}	0.15
$S(s) + 2H^+ + 2e^-$	→	$H_2S(g)$	0.14
$2H^+ + 2e^-$	→	$H_2(g)$	0.00
$Pb^{2+} + 2e^-$	→	$Pb(s)$	-0.13
$Sn^{2+} + 2e^-$	→	$Sn(s)$	-0.14
$Ni^{2+} + 2e^-$	→	$Ni(s)$	-0.25
$Co^{2+} + 2e^-$	→	$Co(s)$	-0.28
$Tl^+ + e^-$	→	$Tl(s)$	-0.34
$Cd^{2+} + 2e^-$	→	$Cd(s)$	-0.40
$Cr^{3+} + e^-$	→	Cr^{2+}	-0.41
$Fe^{2+} + 2e^-$	→	$Fe(s)$	-0.44
$Cr^{3+} + 3e^-$	→	$Cr(s)$	-0.74
$Zn^{2+} + 2e^-$	→	$Zn(s)$	-0.76
$Mn^{2+} + 2e^-$	→	$Mn(s)$	-1.18
$Al^{3+} + 3e^-$	→	$Al(s)$	-1.66
$Be^{2+} + 2e^-$	→	$Be(s)$	-1.70
$Mg^{2+} + 2e^-$	→	$Mg(s)$	-2.37
$Na^+ + e^-$	→	$Na(s)$	-2.71
$Ca^{2+} + 2e^-$	→	$Ca(s)$	-2.87
$Sr^{2+} + 2e^-$	→	$Sr(s)$	-2.89
$Ba^{2+} + 2e^-$	→	$Ba(s)$	-2.90
$Rb^+ + e^-$	→	$Rb(s)$	-2.92
$K^+ + e^-$	→	$K(s)$	-2.92
$Cs^+ + e^-$	→	$Cs(s)$	-2.92
$Li^+ + e^-$	→	$Li(s)$	-3.05

The Periodic Table of Elements



P 4 6 9 3 7 A 0 2 4 2 4

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PMT

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF CHEMISTRY

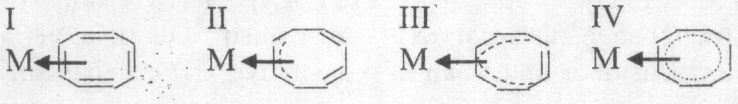
2019/20 END OF YEAR EXAMINATION

CHE3422 ORGANOMETALLICS AND REACTION MECHANISMS

Answer any **FOUR** questions.
Each question carries 15 marks

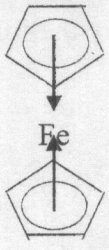
Question 1

(a) (i) The path breaking discovery of sandwich ferrocene, a dicyclopentadienyl iron compound was first reported in Nature Journal in1951. State its uses in our daily lives.
(ii) State hapticity in each of these compounds and what are such ligands called?

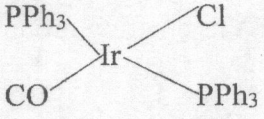


(b) Electron count for the following organometallic complexes and state whether they are stable or unstable, saturated or unsaturated:

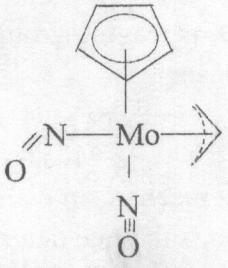
(i)



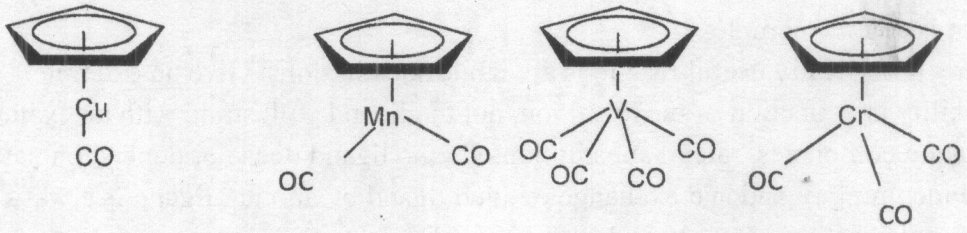
(ii)



(iii)

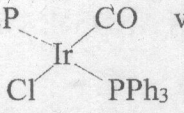


(c) Identify the species that obey the 18 electron rule, from among the following:



Question 2

(a) Is the reaction, $[(CO)_5Mn(Me)] + CO \rightarrow [(CO)_5Mn\{C(O)Me\}]$ an example for: oxidative addition; electrophilic substitution; nucleophilic substitution; migratory insertion. Justify your answer.

(b) (i) Write a reaction between  with CH_3I occurring at room temperature.

(ii) Prepare a drawing that shows the π-bond system in CO that is responsible for it being a very strong ligand (it is at the high end of the spectrochemical series). Clearly show the donor orbital of the metal and the acceptor orbital of the CO ligand.

(c) Calculate the overall complex dissociation equilibrium constant for the $Cu(NH_3)_4^{2+}$ ion, given that β_4 for this complex is 2.1×10^{13}

Question 3

(a) The reaction $[Co(CN)_5\,H_2O]^{2-} + X^- \rightarrow [Co(CN)_5X]^{2-} + H_2O$ follows which reaction mechanism? Is it Interchange dissociative(I_d) mechanism, Dissociative(D) mechanism, Associative (A) mechanism or Interchange Associative (I_a) mechanism? Justify your answer.

(b) Consider the following ligand substitution reaction in O_h complexes

$ML_5X + Y \rightarrow ML_5Y + X$

where X is leaving group X, and Y is entering group proceeding by the following mechanism

$ML_5X \underset{k-1}{\overset{k1}{\rightleftharpoons}} [ML_5] + X$

$[ML_5] + Y \rightarrow_{k2} ML_5Y$

(i) what mechanism pathway does this reaction present?

(ii) what is the rate determining step in this reaction?

(iii) state the factors that affect the rate of the rate-determining step of this reaction.

(c) (i) What is a labile complex?

(ii) Many analytically useful reactions are labile substitutions. Give an example.

(iii) Lability is a function of the metal ion, not the ligands. Illustrate with an example.

(iv) In aquo complexes, rate of substitution of aquo ligand does not depend on nature of the incoming ligand and exchange of aquo ligand by another ligand is always faster than substitution of one ligand by another. Explain why.

QUESTION 4

(a) Suggest a reason why, of the lanthanide tripositive ions the magnetic moment of only Gd^{3+} is in agreement with the moment calculated from spin only formula.

(b) Which tripositive lanthanide ions are most likely to react with chromium (II) chloride? What products are expected? Explain

(c) Explain why none of the lanthanoid sesquioxides, Ln_2O_3, is as acidic as Al_2O_3?

QUESTION 5

(a) Californium undergoes spontaneous fission as follows:

$_{98}Cf^{252} \rightarrow {}_{56}Ba^{142} + {}_{42}Mo^{106} + 4\ {}_{0}n^{1}$

The binding energies per nucleon are, 7.50, 8.25 and 8.50 MeV respectively. Estimate the energy released in this process.

(b) Nuclear fall outs I^{131} and Sr^{90} require 53.17 and 132.92 days respectively for their activity to fall to 1.0% of its initial value. Which radioisotope is likely to produce more serious long-term effects when ingested by mammals? Why?

(c) A piece of wood recovered in an excavation has 60% as much C-14 as ordinary wood has today. Calculate the age of wood piece if $t^{1/2}$ of C-14 is 5770 years.

QUESTION 6

(a) Propose a suitable structure for the complex $K_3[UO_2F_5]$ and support using necessary arguments.

(b) 6 moles of dissolved species are formed when either one mole of boric acid (H_3BO_3) or one mole of boric oxide (B_2O_3) is dissolved in H_2SO_4. Write the net reaction for this dissolution process.

(c) Show the self-ionisation of the solvent SO_2. How does thionyl chloride and caesium sulphite react?

END OF EXAMINATION

PERIODIC TABLE OF ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

hydrogen 1 H 1.00794																	helium 2 He 4.002602
lithium 3 Li 6.941	beryllium 4 Be 9.012182											boron 5 B 10.811	carbon 6 C 12.0107	nitrogen 7 N 14.00674	oxygen 8 O 15.9994	fluorine 9 F 18.9984	neon 10 Ne 20.1797
sodium 11 Na 22.98977	magnesium 12 Mg 24.3050											aluminium 13 Al 26.981538	silicon 14 Si 28.0855	phosphorus 15 P 30.97376	sulphur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.984
potassium 19 K 39.0983	calcium 20 Ca 40.078	scandium 21 Sc 44.95591	titanium 22 Ti 47.867	vanadium 23 V 50.9415	chromium 24 Cr 51.9961	manganese 25 Mn 54.93805	iron 26 Fe 55.845	cobalt 27 Co 58.9332	nickel 28 Ni 58.6934	copper 29 Cu 63.546	zinc 30 Zn 65.409	gallium 31 Ga 69.723	germanium 32 Ge 72.64	arsenic 33 As 74.9216	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.798
rubidium 37 Rb 85.4678	strontium 38 Sr 87.62	yttrium 39 Y 88.90585	zirconium 40 Zr 91.225	niobium 41 Nb 92.90638	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.9055	palladium 46 Pd 106.42	silver 47 Ag 107.8682	cadmium 48 Cd 112.411	indium 49 In 114.818	tin 50 Sn 118.710	antimony 51 Sb 121.760	tellurium 52 Te 127.60	iodine 53 I 126.9045	xenon 54 Xe 131.293
caesium 55 Cs 132.90545	barium 56 Ba 137.327	lutetium 71 Lu 174.967	hafnium 72 Hf 178.49	tantalum 73 Ta 180.9479	tungsten 74 W 183.84	rhenium 75 Re 186.207	osmium 76 Os 190.23	iridium 77 Ir 192.217	platinum 78 Pt 195.078	gold 79 Au 196.96655	mercury 80 Hg 200.59	thallium 81 Tl 204.3833	lead 82 Pb 207.2	bismuth 83 Bi 208.980	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	darmstadtium 110 Ds [271]	roentgenium 111 Rg [272]	ununbium 112 Uub [285]		ununquadium 114 Uuq [289]				

key: element name / atomic number / symbol / atomic mass

lanthanum 57 La 138.9055	cerium 58 Ce 140.116	praseodymium 59 Pr 140.90765	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.964	gadolinium 64 Gd 157.25	terbium 65 Tb 158.9253	dysprosium 66 Dy 162.50	holmium 67 Ho 164.930	erbium 68 Er 167.259	thulium 69 Tm 168.934	ytterbium 70 Yb 173.04
actinium 89 Ac [227]	thorium 90 Th 232.038	protactinium 91 Pa 231.0359	uranium 92 U 238.0289	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY
2019-2020 ACADEMIC YEAR TERM I SESSIONAL EXAMINATIONS
CHE 3611 CHEMICAL KINETICS AND NUCLEAR CHEMISTRY
November/December 2020

TIME: 3 hours
INSTRUCTIONS: 1. ANSWER ANY FIVE OF SIX QUESTIONS
2. ALL QUESTIONS CARRY EQUAL MARKS (20 MARKS)

DATA

Periodic Table; 1u= 1. 660539x1o^{-27}kg = 931.494028 MeV; neutron rest mass m_n = 1.008665u; proton rest mass m_p = 1.007276u; electron rest mass m_e= 0.00054858u; ^{1}H = 1.007825u; $^{234}_{91}Pa$ = 234.043308; $2^{234}_{91}U$ = 234. 040952; c = 2. 997925x108 ms^{-1} ; h = 6. 6262x10^{-34} Js; NA = 6. 02x10^{23}mol^{-1}; 1 eV = 1. 602189x10^{-19}J; 1 J = 1kg m^2 s^{-1} ; 1MW= 3. 6x10^{9}J; Boltzman Constant, k_B = 1.38 x 10^{-23} J/K

QUESTION 1 (20 MARKS)

a) Give two reasons why oxygen-16 is more stable than oxygen-15.

b) Write a nuclear equation for the following process: carbon-12 is bombarded with protons.
The resulting nuclide decays by positron emission.

c) For the most common types of radioactive decay (beta, gamma and alpha) arrange in the order of least to most penetrating to human tissue.

d) Complete the following reaction and calculate the amount of energy released kilojoules per mole:

$$^{234}_{91}Pa \rightarrow \ ? \ + {}^{0}_{-1}\beta$$

QUESTION 2 (20 MARKS)

In a nuclear reactor, electric power is generated by bombardment of uranium-235 (mass =235.0439u) with neutrons. The bombardment splits the fissile nuclide into barium-141 (mass= 140.9143u) and krypton-92 (mass= 91.9263u) with emission of more neutrons.

(a) Write a balanced nuclear equation for the reaction.

(b) Calculate the mass excess, Δ, for the reaction which occurs in part a).

(c) Calculate Q the energy released in Me V by the reaction.

(d) Calculate the amount of energy, in MW, when one kilogram of uranium-235 is used in the reactor.

(e) Suppose the nuclear reactor is transmitting energy at the rate of 1000 MW per day. How long would the energy produced in part d) be available to the consume

QUESTION 3 (20 MARKS)

(a) Manganate ion, MnO_4^{2-}, reacts at 2.0 $mol.L^{-1}$ in acidic solution to form permanganate ions and manganese(iv) oxide:

$$MnO_4^{2-}(aq) + 4H^+(aq) \rightarrow 2MnO_4^-(aq) + MnO_2(s) + 2H_2O(l)$$

(i) What is the rate of formation of permanganate ions?

(ii) What is the rate of reaction of $H^+(aq)$?

(b) The mechanism for the decomposition of gaseous NO_2Cl is

$$NO_2Cl \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} NO_2 + Cl$$

$$NO_2Cl + Cl \xrightarrow{k_2} NO_2 + Cl_2$$

by the steady-state approximation for [Cl], express the rate of appearance of Cl_2 in terms of the concentrations of $[NO_2Cl]$ and NO.

(c) A certain first order reaction has an activation energy of 53kJ/mol. It is run twice, first at 298K and then at 308K (10°C higher). All other conditions are identical. Show that, in the second run, the reaction occurs at double its rate in the first run.

QUESTION 4 (20 MARKS)

(a) Certain bacteria use the enzyme penicillinase to decompose penicillin and render it inactive. The Michaeli-Menten constants for this enzyme and substrate are $K_m = 5 \times 10^{-5}$ mol L^{-1} and $k_2 = 2 \times 10^3$ s^{-1}.

(i) is the maximum rate of decomposition of penicillin if the enzyme concentration is 6×10^{-1}M?

(ii) At what substrate concentration will the rate of decomposition be half that calculated in part (a)?

(b) The decomposition of (N_2O_5); $N_2O_5 + M \rightarrow 2N_2O + \frac{1}{2}O_2 + M$ is an example of Lindemann mechanism for the unimolecular decomposition.

(i) Write down the differential rate law appropriate for the reaction found at low pressure?

(ii) Sketch and label a plot of the reaction rate vs. total pressure.

QUESTION 5 (20 MARKS)

(a) For a reversible, one step reaction $2A \rightleftharpoons B + C$, the rate constant for the forward reaction is 406 M^{-1} min^{-1} and the rate constant for the reverse reaction is 244 M^{-1} min^{-1}. The activation energy for the forward reaction is 26.2 kJ mol^{-1} and that for the reverse reaction is 42.4 kJ mol^{-1}.

(i) Draw a reaction coordinate diagram for this reaction, showing the curve, and labeling (a) ΔE, (b) $E_{a,f}$, and (b) $E_{a,r}$. State whether the reaction is endothermic or exothermic.

(ii) Calculate ΔE for this reaction ($2A \rightleftharpoons B + C$).

(iii) Calculate the equilibrium constant (K) for this reaction ($2A \rightleftharpoons B + C$). Show your work.

(iv) Predict the effect of raising the temperature on the forward rate constant (k_1), and compare it to the effect of raising the temperature on the reverse rate constant (k_{-1}). Explain your answer.

(v) Predict the effect of raising the temperature on the equilibrium constant (K). Explain your answer.

(b) Draw a single reaction coordinate diagram that includes both a catalyzed (dashed line) and a non-catalyzed (solid line) reaction curve, indicating the effect of adding a catalyst to the reaction. Briefly explain what a catalyst does.

QUESTION 6 (20 MARKS)

(a) The following table contains the rate constant, k, for the demethylation reaction of N-methyl pyridinium bromide by aqueous sodium hydroxide as a function of temperature:

T/K	298	313	333	353
$k/10^2\ dm^3\ mol^{-1}s^{-1}$	8.39	21.0	77.2	238

(i) Calculate the activation energy, E_a, and pre-exponential factor A by plotting an Arrhenius graph.

(ii) What is the relationship between ΔH and E_a?

(iii) Calculate $\Delta G°$, $\Delta H°$ and $\Delta S°$ for the reaction at 298 K.

(b) In aqueous solution at 25 °C and pH 7.4 the diffusion coefficient for hemoglobin (radius = 350 nm) is $7.6 \times 10^{-7}\ cm^2s^{-1}$ and of oxygen (radius = 20 nm) is $2.2 \times 10^{-5}\ cm^2s^{-1}$. The rate constant for the binding of oxygen is $4 \times 10^7\ M^{-1}s^{-1}$. Is this a diffusion controlled reaction?

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY
2019-2020 ACADEMIC YEAR TERM I SESSIONAL EXAMINATIONS
CHE 3622 COLLOIDS AND ELECTROCHEMISTRY
November/December 2020

TIME: 3 hours
INSTRUCTIONS: 1. ANSWER ANY FIVE OF SIX QUESTIONS
2. ALL QUESTIONS CARRY EQUAL MARKS (20 MARKS)

DATA

$h = 6.6262 \times 10^{-34}$ Js; $NA = 6.02 \times 10^{23} mol^{-1}$; $F = 96485$ C mol^{-1};
$R = 8.3145$ J mol^{-1} K^{-1}, $g = 9.8$ ms^{-2}, 1 J = 1kg m^2 s^{-1}

QUESTION 1 (20 MARKS)

A two component system is made up of magnesium (melting point = 651°C) and zinc (melting point = 420°C) has two eutectic points. The first eutectic point at 287.5°C with a composition of 86.5 % weight zinc and the second is at 210 °C with composition 56 % weight zinc. The components form a compound (melting point = 575°C) with composition 70 % weight zinc.

(a) Draw a temperature T-%Wt. phase diagram of the magnesium and zinc system.

(b) In each region of the phase diagram, write all the phases that are in equilibrium. (Note: writing a phase as, s (for solid) is not acceptable. Instead write as A(s)).

(c) A liquid melt of composition 70% Wt. zinc is cooled from 600°C to 200°C. At what temperature does the first solid phase appear? Name the solid phase that appears.

(d) Calculate the degree of freedom that a composition of 50 % Wt. zinc has at 550 °C.

(e) Differentiate between a congruent and an incongruent melting.

QUESTION 2 (20 MARKS)

(a) Consider that you have been given a phase diagram for a material for which the following behavior is seen for the coexistence lines:

$$0 < \left(\frac{dP}{dT}\right)_{sublimation} < \left(\frac{-dP}{dT}\right)_{fusion} < \left(\frac{dP}{dT}\right)_{vaporization}$$

If this phase diagram is correct, then this fluid has one unusual property and one property that violates one of the laws of thermodynamics, particularly close to the triple point. Using your knowledge of thermodynamics answer the following questions. Keep in mind that the physical reasons you give must be in mathematical terms, not completely in words.

(i) What property is unusual and why?

(ii) What law is violated and why?

(b) Sulfur transforms from the rhombic form to the monoclinic form under a pressure of 1 bar at 95.4°C. Its reported enthalpy of transition is 0.38 kJ mol^{-1}.

(i) What is the entropy of transition?

(ii) Assume that the heat capacity at constant pressure of rhombic sulfur is independent of temperature between 25°C and 95.4°C. What is the standard entropy of monoclinic sulfur at 95.4°C?

(c) The general thermodynamic relation for dE is

$$dE = TdS - PdV.$$

Prove that the internal energy for an ideal gas depends only on temperature.

QUESTION 3 (20 MARKS)

(a) Differentiate between a lyophobic and a lyophilic colloid. Briefly outline two methods used for the preparation of a lyophobic colloid.

(b) List three methods for purifying colloidal solutions and briefly explain the principle involve in each.

(c) Briefly, explain what emulsions are. State two types of emulsion and give one example for each.

(d) A polymer mixture contains two polymers, one having molecular weight 100,000 and the other having molecular weight 60,000. The two components are present in equimolar concentration. Calculate the number average and the weight average molecular weights.

QUESTION 4 (20 MARKS)

(a) By dipping a U shaped wire in a soap solution, a film is formed between it and a light sliding wire resting on it. The sliding wire supports a weight 0.01N when its length is 20 cm. what is the surface tension of the liquid.

(b) Suppose that pure water is placed in a beaker and a capillary tube of radius 0.2 mm is placed in the beaker. Calculate the surface tension of water if the liquid is measured to travel 7.0 cm above the surface of the liquid in the capillary. The experimenter also observes that the water makes an almost perfect 0°angle with the sides of the glass tube.

The density of water is 1000 kg/m^3.

(c) The data below are for adsorption of CO on Charcoal at 273 K. Confirm that they fit the Langmuir isotherm and calculate

(i) The constant K

(ii) Volume corresponding to complete coverage.

P/torr	100	200	300	400	500	600	700
V/cm^3	10.2	18.6	25.5	31.4	36.9	41.6	46.1

(d) Calculate the gauge pressure inside a soap bubble 2.00×10^{-4} m in radius using the surface tension for soapy water is 0.037 N/m.

QUESTION 5 (20 MARKS)

(a) The molar conductivity of a strong electrolyte in water at 25 °C was found to be 109.9 S cm^2 mol^{-1} for a concentration of 6.2×10^{-3} mol L^{-1} and 106.1 S cm^2 mol^{-1} for a concentration of 1.5×10^{-3} mol L^{-1}. Estimate the limiting molar conductivity of the electrolyte.

(b) Calculate the degree of ionization and the acid dissociation constant at 298 K for a 0.010 M acetic acid solution that has a resistance of 2220 Ω. The resistance of a 0.100 M KCl solution was also found to be 28.44 Ω.

Λ_m(0.1 M KCl) = 129 S cm^2 mol^{-1}

λ^o (H^+) = 349.6 S cm^2 mol^{-1}

λ^o (CH_3COO^-) = 40.9 S cm^2 mol^{-1}

(c) The limiting molar conductivities of KCl, KNO_3, and $AgNO_3$ are 149.9, 145.0, and 133.4 S cm^2 mol^{-1}, respectively (all at 25 °C). What is the limiting molar conductivity of AgCl at this temperature?

QUESTION 6 (20 MARKS)

(a) A Tafel plot is prepared for an electrode process that has an exchange current density of 35 μA cm^{-2}. What is the numerical value of the intercept on this Tafel plot?

(b) An electrode which has an equilibrium potential of 0.47V is at an applied potential of 0.54V. The electrode process taking place has an exchange current density of 28 μA cm^{-2} and the temperature is 25°C. What is the total current that is passed at the electrode under these conditions? (You may assume that the transfer coefficient (α) equals 0.5).

(c) We describe the oxygen reduction reaction using the Tafel equation. Given $j_0 = 10^{-5}$ A/cm^2 and Tafel slope = 70 mV

(i) Calculate the charge-transfer overotential at a current density of 2 A/cm^2.

(ii) Calculate the current density for a charge-transfer overpotential of 210 mV.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2019/2020 ACADEMIC YEAR FIRST TERM FINAL EXAMINATIONS

CHE4211 ANALYSIS OF INORGANIC COMPOUNDS

TIME: THREE HOURS

INSTRUCTIONS

1 There are **five** questions in this paper.

2 Answer any **four** questions.

3 Questions carry equal marks.

Question 1

(a) State the steps (in sequential form) that should be followed in solving a typical analytical problem.

(b) Name all the major nutrients in a fertiliser, and, state the specific one that promotes a good roots system in plants?

(c) Why is sample pre treatment necessary before carrying out the actual analysis on a given sample? Give four examples of pretreatment steps commonly employed for samples in analytical laboratories.

(d) Explain what limit of detection and limit of quantitation of an instrumental method of analysis mean A blank sample gave the following readings: 0.01, 0.02, 0.05, 0.013, 0.012, 0.06. Calculate the

(i) Limit of detection
(ii) Limit of quantitation

Question 2

(a) A 25.00 cm^3 sample of water containing Fe^{3+} and Cu^{2+} required 16.06 cm^3 of 0.05083M ethylenediaminetetraacetic acid (EDTA) for complete titration. A 50.00 cm^3 sample of the water was treated with NH_4F to protect the Fe^{3+}. Then the Cu^{2+} was reduced and masked by addition of thiourea. Upon addition of 25.00 cm^3 of 0.05083M EDTA, the Fe^{3+} was liberated from its fluoride complex and formed an EDTA complex. The excess EDTA required 19.77 cm^3 of 0.01883M Pb^{2+} to reach an end point using xylenol orange. Find the concentration of copper in the water.

(b) (i) List two (2) sources of Cd that are currently leading to the release of Cd in the environment.

(ii) Discuss the health effects of Cd in humans.

(iii) Discuss the effects of CO in humans.

(c) A sample of potassium is analyzed by FES using the standard addition method. Two 0.5ml aliquots are added to 5.0ml portions of water. To one portion is added 10µL 0.05M KCl solution. The net emission signals in arbitrary units are 32.1 and 58.6. What is the concentration of potassium?

(d) (i) What is the difference between BOD and COD?

(ii) With examples, explain the difference between sensitivity and selectivity.

Question 3

(a) There are four most important things to know before beginning any type of chemical analysis. Mention any three of these important points to be considered.

(b) Use of trace metal grade (TMG) acids is advisable during sample dissolution of silicate rocks for their elemental analysis. What are TMG acids?

(c) During silicate analysis of elements, contamination usually occurs during the sample grinding process and originates from two main sources. Name these sources and explain how the contamination can be minimized.

(d) An environmental chemist needs a carbonate buffer of pH 10.00 to study the effects of the acid rain on limsetone-rich rock sample. How many grams of Na_2CO_3 must she add to 1.5 L of freshly prepared 0.20 M $NaHCO_3$ to make the buffer? Ka of HCO_3^- is 4.7×10^{-11}.

(e) Design a sample preparation methodology for a 10 kg silicate rock sample for **quantitative major inorganic elemental analysis using XRF**. In your description include the pressed pellet method and describe the principle of operation of the XRF technique in brief.

Question 4

(a) (i) What are the main primary pollutants in air, water and land?

(ii) Describe three different types of water pollutants that can be found in polluted water.

(iii) A 20 cm^3 water sample was refluxed with 10 cm^3 of 0.25N $K_2Cr_2O_7$ after which 13.60 cm^3 of 0.1N Fe(II) was required to titrate the excess dichromate. What is COD in mg oxygen per litre?

(b) What do the following acronyms mean?

(i) BOD

(ii) TOM

(iii) COD

(c) What methods would you use for the analysis of the following, in the atmosphere?

(i) Nitrogen oxides

(ii) SO_2

(d) (i) Define what is meant by Dissolved Oxygen and state two methods that may be employed for its determination.

(ii) Mention two main sources of dissolved oxygen and two main processes that use it up in natural water bodies.

Question 5

(a) In preparing a maize sample from a stack of bags for mycotoxin determination using HPLC, suggest and discuss a suitable sampling procedure

(b) Given that the analysis of a certain fertilizer yielded the following elemental analysis results 22.67% P, 22.00% N and ballast 8.00% how would you report this result officially according t the N-P-K Convention?

(c) A solution of sodium thiosulphate, $Na_2S_2O_3$, to be used in the determination of a new fertilizer was standardised against 0.13 g potassium bromate, $KBrO_3$, requiring 45.0 mL. What was the molarity of the sodium thiosulphate solution?

(d) The determination of many of the trace elements in fertilisers is amenable to both physic chemical and wet chemical methods. Name two elements which you can be determined for b the former; and one, you could determine for by the latter. Which of the two techniques wou you prefer if you were to submit your results urgently?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2019/2020 ACADEMIC YEAR FINAL EXAMINATIONS

CHE4222 FOOD, DRUGS, PESTICIDES AND DETERGENT ANALYSIS

TIME: **THREE HOURS**

INSTRUCTIONS

1 There are **five** questions in this examination paper.

2 Answer any **four** questions.

3 Questions carry equal marks

4 Show your reasoning and/or calculations clearly.

Question 1

(a) Soaps and detergents are used frequently in our daily life. What is the significant difference between soaps and detergents?

(b) A variety of ingredients are added to detergents to impart a unique nature of a detergent product. Enzymes are an example of such ingredients.

i. Mention four (4) enzymes commonly used in detergents.

ii. Their analysis can be split into three different tests. Mention them.

(c) Milk can be adulterated by addition of sucrose (cane sugar). Describe in brief, a qualitative test that may be used to detect presence in milk samples. Include any physical observations that can be made.

(d) What is the key difference between dry ashing and wet ashing?

Question 2

(a) Proximate analysis involves partitioning of compounds in a feed/food into five categories based on the chemical properties of the compounds. Other than moisture, name the other five categories.

(b) Moisture in foods can be determined using chemical methods. In here, Moisture is determined by reactions between water and certain specific chemical reagents.

(i) The Karl Fischer is one method that can be used. Describe this method including the reagents used, the important chemical reaction and state the type of food sample this method is best suited for.

(ii) Gas production methods is another one that can be used to determine moisture in food samples. Describe this method in brief. Include the necessary reagents and reaction in your description.

(c) Food products containing fat such as butter may sometime go rancid during storage.

(i) Define rancidity. Include products of rancidification and its effects on a sample of butter in your definition.

(ii) Butter becomes rancid by two methods. Name them and briefly describe them.

(iii) Which substance is commonly used as a measure of rancidity in products like butter?

Question 3

(a) What is organic analysis?

(i) What two instruments are mostly used to identify functional groups in organic compounds?

(ii) What is a pesticide?

(iii) Identify five pesticides and explain what they kill.

(b) Explain the possible effects of pesticides on fruits and vegetables.

(c) How are natural soaps prepared?

(d) Where are phospholipids found?

(e) Discuss the importance of steroids, androgens and oestrogens.

Question 4

(a) (i) Discuss five products considered to be pesticides.

(ii) What is meant by a dithiocarbamate in pesticides?

(iii) What do you understand by the term 'PESTICIDES DEGRADATION'?

(iv) What is the difference between CHEMICAL and BIOLOGICAL degradation of pesticides.

(b) A 25-L air sample is determined to 2.8ppm of pesticides. How many grams are contained in 1 litre?

(c) Are fruits and vegetables safe to eat if they have been treated with pesticides?

Question 5

(a) Explain, with at least two examples each, the difference between stimulants and depressants.

(b) How will you differentiate heroin from morphine using screen coloured test?

(c) Why will you need a confirmatory test when you analyze drugs of abuse using screen tests?

(d) You are a trained prosecutor with Drug Enforcement Commission (DEC) and you just confiscated a white powder sample from a suspected drug trafficker. Describe how you would find out what it is and how you would prosecute the suspect, if found to be an illegal drug?

(e) What are the three types of classifications of drugs

(f) What types of other drugs that can be used as analgesics?

END OF EXAMINATION

PERIODIC TABLE OF ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
hydrogen 1 **H** 1.00794																	helium 2 **He** 4.002602
lithium 3 **Li** 6.941	beryllium 4 **Be** 9.012182											boron 5 **B** 10.811	carbon 6 **C** 12.0107	nitrogen 7 **N** 14.00674	oxygen 8 **O** 15.9994	fluorine 9 **F** 18.9984	neon 10 **Ne** 20.1797
sodium 11 **Na** 22.98977	magnesium 12 **Mg** 24.3050											aluminium 13 **Al** 26.981538	silicon 14 **Si** 28.0855	phosphorus 15 **P** 30.97376	sulphur 16 **S** 32.065	chlorine 17 **Cl** 35.453	argon 18 **Ar** 39.984
potassium 19 **K** 39.0983	calcium 20 **Ca** 40.078	scandium 21 **Sc** 44.95591	titanium 22 **Ti** 47.867	vanadium 23 **V** 50.9415	chromium 24 **Cr** 51.9961	manganese 25 **Mn** 54.93805	iron 26 **Fe** 55.845	cobalt 27 **Co** 58.9332	nickel 28 **Ni** 58.6934	copper 29 **Cu** 63.546	zinc 30 **Zn** 65.409	gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.64	arsenic 33 **As** 74.9216	selenium 34 **Se** 78.96	bromine 35 **Br** 79.904	krypton 36 **Kr** 83.798
rubidium 37 **Rb** 85.4678	strontium 38 **Sr** 87.62	yttrium 39 **Y** 88.90585	zirconium 40 **Zr** 91.225	niobium 41 **Nb** 92.90638	molybdenum 42 **Mo** 95.94	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.9055	palladium 46 **Pd** 106.42	silver 47 **Ag** 107.8682	cadmium 48 **Cd** 112.411	indium 49 **In** 114.818	tin 50 **Sn** 118.710	antimony 51 **Sb** 121.760	tellurium 52 **Te** 127.60	iodine 53 **I** 126.9045	xenon 54 **Xe** 131.293
caesium 55 **Cs** 132.90545	barium 56 **Ba** 137.327	lutetium 71 **Lu** 174.967	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.9479	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.207	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.217	platinum 78 **Pt** 195.078	gold 79 **Au** 196.96655	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.3833	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.980	polonium 84 **Po** [209]	astatine 85 **At** [210]	radon 86 **Rn** [222]
francium 87 **Fr** [223]	radium 88 **Ra** [226]	lawrencium 103 **Lr** [262]	rutherfordium 104 **Rf** [261]	dubnium 105 **Db** [262]	seaborgium 106 **Sg** [266]	bohrium 107 **Bh** [264]	hassium 108 **Hs** [269]	meitnerium 109 **Mt** [268]	darmstadtium 110 **Ds** [271]	roentgenium 111 **Rg** [272]	ununbium 112 **Uub** [285]		ununquadium 114 **Uuq** [289]				

key

element name
atomic number
symbol
atomic mass

lanthanum 57 **La** 138.9055	cerium 58 **Ce** 140.116	praseodymium 59 **Pr** 140.90765	neodymium 60 **Nd** 144.24	promethium 61 **Pm** [145]	samarium 62 **Sm** 150.36	europium 63 **Eu** 151.964	gadolinium 64 **Gd** 157.25	terbium 65 **Tb** 158.9253	dysprosium 66 **Dy** 162.50	holmium 67 **Ho** 164.930	erbium 68 **Er** 167.259	thulium 69 **Tm** 168.934	ytterbium 70 **Yb** 173.04
actinium 89 **Ac** [227]	thorium 90 **Th** 232.038	protactinium 91 **Pa** 231.0359	uranium 92 **U** 238.0289	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]

THE UNIVERSITY OF ZAMBIA
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2019/2020 ACADEMIC YEAR
FINAL EXAMINATIONS

CHE 4522
PHYSICAL ORGANIC CHEMISTRY AND NATURAL PRODUCTS CHEMISTRY

TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS:

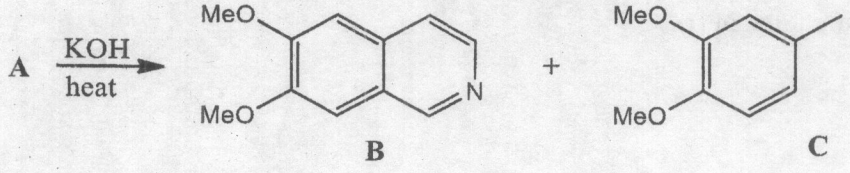
1. Answer any FOUR (4) questions.
2. Each question carries 25 marks.
3. Ensure you have seven (7) printed pages and five (5) questions.
4. Present your answers in a concise and logical manner.
5. Physical constants and spectral data tables are provided.

QUESTION ONE

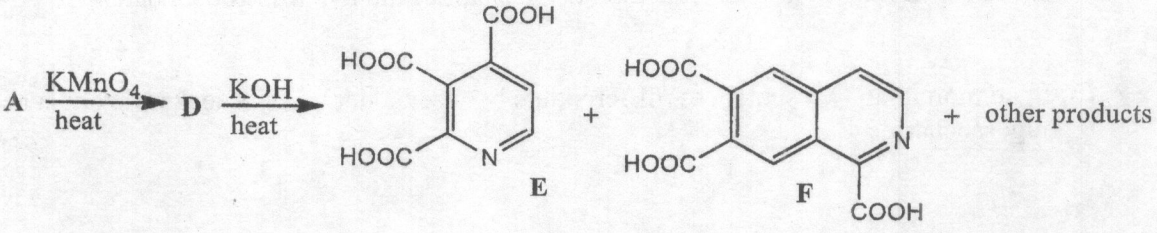
(a) Show how the following experimental evidence can be used to deduce the structure of an alkaloid **A**, $C_{20}H_{21}NO_4$, m.p. 167 °C. Assign the ^{1}HNMR peaks to particular hydrogens, as far as possible.

(i) Upon treatment with HI at 126 °C, **A** gives methyl iodide, which upon treatment with silver nitrate gave a yellow solid, silver iodide. Gravimetric analysis showed that 1 mol of **A** gave 4 moles of silver iodide.

(ii) Upon alkali fusion, **A** gives two fragments, **B** and **C**:



(iii) Permanganate oxidation of **A** gives a ketone, **D**, which upon heating with potassium hydroxide degrades to **E**, **F** and two other products.



(iv) ^{1}HNMR spectral data for the alkaloid **A** is given below.

^{1}H NMR ($CDCl_3$). δ(ppm): 8.31 (1H, s), 8.24 (1H, d), 7.54 (2H, d), 7.03 (1H, s), 6.82 (2H, s), 4.48 (2H, s), 3.90 (6H, s), 3.87 (6H, s)

(8 marks)

(b) Starch is the most widely distributed polysaccharide in the vegetable kingdom with its rich sources being potatoes, wheat, maize, rice, barley and arrow root.

(i) Give the names of two different polysaccharides that make up starch. **(2 marks)**

(ii) State which of these two polysaccharides in starch is responsible for the blue black color during the test for starch and briefly explain how the color arises. **(6 marks)**

(c) Consider the following hypothetical reaction schemes:

$$R + HA \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} RH^+ + A^-$$

$$RH^+ + B \xrightarrow{k_2} P + BH^+ \text{ or } H_3O^+$$

(i) Derive the rate expressions for two conditions: $k_2 >> k_{-1}$ and $k_2 << k_{-1}[A^-]$ and decide which one represents Specific Acid Catalysis (SAC) and which one is General Acid Catalysis (GAC). **(6 marks)**

(ii) Explain your choice in (i). **(3 marks)**

QUESTION TWO

(a) If ρ value for the saponification of methyl esters of substituted benzoic acids is 2.38 and the rate constant for saponification of methyl benzoate under the conditions of interest is 2.0×10^{-4} L mol^{-1} s^{-1}. Calculate the rate constant of methyl *m*-nitrobenzoate. **(4 marks)**

(b) In no more than two sentences, differentiate between a homooligosaccharide and a hetero-oligosaccharide. **(2 marks)**

(c) Consider the hypothetical reaction sequence given below:

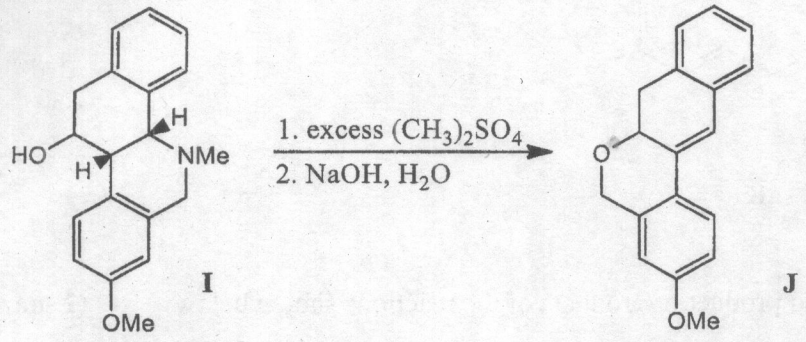
$$G \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} P_1 + H$$

$$H + M \xrightarrow[\text{slow}]{k_2} P_2$$

(i) Apply the steady state approximation to derive the rate expression for this reaction sequence. **(5 marks)**

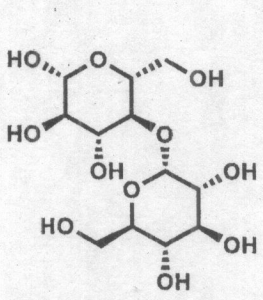
(ii) What do the terms in the numerator and denominator in the rate expression represent? **(3 marks)**

(d) Attempted Hofmann degradation of the alkaloid **I** with excess dimethyl sulfate and aqueous sodium hydroxide *unexpectedly* gave a product **J** in good yield. Suggest a plausible mechanistic explanation to account for the *unexpected* product **J.** **(8 marks)**

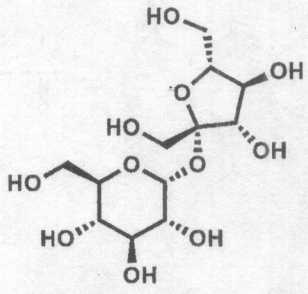


I **J**

(e) Consider the structures of maltose and sucrose shown below:



Maltose



Sucrose

Which one would you expect to reduce Fehling's solution and briefly explain why. **(3 marks)**

QUESTION THREE

(a) In the presence of a base, aniline and nitrosobenzene react to give azobenzene.

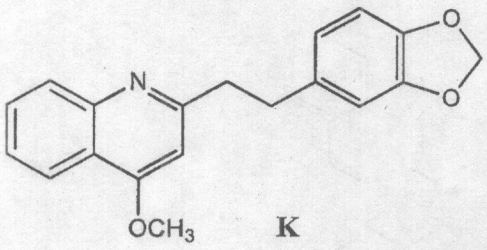
$$PhNH_2 + PhNO \xrightarrow{\text{base}} PhN{=}NPh + H_2O$$

Suggest a plausible mechanism consistent with the following observations:

(i) The rate of the reaction is first order in both aniline and nitrosobenzene.
(ii) With tetramethylammonium hydroxide base, the rate of the reaction was found to be directly proportional to concentration of OH^- ion.
(iii) With substituents in the phenyl ring of aniline, a Hammett plot gave a ρ value of +2.0.
(iv) For substituents in nitroso compound, the ρ value was -2.1.

(10 marks)

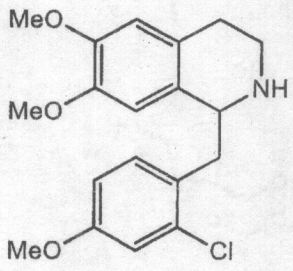
(b) Propose a synthesis for the alkaloid **K**, isolated from *angostura* bark, structure shown below, from readily available non-heterocyclic starting materials. Assume that aniline and catechol (1, 2-dihydroxybenzene) are available. **(8 marks)**



K

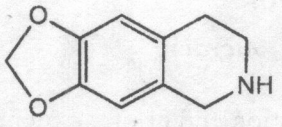
(c) Identify the expected product or products of the reactions shown below: **(2 marks each)**

(i)



1. Ethyl chloroformate
2. hν
→ ?

(ii)



1. excess CH_3I
2. Na-Hg
→ ?

(d) The pK_a of *p*-chlorobenzoic acid is 3.98 and that of benzoic acid is 4.19. Calculate σ for *p*-Cl. **(3 marks)**

QUESTION FOUR

(a) Sucrose undergoes hydrolysis according to the reaction shown below:

$$C_{12}H_{22}O_{11} + H_2O \longrightarrow C_6H_{12}O_6 + C_6H_{12}O_6$$

$[\alpha]_D = +66.5°$

Glucose $[\alpha]_D = +52.7°$

Fructose $[\alpha]_D = -92.4°$

With the aid of appropriate calculations, suggest a reason why this hydrolysis reaction is referred to as inversion. **(5 marks)**

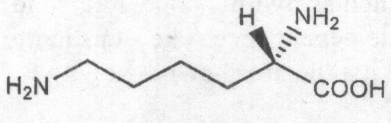
(b) A study of the effect of substituents in phenyl ring on the rate of hydrolysis of substituted methyl benzoates gave the following results. It was found that hydrolysis was rapid in 95% sulphuric acid:

Substituent	*p*-Me	*m*-Me	H	*m*-Cl	*m*-Br
k x (10^{-4} sec^{-1})	2.41	1.51	0.65	0.035	0.032

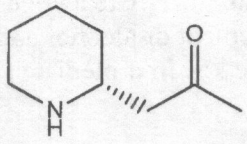
(i) Determine the value of ρ for this reaction and predict the rate constant for the hydrolysis of methyl *p*-fluorobenzoate. **(5 marks)**

(ii) For the hydrolysis of methyl *o*-methylbenzoate and methyl *p*-methoxybenzoate, the rate constants are 182 x 10^{-4} and 10.2 x 10^{-4}, respectively. Comment on these results. **(3 marks)**

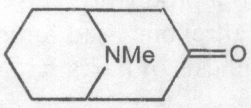
(c) The pomegranate (*Punica granatum*) bark contains a number of alkaloids, including pellitierine, a vermifuge, and isopellitierine, an anthelmintic. Isotopic tracer studies have shown that both pellitierine and pseudopellitierine are derived from the amino acid *L*-lysine and 2,3,4.5-tetrahydropyridin-1-ium ion, **1**, is the key precursor for both alkaloids.



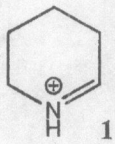
***L*- lysine**



Pelletierine



Pseudopelletierine



1

Based on this information, propose a biogenetic pathway for pelletierine from its amino acid precursor, *L*- lysine and acetoacetyl coenzyme A. **(8 marks)**

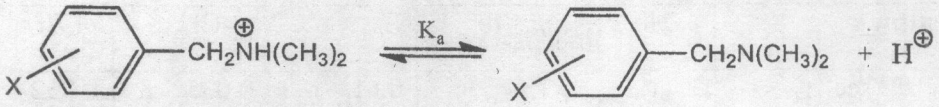
(d) In the presence of acetate ion, nitromethane reacts readily with bromine to give, initially, monobromonitromethane:

$$CH_3NO_2 + Br_2 \longrightarrow CH_2BrNO_2 + HBr$$

The fully deuterated compound (CD_3NO_2) reacts 6.6 times more slowly than CH_3NO_2. Suggest a mechanism and show the rate determining step in this reaction. **(4 marks)**

QUESTION FIVE

(a) Consider the results given below for basicity of a series of substituted benzyldimethyl amines:



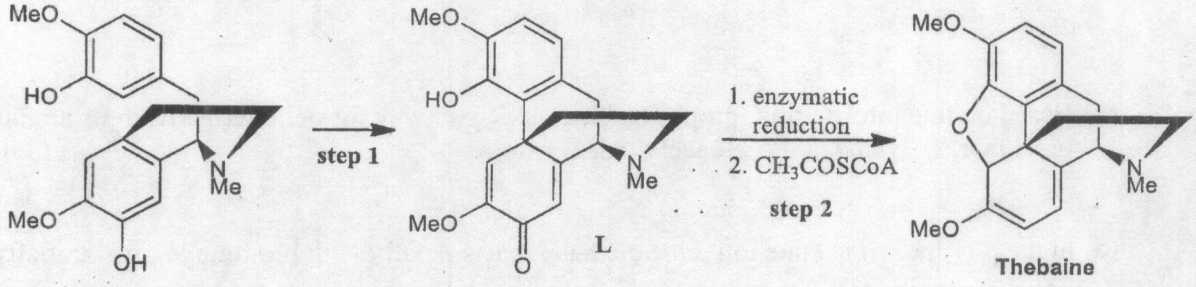
Substituent	*p*-CH_3O	*p*-CH_3	*p*-F	H	*m*-NO_2	*p*-NO_2	*p*-Cl	*m*-Cl
pKa	9.32	9.22	8.94	9.03	8.19	8.14	8.83	8.67

(i) Determine whether these basicity data are correlated by the Hammett equation. Plot the data against σ and σ+ values. **(7 marks)**

(ii) Determine the Hammett ρ values in each case. **(3 marks)**

(iii) Explain the Hammett ρ values obtained in (ii) above. **(5 marks)**

(b) Thebaine, the main alkaloid of *Papaver bracteatum* (Persian poppy) seed, is used for industrial production of semisynthetic opiate analgesics, such as hydrocodone, naloxone and a drug naltrexone used for management of alcohol and opiate dependence. The steps in the biosynthesis of thebaine from the key intermediate (*R*)- reticuline are shown below:



(R)- Reticuline

(i) Given that oxidative phenol coupling is involved, provide a mechanism for **step 1**. State the type of phenol oxidative coupling. **(5 marks)**

(ii) Suggest a mechanistic explanation for the reaction involving acetyl coenzyme A in **step 2**. **(5 marks)**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019/2020 ACADEMIC YEAR
MID YEAR EXAMINATIONS

CHE 4715: ESSENTIALS OF MEDICINAL CHEMISTRY

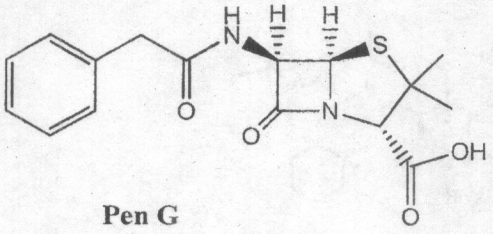
TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS:

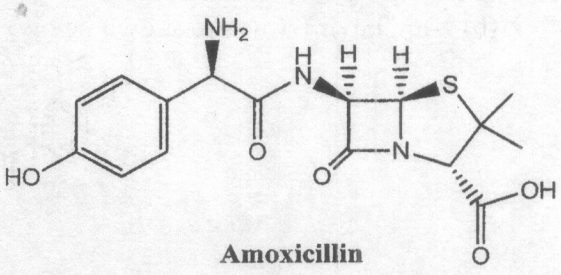
1. **Answer any four (4) questions.**
2. Each question carries 25 marks.
3. Present your answers in a logical manner.
4. Ensure that you have **seven (7)** printed pages and five (5) questions.

QUESTION ONE

(a) Naturally occurring penicillins, such as benzylpenicillin, Pen G, have a narrow spectrum of antibacterial activity and are ineffective for treatment of bacterial infections, when administered orally. Medicinal chemists developed a number of Pen G analogs, such as amoxicillin, which exhibit broad spectrum antibacterial activity and are also effective orally.



Pen G



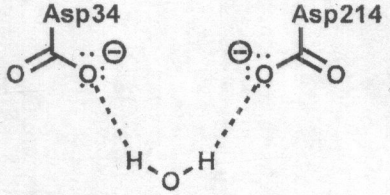
Amoxicillin

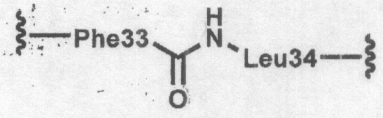
(i) Identify two (2) structural features of naturally occurring penicillins which could account for their oral inactivity and explain briefly. **(3 marks)**

(ii) Suggest a partial synthesis of amoxicillin from Pen G. Clearly show all steps, including the intermediates. Assume that all needed reagents, including *N*-protected tyrosine, are available. **(8 marks)**

(b) Which three drugs are used for multiple drug therapy (MDT) of human *Mycobacterium tuberculum* infection (tuberculosis). **(3 marks)**

(c) Plasmepsin II is an aspartic protease expressed during the asexual blood stage of the malaria parasite development and is said to be involved in the degradation of host haemoglobin. This involves the hydrolysis of the peptide bond mediated by two aspartic acid residues Asp34 and Asp214 (see structures below) in its catalytic site. The first step is the generation of a hydroxide ion through deprotonation of a water molecule by Asp214. On this basis, give a full push-arrow mechanism for the hydrolysis of the shown peptide bond. **(5 marks)**





(d) Briefly explain the therapeutic applications and mechanism of action of <u>*any two*</u> of the following drugs: **(6 marks)**

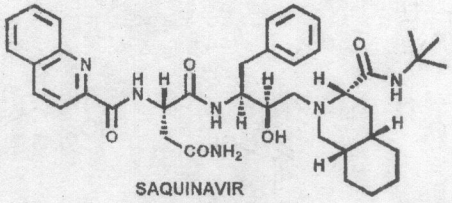
(i) Erythromycin

(ii) Quinine
(iii) Ampicillin

QUESTION TWO

(a) State Lipinski's rule of five. **(5 marks)**

(b) Saquinavir (structure shown below) is an anti-HIV drug.



SAQUINAVIR

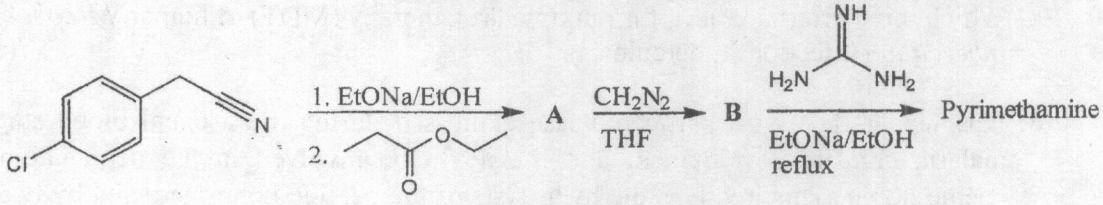
State the number of its:

(i) Hydrogen bond donor (HBD) groups. **(2 marks)**

(ii) Hydrogen bond acceptor (HBA) groups. **(6 marks)**

(iii) State any violations, if any, to Lipinski's rule of five. **(2 marks)**

(c) Identify the intermediates **A** and **B** and deduce the structure of an antimalarial drug pyrimethamine from the following synthesis. **(6 marks)**

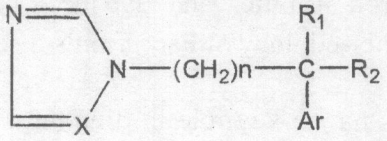


(d) The cell membrane is made up of a phospholipid bilayer. Briefly (in not more than three sentences) explain how the arrangement of the phospholipid bilayer in the cell membrane ensures membrane stability. **(4 marks)**

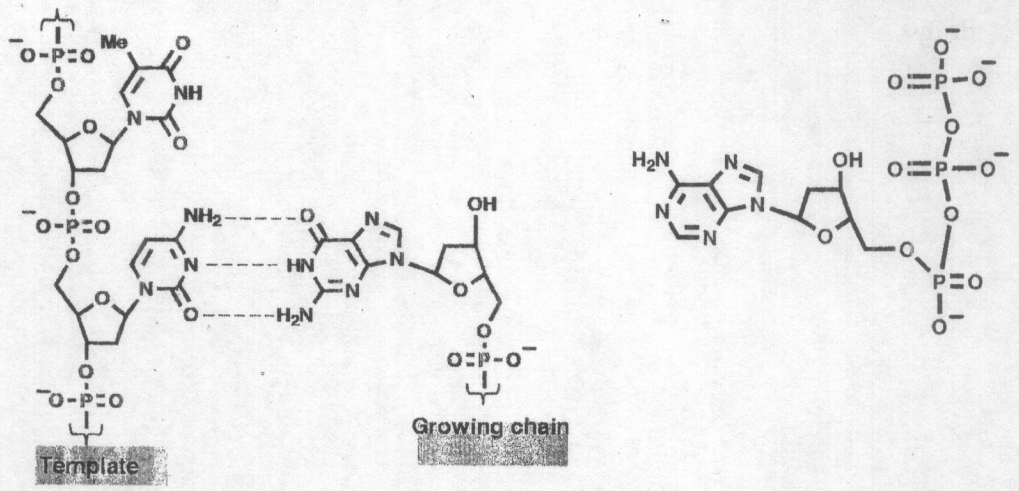
QUESTION THREE

(a) Briefly explain the mechanism of action emerging from the current *in vitro* studies that led to experimental trial of hydroxy-chloroquine (HCQ) for treatment of the novel Coronavirus disease 2019 (COVID-19), in some countries. **(4 marks)**

(b) Discuss the qualitative structure-activity relationships in azole antifungal drugs (see corescaffold below): **(5 marks)**



(c) The structure below is a small section of a DNA strand undergoing replication. Using a nucleotide derivative given, show a push-arrow mechanism depicting how chain elongation of the growing chain occurs. **(4 marks)**



(d) Drug **C** is given intravenously at a dose of 100 mg. The renal clearance of the drug is 7 L/h and the hepatic clearance is 23 L/h. Assuming that these are the only two routes of elimination:

(i) What is the total clearance? **(2 marks)**

(ii) How much drug (in mg) was metabolized? **(4 marks)**

(e) The following data were obtained after intramuscular (IM) and intravenous (IV) administration of drug **D**. Determine the bioavailability of the drug after IM injection. **(6 marks)**

	Dose (mg)	CL (mL/min)	V (L)	$t_{1/2}$ (h)	AUC (mg h/L)
IM	1000	---	---	2	115.5
IV	500	115	20	2	72.1

QUESTION FOUR

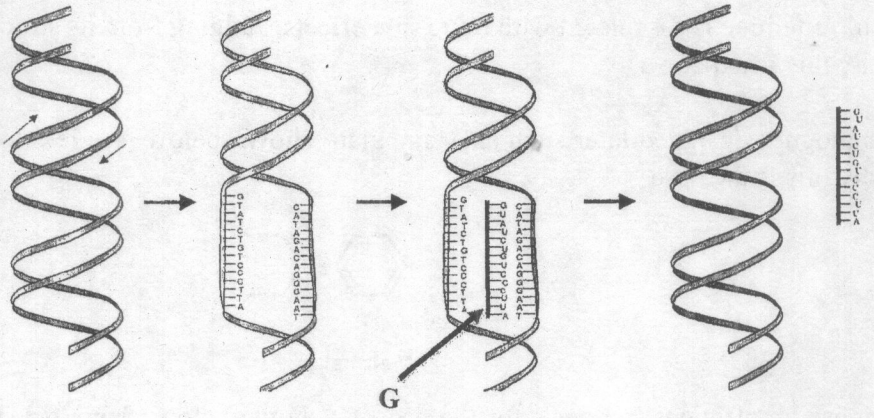
(a) Define the term 'neurotransmitter' and give the structure and name of a neurotransmitter that is implicated in the aetiology of Parkinson's disease. **(3 marks)**

(b) Intermolecular forces play a key role in drug-target binding. State seven types of such intermolecular forces relevant to drug-target binding. **(7 marks)**

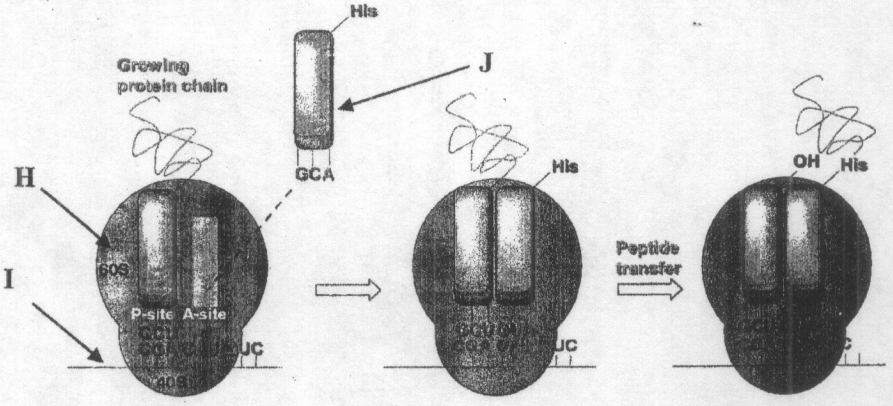
(c) There are growing reports on 'azole-resistant' fungi, including *Aspergillus, Candida,* and *Cryptococcus spp.* Briefly explain the two main mechanisms for fungal resistance to azole drugs. **(4 marks)**

(d) Processes **E** and **F** (shown below) are involved in protein synthesis.

Process E



Process F



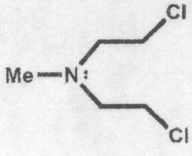
(i) What terms are used to describe processes **E** and **F**? **(2 marks)**

(ii) Label the parts **G – J** **(4 marks)**

(e) Comment on the pharmacokinetics of primaquine and briefly explain its mechanism of antimalarial action. **(5 marks)**

QUESTION FIVE

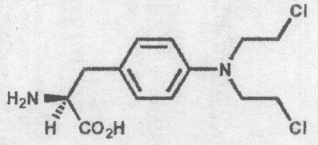
(a) Chlormethine (structure shown below), an anticancer agent, is a nitrogen mustard first used medicinally in 1942.



(i) With the aid of push-arrow mechanistic details, briefly describe the mechanism of action behind its anticancer properties. **(4 marks)**

(ii) Chlormethine is associated with toxic side effects. Judging from its structure, explain why this is expected. **(2 marks)**

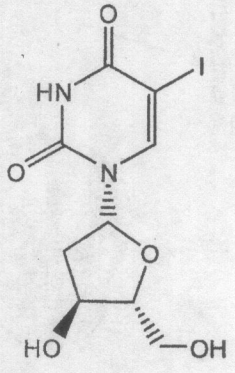
(iii) Analogues designed later such as Melphalan (shown below) are less toxic. Suggest why this is the case. **(2 marks)**



Melphalan

(b) (i) Propose an efficient synthesis for the drug **K**, shown below, from 2-deoxy-D-ribose and readily available non-heterocyclic starting materials. Show all steps, including the intermediates clearly. **(7 marks)**

K:



(ii) State the clinical applications of drug **K** and *briefly* explain its mechanism of action. **(4 marks)**

(c) Based on the mechanism of action, antiretroviral drugs are classified into three categories. Name the three classes of antiretroviral drugs and, for each class, state how it exert its antiviral action (not more than 2 lines for each drug class). **(6 marks)**

END OF EXAMINATION
GOOD LUCK!

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2019/2020 ACADEMIC YEAR FIRST TERM FINAL EXAMINATIONS

CHE5011 GENERAL CHEMICAL TECHNIQUES

TIME: THREE HOURS

INSTRUCTIONS

1 There are **five** questions in this paper.

2 Answer any **four** questions. Answer Q1 and any 3.

3 Questions carry equal marks.

Question 1

(a) Give three reasons to explain why moving boundary electrophoresis is not a good technique for separation of proteins. **[3 marks]**

(b) Suggest the most appropriate technique for purification of the microscale samples of:

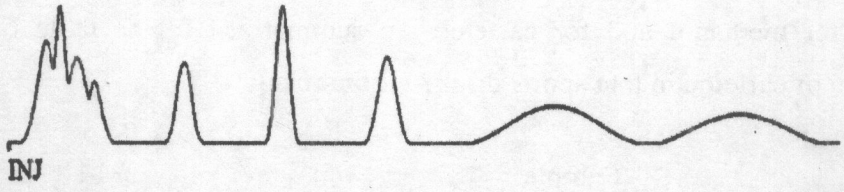
(i) DNA
(ii) Flavonoids

[2 marks]

(c) (i) What experiment would you perform to verify that a particular nmr signal arises from a proton on a hetero atom such as N, O and S. **[1 mark]**

(ii) Give a detailed explanation of the van Deemter equation in HPLC **[5 marks]**

(d) Consider the following gas chromatogram



* What is th [**[5 marks]**

(e) Outline the sample preparation steps for the analysis of a solid sample using IR spectroscopy. **[5 marks]**

(f) How do you collect a fluorescence emission spectrum? Explain how the spectra obtained can be used for the structure elucidation of organic compounds. Use suitable diagrams to explain. **[5 marks]]**

* What is the problem with the first and last peaks and how can this be corrected?

Question 2

(a) IR spectroscopy is a technique mostly used for qualitative analysis of organic compounds.
(i) Explain the two criteria required for a molecule to absorb IR radiation. **[2 marks]**

(ii) Which of the molecules oxygen and hydrogen chloride is IR active and why? **[2marks]**

(b) Briefly describe how you would prepare a KBr pellet for the IR spectroscopic analysis of a sample. **[6 marks]**

(c) Give two advantages (relative to dispersive spectrometry) of using FT-interferometry to acquire spectra. **[4 marks]**

(d) The Nernst Glower is a useful source of radiation in infrared spectroscopy.

(i) Describe the Nernst Glower as used in IR spectroscopy. **[2marks]**

(ii) Which of the molecules oxygen and hydrogen chloride is IR active and why? **[2marks]**

(iii)Why is it not possible to carry out quantitative analyses on dispersive IR? **[2marks]**

Question 3

An HPLC analysis was conducted for caffeine on "Kung Fu Energy drink" trending in Zambia. A 10.1 ppm methanol IS standard was introduced both into the sample and a standardized solution of 304 ppm of caffeine. The measured by a diode-array detector at each λmax for the absorptions for methanol and for caffeine are summarized in the table below. What is the concentration of caffeine in that sports drink? **[20 marks]**

	IS	Caffeine
Sample	23141	52777
304 ppm Caffeine standard	28441	77313

Question 4

(a) (i) Draw the labelled diagram for microscale distillation apparatus for distillation of non-volatile liquids. **[5 marks]**

(ii) How would you determine the purity of the distilled sample? **[2 marks]**

(b) The efficiency of separation (N) in capillary electrophoresis (CE) is given by the expression given below.

$$N = \frac{\mu V}{2D_m}$$

However, application of very high potentials (>20-30 kV) in CE separation leads to loss of resolution.

(i) Define the terms in the above equation. **[1.5 marks]**

(ii) Explain how the use of high potentials leads to loss of resolution in CE. **[3.5 marks]**

(iii) Briefly explain why the efficiency of CE separation is higher than that of HPLC. **[5 marks]**

(c) Analytes from a variety of matrices are generally isolated by Solid phase extraction (SPE) and liquid-liquid extraction (LLE). Briefly explain why SPE is superior to LLE. **[3 marks]**

Question 5

(a) Explain the term quantum yield? Using appropriate examples, discuss conditions under which the quantum yield may low or high. **[10 marks]**

(b) A graduate student at the University of Zambia synthesized ZnO nanoparticles, which showed a purple color when exposed to UV light at 325 nm. The colour of the particles subsequently changed to orange. Explain this observation using a Jablonski diagram. **[10 marks]**

END OF EXAMINATION

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THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS

SCHOOL OF NATURAL SCIENCES

2019 ACADEMIC YEAR FINAL EXAMINATION

CHE5122 **Physiological Chemistry**

INSTRUCTIONS TO CANDIDATES

i) Time: **THREE (3)** hours
ii) This examination paper has **five (5) questions** on three (3) printed pages..
iii) Answer any **FOUR (4) questions**
iv) All questions carry **equal marks (25 marks each)**

QUESTION 1

(a) **What** is homogenization? **Discuss** the benefits of homogenizing fresh milk and **describe** an experiment that can be used to determine the efficiency of homogenization. **[9 marks]**

(b) Proteins and lipids are the major macromolecules in meat. **Discuss** the biochemical changes observed in aged meat and indicate which endogenous enzymes are responsible for the changes. **[10 marks]**

(c) A sample of meat was found to contain sodium nitrite. **Explain** the benefits and dangers of this additive. **[6 marks]**

QUESTION 2

(a) **Describe** any three (3) types of spoilage that can occur to fruits. For each one indicate the enzyme(s) or organism(s) responsible for the spoilage. **[9 marks]**

(b) **Explain** the dangers associated with consuming potatoes that have been exposed to light for a prolonged period of time. **[7 marks]**

(c) **What** is meant by the term water activity? **What** methods are used to alter the water activity of food and **discuss** how water activity influences food spoilage? **[9 marks]**

QUESTION 3

a) **Write** down any four (4) ways by which drugs are administered into the human body. **[10 marks]**

b) Once the drug is in the human body, the liver uses the cytochrome P450 system to chemically transform it for elimination. **Explain** in detail how this one system (cytochrome P450) can catalyse oxidation, reduction and hydrolytic reactions. Where possible, **write** down the biochemical reactions. **[15 marks]**

QUESTION 4

a) Citing the anatomy of the kidney, **discuss** in detail the role of the kidney in the biochemistry of drugs. As you do so, **explain** the paradox that drugs administered into the human body are generally lipid soluble and yet they leave the body by this renal route in excretion. **[9 marks]**

b) **What** is the difference, if any, between ***Toxicology*** and ***Drug Toxicity***? Briefly **explain**. **[4 marks]**

c) **Highlight** the importance of drug toxicity to a nation's development. As you do so, **cite** specific steps that nations take to ensure drug safety. **[12 marks]**

QUESTION 5

a) **What** is a chemical carcinogen? **[1 marks]**

b) **Explain** clearly how carcinogenicity is determined. **[6 marks]**

c) **Give** three (3) examples with a brief explanation on each, of compounds targeted for elimination that are potential carcinogens listed in the Stockholm Convention. **[6 marks]**

d) A group of Zambian women and children filed a suit against Anglo American Plc in South Africa, alleging the company caused widespread lead metal (Pb) poisoning from a mine it operated until 1974 in the northern city of Kabwe. The case was filed in a Johannesburg court on 21 October 2020 by 13 plaintiffs on behalf of an estimated 100,000 people.

Give a clear biochemical approach to forensically identify lead as a teratogen. **[4 marks]**

e) The following is a paraphrased excerpt from the Science Museum (*sciencemuseum.org.uk*). "Thalidomide was developed in the 1950s as a sedative or tranquilizer, but was soon used for treating a wide range of other conditions, including colds, flu, nausea and morning sickness in pregnant women. During early testing, researchers found that it was impossible to give test animals a lethal dose of the drug (based on the LD50 test). Based on this, thalidomide was deemed to be harmless to humans. Thalidomide was licensed in July 1956 for over-the-counter sale. In the 1950s, scientists did not know that the effects of a drug could be passed through the placental barrier and harm a foetus in the womb, so the use of medications during pregnancy was not strictly controlled. And in the case of thalidomide, no tests were done involving pregnant women".

i) Based on the paragraph, **identify** all wrong practices of the pharmaceutical and scientific community of that time. **[5 marks]**

ii) Thalidomide is still used up to date despite its harsh past. **Give** a scientific reasoning why it's used. **[3 marks]**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019/2020 ACADEMIC YEAR
MID-YEAR EXAMINATIONS

CHE 5535: PHYSICAL ORGANIC CHEMISTRY

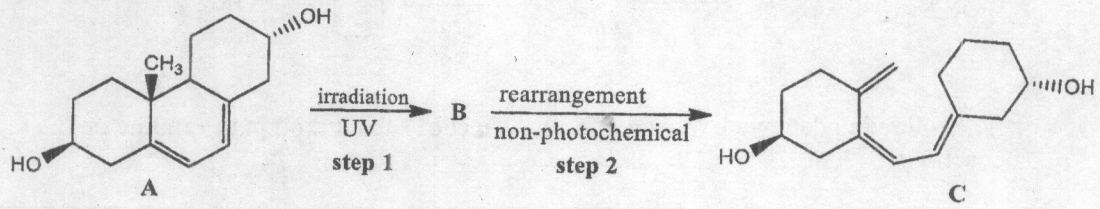
TIME: THREE (3) HOURS

INSTRUCTIONS:

1. ANSWER **ANY FOUR (4)** QUESTIONS.
2. EACH QUESTION CARRIES **25 MARKS**.
3. PLEASE PRESENT YOUR ANSWERS IN A LOGICAL MANNER.
4. ENSURE THERE ARE **NINE (9)** PRINTED PAGES.
5. NMR DATA TABLES AND HAMMET CONSTANTS ARE PROVIDED.

QUESTION ONE

(a) Photochemical irradiation of **A** gives an intermediate **B**, which rearranges to **C** under non-photochemical conditions.

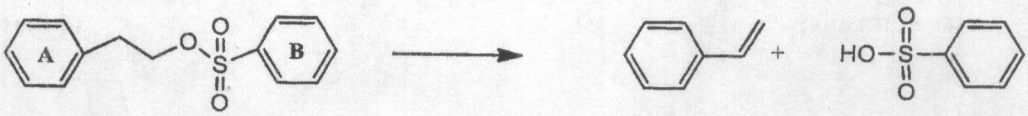


(i) Identify the intermediate **B**. **(2 marks)**

(ii) Suggest a plausible mechanism for **step 1**, name the type of reaction and state the pericyclic processes involved. **(4 marks)**

(iii) Provide a plausible mechanism for the rearrangement of **B** to **C** (**step 2**), name the type of reaction and state the pericyclic processes involved. **(4 marks)**

(b) In the presence of a base (potassium *t*-butoxide in *t*-butanol), 2-phenyl ethylbenzene sulphonate undergoes elimination to give styrene and the mechanism of the reaction is E2.

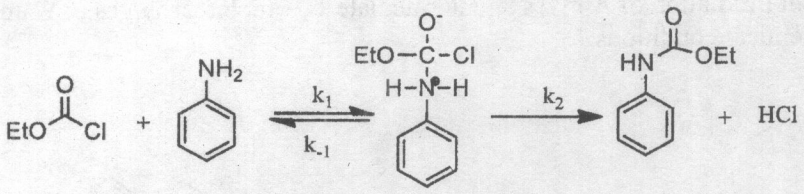


A kinetic study of the effect of substituents in ring **B**, with the same substituent(s) in ring **A**, on the rate of the reaction gives a good Hammett plot with slope of ρ. Values of ρ have been determined as a function of substituent in ring **A**, with the following results.

Substituent A	***p*-OMe**	***p*-Me**	**H**	***m*-OMe**	***p*-Cl**
Hammett ρ value	1.24	1.24	1.08	1.01	0.94

How does the trend in the values of ρ reflect changes in the transition state with different substituents in ring **A**? **(6 marks)**

(c) The reaction between ethyl chloroformate and aniline is a two-step process, involving addition followed by elimination.



The following data were obtained for the effect of substitution in the aniline on the rate of reaction:

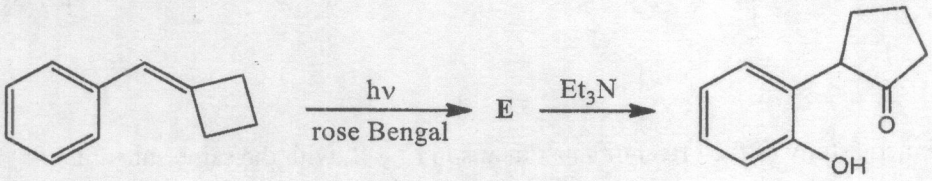
Substituent	***p*-OMe**	***p*-Me**	***m*-Me**	**H**	***p*-Br**	***m*-Cl**	***p*-CO_2Et**	***m*-NO_2**	***p*-NO_2**
$k_{obs\ x}$ (10^3 $Lmol^{-1}s^{-1}$)	1209	286	66.5	42.4	5.57	5.25	1.53	1.92	0.13

(i) What may be deduced about the rate determining step in this reaction from a plot of log k_{obs} against σ^-. **(7 marks)**

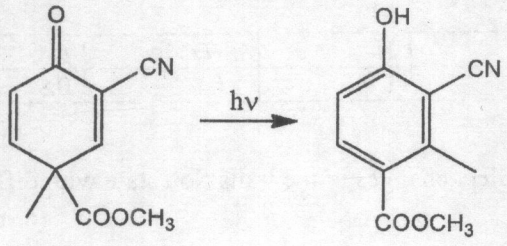
(ii) Suggest an experiment to verify the proposed mechanism. **(2 marks)**

QUESTION TWO

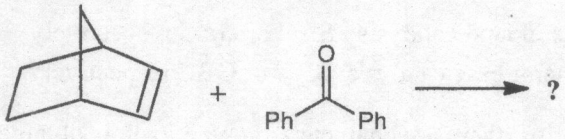
(a) Given that rose Bengal generates singlet oxygen, suggest a mechanism for the following transformation. **(5 marks)**

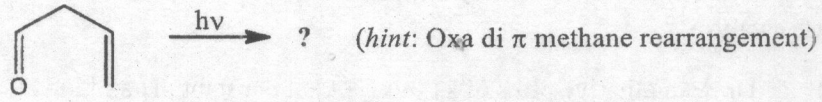


(b) Propose a plausible mechanism to account for the product of the reaction shown below. **(6 marks)**

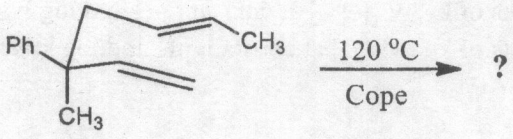


(c) Predict the products of the following reactions. Show stereochemistry, where pertinent. **(8 marks)**

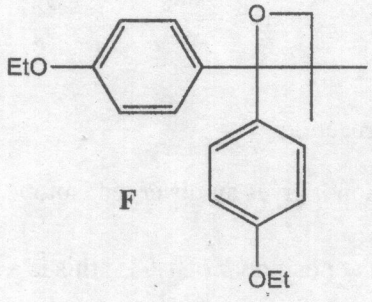
(i) 

(ii) 

(*hint*: Oxa di π methane rearrangement)

(iii) 

(d) Show how Paterno-Buchi reaction can be used to make the insecticidal molecule **F.** Explain the mechanisms of the reactions and the pericyclic processes involved. **(6 marks)**



F

QUESTION THREE

(a) The Hammett correlation is a powerful tool in elucidating reaction mechanisms.

(i) Write the Hammett equation and define all terms. **(4 marks)**

(ii) Explain the significance of σ^+ and σ^- values. **(4 marks)**

(iii)Write the Yukawa-Tsuno equation and explain its significance. **(5 marks)**

(b) Organic reactions are commonly catalyzed by either acid or base. There are two types of catalysis in each case:

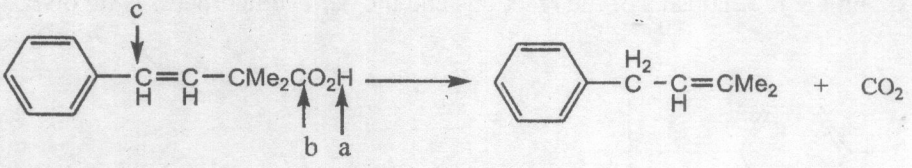
- specific acid or general acid catalysis; SAC or GAC respectively.
- Specific base or general base catalysis; SBC or GBC respectively.

In the above four scenarios, there are characteristic kinetic plots obtained as evidence of either specific acid catalysis or general acid catalysis or specific base catalysis or general base catalysis.

(i) Draw qualitative plots of k_{obs} vs [HA] at constant pH and log k_{obs} vs pH for SAC.
(ii) Draw qualitative plots of k_{obs} vs [B] at constant pH and log k_{obs} vs pH for SBC.
(iii) Draw qualitative plots of k_{obs} vs [HA] at constant pH and log k_{obs} vs pH for GAC.
(iv) Draw qualitative plots of k_{obs} vs [B] at constant pH and log k_{obs} vs pH for GBC.

(8 marks)

(c) Thermal decarboxylation of 2, 2-dimethyl-4-phenylbut-3-enoic acid gives 2-methyl-4-phenylbut-2-ene and carbon dioxide.



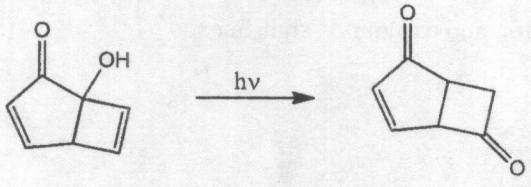
The following information was obtained for this reaction:

- Substitution of protium by deuterium at position *a* gives an observed isotope effect, (k_H/k_D) of 2.87.
- Also, there is a carbon isotope effect (k_{12}/k_{14}) at position *b* of 1.035; this is a large isotope effect.

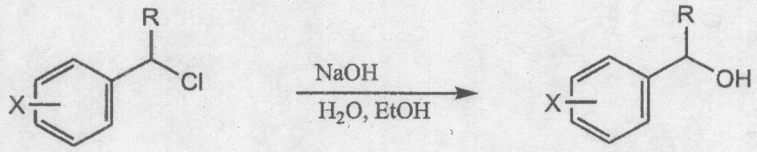
Show how these observations indicate a 'concerted mechanism' for the decarboxylation reaction and suggest a possible transition state. **(4 marks)**

QUESTION FOUR

(a) Suggest a mechanistic explanation to account for the product of the following reaction. **(4 marks)**

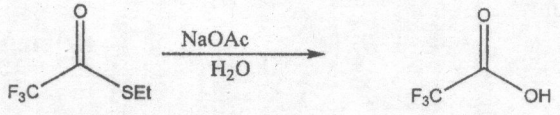


(b) Consider the reaction given below with the following Hammett ρ values; when R = H, ρ = –0.3 but when R = Ph, ρ = –5.1.



Explain the difference between the above Hammett ρ values. **(7 marks)**

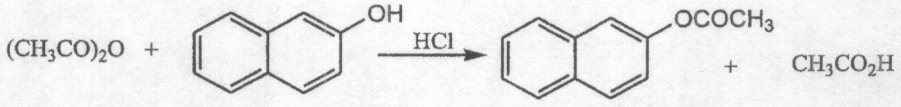
(c) Between pH 2 and 7, the rate of hydrolysis of the ester shown below is independent of pH. At pH 5, the rate is proportional to the concentration of acetate ion (AcO^-) in the buffer solution and the reaction goes twice as fast in H_2O as in D_2O. (*pKa of thiol = 8 and that of alcohol is 16*).



(i) Suggest a mechanism for the pH-independent hydrolysis. **(5 marks)**

(ii) Above pH 7, the rate increases with pH. Briefly explain. **(2 marks)**

(d) The reaction between acetic anhydride and 2-naphthol in acetic acid is catalyzed by HCl.



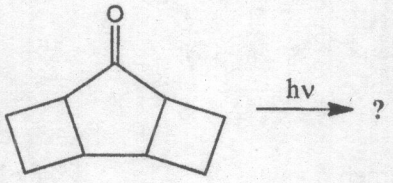
A kinetic study showed that the reaction is first order in acetic anhydride, naphthol and HCl. Addition of acetic anhydride containing ^{14}C resulted in rapid dispersion of the radioactive isotope throughout the solvent. Using these results:

(i) Show that the acylating agent is acetyl chloride by deriving the rate expression for this reaction, assuming that the second step is the rate determining step. **(5 marks)**

(ii) Explain the rapid dispersion of ^{14}C radioactive isotope in the solvent. **(2 marks)**

QUESTION FIVE

(a) Predict the product and give a mechanism of the following reaction. **(6 marks)**



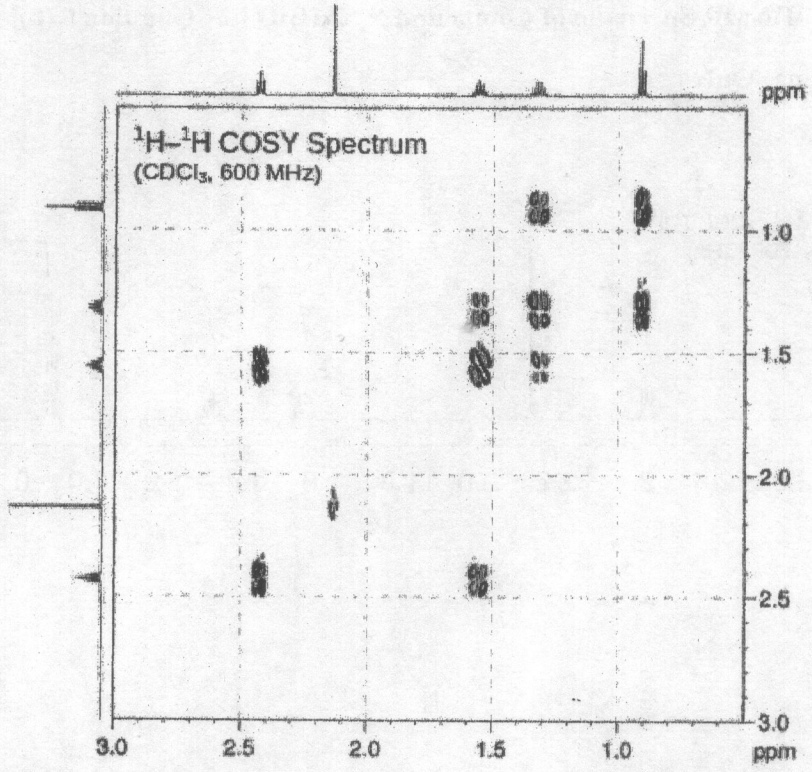
(b) Interpret the attached H-H COSY and ^{1}H-^{13}C HSQC spectra for the compound **X**, $C_6H_{12}O$, given on page 8 and deduce its structure. Assign the NMR signals to particular carbons and hydrogens. The IR spectrum of compound **X** shows a strong absorption band 1715 cm^{-1}.

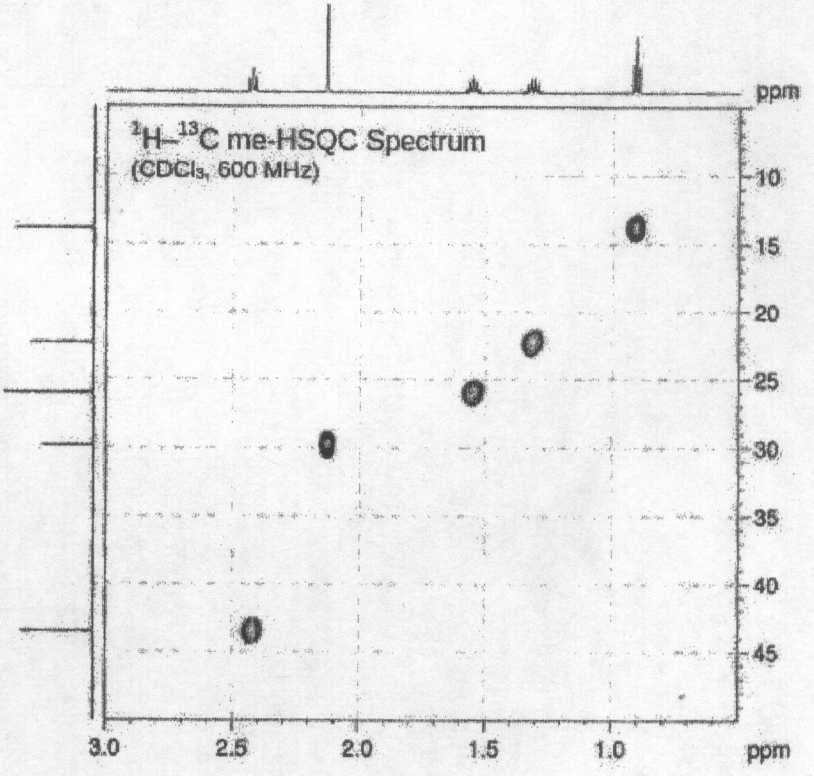
Note: The expanded ^{1}HNMR spectrum is also given on page 9 for reference only; interpretation of ^{1}HNMR is not required.

(19 marks)

END OF EXAMINATION
GOOD LUCK!

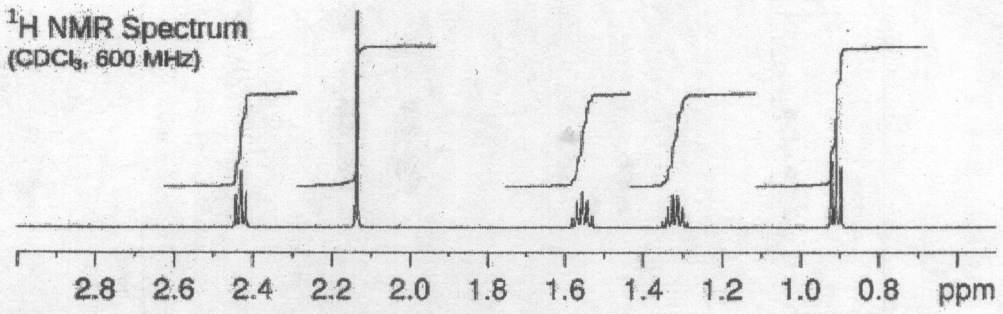
Q5(b) Spectra for Compound X.





Expanded ^{1}HNMR Spectrum of Compound X, $C_6H_{12}O$ [for Question 5 (b)]

For Reference Only



THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC 2000
Computer Programming

Date: 21st December 2020
Time: 14:00hrs – 17:00hrs
Duration: 3 Hours
Venue: NSLT

Instructions

1. There are **two (2) sections** in this exam paper.
2. Only the java programming language should be used in this exam
3. *Answer all* the questions in **Section A** and choose *any three (3)* questions from **Section B**

SECTION A. Short answers (40 marks)

You are required to answer all questions in this section.

1. What is polymorphism and how is it related to dynamic binding and method matching? **[6 marks]**
2. What is method overloading and overriding? **[4 marks]**
3. The Java programming language is said to be both an interpreted and compiled language. Briefly discuss the pros and cons of this approach as compared to interpreted only and compiled only languages. **[6 marks]**
4. Briefly discuss any four key characteristics of Java. **[4 marks]**
5. Is there a difference in performance of Java programs that implicit and explicit importing? **[2 marks]**
6. Java purists often emphasize the importance of following naming conventions when coming up with identifier names. Why is it important to follow naming conventions? **[4 marks]**
7. List relational operators that are implemented in the Java programming language and the corresponding mathematical operators. **[3 marks]**
8. What are selections and why are they important in programming? **[4 marks]**
9. Why are sentinels important when implementing loops in Java? **[2 marks]**
10. Write short code showing the implementation of an enhanced for loop and how it can be used to traverse an array. **[5 marks]**

SECTION B (60 marks)

Answer any three (3) of the five (5) questions. Each question carries **20 marks**

1. Inheritance is fundamental concept in Object Oriented Programming.
   a. What is inheritance and why is it important to understand this concept? **[4 marks]**
   b. A programmer has written code below. But, it is showing a compile time error. Can you identify what mistake he has made? How can it be corrected? **[4 marks]**

```
class X
{
  //Class X Members
}

class Y
{
  //Class Y Members
}

class Z extends X, Y
{
  //Class Z Members
}
```

   c. Briefly discuss the output of running the following code. **[4 marks]**

```
class A
{
  int i = 10;
}
class B extends A
{
  int i = 20;
}
public class MainClass
{
  public static void main(String[] args)
  {
    A a = new B();
    System.out.println(a.i);
  }
}
```

   d. What is constructor chaining? **[4 marks]**
   e. Briefly discuss the output of the following code. **[4 marks]**

```
class A
{
   public A()
   {
      System.out.println("Class A Constructor");
   }
}
class B extends A
{
   public B()
   {
      System.out.println("Class B Constructor");
   }
}
class C extends B
{
   public C()
   {
      System.out.println("Class C Constructor");
   }
}
public class MainClass
{
   public static void main(String[] args)
   {
      C c = new C();
   }
}
```

2. Objects are a very important concept in Object Oriented Programming. For this reason, a good programmer needs to understand classes and objects.

   a) What are objects and how are they related to classes? **[3 marks]**

   b) What are numeric wrapper classes and why are they important in the world of Java programming? **[3 marks]**

   c) What are the four types of relationships that can exist between two classes? **[4 marks]**

   d) Given the following code

```
public class Student{

    private int computerNumber;

    private String name;

}
```

i. Write code that implements accessor and mutator methods for the Student class variables **[4 marks]**

ii. Write code that creates an instance of the Student class, initialises its two variables, and then displays the value of each member variable. **[6 marks]**

3. Methods as procedures are fundamental for defining behavior of objects. Grasping the key aspects of defining methods is crucial when writing good and succinct code.

a) What is a method? **[2 marks]**

b) What is the difference between passing by value and passing by reference? **[4 marks]**

c) What are local variables and how is there scope related to methods? **[4 marks]**

d) Write code for a java class that implements the following

i. a method that gets an array of integers as an argument and returns the sum of the integers. **[5 marks]**

ii. a method that gets an array of integers as an argument and returns indicating whether the sum of the integers is an even number or not. **[5 marks]**

4.

a) Write a Java program to check if a given String is a palindrome or not. **[6 marks]**

b) What is a switch statement and how can it be translated into if statements? **[6 marks]**

c) Write code demonstrating the key aspects of a Java switch statement. **[8 marks]**

5.

a) What are loops and why are they important in programming? **[3 marks]**

b) What impact do nested loops have on performance of a program? **[3 marks]**

c) Write a program that prompts the user to input an integer and then outputs the number with the digits reversed. For example, if the input is 6789, the output should be 9876. **[6 marks]**

d) Write a program that prompts a user to enter a number. If the number entered is not 0 the user is prompted to enter another number. In essence a user enters 0 to terminate the program. Before terminating, the program prints the sum of all the numbers entered. **[8 marks]**

The end of this examination paper

THE UNIVERSITY OF ZAMBIA

School of Natural Science

Department of Computer Science

FINAL EXAMINATION

CSC 2101: INTRODUCTION TO COMPUTER SYSTEMS

Date: Wednesday, 30th December 2020
Time: 09:00hrs – 12:00hrs
Duration: 3 Hours
Venue: NSLT

Instructions

1. There are **Five (5) questions** and **two (2) sections** in this paper.
2. Each question carries **25 marks,**
3. *You are required to answer a total of **Four (4) Questions***
   a. *Answer **all** the questions in **Section A***
   b. Choose ***one (1)** question from **Section B***

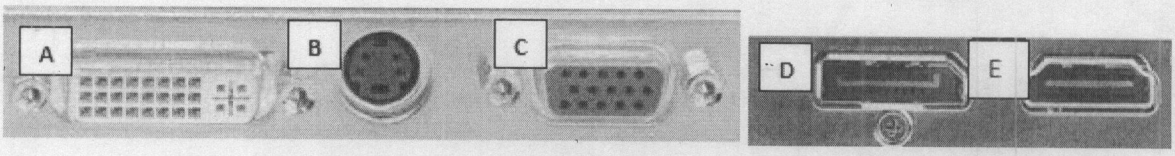
SECTION A

This Section has Three Questions. Answer all the questions

Question I

a) Briefly describe each of the following [3 Marks]
   i. Computer System
   ii. Computer Architecture
   iii. Computer Organisation

b) A video port connects a monitor cable to a computer. Display cables on the other hand transfer video signals from the computer to display devices. Name the five major video ports and connector types shown in the diagram below (A, B, C, D, E) [5 Marks]



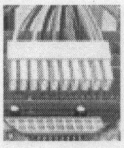
c) Malicious software (malware) is any software designed to damage or to disrupt a system. Briefly describe each of the following types of malware [5 Marks]
   i. Adware
   ii. Spyware
   iii. Viruses
   iv. Worms
   v. Trojan Horses

d) Upon completion of your second-year courses in Computer Science degree programme at the University of Zambia, you have been awarded the 2 months internship job at our power utility company called ZESCO. You Job description will largely be a computer system engineer. The tasks include working at the help desk, repair and troubleshooting of the computers, printers, copiers, switches and routers. In this type of work, injury prevention is everyone's responsibility and part of the company work policy. You will therefore need to stay alert to situations that could result in an injury. Based on what you learnt in the computer systems course, **developing and using safe work practices** is by far the best method for preventing injuries in the workplace. [12 Marks]
   i. Explain the purpose of safe working conditions and procedures
   ii. Identify safety procedures to protect equipment from damage and data from loss
   iii. Identify safety procedures to protect the environment from contamination

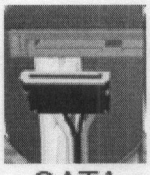
Question II

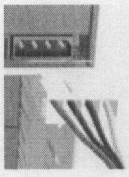
a) Upon graduation in computer science at the University of Zambia, you have been employed to work at the call center at the telecommunication company. The use of communication skills to determine customer problem is an important aspect for you as an expert. One of the first tasks for you as a technician is to determine the type of computer problem or phone problem that the customer is experiencing. Describe the key steps needed as a technician to determine the customer problem [4 Marks]

b) Power cables are used to distribute electricity from the power supply to the motherboard and other components. Give the function of each of the following power cables below and the components to which they supply power [5 Marks]


ATX

AUX


SATA


Molex

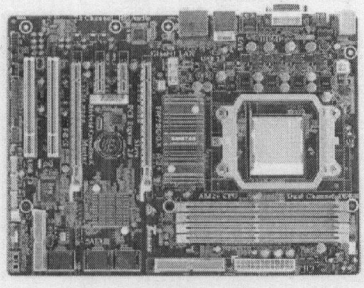
Berg

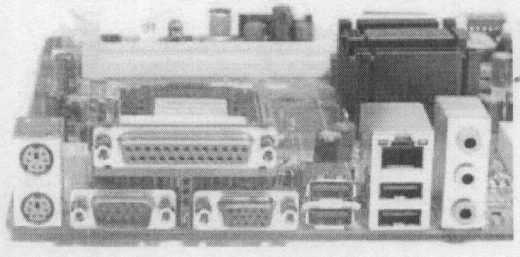
c) Monitors and Projectors are the major display technologies used in computer systems. Briefly discuss each of the following technologies [5 Marks]

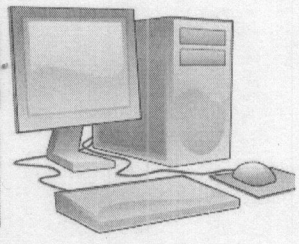
i. Cathode-ray tube (CRT)
ii. Liquid crystal display (LCD)
iii. A light-emitting diode (LED)
iv. Plasma
v. Digital Light Processing

d) The University of Zambia with more than 2000 employees has given you a Job as an intern. You have been attached to the support centre department. Your role will be upgrading old desktop computers, servers and Laptop computers for the university workers. Using your knowledge in the computer systems course, you know that it is important to work in a logical, methodical manner when working with computer components. Using the diagram of the motherboard shown below [11 Marks]

i. Name and List the major hardware components that make up a desktop computer.
ii. Explain how you would go about to assemble the components list in (i) above in a logical, methodical manner to come up with a working computer using the motherboard below



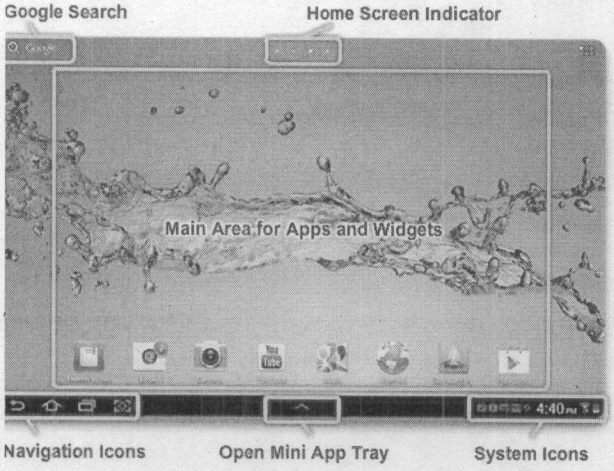


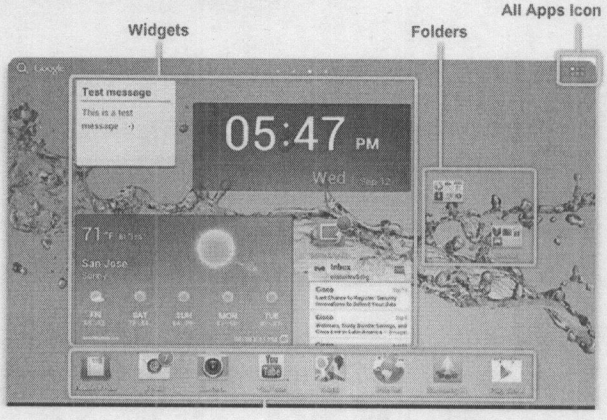


Question III

a) Mobile devices organize icons and widgets on multiple screens for easy access. Android Operating System uses the system bar, displayed on the bottom of the screen, to navigate apps and screens. Describe each of the following features with respect to IOS and Android mobile operating systems [4 Marks].

i. Widgets
ii. Notification Centre
iii. Screen Orientation
iv. Screen Calibration





b) A mobile device is any device that is hand-held, light, and typically uses a touchscreen for input. Most mobile devices use touchscreens to allow users to physically interact with the screen and type on a virtual keyboard. Briefly discuss each of the following types of touch screens below [4 Marks];

i. Capacitive
ii. Resistive

c) On 31 December 2019, the World Health Organization was informed of a cluster of cases of pneumonia of unknown cause detected in China. A novel coronavirus SARS coronavirus-2 was subsequently identified from patient samples. The outbreak of respiratory disease has now been detected in more than 70 locations internationally, including Zambia. The virus has been named "SARS-CoV-2" and the disease it causes has been named "Coronavirus Disease 2019" (abbreviated "COVID-19"). The University of Zambia has been requested by the government to help test the level of infection in four districts in Lusaka Province as shown in the spreadsheet below. Four Schools and four districts are participating on the project [17 Marks].

K13

No.	UNZA - SCHOOL	Districts				Average
		Kafue	Chongwe	Lusaka	Chilanga	
1	UNZA Vet Medicine	71.0	77.0	83.0	74.0	
2	UNZA Public Healthy	75.0	72.0	81.0	69.0	
3	UNZA School of Medicine	73.0	78.0	80.0	75.0	
4	UNZA N/S (CS & Biology Dept.)	68.0	76.0	85.0	72.0	
	Lowest COVID-19 Infection					
	Highest COVID-19 Infection					
	Average COVID-19 Infection					

Copy and Complete the Table by writing the formulae to compute the following

i. Give the formula that can be used to compute the following
   (1) The Lowest infection level in each District
   (2) The Highest infection level in each District
   (3) The Average infection level in each District

ii. The formula used to compute the average level of infection from all the samples collected by each School

iii. Which District has the highest COVID-19 Infection?

iv. Which District has the least COVID-19 Infection?

SECTION B

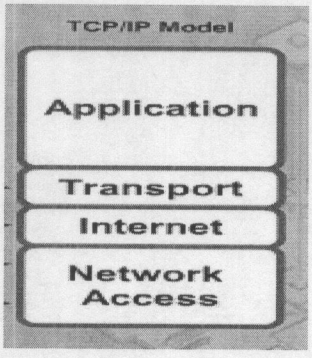
This Section has TWO Questions. Choose one question

Question I

a) Latency is the amount of time it takes data to travel from source to destination. Data is transmitted in one of three modes. Discuss each of the following transmission modes [3 Marks]
   i. Simplex
   ii. Half-duplex
   iii. Full-duplex

b) Briefly describe each of the following types of Computer Networks [4 Marks]
   i. Local Area Network (LAN)
   ii. Metropolitan Area Network (MAN)
   iii. Wireless Local Area Network (WLAN)
   iv. Wide Area Network (WAN)

c) The OSI model and the TCP/IP model are both reference models used to describe the data communication process. The TCP/IP model ***as shown in the diagram below*** is used specifically for the TCP/IP suite of protocols and the OSI model is used for development of standard communication for equipment and applications from different vendors [10 Marks].
   i. Draw a well labelled similar diagram showing the **7 layers of the OSI Model**
   ii. Give the function of each layer of the OSI Model



d) An Operating System (OS) is an interface between a computer user and computer hardware. It is a software which performs all the basic tasks like file management, memory management, process management, handling input and output, and controlling peripheral devices such as disk drives and printers [8 Marks]
   i. Give two examples of open-source operating systems and two examples of none open-source operating systems
   ii. Describe each of the following categories of the operating systems by giving the major characteristics and at least one example in each case
      1. Desktop Operating System
      2. Network Operating System

Question II

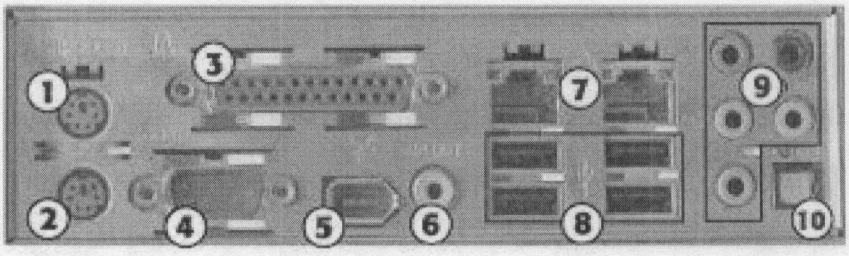
a) To connect to the Internet and other devices, Laptop computers use several different communication methods as shown in the diagram below. Briefly discuss each of the following communication methods below [3 Marks]

i. Bluetooth
ii. Infrared
iii. Wi-Fi

b) The troubleshooting process is a guideline to help solve computer problems in a logical and efficient manner. Usually these are grouped into six (6) major steps. Step 1 to Step 4 have been given below. List and describe the last two steps [4 Marks]

- ***Step 1: Identify the problem***
- ***Step 2: Establish a theory of probable cause***
- ***Step 3: Test the Theory to Determine cause***
- ***Step 4: Establish a Plan of Action to Resolve the Problem and Implement the solution***
- ***Step 5:*** .....
- ***Step 6:*** .....

c) The diagram below shows the backend of the desktop computer. Identity and give the function of each of the ten ports below [10 Marks]



d) System utility software is a set of tools that helps configure, analyse and optimize computer resources to help users perform multiple tasks efficiently. It is software designed to help to analyse, configure, optimize or maintain a computer. Utility software is used to support the computer infrastructure in contrast to application software, which is aimed at directly performing tasks that benefit ordinary users. Briefly discuss each of the following Windows Operating System utility software tools below [8 Marks]

i. Disk Management Utility
ii. The System Utility
iii. Device Manager
iv. Event Viewer

End of the Examination

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC 2202
OPERATING SYSTEMS

Date:	17th DECEMBER 2020
Time:	14:00hrs – 16:00hrs
Duration:	2 Hours
Venue:	NSLT

Instructions

1. There are **two (2) Sections** in this exam, **Section A** and **Section B**.
2. In Section A, **answer all the questions** and in Section B **choose any three (3) questions**.

SECTION A [40 marks]

ANSWER ALL QUESTIONS IN THIS SECTION

Question 1 [20 marks]

a) A parent may terminate the execution of one of its children for a variety of reasons. Explain the reasons. **[4 marks]**

b) Some CPUs provide for more than two modes of operation. What are two possible uses of these multiple modes? **[4 marks]**

c) What are the four main purposes of an operating system? **[4 mark]**

d) Distinguish between the client–server and peer-to-peer models of distributed systems. **[4 marks]**

e) How could a system be designed to allow a choice of operating systems from which to boot? What would the bootstrap program need to do? **[4 marks]**

Question 2 [20 marks]

a) What are two differences between user-level threads and kernel-level threads? Under what circumstances is one type better than the other? **4 marks]**

b) The memory layout of a process is typically divided into multiple sections. List the sections. **[4 mark]**

c) List the process states. **[4 marks]**

d) What resources are used when a thread is created? How do they differ from those used when a process is created? **[4 marks]**

e) What is the main difficulty that a programmer must overcome in writing an operating system for a real-time environment? **[4 marks]**

SECTION B [60 marks]

ANSWER ANY THREE (3) QUESTIONS IN THIS SECTION

Question 3 [20 marks]

a) Discuss multithreading models. **[7.5 marks]**

b) There are several reasons for providing an environment that allows process cooperation. Explain the reasons. **[5 marks]**

c) Some early computers protected the operating system by placing it in a memory partition that could not be modified by either the user job or the operating system itself. Describe two difficulties that you think could arise with such a scheme. **[7.5 marks]**

Question 4 [20 marks]

a) What is the main advantage of the layered approach to system design? What are the disadvantages of the layered approach? **[7.5 marks]**

b) Discuss the operating-system structure. **[5 marks]**

c) Give two reasons why caches are useful. What problems do they solve? What problems do they cause? If a cache can be made as large as the device for which it is caching (for instance, a cache as. **[7.5 marks]**

Question 5 [20 marks]

a) What resources are used when a thread is created? How do they differ from those used when a process is created? **[7. 5 marks]**

b) Discuss the operating-system design and implementation. **[5 marks]**

c) Describe the actions taken by a kernel to context-switch between kernellevel threads. **[7.5 marks]**

Question 6 [20 marks]

a) Briefly explain any three scheduling algorithms. **[7.5 marks]**

b) Discuss the computing environments. **[5 marks]**

c) List five services provided by an operating system, and explain how each creates convenience for users. In which cases would it be impossible for user-level programs to provide these services? Explain your answer. **[7.5 marks]**

THE END

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

DATABASES AND INFORMATIONS MANAGEMENT SYSTEMS
CSC 2702

Date:	31st December, 2020
Time:	14:00hrs – 17:00hrs
Duration:	3 Hours
Venue:	NSLT

Instructions

1. *Answer **all** the questions in Section A.*
2. Choose ***any THREE** (3) questions in Section B.*

SECTION A

Answer ALL Questions in this section. Both questions carry an equal weight of **20 Marks**.

Question 1 [20 Marks]

i. Define the following terms briefly in not more than 3 lines: [**5 Marks**]
   a. *Database*
   b. *Database program*
   c. *Database System*
   d. *Record*
   e. *Attribute*

ii. What is a DBMS, and what are its functions? (list at least 3 functions) [**5 Marks**]

iii. Describe the main components you are likely to find in a DBMS environment? [**5 Marks**]

iv. Give at least 5 reasons why the file based system approach is desirable over the database approach. [**5 Marks**]

Question 2 [20 Marks]

i. Explain what it means to say a database displays both *entity integrity* and *referential integrity*? [**4 Marks**]

ii. Define the following terms in relation to the database: [**4 Marks**]
   a. Intentions
   b. Extension

iii. Draw a well labelled diagram of the ANSI-SPARC DBMS architecture and describe the different aspect of it. [**6 Marks**]

iv. What are the three components that describe a data model? [**3 Marks**]

v. State three categories in which you can classify data models? [**3 Marks**]

SECTION B

There are FOUR questions in this section. All questions carry an equal weight of **20 Marks**. Choose only **three** (**3**) question!

Question 1

i. In relation to Relational Database Model, list at least five (5) attributes that differentiate relations from tables. [**5 Marks**]

ii. Suppose you wanted to apply for a Job in a database computing environment, what are the five (5) different roles you may likely find? [**5 Marks**]

iii. What do you mean when you say "cardinality of the relation" and "degree of the relation" when you are talking about relational databases? [**4 Marks**]

iv. What two conditions must be met before an entity can be classified as a weak entity? Give an example of a weak [**2 Marks**]

v. Discuss the difference between a composite key and a composite attribute. How would each be indicated in an Entity Relationship Diagram? [**4 Marks**]

Question 2

i. Define the following terms: [**5 Marks**]

   a. *Composite key*
   b. *Super key*
   c. *Candidate key*
   d. *Foreign key*
   e. *Primary key*

ii. Briefly describe the four (4) integrity constraints that are associated with relational database model? [**4 Marks**]

iii. What is the difference between a "view" and "base relation"? [**2 Marks**]

iv. Give at least 3 reasons why the file based system approach is undesirable over manual filing system? [**3 Marks**]

v. What three data anomalies are likely to be the result of data redundancy? [**6 Marks**]

Question 3

i. What is a partial dependency? With what normal form is it associated? [**4 Marks**]

ii. Explain the difference between "Functional Dependency" and "Transitive Dependency". [**4 Marks**]

iii. What two conditions must be met before an entity can be classified as a weak entity? Give an example of a weak [**4 Marks**]

iv. Discuss the difference between a composite key and a composite attribute. How would each be indicated in an Entity Relationship Diagram? [**4 Marks**]

v. Briefly, but precisely, explain the difference between single-valued attributes and simple attributes. Give an example of each. [**4 Marks**]

Question 4

i. In database development process, what does the term "fact-finding" mean? [**2 Marks**]

ii. State when "fact-finding" in Q3 (i) is particularly important during database development life cycle? [**2 Marks**]

iii. Explain why "fact-finding" is crucial to the database development process? Especially to phase you have stated in Q3 (ii). [**4 Marks**]

iv. State and briefly explain the five (5) most used fact-finding techniques you may adopt for your database design.[**10 Marks**]

v. Why is a table whose primary key consists of a single attribute automatically in 2NF when it is in 1NF? [**2 Marks**]

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

END OF YEAR EXAMINATION

CSC 2901
DISCRETE STRUCTURES

Date: Friday 18th December, 2020
Time: 09:00hrs – 12:00hrs
Duration: 2 Hours

Instructions

1. There are **two (2) sections** in this paper.
2. *Answer all the questions in Section I* and choose ***any two (2) questions*** *from Section II*

SECTION A: ANSWER ALL QUESTIONS. **[40 Marks]**

1. Let A and B be sets. Define the following
   a. $A \subseteq B$ [2 Marks]
   b. $A - B$, the difference set [2 Marks]
   c. $A \otimes B$, the symmetric difference set [2 Marks]
   d. A' [2 Marks]
   e. $|A|$, the cardinality of A [2 Marks]
2. Define the following
   a. What is an algorithm? [4 Marks]
   b. Mention four of the characteristics of algorithms. [4 Marks]
   c. Discuss the two ways in which an algorithm can be expressed [2 Marks]
3. Let A and B be sets, define the following
   a. The Cartesian product of A and B [2 Marks]
   b. The relation R of from A and B [2 Marks]
   c. Equivalence relation [4 Marks]
4. State the division algorithm. [2 Marks]
5. Let a, b be integers and n be a positive integer. Explain what does a is congruent to b *modulo* n i.e. $a \equiv b(mod\ n)$ mean? [4 Marks]
6.
   a. Let A be a set of $0s$ and $1s$ and $(A, +, ., ', 0, 1)$ be a Boolean algebra. Suppose x, y and z be in A. State the following laws of a Boolean algebra.
      i. Commutative law [2 Marks]
      ii. Distributive law [2 Marks]
      iii. DeMorgan's law [2 Marks]

SECTION B: ANSWER ONLY TWO OF THE FOUR QUESTIONS. EACH QUESTION HAS 30 MARKS.

1. Consider the algorithm in the pseudocode below

```
algorithm mystery(m, n)
        input: m and n, positive integers
        output: ???
        q := 0
        r := m
        while m > n do
                m := m - n
                q := q + 1
        end while
        print q
        print m
end.
```

   a. Draw the flowchart for the code above. [10 Marks]
   b. Simulate the execution of
      i. *mystery(8, 3)* [6 Marks]
      ii. *mystery(3, 8)* [4 Marks]

c. What does *mystery* do? [5 Marks]

d. Write a java method, which implements mystery. [5 Marks]

2. Let $A = \{1, 2, 3, 4\}$. Let R and S be relations defined on A with
   - $xRy\ iff$ a + b is even
   - $xSy\ iff\ x \leq y$

   For each of the relations above

   a. List the elements of the relation [8 Marks]

   b. Give the matrix representation of the relations [6 Marks]

   c. Draw the digraph of the relations [6 Marks]

   d. What are the equivalence classes of R? [4 Marks]

   e. Draw the Hasse diagram of S [6 Marks]

3. Suppose Alice selects two primes $p = 7$ and $q = 5$. She chooses $(e, n) = (13, 35)$ as the public key for the RSA encryption.

   a. What is her private key? [10 Marks]

   b. Suppose Bob encrypts the plain message $m = 3$, what is the ciphertext c received by Alice? [10 Marks]

   c. Show that the ciphered text is deciphered correctly [10 Marks]

4.

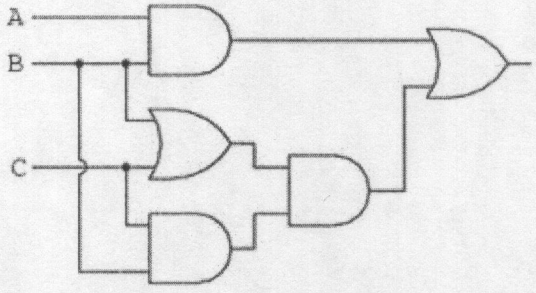
   a. Let (A, +, ., ', 0, 1) be a Boolean Algebra. Let x and y be members of A.

      Show that x +x'.y = x + y using

      i. analytical means, [5 Marks]

      ii. K-map [5 Marks]

   b. Given the logic network below.



      i. Derive a Boolean expression of this network [6 Marks]

      ii. Simplify the expression. [10 Marks]

      iii. Draw the logic network of the simplified expression [4 Marks]

**********END OF EXAMINATON**********

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

END OF YEAR EXAMINATION

CSC 2912
NUMERICAL ANALYSIS

Date: Monday 28th December, 2020
Time: 14:00hrs – 16:00hrs
Duration: 2 Hours

Instructions

1. There are **two (2) sections** in this paper.
2. *Answer all the questions in Section A* and choose ***any two (2) questions*** *from Section B*

SECTION A: ANSWERR ALL QUESTIONS **[40 MARKS]**

1. Let $f: X -> Y$ be a function and x_0 be a point in X. Define the following.
   a. f is continuous at x_0 [4 Marks]
   b. f is differentiable at x_0 [4 Marks]
2. Let p* be the approximation of a value p. Define the following
   a. Absolute error of approximating p by p^* [4 Marks]
   b. Relative error of approximating p by p^* [4 Marks]
3. State the following
   a. Rolle's theorem [4 Marks]
   b. Intermediate value theorem [4 Marks]
   c. Fixed-point theorem [4 Marks]
4. Suppose (x_0, y_0), (x_1, y_1),and (x_2, y_2), are points for a function f. Outline the appropriate approximations of the
   a. three-point formulas for $f'(x_0)$, $f'(x_1)$, and $f'(x_2)$, [6 Marks]
   b. $\int_{x1}^{x2} f(x)dx$ Using the
      i. Trapezoidal rule [3 Marks]
      ii. Simpsons [3 Marks]

SECTION B: ANSWER TWO OF THE FOUR QUESTIONS. EACH QUESTION CARRIES 30 MARKS

1.
   a. Let $f: X -> Y$ be a function and x0 be a point in X.
      i. Show that if f is differentiable on x_0, then it is also continuous at x_0 [8 Marks]
      ii. Suppose f is continuous in $[a, b] \subseteq X$, and $f'(x) \neq 0$ for all x in $[a, b]$, show that f has at most one root in [a, b]. [Hint: assume f has two roots in $[a, b]$ and show this lead to a contradiction using the Rolle's theorem [6 Marks]
   b. Let $f: R -> R$ be a function defined as f(x) = $e^{x/2}$.
      i. Derive P_4, the 4th Taylor polynomial about $x_0 = 0$. [8 Marks]
      ii. Use P_4 to approximate $\sqrt{e}$ [4 Marks]
      iii. What is the error bound for this approximation [4 Marks]

2.

a. Show that $f(x) = x^2 - 2$ has a root in $[1, 2]$ [6 Marks]

b. How many iterations are required to approximate $\sqrt{2}$ in [1, 2], to 10^{-3}accuracy using the Bisection method. [6 Marks]

c. Show that the fixed point of $g(x) = 1 + 1/(x + 1)$, is the root of $f(x) = x^2 - 2$. [8 Marks]

d. Hence use the fixed-point iteration to approximate $\sqrt{2}$ [10 Marks]

The following values are to be used in questions 3 and 4 below.

x	0.2	0.4	0.6	0.8	1.0
f(x)	0.31	0.65	0.94	1.32	1.46

3. Approximate $f(0.5)$ using

a. Neville's iterated method [15 Marks]

b. Newton's divided differences [15 Marks]

4.

a. Use the correct three-point formula to find $f'(0.6)$ [8 Marks]

b. Approximate

$$\int_{0.2}^{1.0} f(x)dx$$

c. Using the composite

i. Trapezoidal rule [10 Marks]

ii. Simpsons rule. [12 Marks]

[Ensure you use all the points in both cases]

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

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

END OF YEAR EXAMINATION

CSC 3011
ALGORITHM & COMPLEXITY

Date: FRIDAY, 27TH NOVEMBER 2020
Time: 09:00 – 12:00
Duration: 3 HOURS

Instructions

1. There are **two (2) sections** in this paper, Section I and Section II
2. Answer all the questions in Section I and choose **any two (2) questions** from Section II

SECTION I: ANSWER ALL THE QUESTIONS IN THIS SECTION

1. .

   a. What does $y = log_a(x)$ mean? [2 Marks]

   b. Suppose $3 = log_2(x)$ and $x = log_3(z)$, what is z? [2 Marks]

2. Why is it important to analyse algorithms? [4 Marks]

3.

   a. Define recursion [2Marks]

   b. Outline the four basic rules of recursion [4 Marks]

4.

   a. What is a data structure?

   b. Explain the difference between a queue and stack [4 Marks]

   c. Give two application of a

      i. queue

      ii. stack

5.

   a. What is a binary tree? [2 Marks]

   b. What is a perfect binary tree? [2 Marks]

   c. A Binary search tree and a min-heap are both binary trees. What is the difference between the two? [2 Marks]

   d. Suppose a perfect binary tree has a height of h. How many nodes, in terms of h, dos this tree have? [2 Marks]

6.

   a. What are the two imbalance conditions in an AVL tree? [2 Marks]

   b. How is each of the conditions above resolved? [2 Marks]

7.

   a. In hashing, explain the two collision resolution mechanisms, which can be implemented? [2 Marks]

   b. What does rehashing mean? [2 Marks]

8. Suppose you have an array of n numbers to be sorted in ascending order. What is the maximum number of comparisons and swaps performed on the list in sorting by

Algorithm	Comparisons	Swaps
Bubble		
Selection		
Insertion		

[6 Marks]

[Hint: Consider the case when the input array is sorted in descending order].

SECTION II: ANSWER TWO OF THE THREE QUESTIONS IN THIS SECTION. EACH QUESTION CARRIES 30 MARKS.

1.

a. Given two arrays, l1 and l2 both sorted in ascending order.
   i. Devise an algorithm, merge(l1, l2), which merges the two list such the merged list is also sorted. [8 Marks]
   [Note that a new array of length equal to the sum of the lengths of l1 and l2 should be created first]
   ii. What is the asymptotic complexity of your algorithm? [6 Marks]

b. Suppose an algorithm runs in $O(nlogn)$ and takes t time units to process a list of N items. How much time will this algorithm take to process twice the number of items? [8 Marks]

c. Describe an algorithm to reverse the contents of a queue, using the stack as an auxiliary data structure. [8 Marks]

2.

a. Design an algorithm findXY(A, n, z) which receives an array of n numbers and a number z, then checks if A contains adjacent numbers x and y such that [5 Marks]

$$x + y = z.$$

b. What is the asymptotic complexity (Big-oh analysis) of your algorithm? [count the number of operations executed, in terms of n] [5 Marks]

c. Consider the pseudocode below

```
algorithm mystery(n)
        input: n, a non-negative integer
        output: ??
        if n < 2 then
                print n
        else
                mystery(n/2)          //Integer division
                print n%2             //modulo operator
        end if
end.
```

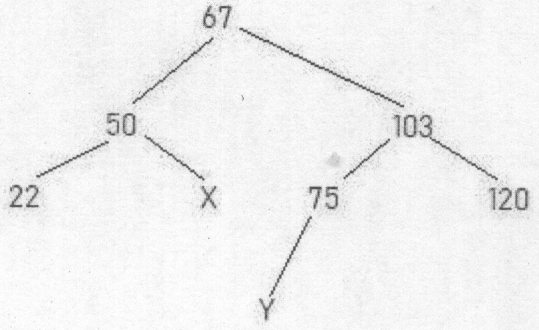
   i. Simulate the execution of mystery(10). [Note that this is right recursion. I.e. Print n%2 is executed after the recursive call in the else part.] [10 Marks]

ii. Devise the recurrence relation of mystery. [5 Marks]

iii. Solve the recurrence relation to show that mystery is of $O(\log(n))$. Note the base of log is 2 [5 Marks]

3.

a. Consider the binary search tree below



i. What is the height of this tree? [2 Marks]

ii. State the possible ranges of values of X and Y? [2 Marks]

iii. Show the order in which nodes are visited in

1. Pre-order traversal [4 Marks]
2. In-order traversal [4 Marks]
3. Post-order traversal [4 Marks]

iv. Use delete by copying to remove 67 from the tree

b. Insert the following numbers into an initially empty

103, 50, 75, 150, 120, 30, 10

i. AVL tree. [8 Marks]

ii. Hashtable of size 7, quadratic probing and rehash at 50% [6 Marks]

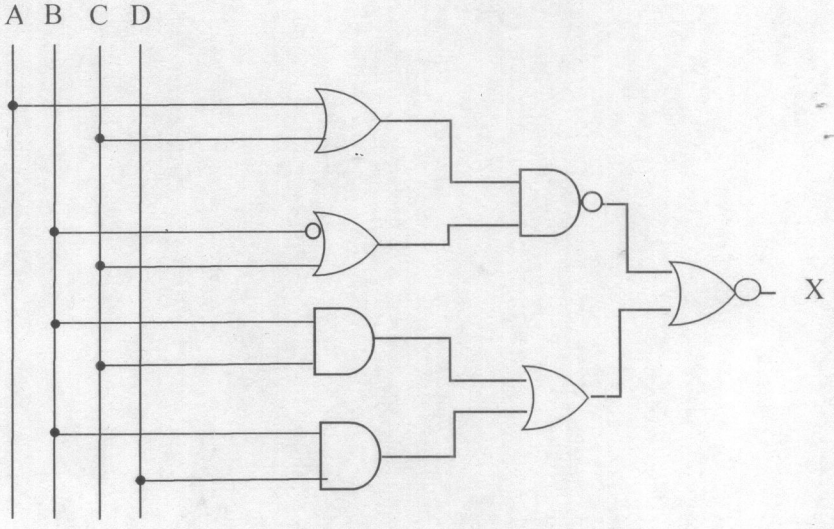
********** **END OF EXAMINATION** **********

The University of Zambia Examination 2020
School of Natural Science
Digital Electronics CS3120

Time: 3 Hours
Instructions: Answer any 4 questions
All questions carry 25 marks

1.

a. Write the Boolean equation for the circuit below.



b. Use De Morgan's theorem and Boolean algebra rules to simplify the equation.
c. Draw the simplified circuit.
d. Simplify the same circuit using a K-Map from the SOP. Draw the circuit.

2. The truth table below represents a voting system for a tribunal. A motion is accepted if at least two of the three judges vote yes (1). A, B and C represent each of the judge's votes and Y represents the output (1 for yes)

A	B	C	Y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

a. Make a K-Map to represent this truth table.
b. From the K-Map derive the simplified Boolean expression.
c. Draw the circuit.

3. Derive a circuit for a full adder.
   a. Draw the circuit.
   b. Draw the circuit for a four bit adder.

4.
   a. Draw the circuit for 3 to 8 bit decoder.
   b. Explain how a multiplexer operates and give an example of where it is used.

5. Draw the circuit of a 4 bit ripple counter.
   a. Draw the waveforms.
   b. What is the difference between a ripple counter and a synchronous counter?
   c. Draw the circuit of a 4 bit d-type register.

End of Exam

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

END OF YEAR EXAMINATION

CSC 3301
PROGRAMMING LANGUAGE DESIGN AND IMPLEMENTATION

Date: MONDAY, 30TH NOVEMBER 2020
Time: 14:00 – 16:00
Duration: 2 HOURS

Instructions

1. There are **Two Sections** in this paper.
2. You are required to answer ALL the questions in Section I and only two from section II.
3. All answers should be on a separate answer booklet.

SECTION I: ANSWER ALL QUESTIONS [40 Marks]

1. List the principal phases of compilation, and describe the work performed by each.
2. Describe the form in which a program is passed from the scanner to the parser; from the parser to the semantic analyzer; from the semantic analyser to the intermediate code generator.
3. What distinguishes the front end of a compiler from the back end?
4. What is the purpose of the compiler's symbol table?
5. What is the difference between static and dynamic semantics?
6. Why is it impossible to detect certain program errors at compile time, even though they can be detected at run time?
7. What is an attribute grammar?
8. What is the difference between synthesized and inherited attributes?
9. Suppose you have the following CFG

   A -> A r | A p | q

   a. Translate it into LL(1) parsable grammar

SECTION II: ANSWER TWO OF THE THREE QUESTIONS. ALL QUESTIONS CARRY 30 MARKS [60 MARKS]

1.

   a. Programming Languages are conceptually categorised as either Declarative or Imperative. These high level categories have sub categories.

      i. Briefly explain how declarative languages differ from imperative languages

      ii. Give one comparative advantage of one over the other. (i.e. advantage of declarative over imperative and advantage of imperative over declarative)

   b. A programming language can be implemented as compiled or interpreted, or a hybrid of the two.

      i. Explain the distinction between Compilation and Interpretation, with the illustration of diagrams

      ii. Give one comparative advantage of one over the other.

      iii. Give three reasons why there are several high-level programming languages today.

2. .

a. Write the regular expression which describe the language of binary numbers. The langusge does not recognise leading 0s. E.g it can recognise 100 but not 001.
b. Generate the NFA for the RE above
c. Convert the NFA into a DFA
d. Minimise the DFA

3.

a. Errors in a programming language can be classified according to when they are detected and if they are detected at compile time, what part of the compiler detects them. Using Java, give an example of the following errors and the part of the compiler that detects them.
    i. A lexical error
    ii. A syntax error
    iii. A static semantic error
    iv. A dynamic semantic error

b. Write an unambiguous context free grammar for the language of propositional logic and the Boolean expressions. E.g. the language should be able to describe variables p, q, and r, constants true and false and if E1 and E2 are Boolean expressions, then E1 $\wedge$ E2, E1 $\vee$ E2 and $\neg$E1 are also Boolean expressions. Further, $\neg$ has a higher precedence than $\wedge$ which is of higher precedence than $\vee$.

    i. Is your grammar LL(1) parsable? If not, translate it to one which is LL(1) parsable.

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC 3311

Structure and Interpretation of Computer Programs

Date:	30th November 2020
Time:	14:00hrs – 16:00hrs
Duration:	2 Hours
Venue:	NSLT

Instructions

1. There are **two (2) sections** in this paper.
2. *Answer all the questions in Section A* and choose *any two (2) questions from Section B*

SECTION A (Answer all questions) [40 marks]

1. Factorials can be implemented as a linear recursive or linear iterative process. What is the difference between a linear recursive and a linear iterative processes? **[4 marks]**
2. Each of the following two procedures defines a method for adding two positive integers in terms of the procedures inc, which increments its argument by 1, and dec, which decrements its argument by 1. Using the substitution model, illustrate the process generated by each procedure in evaluating (+ 4 5). Are these processes iterative or recursive? **[8 marks]**

```
(define (+ a b)
  (if (= a 0)
      b
      (inc (+ (dec a) b))))

(define (+ a b)
  (if (= a 0)
      b
      (+ (dec a) (inc b))))
```

3. What are higher order procedures and why are they important in programming? **[6 marks]**
4. What is procedural abstraction and why is it important with regards to software reuse? **[4 marks]**
5. Briefly discuss applicative and normal order of evaluation? **[4 marks]**
6. What are the three elements of a programming language? **[3 marks]**
7. Why is tagged data important in programming? **[4 marks]**
8. What is the output of running each of the following lines of code? **[4 marks]**

```
(= 4 10)
(= 4 4)
(equal? 4 4)
(+ x 3)
`(+ x 3)
(list (quote +) x '3)
(= "foo" "foo")
(eq? "foo" "foo")
```

9. What are local state variables and why are they an important concept in programming? **[3 marks]**

SECTION B (Answer any two questions) [60 marks]

1. Mathematical operations are fundamental building blocks of programming languages. There are several forms of notation that can be used to express mathematical instructions. Three main kinds of notations, prefix, postfix and infix notation are often used.
   a) What is infix, postfix and prefix notation? **[6 marks]**
   b) Translate the following expression into prefix form **[4 marks]**

$$\frac{5+4+(2-(3-(6+\frac{4}{5})))}{3(6-2)(2-7)}$$

   c) Assuming that prefix and postfix notations are limited to two operands per operator complete the table below **[8 marks]**

Infix Notation	Prefix Notation	Postfix Notation
`A + B * C + D`		
`(A + B) * (C + D)`		
`A * B + C * D`		
`A + B + C + D`		

   d) Draw parse trees for each of the prefix notation expressions in Question 1(c) above. **[12 marks]**

2. Parallel execution of objects places its own challenges in state management of objects and their consistency. Given the following code

```
(define x 10)
(parallel-execute (lambda () (set! x (* x x)))
                  (lambda () (set! x (* x x x))))
```

   a) Deduce all possible values of x that can result from executing the code if processes are interleaved **[10 marks]**
   b) What is serialization? **[2 marks]**
   c) Which of the possibilities in question 2(a) remain if we instead use serialized procedures. **[3 marks]**
   d) Explain how the environmental model of execution works and why it is important in object oriented programming? **[5 marks]**
   e) Given that environment E1 is a sub environment of the global environment GE, illustrate the following using frames; **10 marks]**
      i. `(define z 20)` | GE `(define z 25)` | E1
      ii. `(set! z 20)` | GE `(set! z 25)` | E1

3. With the simplest of constructs, it is possible to build complex compound data types
   a) What is a procedure and how is it related to data? **[3 marks]**
   b) Write code for the implementation of Rational numbers showing

i. a Constructor **[4 marks]**
ii. Accessors **[4 marks]**
iii. Contracts **[4 marks]**
iv. Operations for addition and multiplication of rational numbers. **[6 marks]**

c) Using box and pointer notation illustrate
$(cons\ (cons\ 1\ (cons\ 2\ 3))4)$ **[2 points]**

d) Lists are very useful constructs in programming languages
i. What is a list?
[3 marks]
ii. Write code implementing a list using scheme with insertion and removal functionality.
[4 marks]

The end of this examination paper

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

END OF YEAR EXAMINATION

CSC 3402
ARTIFICIAL INTELLIGENCE

Date: TUESDAY, 17TH NOVEMBER 2020
Time: 09:00 – 12:00
Duration: 3 HOURS

Instructions

1. There are **two (2) sections** in this paper, Section I and Section II
2. Answer all the questions in Section I and choose **any two (2) questions** from Section II

SECTION I: ANSWER ALL THE QUESTIONS IN THIS SECTION

1. Define the following
   a. Agent [2Marks]
   b. Rational agent [2 Marks]

2. Explain what the following types of agent environments are.
   a. Discrete [2 Marks]
   b. Episodic [2 Marks]

3.
   a. Describe the four elements that need to be defined in formulating a problem for search [4 Marks]
   b. Give a generic algorithm for a search [4 Marks]

4. Define the following
   a. Heuristic [2 Marks]
   b. Admissible heuristic [2 Marks]
   c. Consistent heuristic [2 Marks]

5.
   a. Define the following, what local search is. [2 Marks]
   b. Describe two examples of local search algorithms. [2 Marks]

6.
   a. What is constraint satisfaction problem? [2 Marks]
   b. Describe the three procedures used in determine the order in which the assigning values to variables proceeds in a CSP [2 Marks]

SECTION II: ANSWER TWO OF THE THREE QUESTIONS IN THIS SECTION. EACH QUESTION CARRIES 30 MARKS.

1.

a. Prove that if a heuristic is consistent, then it is also admissible. [8 Marks]

b. Describe the fours factors used in measuring the performance of the search algorithm. [8 Marks]

c. Use these factors to give a comparative assessment of the breadth-first search and the depth-first search. [8 Marks]

d. Depth-first search is said to be prone to loops. Discuss some one measure, which can be taken to solve this problem. [6 Marks]

2. Consider the following farmer problem puzzle.

> "A farmer and his wolf, goat, and cabbage come to the north side of a river that they wish to cross. There is a boat, but it has only room for two, and the farmer is the only one that can row. If the goat and the cabbage are left alone together, the goat will eat the cabbage. Similarly, if the wolf and the goat are together without the farmer, the goat will be eaten."

a. Devise the formulation for solving this problem using search. [Devise the state representation, start state, goal-test, operators] [12 Marks]

b. Develop a heuristic h for this problem. [Ensure that $h(n) \geq 0$ and $h(G) = 0$ for any node n and the goal node G.] [4 Marks]

c. Explain whether your heuristic is admissible or not. [4 Marks]

a. Suppose each operator costs 1 unit. Draw an A* search tree of depth 4 for this problem, using the heuristic above. Use no return to ancestor procedure in your search. [10 Marks]

3.

a. A factory manufactures equipment, by performing the tasks A, B, C and D. Each of the tasks, take 1 hour so the factory opens at 8:00hrs and closes at 13:00hrs, every weekday (it is closed on weekends). Currently all the 4 personnel spend the full 4 hours at the factory getting a wage of K1,500.00 per hour.

i. What is the total weekly wage bill for the factory? [5 Marks]

b. The factory realises that it can save by letting the personnel report at appropriate times, when their tasks starts and leave when the task is completed. It is noticed that tasks B and D can't begin before Task A ends a and C only starts after B and D are completed. Task B and D can run at the same time.

i. Draw the constraint graph for this problem. [5 Marks]

ii. Show the order in which the start times are allocated to the tasks to come up with a schedule. (Use alphabetical or numerical order for tie-breaker) [5 Marks]

iii. Using your schedule, how long does the factory need to be open for all the tasks to be completed? [5 Marks]

iv. Calculate the new wage bill using your schedule. [5 Marks]

v. Suppose task B and D cannot be performed at the same time, come up with the new schedule taking this into account? [5 Marks]

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

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC 3600
SOFTWARE ENGINEERING

Date: 23rd NOVEMBER 2020
Time: 14:00hrs – 17:00hrs
Duration: 3 Hours
Venue: NSLT

Instructions

1. *Answer **all** the questions in Section A* and choose *any **three (3)** questions from Section B*

SECTION A
ANSWER ALL QUSTIONS IN THIS SECTION

QUESTION 1 [20 marks]

A. Assume that you are a project manager of three projects with the following characteristics:

- Project 1. A complex real-time system whose requirements can be relatively easily identified and are stable.
- Project 2. A website for a local library. Requirements are vague and are likely to change in the future.
- Project 3. An order processing system with a website for a local business. Requirements are vague but stable (i.e. unlikely to change in the near future).

Consider also the following software development approaches/models: waterfall, incremental, evolutionary prototyping, throw-away prototyping and component based development. Which of the above models would you choose for each of your projects? Your choices should be properly justified. **[9 marks]**

B. Explain the difference between software reusability and software reuse.

[4 marks]

C. Agile Development is a process that values customer collaboration over contract negotiation. Discuss THREE issues a Software Engineer should be mindful of when adopting this approach during software development. **[7 marks]**

QUESTION 2 [20 marks]

A. What is a user story? Answer with an example. What is a product backlog? How is it related to a sprint backlog? **[6 marks]**

B. Who is an actor? List all variations of an actor with examples. **[5 marks]**

C. Explain the differences between coupling and cohesion **[6 marks]**

D. Explain how the DFD model can help one understand the working of a software system **[3 marks]**

SECTION B
ANSWER ANY THREE (3) QUESTIONS IN THIS SECTION

QUESTION 3 [20 marks]

A. Identify the objects from the following dental office problem statement:
Tom is starting a dental practice in a small town. He will have a dental assistant, a dental hygienist, and a receptionist. He wants a system to manage the appointments.

When a patient calls for an appointment, the receptionist will check the calendar and will try to schedule the patient as early as possible to fill in vacancies. If the patient is happy with the proposed appointment, the receptionist will enter the appointment with patient name and purpose of appointment. The system will verify the patient name and supply necessary details from the patient records including the patient's ID number. After each exam or cleaning, the hygienist or assistant will mark the appointment as completed, add comments, and then schedule the patient for the next visit if appropriate.

The system will answer queries by patient name and by date. Supporting details from the patient's records are displayed along with the appointment information. The receptionist can cancel appointments. The receptionist can print out a notification list for making reminder calls 2 days before appointments. The system includes the patient's phone numbers from the patient records. The receptionist can also print out daily and weekly work schedules with all the patients. **[4 marks]**

B. Draw a class diagram for the dental problem **[7 marks]**

C. Compare and contrast the three different modelling spaces—especially in terms of the roles within those spaces. **[6 marks]**

D. Give meaningful examples of each of the following types of relations among classes. Only class diagram and a line of explanation is required in each case. **[3 marks]**

i. Aggregation

ii. Association

iii. Dependency

QUESTION 4 [20 marks]

A small specialist language training company would like to improve the services offered to existing clients and increase its client base by replacing existing call centre and paper-based mailshots, with online web technology deployment.

A. As a consultant requirements engineer, discuss the tools and techniques that you would deploy to elicit, analyse, document, and check services requested by the company and any actual or implied constraints. **[12 marks]**

B. Discuss whether it is advantageous for the company to continue requirements engineering beyond the first phase of the development process. **[8 marks]**

QUESTION 5 [20 marks]

A. Explain what is meant by software product complexity, and demonstrate how measures of module coupling, cohesion, and size can help the engineer monitor the build quality of software **[10 marks]**

B. Functionality is one of the most important software quality characteristics. Give the definition of functionality. It has been suggested that the functionality is influenced by the following software quality sub-characteristics: suitability, accuracy, interoperability and security. Justify this claim. **[10 marks]**

QUESTION 6 [20 marks]

A. Explain what is meant by the phrase "software as a service" giving at least 3 examples of software services available today. **[8 marks]**

B. As a Software Engineering consultant, you have been asked to advise a small company on the advantages and disadvantages of using an externally provided payroll system provided as a software service. In your answer, outline both the advantages and disadvantages to the company. **[12 marks]**

END OF PAPER

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

IT PROJECT MANAGEMENT
CSC 3612

2019-2020 FINAL EXAM

Date:	20th November 2020
Venue:	NSLT
Time:	14:00hrs – 16:00hrs
Duration:	2 Hours

Instructions

1. *This examination has two sections A and B*
2. *Section A comprises four [4] questions. Answer any two [2] questions. Each question carries 20 marks.*
3. *Section B comprises one [1] question. Answer the question. It carries 20 marks.*

Section A

[2x20 = 40 Marks]

Answer any Two [2] questions. Each question carries 20 Marks

Question 1 [20 marks]

A. What is Project Management? [2] List and briefly explain the different project managent knowledge areas? [10]

B. How do you define the success or failure of the Project? [3] What factors helps project succeed? [5]

Question 2 [20 marks]

A. XYZ Corporation is using weighted scoring model to select one project out of four projects. The importance criteria as well as ratings of four projects are given below. Which of the following projects will be selected? [4]

Criteria	Weight	Project 1	Project 2	Project 3	Project 4
Supports business objectives	35%	90	80	80	85
Customer support	22%	65	70	15	5
Shorter implementation period	18%	85	60	40	15
Tax incentives	25%	50	60	55	40

B. Write short notes on Net Present Value, Return on Investment and Payback Period? [6]

C. Explain in detail about the integrated change control? [6]

D. List out the common elements of a Project Management Plan? [4]

Question 3 [20 marks]

A. What are the processes in the project scope management? [6]

B. Explain the different methods for collecting requirements? [6]

C. Describe the different approaches to develop WBS? [5]

D. What are the best practices to avoid scope problem? [3]

Question 4 [20 marks]

A. Explain the following schedule development tools and concepts: Gantt Charts, Critical path method, PERT, and Critical chain scheduling? [12]

B. Explain the different processes involved in Project time management? [8]

Section B[Compulsory] [1x20 = 20 Marks]

Answer the question. This question carries 20 Marks

Question 5 [20 marks]

A. Given the following information for a one-year project, answer the following questions.

Planned Value (PV)	= $35,000
Earned Value (EV)	= $30,000
Actual Cost (AC)	= $40,000
Budget at completion (BAC)	= $150,000

i. What is the cost variance, schedule variance, cost performance index (CPI), and schedule performance index (SPI) for the project? [4]

ii. How is the project doing? Is it ahead of schedule or behind of schedule? Is it under budget or over budget? [2]

iii. Use the CPI to calculate the estimate at completion (EAC) for this project, Is the project performing better or worse than planned?[2]

iv. Use the SPI to estimate how long it will take to finish this project? [2]

B. What is cost estimating? What are the different types of cost estimates? Explain the basic tools and techniques used for cost estimates? Give some reasons of problems faced in cost estimates [10]

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC 3712
ADVANCED DATABASES

Date:	19th NOVEMBER 2020
Time:	14:00hrs – 16:00hrs
Duration:	2 Hours
Venue:	NSLT

Instructions

1. *Answer **all** the questions in Section A* and choose *any **three (3)** questions from Section B*

SECTION A (Answer all questions)

QUESTION 1 (20 marks)

A. **[8 marks]** With respect to database transaction management explain the following terms.
   i.) Atomicity.
   ii.) Consistency.
   iii.) Isolation.
   iv.) Durability

B. **[4 marks]** What is the difference between attributes and elements in XML? List some of the important attributes used to specify elements in XML schema.

C. **[4 marks]** What does RAID stand for, and what are some commonly used RAID levels?

D. **[2 marks]** What is SQL performance tuning?

E. **[2 marks]** Explain the following statement: A transaction is a logical unit of work.

QUESTION 2 (20 marks)

A. **[3 marks]** What three join types are included in the OUTER JOIN classification?

B. **[4 marks]** How is a horizontal partitioning of a relation specified? How can a relation be put back together from a complete horizontal partitioning?

C. **[6 marks]** Discuss the architecture of a DDBMS. Within the context of a centralized DBMS, briefly explain new components introduced by the distribution of data.

D. **[5 marks]** What are the five types of knowledge produced from data mining?

E. **[2 marks]** What are the goals or tasks that data mining attempts to facilitate?

SECTION B (Choose any three)

QUESTION 3 (20 marks)

A. Use the Tables provided below to write the SQL queries:

Books

book_id	title	author
1	Way We Live Now	Anthony Trollope
2	Dual	Giacomo Casanova
3	Wuthering Heights	Emily Bronte
4	My Friend Maigret	Georges Simenon
5	Dracula	Bram Stoker
6	Moby Dick or the Whale	Herman Melville
7	Power and the Glory	Graham Green
8	Years	Virginia Wolf
9	Oliver Twist	Charles Dickens
10	Emma	Jane Austen

Members

mem_id	fname	lname
100	Mel	Gibson
101	Kenneth	Branagh
102	Keifer	Sutherland
103	Bert	Newton
104	Ray	Liota
105	John	Cusak

Loan_Data

book_id	mem_id
2	101
4	103
5	105
8	100
7	104

I. **[3 marks]** What book/s does member 103 have out, if any?

II. **[3 marks]** The names and numbers of those with no books out?

III. **[3 marks]** Books in stock but not checked out to anyone?

IV. **[4 marks]** Books currently checked out, together with the name of the member they've been checked out to?

B. [3 marks] What is a subquery, and what are its basic characteristics?

C. [4 marks] What is a CROSS JOIN? Give an example of its syntax

QUESTION 4 (20 marks)

A. Document 1

```
<?xml version="1.0" encoding="UTF-8"?>
<student>
        <firstName>Luca</firstName>
        <lastName>Rossi</lastName>
        <id>281283</id>
        <plan>
        <courses year="3">
        <course>
        <name> Programmazione Orientata agli Oggetti </name>
        <shortName>POO</shortName>
        <record>
        <grade>30</grade>
        <date>13/06/11</date>
        </record>
        </course>
        <course>
        <name>Analisi e progettazione del software</name>
        <shortName>APS</shortName>
        </course>
        </courses>
        </plan>
</student>
```

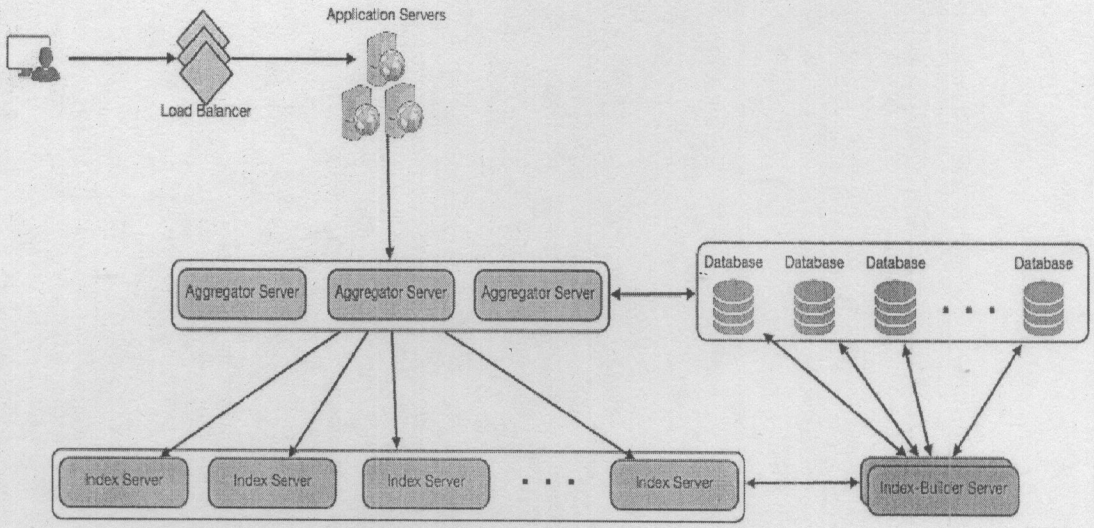
[10 marks] Define a **DTD** that validates **Document 1**

B. **[4 marks]** What is the difference between data-centric and document-centric XML documents?

C. **[6 marks]** What are the differences between structured, semistructured, and unstructured data?

QUESTION 5 (20 marks)

A. Below is detailed component design diagram for a twitter app.



I. **[6 marks]** Explain the functions and benefits of a load balancer

II. **[6 marks]** Discuss the differences between Horizontal and Vertical Scaling

III. **[8 marks]** Discuss the differences between SQL and NoSQL. For each state the instances where it can be applied.

QUESTION 6

A. **[4 marks]** How is the processing of SQL DDL statements (such as CREATE TABLE) different from the processing required by DML statements?

B. **[6 marks]** In simple terms, the DBMS processes a query in three phases. What are the phases, and what is accomplished in each phase?

C. **[4 marks]** What is the difference between a rule-based optimizer and a cost-based optimizer?

D. **[6 marks]** Most query optimization techniques are designed to make the optimizer's work easier. What factors should you keep in mind if you intend to write conditional expressions in SQL code?

END OF EXAM

That's it! Happy holidays!!!

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

MANAGEMENT INFORMATION SYSTEMS
CSC 3750

2019-2020 FINAL EXAM

Date: 18th November 2020
Venue: NSLT
Time: 09:00hrs – 11:00hrs
Duration: 2 Hours

Instructions

1. *This examination has two sections A and B*
2. *Section A comprises one [1] question. Answer the question. It carries 20 marks.*
3. *Section B comprises four [4] question. Answer any two [2] questions. Each question carries 20 marks.*

Section A[Compulsory] [1x20 = 20 Marks]

Answer the question. This question carries 20 Marks

Question 1 [20 marks]

A. What is a Business Process? [2] Identify four functional area and give 2 examples of business processes in each area? [4]

B. Identify the steps that are performed in the process of selecting and checking out a book from your college library and the information that flows among these activities. Diagram the process. Are there any ways this process could be changed to improve the performance of your library or your school? Diagram the improved process. [4]

C. What are the basic concepts for ethical analysis? [4]

D. Identify and describe six ethical principles? [6]

Section B [2x20 = 40 Marks]

Answer any four [2] questions. Each question carries 20 Marks

Question 2 [20 marks]

A. Explain the different technology drivers of infrastructure evolution? [4]

B. List any four main components in the IT infrastructure?[2] Briefly Explain any two components? [4]

C. What are the contemporary tools and technologies in business intelligence infrastructure? [5]

D. What is the difference between Data Mining, Text Mining and Web Mining?[5]

Question 3 [20 marks]

A. Define and describe VoIP and virtual private networks, and explain how they provide value to businesses? [6]

B. Explain any two key digital networking technologies? [4]

C. Define Malware? Briefly explain the different malware which affects the information systems? [10]

Question 4 [20 marks]

A. Distinguish between a push-based and a pull-based model of supply chain management [4] and explain how contemporary supply chain management systems facilitate a pull-based model [2].

B. What is the Business value of CRM systems? [4]

C. Explain the three major types of Knowledge Management Systems? [10]

Question 5 [20 marks]

A. What is Business Process Management? [3] Identify the steps involved in the BPM? [5]

B. Lincoln Pizza is a small restaurant on Lincoln Ave. Most of its customers are EIU students. In the current manual ordering system, the restaurant employees have to go through three different activities in order to process a pizza order. The first activity, called Receiving the order, consists in getting customers' information (such as name, phone number, and address), and getting orders' information (such as the pizza size, the type of crust, and the ingredients needed to make the pizza). The same process also checks the availability of the ingredients needed before setting the status of the pizza order as "valid". When a pizza order is valid, the employee in charge of Receiving the order provides the valid order information to the cooks who make the pizza. The second activity, Making the pizza, consists in getting the ingredients needed (from containers in the kitchen) and actually cooking the pizza. At the end of that process, the cooks have to update the manual file that keeps track of the ingredients. They, then, provide the drivers in charge of delivering the pizza with the (completed) status of the order. The final activity, Delivering the pizza, done by the drivers consists in getting address and payment information from the employee in charge of Receiving the order, and actually delivering the pizza. The drivers provide the customers with a receipt and get the payment.

   a) Name all the processes to be found in the Data Flow Diagram of the system. [4]

   b) Name all the external entities to be found in the Data Flow Diagram of the system.[2]

   c) Name all the data stores to be found in the Data Flow Diagram of the system.[2]

   d) Draw the Data Flow Diagram for the new Lincoln Pizza's ordering system. [4]

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC 3801
COMPUTER NETWORK AND DATA COMMUNICATION

Date:	25th NOVEMBER 2020
Time:	14:00hrs – 16:00hrs
Duration:	2 Hours
Venue:	P207

Instructions

1. There are **two (2) Sections** in this exam, **Section A** and **Section B**.
2. In Section A, **answer all the questions** and in Section B **choose any three (3) questions**.

SECTION A [40 MARKS]

ANSWER ALL THE QUESTIONS IN THIS SECTION

Question 1 [20 marks]

a) List the service primitive types. **[4 marks]**

b) Explain the relationship between data rate and bandwidth. **[4 marks]**

c) What is the relationship between the wavelength and frequency of a sine wave? **[4 marks]**

d) Names the examples of requirements that call for higher-speed LANs. **[4 marks]**

e) What are important characteristics of a periodic signal? **[4 marks]**

Question 2 [20 marks]

a) What are the advantages and the disadvantages of the digital signals? **[4 marks]**

b) What are some advantages to layering as seen in the TCP/IP architecture? **[4 marks]**

c) List any four protocols in the application layer **[4 marks]**

d) Differentiate synchronous from asynchronous transmission. **[4 marks]**

e) What is the shannon capacity formula? **[4 marks]**

SECTION B [60 MARKS]

ANSWER ANY THREE (3) QUESTIONS FROM FOUR (4) IN THIS SECTION

Question 3 [20 marks]

a) The three guided media commonly used for data transmission are twisted pair, coaxial cable, and optical fiber. Discuss these media. **[7.5 marks]**

b). Trends in technology enable the provision of increasing traffic capacity and the support of a wide range of services. Four technology trends are particularly notable. Discuss the trends. **[7.5 marks]**

c) In the last 20 years, two significant trends altered the role of the personal computer and therefore the requirements on the LAN. Discuss the two significant trends. **[5 marks]**

Question 4 [20 marks]

a) Explain in detail about the satellite microwave. **[7.5 marks]**

b) Discuss the characteristics distinguishing optical fiber from twisted pair. **[7.5 marks]**

c) Discuss the factors that determine how successful the receiver will be in interpreting the incoming signal. **[5 marks]**

Question 5 [20 marks]

a) Explain in detail about the infrared communications. **[7.5 marks]**

b) With any communications system, the signal that is received may differ from the signal that is transmitted, due to various transmission impairments. Discuss the most significant impairments. **[5 marks]**

c) A number of design factors relating to the transmission medium and the signal determine the data rate and distance. Discuss these design factors. **[7.5 marks]**

Question 6 [20 marks]

a) Explain in detail about broadcast radio. **[7.5 marks]**

b) The Internet today is made up of thousands of overlapping hierarchical networks. Discuss the six internet terminologies. **[5 marks]**

c) The question naturally arises as to which is the preferred method of transmission. The answer being supplied by the telecommunications industry and its customers is digital. Both long-haul telecommunications facilities and intrabuilding services have moved to digital transmission and, where possible, digital signaling techniques. Discuss the most important reasons for moving into digital transmission **[7.5 marks]**

THE END

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

WEB PROGRAMMING AND TECHNOLOGIES
CSC4035

FINAL EXAMINATION

Date:	Tuesday, 24th November, 2020
Venue:	NSLT
Time:	14 – 17hrs
Duration:	3hrs

Instructions

1. This exam has two sections A and B.
2. Answer **ALL** the questions from **Section A.**
3. Answer any **three (3)** questions from **Section B.**

SECTION B – Choose any three (3) questions

QUESTION 1

A. **[2 marks]** Below you will see some snippets of HTML from a Web page. Fill in the body of the Javascript function *changeColor* so that the color of the text changes in response to the selection made in the menu

```
<style type="text/css">
    .a {color:red;}
    .b {color:green;}
    .c {color:blue;}
</style>
...
<div id="colorText">Select below to change the color of this text</div>
    <select onchange="changeColor(this.value)">
        <option value="a">Red</option>
        <option value="b">Green</option>
        <option value="c">Blue</option>
    </select>
    <script type="text/javascript">
        //<![CDATA[
        function changeColor(value) {
        }
        //]]>
</script>
```

B. **[4 marks]** Explain how client-side form validation is different from server-side form validation. What benefits does each bring?

C. **[4 marks]** Internet of things (IoT) is defined as "the infrastructure of the information society." Briefly explain what this means using appropriate examples.

D. **[4 marks]** Determine the output of the code below. Explain your answer.

```
var myObject = {
      egg: "plant",
      func: function() {
            var self = this;
            console.log("outer func: this.egg = " + this.egg);
            console.log("outer func: self.egg = " + self.egg);
           (function() {
            console.log("inner func: this.egg = " + this.egg);
            console.log("inner func: self.egg = " + self.egg);
            }());
       }
};
myObject.func();
```

```
        </script>
    </body>
</html>
```

Once the above web page is loaded what will be the outcome?

6. **[6 marks]** HTML5 adds new tags for `<header>`, `<nav>` and `<footer>`. What are these used for and what was the reason that they were added to the new standard?
7. **[8 marks]** Identify and describe four properties that are used in the CSS box model (feel free to draw a figure if you want).
8. **[2 marks]** Explain the differences between POST and GET when sending HTML form data

E. [6 marks] Write a JavaScript function that calculates the number of days left till the Christmas Date

QUESTION TWO

A. **[10 marks]** Consider the following HTML file:

```
<!DOCTYPE html>
<html>
    <head>
        <title> Test Page </title>
    </head>
    <body>
        <header ><h1> This is a test page </h1></header>
        <nav id="menu">
            <ul>
                <li><a href ="home.php">Home </a/> </li>
                <li><a href ="login.php">Login </a> </li>
                <li><a href ="register.php">Register </a/> </li>
            </ul>
        </nav>
        <section id="main">
            <article>
                <p>This is a line </p> This is another line with a
                <a href="link.html">link </a> </article>
            <article>
                <p> This is a line.</p>
                <p> This is another line.</p>
            </article>
        </section>
    </body>
</html>
```

Write the CSS rules needed to:

(1) Change the width of the menu to 400px.

(2) Make all links in the menu bold

(3) Change the color of the link in the first article to green

(4) Turn the list into an inline element

(5) Delete the Home line of the list

B. **[2 marks]** What key issues will need to be addressed for IoT to be fully accepted?

C. **[2 marks]** How would you empty the array below?

```
Var emptyArray = ['this', 'array', 'is', 'full'];
```

D. **[6 marks]** Define the term API and state the purpose it serves.

QUESTION THREE

A. **[10 marks]** Write a simple function (less than 80 characters) that returns a boolean indicating whether or not a string is a palindrome (A palindrome is word, phrase, or sequence that reads the same backward as forward, e.g., *madam* or *nurses run*)

B. **[4 marks]** Determine the output of the code below. Explain your answer.

```
var lorem = { ipsum : 1};
var output = (function(){
    delete lorem.ipsum;
    return lorem.ipsum;
})();

console.log(output);
```

C. **[6 marks]** Discuss eight (8) principles of user interface design clearly stating the problem addressed by each

QUESTION FOUR

A. **[4 marks]** Determine the output of the code below. Explain your answer.

```
console.log(0.1 + 0.2);

console.log(0.4 + 0.1 == 0.5);
```

B. **[10 marks]** As a Web Engineer, identify at least FIVE major challenges in the design and development of an image-hosting site, where users can upload their images to a central server and the images can be retrieved via a web link or an API.

C. **[4 marks]** List two things a website author can do to improve the ranking of a page on a web search engine and explain why these things have this effect.

D. **[2 marks]** Compare XML and HTML

QUESTION FIVE

A. **[4 marks]** Write a JavaScript program to compute the sum of three elements of a given array of integers of length 3.

B. **[6 marks]** Write short notes on MVC

C. **[4 marks]** Give an example of a framework for Mobile Hybrid apps. Compare this with traditional mobile development tools.

D. **[2 marks]** Write short notes on DNS

E. **[4 marks]** An XML document can be validated against a DTD (Document Type Definition). Explain what this means and why it is useful to be able to do this for some applications.

Omnium Optimi!!

THE UNIVERSITY OF ZAMBIA

School of Natural Science

Department of Computer Science

FINAL EXAMINATION

CSC 4130: ADVANCED HARDWARE DESIGN AND IMPLEMENTATION

Date:	Friday, 20th November 2020
Time:	14:00hrs – 17:00hrs
Duration:	3 Hours
Venue:	NSLT

Instructions

1. There are **five (5) questions** and **two (2) sections** in this paper.
2. Each question carries **25 marks,**
3. *You are required to answer a total of **Four (4) Questions***
   a. *Answer **all** the questions in **Section A***
   b. Choose ***One (1)** questions from **Section B***

SECTION A

This Section has Three Questions. Answer all the questions

Question I

a) Draw a well labelled diagram showing the following memory units. Discuss how each memory unit store a bit. [6 Marks]
   i. DRAM
   ii. SRAM

b) An instruction is a binary pattern designed inside a microprocessor to perform a specific function. The entire group of instructions, called the instruction set, determines what functions the microprocessor can perform. The intel 8085 Instruction set can be classified into the following five functional categories:
   i. data transfer (copy) operations,
   ii. arithmetic operations,
   iii. logical operations,
   iv. branching operations, and
   v. machine-control operations

   Discuss each of the instruction set with at least one example of the actual instruction performed by the intel 8085 microprocessor [10 Marks].

c) The 8085-instruction set is classified into the following three groups according to word size [6 Marks]
   i. One-word or 1-byte instructions
   ii. Two-word or 2-byte instructions
   iii. Three-word or 3-byte instructions

   Briefly discuss each of the above Intel 8085 instruction set above

d) A servo motor is a motor that pulses at a certain rate moving its gear at a certain angle. Using PIN 13 as the digital PIN, write the full well commented code for the **Arduino Standard Servo Rotation to Exact Angel** [3 Marks].

Question II

a) The intel 8085 uses Machine language which is a set of instructions executed directly by the processing unit. Each instruction of the intel 8085 performs a very specific task, such as LOAD, JUMP, or an ALU operation on a unit of data in a CPU register or memory. **Write the machine code** for the Intel 8085 microprocessor used to [6 Marks]

i. Add two numbers (11010011 and 10001010)

ii. Subtract two numbers, 10001010 from 11010011

b) The 8085-programming model includes six registers, one accumulator, and one flag register, as shown in the diagram below. In addition, it has two 16-bit registers, the stack pointer and the program counter. Describe each of the following [7 Marks]

i. Six registers,

ii. Accumulator,

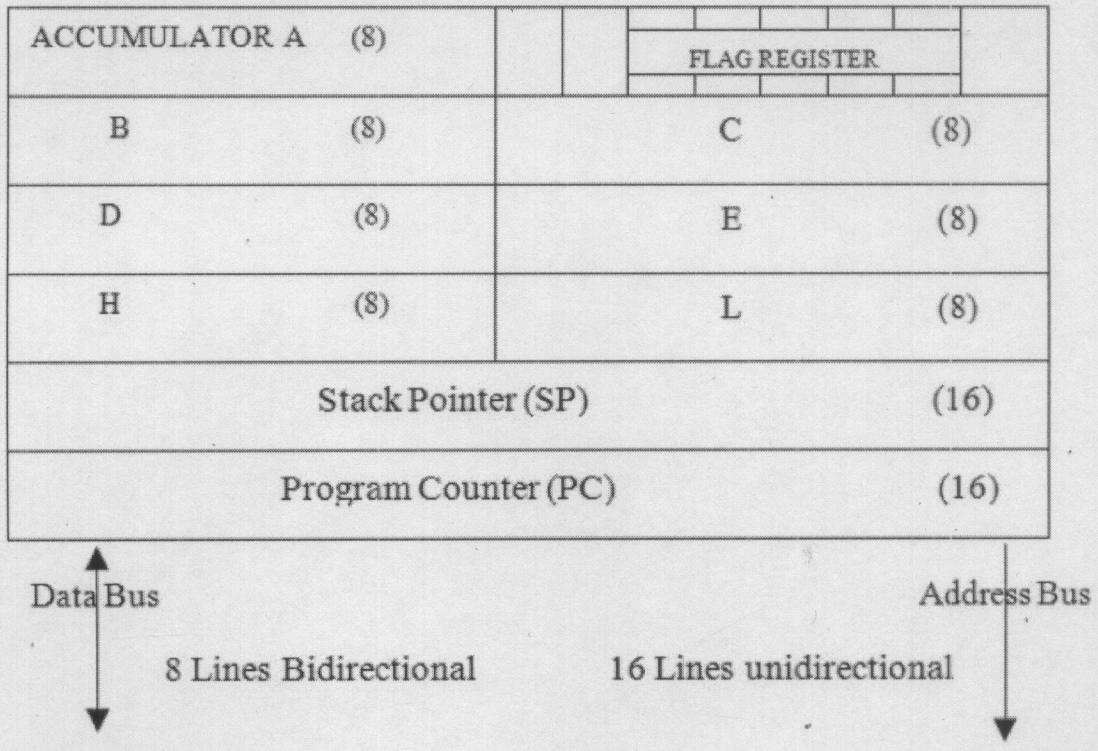
iii. flag register

iv. Stack Pointer

v. Program Counter

vi. 8 Data Bus lines bidirectional

vii. 16 address lines unidirectional



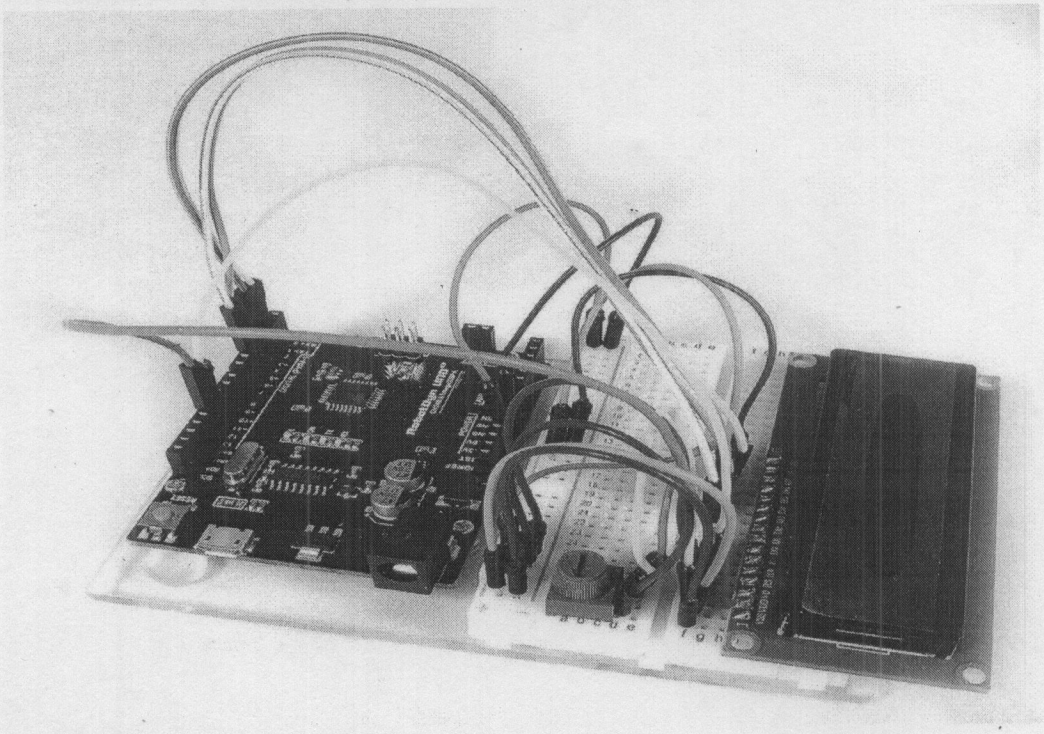
c) The University of Zambia would like to improve on the COVID-19 Contact Tracing data recording and collection. As a new graduate in Computer Science and recently employed by the University, you have been assigned to design and write the code for the prototype that would display the **Date, Time of the Day, Temperature Reading of Student** and **Welcome Message** to anyone accessing the University infrastructure which include offices, lecture rooms and Labs. The diagram below shows the setup for information display on the LCD screen with three rows.

Write the full code to display the following [12 Marks]

i. Row Number 1: **Time** (Hours: Minutes: Seconds) and **Date** (Day, Month, Year)

ii. Row Number 2: **Temperature** Reading of the Student (°C)

iii. Row Number 3: **Welcome Message as Scrolling Text** (WELCOME TO THE UNIVERSITY OF ZAMBIA)



Question III

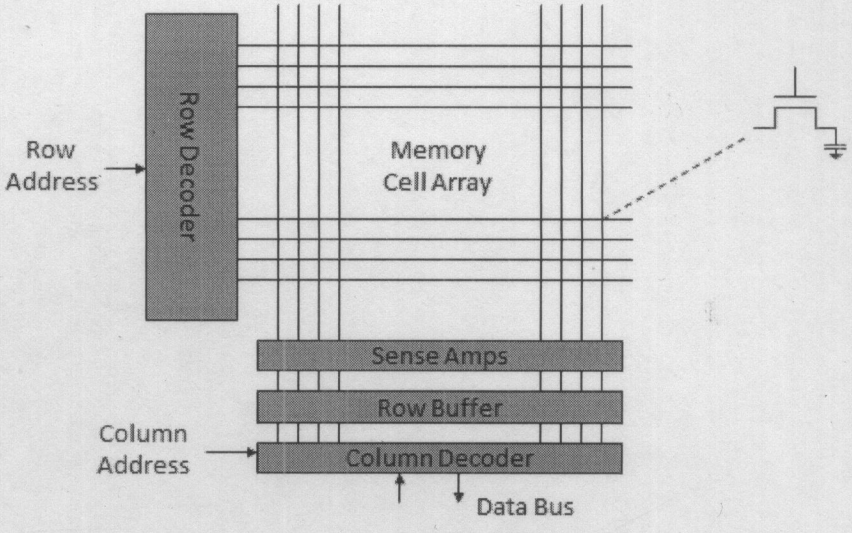
a) Computer memory can be defined as any physical device capable of storing information temporarily or permanently. Sequential circuits all depend upon the presence of memory. Briefly describe each of the following in relation to computer memory [4 Marks]

i. Bit
ii. Word
iii. Memory Module
iv. Memory Interfacing

b) Machine language is a set of instructions executed directly by a computer's central processing unit (CPU). Each instruction performs a very specific task, such as LOAD, JUMP, or an ALU operation on a unit of data in a CPU register or memory.
Write the machine code for the Intel 8085 microprocessor used to add two numbers 2H and 4H [6 Marks]

c) The diagram below shows the basic DRAM Chip Organization. Explain with reference to the diagram below how a computer stores and read data from memory using DRAM as your example. In your discussion make reference to [10 Marks]

i. Row Decoder
ii. Sensing Amps
iii. Row Buffer
iv. Column Decoder



d) To implement process control, the computer must collect data from and transmit signals to the production process. Give a brief description for each of the following in relation to computer process interfaces [5 Marks]

i. Sensors
ii. Actuators
iii. Analog-to-Digital Conversion
iv. Digital-to-Analog Conversion
v. Input / Output Devices

SECTION B

This section has Two Questions. Choose one questions

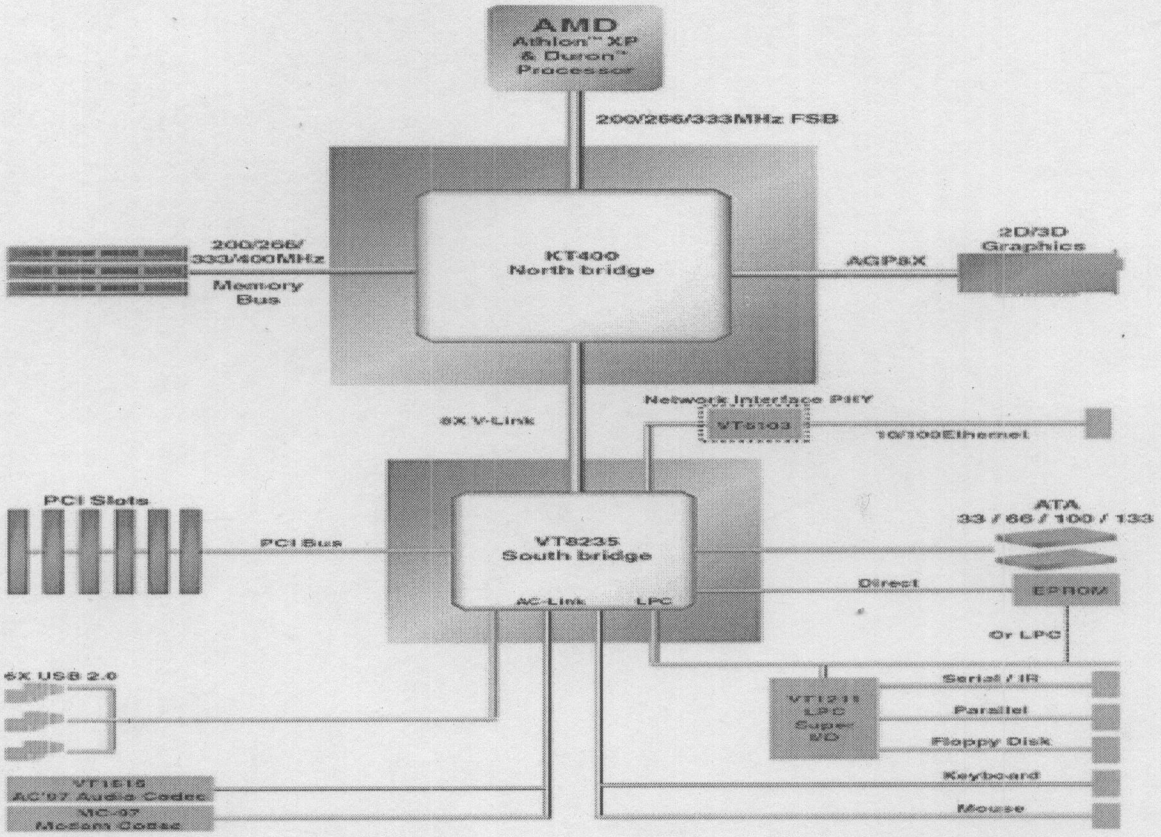
Question I

a) Typical system uses a number of busses, collection of wires, which transmit binary numbers, one bit per wire. A typical microprocessor communicates with memory and other devices (input and output) using three busses namely [6 Marks]

i. Address Bus
ii. Data Bus
iii. Control Bus

Using the Intel 8085 System Bus, give a brief description of each of three types of the bus systems above

b) A chipset is a group of integrated circuits, sold as one unit, designed to perform one or more related functions. The diagram below shows the VT8235 and the VT8377 Chipsets designed for the AMD KT400 processor. With reference to the diagram below, discuss in details the functions and roles of the chipsets (North Bridge and South Bridge) in relation to the AMD KT400 processor to manage the operation of the computer [8 Marks]



c) The diagram below shows the basic principles used by sensors to collect and process information [7 Marks].

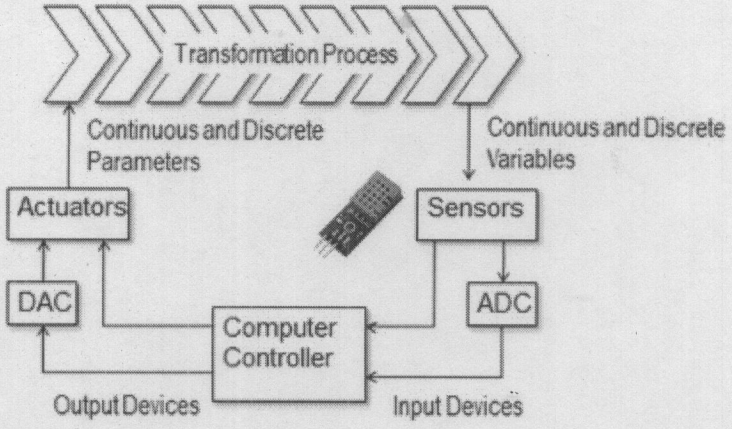
i. Discuss the principle behind sensing technologies

ii. Discuss each of the following sensor technologies

(1) Proximity

(2) Gyroscope

(3) Tilt/Acceleration

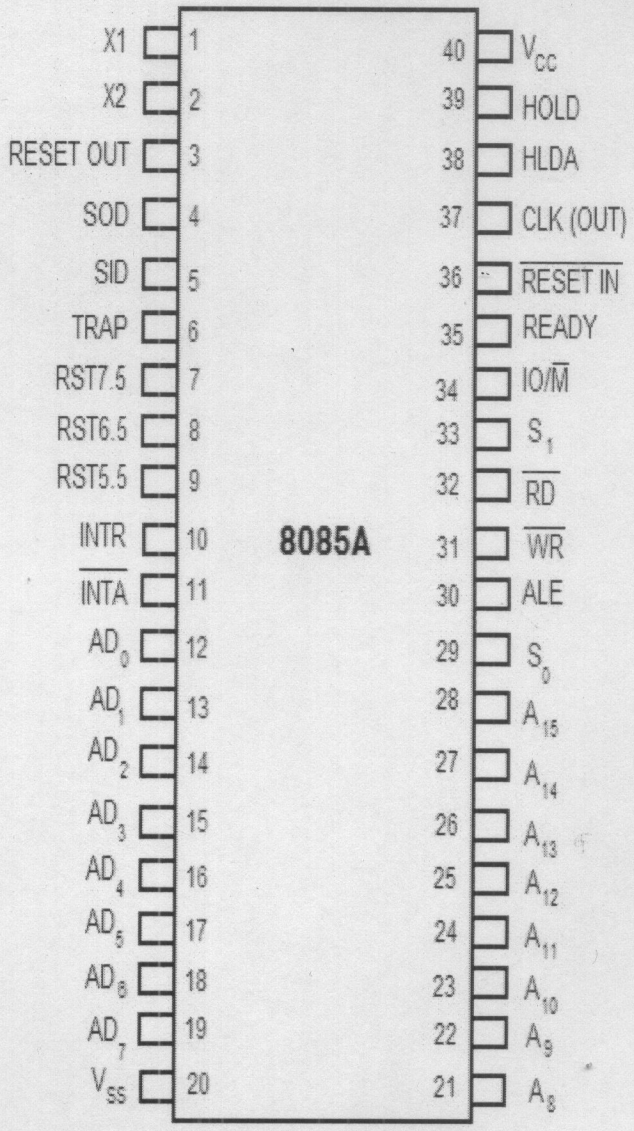


d) An actuator is usually activated by a low-level command signal; hence an amplifier may be required to provide sufficient power to drive the actuator. **Name and discuss** the three main categories of the actuators [4 Marks]

Question II

a) A Piezo is an electronic piece that converts electricity energy to sound. It is a digital output device. You can make white noise or even exact musical notes based on the duration that you iterate between HIGH and LOW signals. Give the full well commented code for the **Arduino Digital Output Sound Piezo** using the setup below by using PIN 13 for the Sound-Piezo in your design [5 Marks]

b) The figure below shows the Intel 8085 Pin configuration. With reference to the diagram below, **Give** the function of each of the 40 PINS of the Intel 8085 processor chip [20 Marks]



End of the Examination

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

END OF YEAR EXAMINATION

CSC 4505
COMPUTER GRAPHICS

Date: MONDAY, 30TH NOVEMBER 2020
Time: 14:00 – 16:00
Duration: 2 HOURS

Instructions

1. There are **five questions** in this paper, and you are required to answer only four of them in any order.
2. All answers should be on a separate page

1.

a. Describe what computer graphics is and explain 5 areas in which it is applied in our day to day activities.
b. Describe four input devices commonly used in Computer Graphics.
c. Define the following
    i. Resolution
    ii. Aspect ratio
d. Explain the difference between Vector display and the Raster display system.

2.

a. Using a labeled diagram, illustrate the function of the Cathode Ray Tube (CRT) technology.
b. Describe the two mechanisms used to realize color in the CRT.
c. Differentiate between the operations Plasma and LCD technologies.
d. Consider the following Raster system with resolution 1024 by 1024 with 24 bits per pixel with a frame refresh of 60Hz.
e. How much memory is required for frame buffer of this system?
f. Suppose you are given that the system has a horizontal retrace of 0.005 seconds and a vertical retrace of 0.25seconds. How much time is wasted in retrace in 1 minute?

3.

a. Outline the steps of the DDA line drawing algorithm
b. Outline the steps of the Bressenham for rasterizing a line.
c. You are using the algorithm above to scan convert the line $y = 5x + 2$ from (0, 0) to (5, 7). Show the set of points that will be selected.

4.

a. When drawing primitives, a number of attributes are taken into account. Describe three attributes of a line.
b. Describe how each of the attributes above is realized.
c. Consider the following Java code in a JFrame class.

```
public void paint(Graphics g){
        g.setColor(Color.BLUE);
        g.drawOval(12, 13, 80, 80);
}
```

    i. Briefly explain what the piece of code does. What is the centre and radius of the circle drawn in this method?

5.

a. Describe the following transformations
    i. Translation
    ii. Rotation
    iii. Stretch
b. Derive the vectors/matrices for each of the transformations above
c. Let P be the point (10, 12). What world be the final position if P is translated by the vector [5, 3] then rotated 900 about the origin.

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC 4630
ADVANCED SOFTWARE ENGINEERING

Date:	23rd NOVEMBER 2020
Time:	14:00hrs – 17:00hrs
Duration:	3 Hours
Venue:	NSLT

Instructions

1. *Answer **all** the questions in Section A* and choose *any **three (3)** questions from Section B*

University of Zambia – Department of Computer Science

CSC 4630: Advanced Software Engineering – Exam Questions

SECTION A
ANSWER ALL QUSTIONS IN THIS SECTION

QUESTION 1 [20 marks]

1. Who is an actor? List all variations of an actor with examples [**6 Marks**]

2. Draw a class diagram representing the relationship between parents and children. Take into account that a person can have both a parent and a child. Annotate associations with roles and multiplicities. [**4 Marks**]

3. Outline in one paragraph the information you would need to gather in order to perform domain analysis for an airline reservation system. [**6 Marks**]

4. What differentiates a 3-tier client-server architecture from a 2-tier client-server architecture. [**4 Marks**]

QUESTION 2 [20 marks]

1. We discussed architectural styles, architectural design patterns and basic design patterns. Explain the difference between these concepts and when (during the development cycle) they could be used. Why would one even consider applying these methods? Is there any useful result in the short or long term for the software system? [**6 Marks**]

University of Zambia – Department of Computer Science

CSC 4630: Advanced Software Engineering – Exam Questions

i. Sometimes, sequence diagrams can be somewhat similar to the actual code. Why not just code up the algorithm? Why bother with sequence diagrams? **[4 Marks]**

ii. What are two aspects of a software system design that are explicitly omitted from a UML class diagram? **[6 Marks]**

iii. When is a good time to do paper prototyping in the software development process? **[4 Marks]**

SECTION B
ANSWER ANY THREE (3) QUESTIONS IN THIS SECTION

QUESTION 3 [20 marks]

Lusaka City Council (LCC) have hired your company to build a bus reservation system for all bus trips taken from Intercity Bus Terminal (IBT).

1. Outline in one paragraph the information you would need to gather in order to perform domain analysis for the LCC IBT bus reservation system. **[7 marks]**

2. Requirements can be divided into four major types functional, quality, platform and process. Describe quality requirements and give 2 examples of main categories for quality requirements. **[3 marks]**

3. Classify the following aspects of the LCC IBT bus reservation system into F for functional, Q for quality, PL for platform, PR for process, and X for 'should not be a requirement'. Also indicate the subcategory of requirement. For something that should not be a requirement, explain why not.

    1. What information appears on tickets and reports.
    2. How fares are calculated.
    3. The system must be available at all times. Only 2 minutes' downtime a week is to be permitted.
    4. The system must run on any Linux system.
    5. A merge-sort algorithm must be used to sort the flights by departure time.

    [5 marks]

4. In describing *simplified use cases* of the LCC IBT bus reservation system, giving the **name** and **steps** of the use cases is enough, however your project manager insists that you describe *complete use cases*. State 5 other components you would add to the description of the use cases of the LCC IBT bus reservation in order to make them complete. Give a short explanation for each component that you state.

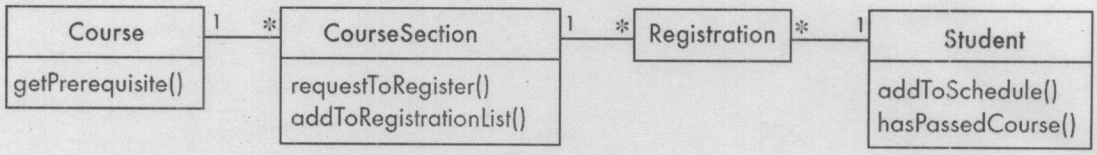
    [5 marks]

University of Zambia – Department of Computer Science

CSC 4630: Advanced Software Engineering – Exam Questions

QUESTION 4 [20 marks]

1. The diagram below shows the classes involved in a fictitious Student Registration System (SRS) for the University of Zambia (UNZA). It shows the classes involved when a student attempts to register for a course.



   i. Draw a **simple sequence diagram** based on the given class diagram that shows the interactions that occur in the UNZA SRS when a student attempts to register for a course.

   [4 marks]

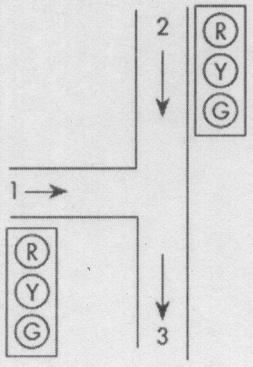
   ii. Assume that a student is only allowed to register for a course if he has passed the course prerequisites. Draw a new detailed sequence diagram, by expanding on your previous answer, showing a GUI and Course object as well as showing an optional combined fragment for the prerequisite. **[8 marks]**

   iii. You can use communication diagrams as opposed to sequence diagrams to show the interactions occurring in the UNZA SRS since both types of diagrams contain much of the same information. Describe 4 situations/reasons that make sequence diagrams the better choice when depicting interaction within a software system diagrammatically.

   [4 marks]

2. Assume the diagram below represents the road layout when exiting the UNZA Main Campus along Great East Road with a vehicle. Assume movement in the direction from 2 to 3 represents vehicles moving on Great East Road from Arcades roundabout to Manali roundabout. Traffic lights have been installed at this junction as follows:
   i. The traffic light at point 1 has three colors Green, Yellow and Red. When the system starts up the robot is Red.
   ii. After startup, the system indefinitely rotates among Green, Yellow and Red. The Red light only stays on for 30 seconds, at which time the Green light comes on.

iii. The Green light stays on for 25 seconds, at which time the system changes to Yellow.
iv. After five more seconds the Yellow light gives way to the Red light again.
v. Traffic moving from point 2 to 3 always has a Green light unless a vehicle arrives at point 1 and triggers a sensor.
vi. When the sensor at point 1 is triggered, the robot their changes to Yellow, but only after the traffic coming from point 2 has had at least 25 seconds of Green light. Without this a steady series of vehicles arriving at point 1 would prevent the light at point 2 from staying green long enough for traffic to flow.



Draw a state diagram for the UNZA traffic light system described above, illustrating elapsed-time transitions.

[4 marks]

QUESTION 5 [20 marks]

1. Give the three basic principles for object-oriented design patterns. **[6 marks]**

2. Give a concise description of the differences between the Facade and the Adapter pattern. **[6 marks]**

3. For Kenneth Kaunda International airport information system, we have a class UserInfo. This class provides two services with respect to travelling to the airport. There are three ways of travelling: public transportation (train, tram, bus), private car

and taxi. One service is calcTime(...), which gives an estimation of the travelling time to the airport. The other service is calcPrice(...), which gives an estimation of the price. The UserInfo class has information about the desired arrival date and time, the starting place (from an address database) and the way of traveling. Which design pattern would you apply in this case? Draw a class diagram. Which parameters should the two methods have? **[8 marks]**

QUESTION 6 [20 marks]

1. What is the relevance of writing <<include>>, <<extends>>, and <<inherits>> for the use case relationship? Give an example for each one. **[6 marks]**
2. List he Six fundamentals (Cornerstone) of object-oriented Software Engineering **[6 marks]**
3. What aret the similarities between sequence and collaboration diagrams? **[4 marks]**
4. Consider a *messageXYZ()* sent by *ObjectA* to *ObjectB*. Which of the two objects will have the code to execute the *messageXYZ()*? Why? **[4 marks]**

END OF PAPER

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

CSC4631 – Software Testing & Maintenance

FINAL EXAMINATION

Date:	Wednesday 18th November, 2020
Venue:	P207
Time:	14:00 – 17:00 hrs
Duration:	3 Hours

Instructions

1. This exam has two sections A and B.
2. Answer **ALL** questions in **Section A.**
3. Answer **any three (3)** questions in **Section B.**
4. **Total number of questions answered should be 4.**

SECTION A

QUESTION 1 [25 marks]

1. **[2 mark]** Define software maintenance as described by the IEEE software maintenance standard, IEEE STD 1219-1993.

2. **[6 marks]** The components of the software maintenance framework are *user, environment, maintenance process, software product* and *maintenance personnel.* Discuss in-brief the *user* and *environment* components.

3. **[4 marks]** Under what circumstances might an organization decide to scrap a system when the system assessment suggests that it is of high quality and high business value?

4. **[8 marks]** Give 4 external factors that would motivate or influence change in a software system.

5. **[3 marks]** One of the reasons why software maintenance is needed is *to support mandatory upgrades.* Expound on why this can be said, giving an example of what would be involved.

6. **[2 marks]** Give 2 strategic options for legacy system evolution?

SECTION B

QUESTION 2 [25 marks]

1. **[9 marks]** Describe at least 3 types of change that a software product may undergo in a software maintenance project, giving rationale for each.

2. **[4 marks]** From the period 1974 to 1996, Meir Lehman and Laszlo Belady formulated 8 *laws of software evolution.* The laws describe a balance between forces driving new developments on one hand, and forces that slow down progress on the other hand. Describe the *Law of Conservation of Familiarity* and the *Law of Increasing Complexity*.

3. **[4 marks]** How does *provision of business information* as part of on-going support assist in software maintenance activities?

4. **[8 marks]** As part of the work on a software maintenance project proposal that your team is working on, the team lead asks you to itemize artifacts needed for the design and implementation phases of the project. Give 2 examples of implementation artifacts and design artifacts that you would submit?

QUESTION 3 [25 marks]

1. **[6 marks]** Describe the activities of an individual or team handling configuration management in a software maintenance project?

2. **[6 marks]** Describe briefly the economic implications of modifying software.

3. **[3 marks]** What is a baseline in software configuration management?

4. **[6 marks]** There are several vendors developing and marketing a wide variety of tools that claim to support software maintenance. Bearing this in mind, describe at least 3 factors you should consider before acquiring a tool for software maintenance work?

5. **[4 marks]** The Quick-Fix model of maintaining software in commercial operations is unreliable. Why though is it still used in such settings? And what would be the correct way to use it?

QUESTION 4 [25 marks]

1. **[3 marks]** What is reverse engineering and what is the motivation behind doing it?

2. **[6 marks]** Your co-workers in a software engineering team, Machaka and Shemaiah are arguing about where it is best to begin reverse engineering. Machaka says the architectural design, Shemaiah says the source code. Who is right and why?

3. **[6 marks]** Software system abstraction is achieved by highlighting the important features of the subject system and ignoring the irrelevant ones. Briefly describe 3 types of abstractions that can be performed on software systems.

4. **[4 marks]** There are no hard and fast rules as to what criteria a program must fulfil before it may usefully be subject to reverse engineering. There are, however, some indicators which may serve as warning signs. Name at least 2 *product/environment related* indicators that may prove helpful.

5. **[6 marks]** Reverse engineering, in-itself, does not directly lead to modification of a system. The understanding of a system that we obtain through reverse engineering can support the implementation of change. Briefly describe 3 techniques that are used to implement changes after performing reverse engineering.

QUESTION 5 [25 marks]

You are the **maintenance administrator** of a permanent software maintenance team at Zambia Revenue Authority. The revenue authority's taxing software system is large and complex. It is the responsibility of you and your team to ensure that the software system under maintenance is of satisfactory quality. You must also make sure that system changes are effected with minimum possible delay at the least possible cost.

1. **[4 marks]** Briefly describe how you can achieve this.

2. **[12 marks]** Describe 4 ways you can motivate personnel on your software maintenance team.

3. **[2 marks]** One of the benefits of exposing your team to education and training is that it enhances recognition. Explain how this is so?

4. **[4 marks]** The rest of your team is made up of a *maintenance leader,* a *user liaison person*, and *maintenance programmers*. What are the typical roles of the these personnel?

5. **[3 marks]** Why do large and complex software systems present challenges for managers of software maintenance projects?

QUESTION 6 [25 marks]

As team lead on the University of Zambia Student Portal System you are putting together a maintenance plan. Part of your plan involves selecting software maintenance measurements.

1. **[2 marks]** Is software measurement different from software metric? Explain.

2. **[4 marks]** In software measurement, there are 2 types of attributes internal attributes and external attributes. Using examples explain how they differ.

3. **[15 marks]** Give 5 main reasons, in brief, of why it is important to carry out software maintenance measurement on the student portal system.

4. **[4 marks]** Some guidelines that can prove helpful in selecting suitable maintenance measures for the student portal system are that the measure should have *well defined objectives*, they should be *fit for purpose,* they should be *easy to use,* they should have *low implementation cost and sensitivity*. Explain how *well defined objectives* and *ease of use* are helpful?

- END OF QUESTION PAPER -

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC 4642
SOFTWARE QUALITY ASSURANCE

Date: 20TH NOVEMBER 2020
Time: 14:00 – 16:00 hrs.
Duration: 2 Hours
Venue: NSLT

Instructions

- The question paper has TWO SECTIONS (A and B).
- Answer ALL questions in SECTION A.
- Section B comprises TWO (2) questions. Answer any ONE (1).
- Clearly number your answers.
- Use the marks as a guide to the detail required in your answers while keeping your answers concise and relevant.

SECTION A: ANSWER ALL QUESTIONS [60 Marks]

1. List the situations that can lead a software company to sign a contract with a customer. **[4 marks]**

2. *Project technical complexity* impacts the extent of the contract review effort. What are the aspects that define "Project technical complexity"? **[4 marks]**

3. Outline the four (4) direct objectives of a review. **[4 marks]**

4. It is agreed that the factor that determines the benefits of peer review to total quality is not the percentage of pages covered but the choice of those pages.
   a. Outline the recommended sections for inclusion in a peer review. **[4 marks]**
   b. What is the recommended percentage coverage of document pages? **[2 marks]**

5. *Project interfaces* are one element of a Development Plan. What types of '*project interfaces*' are being referred to here? **[3 marks]**

6. Systematic risk management activities should be initiated to deal with risk. What activities are included in the risk management process? **[5 marks]**

7. "Preparing full-scale development and quality plans for internal projects, and applying regular full customer–supplier relationships for the implementation of internal projects is highly beneficial to both sides".
   a. Explain four benefits of these procedures to the developer. **[4 marks]**
   b. Explain four benefits to internal customers. **[4 marks]**

8. Distinguish between bottom-up and top-down testing. **[4 marks]**

9. State the type of testing for which a stub is required, clearly explaining its role in this type of software testing? **[3 marks]**

10. State the type of testing for which a driver is required, clearly explaining its role in this type of software testing? **[3 marks]**

11. Referring to the model for defect removal efficiency and costs:

a. Explain the six assumptions that rest at the foundations of the model? **[10 marks]**

b. Which three of the model's data components are based on published survey results? **[6 marks]**

SECTION B: ANSWER ONE QUESTION [40 Marks]

Question 1

Consider the following source code to display the values of different variables based on the comparison.

```
public class WhiteBoxTesting{
    public static void main(String[] args) {
        int var1 = 10;
        int var2 = 9;
        int var3 = 8;
        int var4 = 7;

        if (var1 = = 10){
            if (var2 > var3){
                var2 = var3;
            }
            else{
                if (var3 > var4){
                    var3 = var4;
                }
                else{
                    var4 = var1;
                }
            }
        }
        else{
            var1=var4;
        }
```

```
            System.out.println("Printing value for var1, var2, var3, and
var4"+var1+" "+var2+" "+var3+" "+var4);
        }
}
```

i. Develop the Flow Chart for the program. **[16 marks]**

ii. Develop the Program Flow Graph for the program. **[12 marks]**

iii. Compute the Cyclomatic Complexity of the program. **[8 marks]**

iv. Comment on the overall complexity of the program based on the Cyclomatic Complexity you computed. **[4 marks]**

Question 2

A module that calculates bus ticket prices has been developed for the Lusaka City Council Transport unit. The bus ticket price table is shown below. Peak time = 5.00 am – 9.00 am; off-peak = 9.01 am – 23.45 pm.

	Monday-Friday				**Saturday-Sunday**			
Mode of Payment	Cash	Cash	Card	Card	Cash	Cash	Card	Card
Time of Travel	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak
	Bus Fare - ZMK							
Passenger Years								
Child: 0.00 -13.00	2.00	1.00	1.50	0.50	1.80	0.80	1.30	0.30
Senior Citizen 60.01-120.00	5.00	4.00	4.50	3.50	4.80	3.80	4.30	3.30
Adult: 13.01- 60.00	10.00	8.00	8.50	6.50	9.80	7.80	8.30	6.30
	Special Needs Passengers							
	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00

i. What are the variables in the bus ticket system? [4 mark]

ii. List the valid equivalence classes for the module? [8 marks]

iii. Suggest representational values for each of the equivalence classes from (ii).[8 marks]

iv. What are the boundary values for valid equivalence classes? [4 marks]

v. List the invalid equivalence classes for the module? [8 marks]

vi. Suggest representational values for each of the invalid equivalence classes from (ii). [8 marks]

END OF EXAM

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC ~~4772~~ 4722

Distributed Systems

Date:	27th NOVEMBER 2020
Time:	14:00hrs – 16:00hrs
Duration:	2 Hours
Venue:	NSLT School of Natural Sciences

Instructions

1. There are **two (2) sections** in this exam paper.
2. *Answer all the questions in **Section A*** and choose *any two (2) questions from **Section B***

SECTION A. Short answers (40 marks)

You are required to answer all questions in this section. Each question carries ***4 marks***.

1. An alternative definition for a distributed system is that of a collection of independent computers providing the view of being a single system, that is, it is completely hidden from users that there even multiple computers. Give an example where this view would come in very handy.
2. Explain what is meant by (distribution) transparency, and give examples of different types of transparency.
3. Why is it sometimes so hard to hide the occurrence and recovery from failures in a distributed system?
4. What is an open distributed system and what benefits does openness provide?
5. Describe precisely what is meant by a scalable system and briefly discuss techniques that can be applied to achieve scalability in a distributed system.
6. When a transaction is aborted, it is said that the world is restored to its previous state, as though the transaction had never happened. Give an example where resetting the world is impossible.
7. What is a three-tiered client-server architecture?
8. Consider a chain of processes P1 , P2 , ..., Pn implementing a multitiered client-server architecture. Process Pi is client of process Pi+1 , and Pi will return a reply to Pi−1 only after receiving a reply from Pi+1 . What are the main problems with this organization when taking a look at the request-reply performance at process P1?
9. While developing a distributed system a developer tries to analyze how message passing can be achieved. What is the difference between a blocking and non-blocking send primitives and what impact does the choice of a send primitive have on the performance of a distributed system?
10. What are the two main types of Web services and why are Web services important in Cloud Computing?

SECTION B (60 marks)

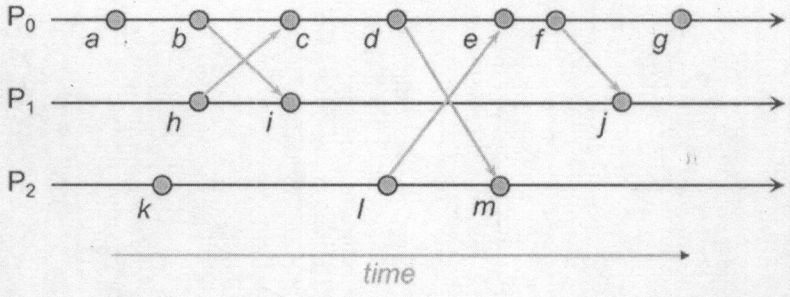
Answer any two (2) of the three (3) questions.

1.

a. Consider the behavior of two machines in a distributed system. Both have clocks that are supposed to tick 1000 times per millisecond. One of them actually does, but the other ticks only 990 times per millisecond. If UTC updates come in once a minute, what is the maximum clock skew that will occur? **[4 marks]**

b. In the centralized approach to mutual exclusion, upon receiving a message from a process and releasing its exclusive access to the resources it was using, the coordinator normally grants permission to the first process on the queue. Give another possible algorithm for the coordinator. **[4 marks]**

c. Synchronization is a very important concept in distributed systems and can be achieved using approaches like that proposed by Lamport. Given the following diagram portraying order of processing as well as messages exchanged between three processes



i. Show the ordering of events using Lamport's approach **[8 marks]**
ii. Show the ordering of events using Vector timestamps **[8 marks]**
iii. Define concurrent events based on Lamport's happens before principle and also list the concurrent events in the illustration **[6 marks]**

2. Big Data is a term used to describe a collection of data that is huge in volume and yet growing exponentially with time. In short such data is so large and complex that none of the traditional data management tools are able to store it or process it efficiently.

Frameworks have been developed that can be used to handle Big Data. One such framework is the Hadoop framework.

a. What is Hadoop? **[2 marks]**
b. Briefly discuss the motivations that led to the development of Hadoop? **[6 marks]**
c. How is the Hadoop File System implemented and how does it support fault tolerance and recovery? **[6 marks]**
d. What is Map-Reduce programming? Discuss why it is important in the Hadoop framework. **[6 marks]**
e. Briefly discuss the anatomy of a Hadoop cluster **[10 marks]**

3. More often than not distributed systems require coordination of processes. This often brings up a lot of discussion about how distributed the resulting algorithms are since there is still need for a coordinator.

a. Many distributed algorithms require the use of a coordinating process. To what extent can such algorithms actually be considered distributed? Discuss. **[6 marks]**
b. Suppose that two processes detect the demise of the coordinator simultaneously and both decide to hold an election using the bully algorithm. What happens? **[4 marks]**
c. Suppose in a Ring election algorithm based distributed system two processes discover a crashed coordinator. We then have two ELECTION messages circulating simultaneously. While it does no harm to have two of them, it would be more elegant if one could be killed off. Devise an algorithm for doing this without affecting the operation of the basic election algorithm. **[6 marks]**
d. What are the major assumptions when designing an election algorithm? **[6 marks]**
e. Using an appropriate example and illustration explain how the ring election algorithms work? **[8 marks]**

The end of the examination paper

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC 4765
IT AUDIT AND CONTROLS

Date:	16TH NOVEMBER, 2020
Time:	09:00 – 12:00 HRS
Duration:	3 HRS
Venue:	SPORTS HALL

Instructions

- The question paper has TWO SECTIONS (A and B).
- Section A. Answer **ALL**.
- Section B comprises **FIVE (5)** questions. Answer any **THREE (3).**
- Clearly number your answers.
- Use the marks as a guide to the detail required in your answers while keeping your answers concise and relevant

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SECTION A: ANSWER ALL QUESTIONS IN THIS SECTION [40 MARKS]

1. Outline the three (3) outcomes an organisation ensures by implementing a system of internal controls. [**3 Marks**]
2. Even with the best security tools, information systems may not be reliable and secure. What must organisations know in order to avoid this situation? [**3 Marks**]
3. What is the function of each of the following controls?
    a. Software controls [**2 Marks**]
    b. Hardware controls [**2 Marks**]
    c. Computer operations controls [**2 Marks**]
    d. Implementation controls [**2 Marks**]
    e. Administrative controls [**2 Marks**]
4. *Identify* and *define* the different categories of ICT assets and *state* one example of an asset for each group. [**8 marks**]
5. State four good practices that businesses should demonstrate over assets. [**4 Marks**]
6. In what ways has information technology impacted the auditing profession?[**3 Marks**]
7. Organisations need to assess the risk associated with audit findings and determine the best response to that risk. Explain the set of possible responses to risk. [**9 Marks**]

SECTION B: ANSWER THREE (3) QUESTIONS IN THIS SECTION [60 MARKS]

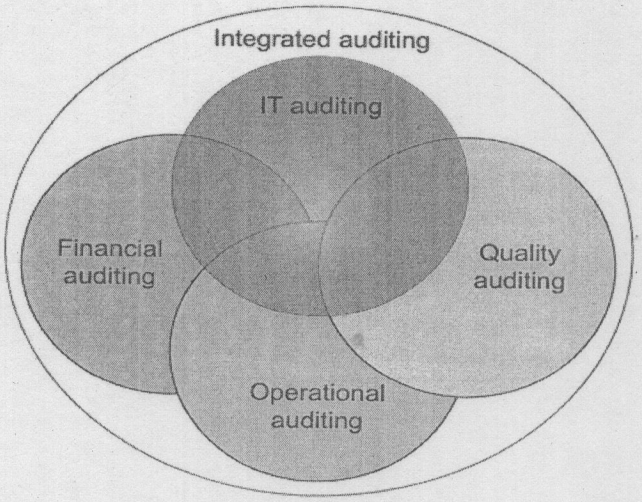
QUESTION ONE [20 marks]

IT auditing is a key component of an organisations audit processes.

i. With the aid of a clearly labelled conceptual diagram, distinguish between an Information System (IS) and Information Technology (IT). [**6 marks**]

ii. With reference to your answer in (i) above, elaborate the concept of IT Audit and controls in terms of;
    a. Its characteristics and what it does. [**5 marks**]
    b. What its intended outcomes are. [**4 marks**]

iii. Consider the figure below. Explain the intersection between IT auditing and Operational auditing. [**5 Marks**]



QUESTION TWO [20 marks]

Computer systems are controlled by a combination of what are called IT general controls and IT application controls.

i. Explain the relationship between business rules and IT application controls. [**4 Marks**]

ii. IT application controls are built into segments of an application.

   a. What are these segments called? [**4 Marks**]

   b. What is the objective of controls in each segment from (a) above? [**8 Marks**]

iii. Explain the reason for performing a cost/benefit analysis in the implementation of IT Application controls. [**4 Marks**]

QUESTION THREE [20 marks]

Planning and Performing in the single-audit context are two of the major steps in the IT Audit process.

i. What are the other stages in the process? [**2 Marks**]

ii. What activities comprise the *Planning step*? [**2 Marks**]

iii. Mention three (3) ways in which planning an IT audit is conceptually similar to planning an IT project. **[3 marks]**

iv. What is the importance of establishing a project baseline when planning an IT audit? [**3marks**]

v. What is the meaning of evidence in IT audit? [**2 Marks**]

vi. Explain the key evidence collection activities typically included in the *Performing* an IT audit step. [**4 Marks**]

vii. Consider the concept of information sampling in the *Performing* an IT audit step.

a) What is information sampling in this context? [**2 marks**]

b) State the challenge of information sampling in the audit context? [**2 marks**]

QUESTION FOUR [20 MARKS]

Consider the University of Zambia's Academic Promotion System.

1. Explain three criteria that should be used to determine how much control is built into a system. [**6 marks**]
2. Given the following risk assessment information:

i. The likelihood of physical damage to the system's operations over a one-year period is 5%, with a minimum and maximum loss to the organisation of K20, 000 and K100, 000, respectively.

ii. The likelihood of data, programs and software loss over a one-year period is 30%, with a minimum and maximum loss to the organisation of K30, 000 and K150, 000, respectively.

iii. The likelihood of virus attacks over a one-year period is 90%, with a minimum and maximum loss to the organisation of K50, 000 and K170, 000, respectively.

iv. The likelihood of denial of service attacks over a one-year period is 40%, with a minimum and maximum loss to the organisation of K20, 000 and K200, 000, respectively.

v. The likelihood of hacking and site penetrations attacks over a one-year period is 10%, with a minimum and maximum loss to the organisation of K80, 000 and K200,000, respectively.

vi. The likelihood of Website hijacking, threats and/or extortion attacks over a one-year period is 5%, with a minimum and maximum loss to the organisation of K8, 000 and K20, 000, respectively.

Required:

Calculate the expected annual loss for each exposure. (14 marks)

Note: Prepare your answer using a table with appropriate column headings.

QUESTION FIVE [20 marks]

The establishment and maintenance of a system of internal control in an organisation is an important management obligation.

1. Explain the PDC model of internal controls. **[6 marks]**

2. Which of the three types of controls in the PDC model is the most effective? Why? **[2 marks]**

3. Explain the function based model of internal controls. **[6 marks]**

4. Classify the following controls according to the classifications in (1 & 3) above. Note: Use a single table/matrix **[6 marks]**

   i. *control totals*
   ii. *physical inventory counts*
   iii. *data backups*
   iv. *segregation of duties*
   v. *security camera systems*
   vi. *password protected access*
   vii. *physical locks on asset storage rooms*
   viii. *IT Audit program*
   ix. *Application firewall*

END OF EXAM

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC 4792

Data Mining and Warehousing

Date:	16th NOVEMBER 2020
Time:	14:00hrs – 16:00hrs
Duration:	2 Hours
Venue:	NSLT

Instructions

1. There are **two (2) Sections** in this exam, **Section A** and **Section B.**
2. In Section A, **answer all the questions** and in Section B **choose any three (3) questions.**

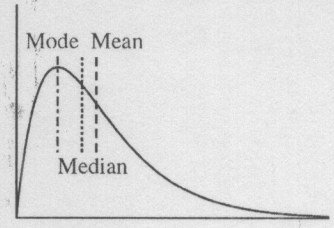
Section A: Answer **ALL** questions

1. A Breathalyzer registers someone's blood alcohol content to tell if they are "over the limit" or "under the influence" of alcohol. It is typically used at RTSA to determine if someone is legally able to drive.
    a. What is the positive class?
    b. What would a recall of 70% mean?
    c. What would a precision of 90% mean?
    d. If the recall is 80% and the precision is 75%, what is the True Positive Rate?
    e. If the recall is 80% and the precision is 75%, what is the False Positive Rate?
2. What is meaning of "Curse of Dimensionality?"

3. You are hired to design a machine learning algorithm by the Zambia Police to be able to predict crimes before they occur. In order for your algorithm to ensure that no innocent person is sent to jail, what evaluation metric would use maximise (where crime is the positive label)?
    a) Accuracy
    b) Precision
    c) Recall
    d) AUC

4. Given a regression equation y = -0.0127 + 0.018x. Which statement is true about the equation?
    a) Each value of x increases the value of y by 1.27%
    b) On average it takes 1.8 y to increase the value of y by 1%
    c) Each value of x increases the value of y by an average amount of 1.8%
    d) Each value of x increases the value of y by 0.018

5. The figure below represents a distribution of _____
    a) Positively skewed data
    b) Negatively skewed data
    c) Symmetric data
    d) Normal distributed data



6. Given Ò = $\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2$, what does Ò compute?
    e) Standard Deviation
    f) Covariance
    g) Correlation
    h) Variance

7. The observations $X_1, \ldots . X_n$ have a mean of 52, a median of 52.1 and standard deviation of 7. 8% of the observations are greater than 66; 7.9% of the observations are below 38. Based on this information, which of the following statement best describes the data?
    i) The distribution has positive skew
    j) The distribution has negative skew
    k) The distribution has high kurtosis
    l) The distribution conforms to a normal distribution

8. The range of a data points gives an indication of the degree to which the mean value differs from its expected value.
    m) True
    n) False

9. The shape of the normal curve depends on its _____
    o) Mean deviation
    p) Standard deviation
    q) Quartile deviation
    r) Correlation

10. Predicting the amount of rainfall in a region based on various cues is a _____ problem.
    s) Supervised learning
    t) Unsupervised learning
    u) Clustering
    v) None of the above

11. A and B are two events. If P(A, B) decreases while P(A) increases, which of the following is true?
    w) P(A|B) decreases
    x) P(B|A) decreases
    y) P(B) decreases
    z) All the above

12. You trained a binary classifier model which gives very high accuracy on the training data, but much lower accuracy on validation data. Which of the following may be true?
    aa) This is an instance of overfitting.
    bb) This is an instance of underfitting.
    cc) The training was not well regularized
    dd) The training and testing examples are sampled from different distributions.

13. The mean of 11 numbers is 7. One of the numbers, 13, is deleted. What is the mean of the remaining 10 numbers?
    ee) 7.7
    ff) 6.4
    gg) 6.0
    hh) 5.8
14. If we would like to produce learning rules that are easily interpreted by humans, which of the following machine learning task would we use?
    ii) Logistic regression
    jj) Nearest neighbor
    kk) Decision tree learning
    ll) Support Vector Machine

15. Which evaluation metrics are commonly used for evaluating the performance of a classification model when there is a class imbalance problem?
    mm) precision and recall
    nn) precision and accuracy
    oo) accuracy and error
    pp) precision and error

16. How do you determine the classifier accuracy from the confusion matrix?
    qq) Divide the sum of the diagonal values in the confusion matrix by the sum of the off-diagonal values.
    rr) Divide the sum of all the values in the confusion matrix by the total number of samples.
    ss) Divide the sum of the diagonal values in the confusion matrix by the total number of samples.
    tt) Divide the sum of the off-diagonal values in the confusion matrix by the total number of samples.

Section B: Answer any **THREE (3)** questions

1. You are given a task to diagnose 100 patients with a disease present in 50% of the general population. Assume a black box model, where you put in information about patients and receive a score between 0 and 1. The table below gives information about the threshold for labelling a patient as positive (has the disease) to maximize the classifier performance. Using the threshold at 0.5, answer the following questions

Threshold	TP	FP	TN	FN
0.0	50	50	0	0
0.1	48	47	3	2
0.2	47	40	9	4
0.3	45	31	16	8
0.4	44	23	22	11
0.5	42	16	29	13
0.6	36	12	34	18
0.7	30	11	38	21
0.8	20	4	43	33
0.9	12	3	45	40
1.0	0	0	50	50

   a) Create a confusion matrix **(5marks)**
   b) Calculate the recall, precision, f1 score, true positive rate and false positive rate. **(5 Marks)**
   c) Draw the ROC curve **(10 Marks)**

2. The table below show the data collected for a period of 14 days about deciding whether to play Tennis or not. Using the data collected, draw a decision tree. **(20 Marks)**

day	outlook	temperature	humidity	wind	play
1	sunny	hot	high	weak	no
2	sunny	hot	high	strong	no
3	overcast	hot	high	weak	yes
4	rain	mild	high	weak	yes
5	rain	cool	normal	weak	yes
6	rain	cool	normal	strong	no
7	overcast	cool	normal	strong	yes
8	sunny	mild	high	weak	no
9	sunny	cool	normal	weak	yes
10	rain	mild	normal	weak	yes
11	sunny	mild	normal	strong	yes
12	overcast	mild	high	strong	yes
13	overcast	hot	normal	weak	yes
14	rain	mild	high	strong	no

3. In an oral exam you have to solve exactly one problem, which might be one of three types, A, B, or C, which will come up with probabilities 30%, 20%, and 50%, respectively. During your preparation you have solved 9 of 10 problems of type A, 2 of 10 problems of type B, and 6 of 10 problems of type C.
   a) What is the probability that you will solve the problem of the exam? **(10 Marks)**
   b) Given you have solved the problem, what is the probability that it was of type **(10 Marks)**

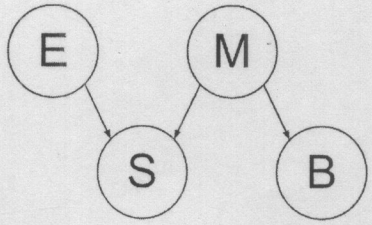
4.
   a) Given a data set with 1-dimensional points D = {1, 3, 6, 10, 20, 100}, using the K-means algorithm with K = 2 and the initial mean values be 1 and 100, what is the clustering results of running two iteration of the K-means algorithm (use Euclidean distance). **(15 Marks)**

   b) A regression was done for 20 cities with latitude as the explanatory variable (x) and average January temperature as the response variable (y). The latitude is measured in degrees and average January temperature in degrees Fahrenheit. The latitudes ranged from 26 (Lusaka) to 47 (Ndola). The regression equation is $\hat{y} = 49.4 - 0.313\ x$
      i. Chipata has latitude 40 degrees with average January temperature of 25 degrees Fahrenheit. What is the estimated average January temperature for Chipata, based on the regression equation? What is the residual? **(5 Marks)**

5. A smell of sulphur (S) can be caused either by rotten eggs (E) or as a sign of the doom brought by the Mayan Apocalypse (M). The Mayan Apocalypse also causes the oceans to boil (B). The Bayesian network and corresponding conditional probability tables for this situation are shown below.

$P(E)$	
$+e$	0.4
$-e$	0.6

$P(S\|E,M)$			
$+e$	$+m$	$+s$	1.0
$+e$	$+m$	$-s$	0.0
$+e$	$-m$	$+s$	0.8
$+e$	$-m$	$-s$	0.2
$-e$	$+m$	$+s$	0.3
$-e$	$+m$	$-s$	0.7
$-e$	$-m$	$+s$	0.1
$-e$	$-m$	$-s$	0.9



$P(M)$	
$+m$	0.1
$-m$	0.9

$P(B\|M)$		
$+m$	$+b$	1.0
$+m$	$-b$	0.0
$-m$	$+b$	0.1
$-m$	$-b$	0.9

   a) Compute the following entry from the joint distribution: P(−e, −s, −m, −b) **(6 Marks)**
   b) What is the probability that the oceans boil? **(6 Marks)**
   c) What is the probability that the Mayan Apocalypse is occurring, given that the oceans are boiling? **(8 Mark)**

THE UNIVERSITY OF ZAMBIA

School of Natural Science

Department of Computer Science

FINAL EXAMINATION

CSC 4812: CLOUD AND HIGH PERFORMANCE COMPUTING

Date:	Monday, 30th November 2020
Time:	09:00hrs – 12:00hrs
Duration:	2 Hours
Venue:	NSLT

Instructions

1. There are **Five (5) questions** and **two (2) sections** in this paper.
2. Each question carries **25 marks,**
3. *You are required to answer a total of **Four (4) Questions***
   a. *Answer **all** the questions in **Section A***
   b. Choose ***one (1)** question from **Section B***

SECTION A

This Section has Three Questions. Answer all the questions

Question I

a) Clouds are a large pool of easily usable and accessible virtualized resources such as hardware, development platforms and/or services. These resources can be dynamically reconfigured to adjust to a variable load, allowing also for optimum resource utilization. The key characteristics of cloud computing include [6 Marks]

i. Pay-per-use
ii. Elastic capacity
iii. Illusion of Infinite Resources
iv. Self-Service interface
v. Resources that are abstracted or virtualized
vi. Provide API and Development tools for developers to build scalable applications on their services.

Briefly discuss each of the characteristics above

b) With the aid of a diagram, describe each of the following Deployment Models of a Cloud [8 Marks]

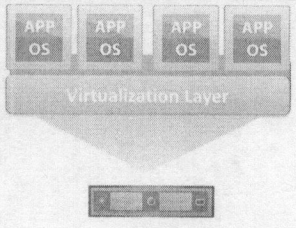
i. Private/Enterprise
ii. Dedicated
iii. Hybrid/Mixed
iv. Cloud/Public

c) Infrastructure as a Service (IaaS) allows existing applications to run on its hardware. IaaS rents out resources dynamically wherever they are needed. Briefly discuss each of the following in relation to IaaS [6 Marks]

i. Services
ii. Geographical Presence
iii. User Interfaces and Access to Servers
iv. Advance Reservation of Capacity
v. Automatic Scaling and Load Balancing
vi. Service-Level Agreement

d) The diagram below shows a virtual machine implementation [5 Marks].

i. What is the Virtual Infrastructure Managers (VIMs)
ii. Discuss the Key Features of the Virtual Infrastructure Managers



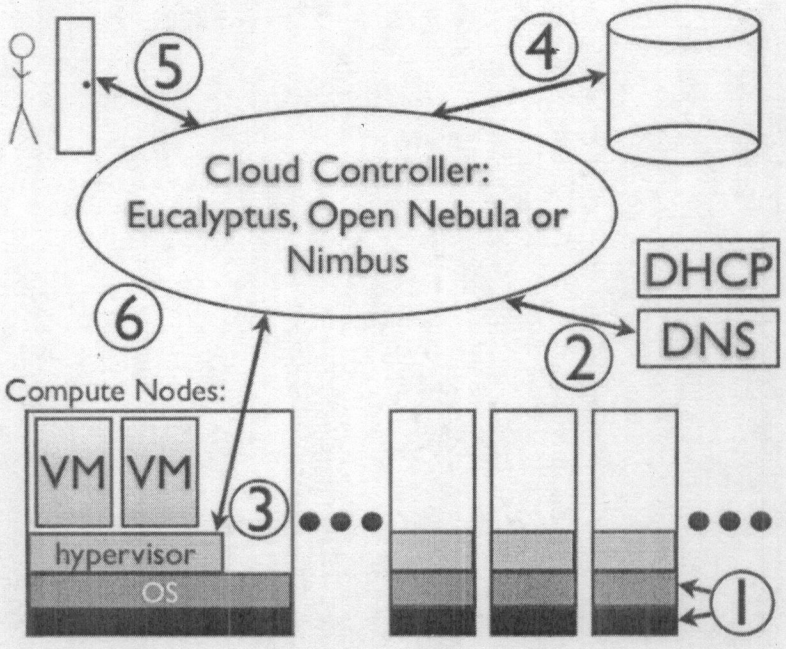
Question II

a) Cluster Middleware is an interface between user applications, cluster hardware and Operating System platform. Middleware packages support each other at the management, programming, and implementation levels. Discuss the key Middleware Design Goals [6 Marks]

b) Scalable Parallel Computer Architectures is based on how processors, memory and interconnect are laid out. Briefly discuss each of the groupings below [6 Marks].

i. Massively Parallel Processors (MPP)
ii. Symmetric Multiprocessors (SMP)
iii. Cache-Coherent Nonuniform Memory Access (CC-NUMA)

c) The diagram below shows the basic implementation of cloud services using one of the open source software [13 Marks]



i. Using the diagram above, explain the cloud implementation using an open source software by referring to item number (1) to item number (6)
ii. Draw a well labelled diagram showing the Cloud Controller and explain the role of Cloud Controller in cloud implementation
iii. Discuss each of the following
   1. Client
   2. CC
   3. NC

Question III

a) There are several causes of problems associated with cloud computing. However, most security problems stem from [6 Marks]:
   i. Loss of control
   ii. Lack of trust (mechanisms)
   iii. Multi-tenancy

   Discuss each of these challenges and how they are being addressed in cloud implementation

b) In order to ensure that data is secure, that it cannot be accessed by unauthorized users or simply lost, and that data privacy is maintained, cloud providers attend to the following areas [6 Marks]
   i. Data protection
   ii. Identity management
   iii. Physical and personnel security
   iv. Privacy
   v. Legal issues
   vi. Application security

   Discuss each of the items above in relation to cloud computing security

c) Platform as a Service (PaaS) provides all infrastructures needed for a consumer to run applications over the internet. PaaS is a Cloud Computing service that offers a computing platform and solution stack for users [4 Marks].
   i. List two categories of software applications offered as a PaaS
   ii. A PaaS Cloud should be able to support various programming models for different types of programming. List and discuss two examples of PaaS programming Models

d) Cloud computing provides computation, software, data access, and storage resources without requiring cloud users to know the location and other details of the computing infrastructure [9 Marks].
   i. Draw a well labelled diagram showing the three Cloud Service Models as follows;
      1. Software as a Service
      2. Platform as a Service
      3. Infrastructure as a Service
   ii. Show how each of the three services above are related to each other.
   iii. For each of the three service models above,
      1. Give a brief description by citing the characteristics of the service model and the benefits that comes with the implementation
      2. Give at least one major challenge that comes with each service model
      3. Give one example implementation in real life

SECTION B

This section has TWO Questions. Choose one question

Question I

a) You have just been employed by the University of Zambia as a new graduate. The University would like you to advise management on the issues surrounding cloud computing. They intend to move the students records and Library repositories to the cloud. Management has requested that you give them a report on cloud services sourcing and concerns that come with cloud service sourcing [8 Marks].

i. In your report to management, **give** any **four** major reasons why **cloud sourcing** is becoming a Big Deal today why you would like the university to use this service

ii. In your report, highlight the major concerns that come with cloud sourcing

b) A cluster is a type of parallel or distributed processing system, which consists of a collection of interconnected stand-alone/complete computers cooperatively working together as a single, integrated computing resource [9 Marks]

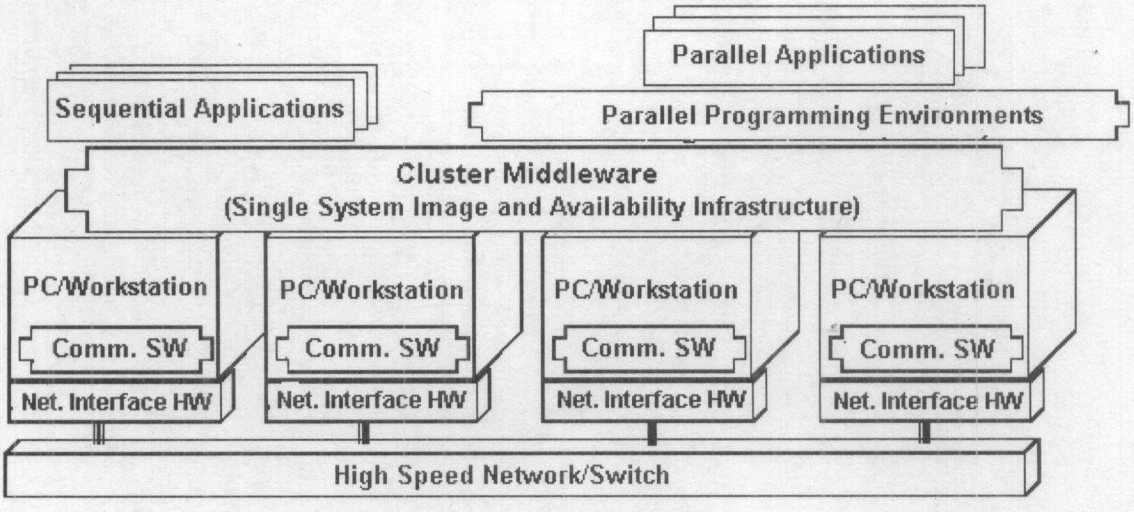
i. List and discuss the key characteristics of Cluster Computing

ii. Discuss the main motivation in using Clusters Computing

c) The diagram below shows the cluster implementation showing a **single system image** (SSI). A SSI is the illusion, created by software or hardware, that presents a collection of resources as one, more powerful resource. It makes the cluster appear like a single machine to the user, to applications, and to the network [8 Marks].

i. Discuss the major and key benefits of a Single System Image

ii. What are the desired single system image services?



Question II

a) Briefly discuss each of the following Prominent Components of Cluster Computers [5 Marks]

i. State of the art Operating Systems
ii. High Performance Networks/Switches
iii. Fast Communication Protocols and Services
iv. Cluster Middleware
v. Applications and Subsystems

b) As a new graduate and an expert in cloud computing, you have been subcontracted by the one of the commercial banks to give the major challenges of cloud computing in order to ensure that the bank data is secure, that it cannot be accessed by unauthorized users or simply lost, and that data privacy is maintained. In the SLA the cloud service providers have promised to attend to the following areas [4 Marks]

i. Privacy
ii. Security
iii. Compliance
iv. Legal

As an expert, describe each of the items above to the bank officials in relation to cloud computing security

c) With reference to Cloud Computing discuss each of the following Cloud Management Services [8 Marks]

i. deployment
ii. monitoring
iii. reporting
iv. metering billing

d) Virtual Infrastructure Managers is the Operating System of the Cloud responsible for the allocation of resources in a cloud. It helps to aggregates resources from multiple sources. Discuss the following features of Virtual Infrastructure Managers [8 Marks]

i. Multiple Backend Hypervisors
ii. Virtual Networking
iii. Dynamic Resource Allocation
iv. Reservation and Negotiation Mechanism

End of the Examination

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC 4835
WIRELESS AND MOBILE NETWORKS

Date: 26th NOVEMBER 2020
Time: 09:00hrs – 11:00hrs
Duration: 2 Hours
Venue: NSLT

Instructions

1. There are **two (2) Sections** in this exam, **Section A** and **Section B.**
2. In Section A, **Answer all the questions** and in Section B **choose any three (3) questions.**

SECTION A [40 MARKS]

ANSWER ALL THE QUESTIONS IN THIS SECTION

Question 1 [20 marks]

a) What is the effect called when energy intended for one symbol spills over to the adjacent symbol? **[4 marks]**

b) What do you call the scheme where cells with more traffic are dynamically allotted more frequencies? **[4 marks]**

c) What are the main reasons for using cellular systems? How is SDM typically realized and combined with FDM? How does DCA influence the frequencies available in other cells? **[4 marks]**

d) What are advantages and problems of forwarding mechanisms in Bluetooth networks regarding security, power saving, and network stability? **[4 marks]**

e) Bluetooth device can go into one of three low power states. Name the states. **[4 marks]**

Question 2 [20 marks]

a) What are the main problems of signal propagation? Why do radio waves not always follow a straight line? Why is reflection both useful and harmful? **[4 marks]**

b) Name the three ways in which the signal can be represented. **[4 marks]**

c) Explain why a cell can cover a larger area under a light load and it shrinks if the load increases. **[4 marks]**

d) Why, typically, is digital modulation not enough for radio transmission? What are general goals for digital modulation? What are typical schemes? **[4 marks]**

e) Which of the MAC schemes can give hard guarantees related to bandwidth and access delay? **[4 mark]**

SECTION B [60 MARKS]

ANSWER ANY THREE (3) QUESTIONS FROM FOUR (4) IN THIS SECTION

Question 3 [20 marks]

a) Discuss the advantages and disadvantages of infrared transmission. **[7.5 marks]**

b) Like wired networks, wireless communication networks also have senders and receivers of signals. However, in connection with signal propagation, these two networks exhibit considerable differences. Discuss signal propagation. **[5 marks]**

c) In the last few decades, Mobile Wireless Communication networks have experienced a remarkable change. The mobile wireless Generation (G) generally refers to a change in the nature of the system, speed, technology, frequency, data capacity, latency etc. Discuss the evolution of mobile technologies. **[7.5 marks]**

Question 4 [20 marks]

a) GSM offers several security services using confidential information stored in the AuC and in the individual SIM (which is plugged into an arbitrary MS). Discuss the security services offered by GSM. **[7.5 marks]**

b) Briefly explain about the types of modulation.**[7.5 marks]**

c) Discuss the advantages and disadvantages of radio transmission.**[5 marks]**

Question 5 [20 marks]

a) GSM permits the integration of different voice and data services and the interworking with existing networks. Services make a network interesting for customers. Discuss the mobile services. **[7.5 marks]**

b) Multiplexing is not only a fundamental mechanism in communication systems but also in everyday life. Discuss multiplexing.**[7. 5 marks]**

c) Spreading the spectrum can be achieved in two different ways. Explain the ways. **[5 marks]**

Question 6 [20 marks]

a) TDMA comprises all mechanisms controlling medium access according to TDM. But what happens if TDM is applied without controlling access? This is exactly what the classical Aloha scheme does. Discuss classical Aloha.**[7.5 marks]**

b) Radio waves can exhibit three fundamental propagation behaviors depending on their frequency. Explain the three fundamental propagation behaviors. **[7.5 marks]**

c) The Bluetooth specification already comprises many protocols and components. Starting as a simple idea, it now covers over 2,000 pages dealing with not only the Bluetooth protocols but many adaptation functions and enhancements. Discuss the core protocols of Bluetooth. **[5 marks]**

THE END

THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Science

FINAL EXAMINATION

CSC 4845
FUNDAMENTALS OF CLUSTER AND HIGH-PERFORMANCE COMPUTING

Date: 20th November 2020
Time: 09:00hrs – 12:00hrs
Duration: 3 Hours
Venue: NSLT

Instructions

1. There are **Five (5) Questions** and **Two (2) Sections** in this paper.
2. Each question carries **25 marks,** *you are required to answer a total of* ***four (4) Questions***
3. *Answer* ***ALL*** *the questions in* ***Section A*** and choose ***Any Two*** *(2) questions from* ***Section B***

SECTION A

This Section has Two Question. Answer **ALL** the Questions

QUESTION ONE

a) Give a brief description for each of the following terminologies with respect to Grid and Cluster Computing [8 Marks]

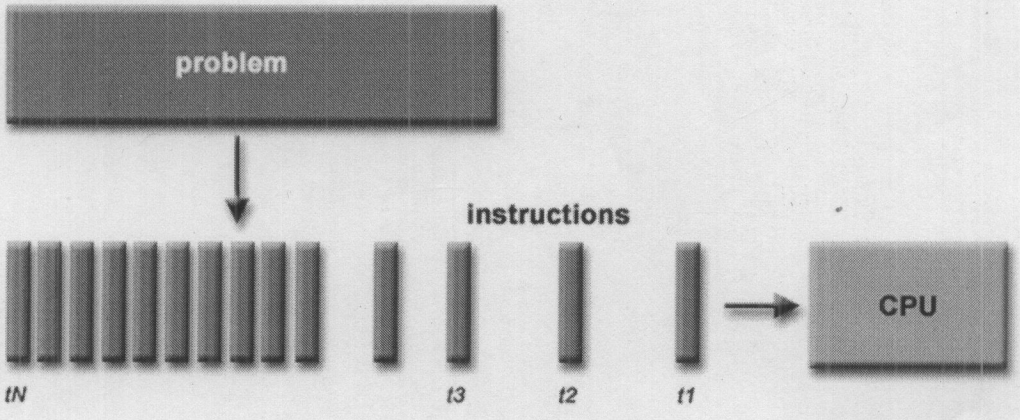
i. Task
ii. Parallel Overhead
iii. Massively Parallel
iv. Granularity

b) Scalable Parallel Computer Architectures is based on how processors, memory and interconnect are laid out. These can be classified in five major groupings. Briefly discuss each of the groupings below [8 Marks].

a. Massively Parallel Processors (MPP)
b. Symmetric Multiprocessors (SMP)
c. Cache-Coherent Nonuniform Memory Access (CC-NUMA)
d. Clusters

c) Traditionally, software has been written for serial computation. In order to be run on a single computer having a single Central Processing Unit (CPU), a problem is broken into a discrete series of instructions as shown in the diagram below. Instructions are then executed one after another. [9 Marks]

i. Draw a diagram similar the diagram below for Parallel computing and explain how parallel computing works
ii. Give any two reasons why we need Parallel Computing?
iii. What are some of the Limitations of Serial Computing?
iv. Give any two (2) Examples of the grand Challenging Problems



QUESTION TWO

a) Virtualization uses software to create an abstraction layer over computer hardware that allows the hardware elements of a single computer processors, memory and storage to be divided into multiple virtual computers, commonly called virtual machines [12 Marks].

i. Draw a diagram showing the difference between a virtualised and none virtualised implementation

ii. Discuss each of the following with respect to visualization

1. Host Operating System
2. Guest Operating System

iii. What are the main purposes of visualization?

iv. Name any two open source virtualisation software for both Windows and LINUX

b) Cluster computing is the process of sharing the computation tasks among multiple computers that form the cluster and works on the distributed system with the networks. Describe the major steps required in building a **Virtual Beowulf Cluster** using **VirtualBox** [8 Marks]

c) A single system image is the illusion, created by software or hardware, that presents a collection of resources as one, more powerful resource. Single system image makes the cluster appear like a single machine to the user, to applications, and to the network. **Discuss the major benefits** of the Single System Image (SSI) [5 Marks]

SECTION B

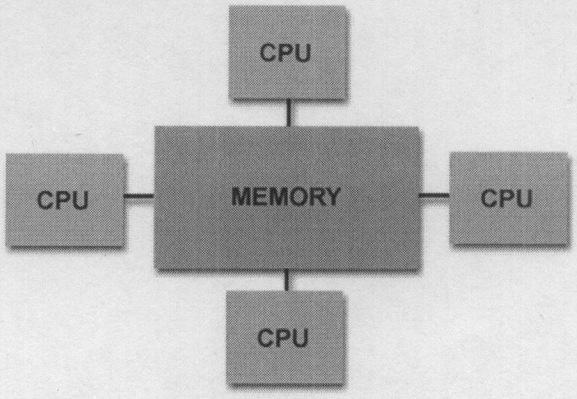
This Section has Three (3) Questions. Choose any **two** (2) questions

QUESTION ONE

a) With the help of a diagram, **briefly** discuss each of the following with respect to **Designing Parallel Programs** [8 Marks]
   i. Communications
   ii. Partitioning
   iii. Load Balancing
   iv. Granularity

b) A cluster is a type of parallel or distributed processing system, which consists of a collection of interconnected stand-alone computers cooperatively working together as a single, integrated computing resource. Briefly discuss each of the following Prominent Components of Cluster Computers [8 Marks]
   a. State of the art Operating Systems
   b. Fast Communication Protocols and Services
   c. Cluster Middleware
   d. Applications and Subsystems

c) Shared memory parallel computers vary widely, but generally have in common the ability for all processors to access all memory as global address space as shown in the Figure below. Multiple processors can operate independently but share the same memory resources. Changes in a memory location effected by one processor are visible to all other processors. Shared memory machines can be divided into two main classes based upon memory access times namely UMA and NUMA. With the help of a diagram, **describe** each of the following in details [9 Marks]
   i. UMA and NUMA
   ii. Distributed Memory
   iii. Hybrid Distributed-Shared Memory



QUESTION TWO

a) A parallelizing compiler generally works in two different ways namely
   i. Fully Automatic
   ii. Programmer Directed

   Discuss each of these parallel programming methods [4 Marks]

b) A cluster is a type of parallel or distributed processing system, which consists of a collection of interconnected stand-alone computers cooperatively working together as a single, integrated computing resource called NODES. Give any five major characteristics of a node in the context of cluster computing [5 Marks]

c) Resource Management and Scheduling is the act of distributing applications among computers to maximize their throughput and enable the effective and efficient utilization of the resources available [8 Marks].
   i. Draw the diagram showing **cluster scheduler.** *Use **Libra** as an example of the **cluster scheduler** (Show the Server Master Node and Cluster Worker Nodes)*
   ii. Explain how RMS enables the effective and efficient utilization of the resources available through the services provided by RMS

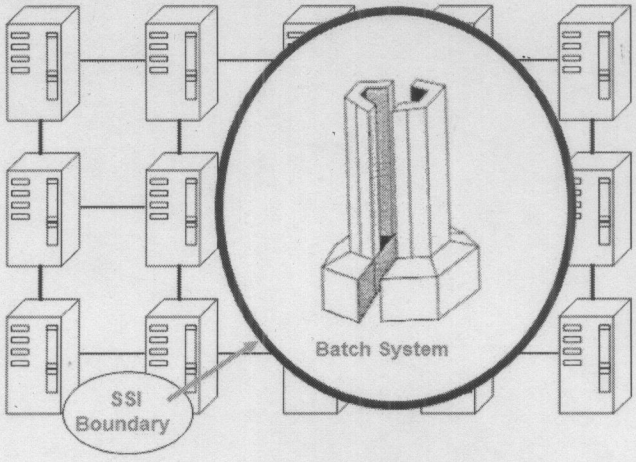
d) There are different ways to classify parallel computers. One of the more widely used classifications is called Flynn's Taxonomy. Flynn's taxonomy distinguishes multi-processor computer architectures according to how they can be classified along the two independent dimensions of Instruction and Data. Each of these dimensions can have only one of two possible states. Discuss each category with the help of a diagram [8 Marks]

QUESTION THREE

a) There are several parallel programming models in common use today which exist as an abstraction above hardware and memory architectures. These include;
   i. Shared Memory
   ii. Threads
   iii. Message Passing

   With the help of the diagram where possible, discuss each of the models above [9 Marks]

b) The diagram below shows an applications single system image (SSI) boundary. A cluster without a single system image is not a cluster [10 Marks]
   i. What is Single System Image (SSI)?
   ii. Briefly discuss each of the following
      1. Cluster Middleware and Single System Image
      2. Single System Image Boundaries
      3. Five major benefits of Single System Image



c) With reference to single image system, discuss each of the following middleware design goals [6 Marks]
   i. Complete transparency in resource management
   ii. Scalable performance
   iii. Enhanced availability

END OF EXAMINATION PAPER