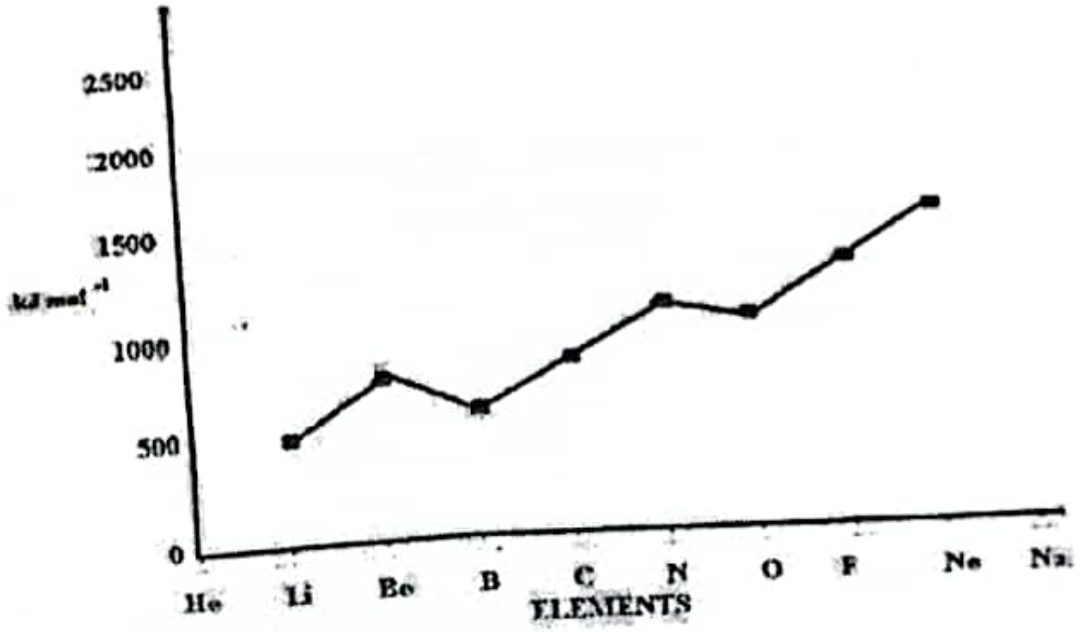
SECTION A

ANSWER ALL QUESTIONS IN THE MAIN BOOKLET

Question A1

(a) Differentiate between an orbit and an orbital.

(b) Explain in brief the discontinuities in ionization energy of the elements in the second period as evidenced in the diagram below in going across a period



[4]

Question A2

(a) Define the photoelectric effect and state one condition that must be fulfilled for the photoelectric effect to be observed.

(b) The threshold frequency V_0 for a metal is $6.0 \times 10^{13} s^{-1}$. Calculate the kinetic energy of an electron when the radiation of frequency $v = 1.0 X 10^{14} S^{-1}$ hits the metal. [4]

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SECTION B ANSWER QUESTION B1 AND ANY THREE QUESTIONS

Question B1

In CHE 1000 experiment, the titration using the sequential reaction below was performed.

$$4NH_4Cl(aq) + 6HCHO(aq) \rightarrow C_6H_{12}N_4(aq) + 4HCl(aq) + 6H_2O(aq) \quad (1)$$

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l) \quad (2)$$

A 25.00 cm^3 Solution containing 130 g of general purpose NH4Cl was pipetted to the conical flask and 5 cm3 of formaldehyde, HCHO, Was added to it. After reaction (1) was completed, two drops of an indicator were added. The titration required 21.90 cm^3 of 0.100 mol dm^3 NaOH to reach the endpoint.

(a) Name the indicator used for the titration. **[1 Mark]**

(b) Students were advised to rinse the apparatus with appropriate solutions. Name the Solutions used for rinsing the burette, the pipette, and the conical flask. **[3 marks]**

(c) From the titration reaction (2), determine the moles of HCl in the conical flask. **[14 marks]**

(d) (i) Calculate the moles Of NH4Cl that produced HCl in reaction (l) 13 marks **[2 marks]**

(ii) Determine the mass ofNH4Cl

(e) Calculate percent Of NH4Cl in the sample of the general purpose reagent used in the titration **[12 marks]**

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Question A4

The atoms Of N20 (nitrous oxide, laughing gas) are connected:

(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 $CO(s)$

$$Co^{2+}(aq) + 2e^- \rightleftharpoons Co(s) \qquad -0.28\,V$$

$$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s) \qquad -0.76\,V$$

(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^0, for the overall reaction at 25°C.

[4 Marks]

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QUESTION A3

(a) Calculate the frequency of light having a wavelength of 456 nm.

(b) Draw the Lewis dot resonance structures for the carbonate ion, CO_3^{2-}.

[4 Marks]

QUESTION A4

Consider the following half reactions and their standard reduction potentials.

$$2Cl_3^- + 12H^+ + 10e^- \rightarrow Cl_2 + 6H_2O, \quad E^\circ = 1.47\,V$$

$$S_2O_8^{2-} + 2e^- \rightarrow 2SO_4^{2-}, \quad E^\circ = 2.01\,V$$

(i) Give the overall cell reaction and

(ii) Calculate ΔG° for the cell reaction at 25°C given that is 0.54 V.

[4 Marks]

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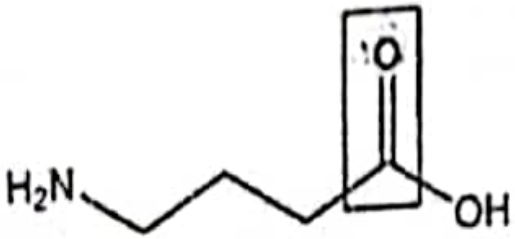
(b) Classify the molecule shown below and describe the bonding of t group in the box.

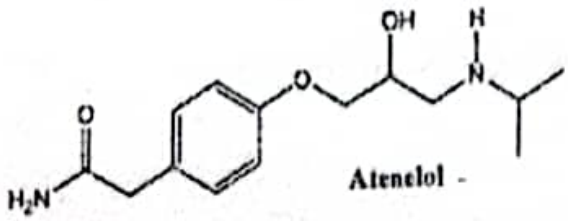


[4 Marks]

Question A10

(a) Give the IUPAC name for the molecule shown below:

(b) Identify all functional groups in the drug atenolol, used for treatment of hypertension (high blood pressure), shown below:



[4]

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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
1 J = 1 kg m^2 s^{-2}

(c) Calculate the maximum kinetic energy (in joules) and velocity of an electron ejected from zinc by a 275 nm photon. (Threshold energy for Zn 4.31 eV).

Report the answer to 3 significant figures **[3 Marks]**

(d) A water desalination plant is set up near a salt marsh containing water that is 0.10 M NaCl is completely dissociated. **[3 Marks]**

(e) Diethyl ether ($CH_3CH_2OCH_2CH_3$) was one of the first chemicals used as anesthetic. At 34.68°C , Diethyl ether has vapor pressure of 760 torr, and at 17.98°C, it has a vapour pressure of 400 torr. What is the ΔH of vaporization for Diethyl ether? **[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:

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

The mass of each solid electrode is 2.00 g.

The electrode potentials for the half reactions are:

$$Cu^{2+} + 2e^- \rightarrow Cu \qquad E^0 = +0.3419\ V$$

$$Zn^{2+} + 2e^- \rightarrow Zn \qquad E^0 = -0.7618\ V$$

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

(ii) Calculate the cell potential when this battery is first connected.

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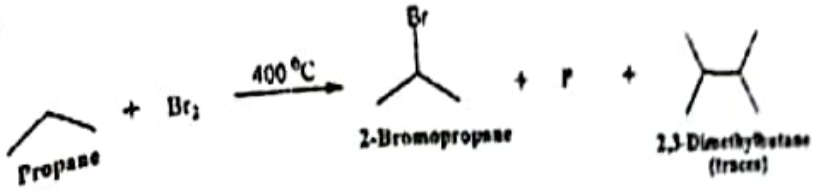
Question B5

(a) Under certain reaction conditions, mono-bromination of propane gave a mixture of two mono-brominated products, 2-bromopropane and P. In addition to mono-brominated products, traces of 2,3-dimethylbutane were also detected in the reaction mixture.

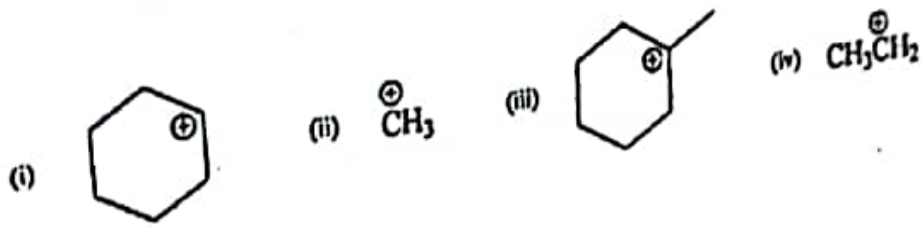


(i) Give the structure of the mono-brominated product P. [1]

(ii) Suggest mechanism of the reaction for formation of 2-bromopropane. [6]

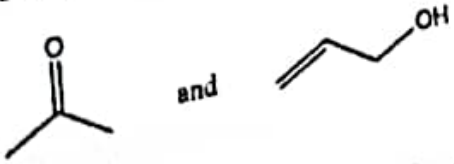
(iii) Propose a possible mechanism to account for formation of 2,3-dimethyl- butane in this reaction. [2]

(b) Arrange the following reactive intermediates in order of decreasing stability: [3]



(c)

(i) Identify the relationship between the following pair of molecules as Identical, chain isomers, positional isomers, functional isomers or geometrical isomers. [1.5]



(d) Provide the stereochemical structure for a Trans-alkene, C4H8, with two vinylic hydrogens and two allylic carbons. [1.5]

QUESTION B4

(a) Initial rate of the reaction between compound X and Y was measured in a series of experiments at fixed temperature. The following rate equation was deduced.

$$Rate = k[X]^2[Y]^0$$

Experiment	Initial [X] mol dm^{-3}	Initial [Y] mol dm^{-3}	Initial rate (mol dm^{-3}s^{-1})
1	1.20×10^{-3}	3.30×10^{-3}	2.68×10^{-1}
2	1.20×10^{-3}	6.60×10^{-3}	A
3	2.40×10^{-3}	6.60×10^{-3}	B
4	C	9.90×10^{-3}	8.04×10^{-1}

What is the value of A, B, and C in the table above?

[4 marks]

(b) Calculate the solubility product, K_{sp} for $Pb_3(PO_4)_2$ solid with a solubility of $6.2 \times 10^{-12}\ mol/L$. **[5 marks]**

(c) Calculate the pH of a buffer solution containing 0.20 M CH_3COOH and 0.3 M CH_3COONa. K_a of $CH_3COOH = 1.8 \times 10^{-5}$

[6 marks]

[Total: 15 Marks]

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THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2017/2018 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 THREE 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. ENSURE that you have eight (8) printed pages containing questions A1 to A10 and B1 to B5.

ADDITIONAL INFORMATION TO THE CANDIDATES:

Useful data is provided on page 9.
Periodic Table of Elements is on last page.

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SECTION A

ANSWER ALL QUESTIONS IN THIS SECTION IN THE MAIN BOOKLET

Question A1

Hemoglobin is the protein that transports oxygen through the blood from the lungs. In doing so, each molecule of haemoglobin combines with four molecules of oxygen. - If 1.00 g of Haemoglobin combines with $1.53\ X\ 10^{-6}$ s of O_2 at 310K and 99059 Pa, what is the molar mass of haemoglobin? **[4 Marks]**

Question A2

(a) Two factors can determine the size (radius) of an atom. State any one of them and explain in three lines or less, how it influences the size of an atom.

(b) Is it more difficult to remove a valence electron from a magnesium atom or a chlorine atom? Explain in three lines or less. **[4 Marks]**

Question A3

The following standard electrode potentials are needed for this question:

	$E°/V$
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2 + H_2O$	+ 0.81
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+ 0.34

Calculate the standard cell emf for the reaction between copper and nitric acid and derive the balanced reaction equation. [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 CHE 1000 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).

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

Step 2 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]**

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THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2016/2017 ACADEMIC YEAR

FINAL EXAMINATIONS

CHE 1000: INTRODUCTION TO CHEMISTRY
TIME: THREE (3) HOURS
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6. **ENSURE** that you have eight (8) printed pages and Periodic Table.

ADDITIONAL INFORMATION TO THE CANDIDATES:

Useful data is printed on **page 8.**

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Question B2

(a) The active agent in many hair bleaches is hydrogen peroxide. The amount of hydrogen peroxide in 15.8 g hair bleach was determined by titration with a standard potassium permanganate solution:

$$2MnO_4^-(aq) + H_2O_2(aq) + 6H^+(aq) \longrightarrow 5O_2(g) + 2Mn^{2+}(aq) + 8_2O(l)$$

(i) How many moles of Mn were required for the titration if 43.2 ml of 0.015 M $KMnO_4$ was needed to reach the end point? **(1 mark)**

(ii) HOW many moles of H_2O_2 were present in the 15.8 g of hair bleach? **(2 marks)**

(iii) How many grams of H_2O_2 were present in the hair bleach? **(1 mark)**

(iv) What is the mass percent H_2O_2 in the hair bleach? **(2 marks)**

(v) What is the reducing agent in the redox reaction? **(1 mark)**

(b) Consider the following precipitation reaction:

$$Hg_2(NO_3)_2(aq) + KI(aq) \longrightarrow Hg_2I_2(s) + KNO_3(aq)$$

(i) Balance the reaction **(2 marks)**

(ii) Write the net ionic reaction. **(2 marks)**

(iii) Identify the spectator ions. **(2 marks)**

(c) Determine the oxidation number of the underline atom in each of the following:

(i) H_2SO_4

(ii) $SbCl_3$

(2 marks)

[Total: 15 marks]

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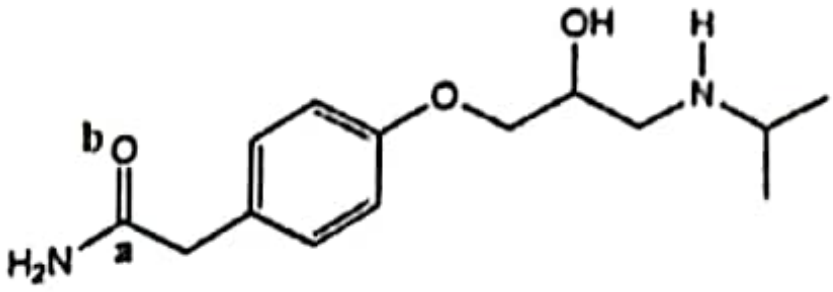
(c) Consider the drug atenolol, used for treatment of hypertension (high blood pressure), shown below:

Atenolol:



(i) Identify all functional groups in atenolol. (2 marks)

(ii) For the labeled atoms a and b, state the kind of orbitals that overlap to form each bond. (2 marks)

(d) Give the structures for **two** Cs alkane constitutional (structural) isomers with parent chain name as hexane. (2 marks)

----------END OF EXAM----------

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THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2018/2019 ACADEMIC YEAR
FINAL EXAMINATIONS

CHE1000: INTRODUCTION TO CHEMISTRY

TIME: THREE (3) HOURS

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ADDITIONAL INFORMATION TO THE CANDIDATES:

Useful data is provided on page 10.
Periodic Table of Elements is on last page.

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Question A7

What is the vapour pressure of a solution at 298 K containing 68 g of glucose (M, 180 g/mol) in 600 g of water? The vapor pressure of pure water at 298 K is 0.03173 bar. [4]

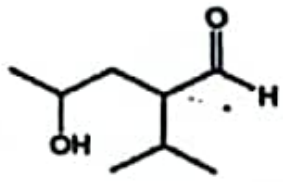
Question A8

Calculate ΔH_{vap} for ethanol, given vapor pressure at 313 K = 0.19999 bar. The normal boiling point for ethanol is 351 K.

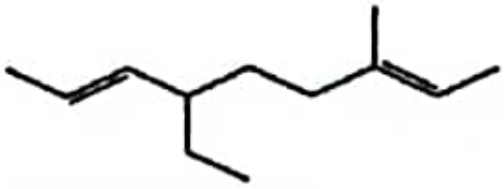
Question A9

Provide the IUPAC name for each of the following compounds:

(a)



(b)



[4]

Question A10

(a) Write the line formula for 4-aminobutanoic acid.

(b) Describe the highlighted carbon oxygen double bond of the ketene, $CH_2 = C = O$.

(c) Provide the stereochemical structure for the Cis-alkene, C_4H_8, which has two vinylic and six allylic hydrogens. [4]

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Question B5

(a) Several constitutional isomers can be written for molecular formula

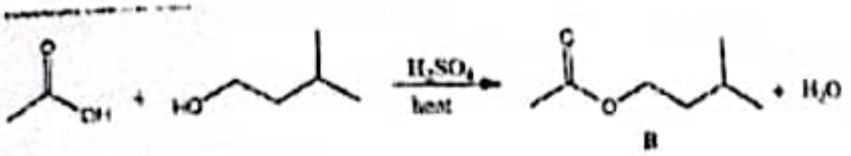
(i) Calculate the IHD and state all possible interpretations. **(2 marks)**

(ii) Draw line-bond formula and give IUPAC name for. an isomer that is a straight chain acyl chloride (acid chloride). **(3 marks)**

(iii) Draw line-bond formulae for two (2) isomers with cyclobutene as parent chain and state their isomeric relationship as chain, positional or functional isomers. **(3 marks)**

(iv) One of the isomers decolorizes bromine water. Interpret this result and state two (2) other functional groups that could be present in this isomer. **(2 marks)**

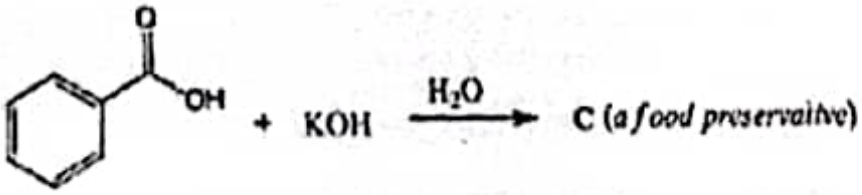
(b) Esters are pleasant sweet-fruity smelling substances frequently used in perfumery and food industry. One common banana flavor B used for candy products is prepared by the reaction shown below:



(i) Name the type of reaction. **(1 mark)**

(ii) Give the IUPAC name for B. **(2 marks)**

(c) A frequently used food preservative, C, is prepared as shown below:



Identify C (line-bond structure) and circle the most electrophilic center on its structure. **(2 marks)**

[TOTAL: 15 Marks]

END OF EXAMINATION

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(b) Consider a compound **X**, with molecular formula, C_3H_6O;

(i) Calculate the IHD (also called DBE and DU) of X and interpret it. [2]

(ii) Write any two (2) possible structures (line formulae) for **X**. [2]

(iii) Given that compound **X** is a primary alcohol which has 3 vinylic hydrogens, identify **X**, give line formula and IUPAC name. [2]

END OF EXAMINATION

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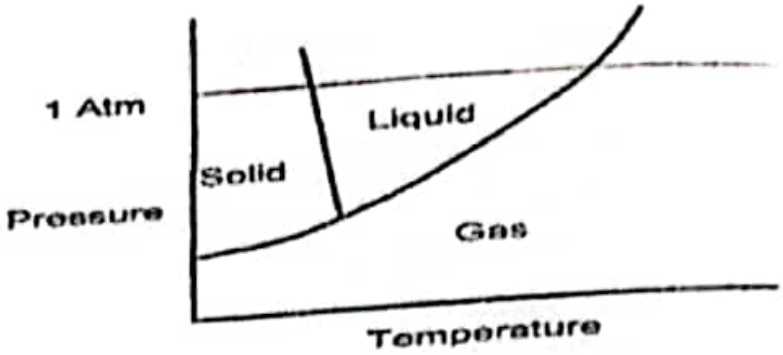
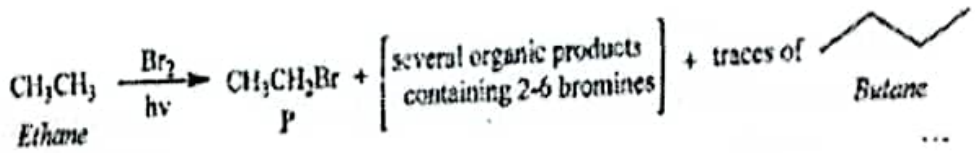
(c) The diagram below shows a simplified phase diagram for water. Reproduce the phase diagram for water in your answer booklet and the answer the questions that follow.



(i) Indicate the triple point With the letter **A** and critical temperature **B**.
(ii) On the Same diagram show the lines for the phase changes when a solute is added to water. Indicate the triple point for the solution as **C** and critical temperature **D** Indicate on the diagram the position (temperature axis) ΔT_f and ΔT_b

Question B5

(a) Consider the following reaction:



(i) Name the type of reaction. [1]
(ii) Provide detailed reaction mechanisms for formation of P from ethane. [6]
(iii) Propose a possible mechanism to account for the traces of butane found in the reaction mixture. [2]

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THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2019/2020 ACADEMIC YEAR
FINAL EXAMINATIONS

CHE1000: INTRODUCTION TO CHEMISTRY

TIME: THREE (3) HOURS

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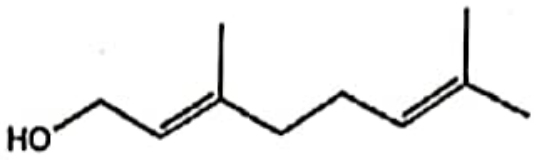
ADDITIONAL INFORMATION TO THE CANDIDATES:

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

PLEASE TURN OVE

Question B5

(a) Geraniol, a naturally occurring monoterpenoid, is found in rose, palmarosa and citronella oils. It has rose-like scent and is commonly used in perfumes and food flavours.



Geraniol

(i) Give the complete TUPAC name for geraniol. **[2 marks]**

(ii) When reacted with excess hydrogen in the presence of palladium (catalyst), geraniol gives a product **P**, $C_{10}H_{22}O$. Propose the structure (bond-line) for **P** and give balanced chemical equation for the reaction. **[3 marks]**

(b) Several constitutional (structural) isomers can be written for the molecular formula $C_4H_8O_2$. **[12 marks]**

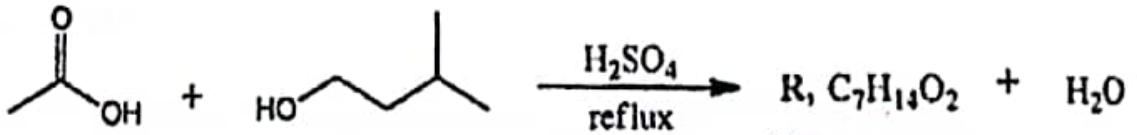
(i) Calculate the IHD and state all possible interpretations.

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

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

(iv) State the isomeric relationship between **P** and **Q**. **[1 mark]**

c) The characteristic flavour of the fruit, pear, is ascribed to the molecule **R**, $C_7H_{14}O_2$ ('pearessence'), which is made by the reaction shown below:



Acetic acid **Isoamyl alcohol** **'Pear essence'**

(i) State the type of reaction, shown above. [1 MARK]

(ii) Suggest the structure (bond-line) for **R**. [1 MARK]

END OF EXAM

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Question A 10

Give a skeletal (line) formula:

(a) Allyl benzyl ether

(b) 3-Methylheptane-2,5-dione

(c) 2-aminobenzenenitrile (2-aminobenzonitrile).

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

Question B 1

In Experiment 3 — The Stoichiometry of Chemical reaction — one of the experimental run involved mixing 2.50 mL of 0.500 M barium chloride, BaC12, and 7.50 mL of 0.500 M sodium sulphate, Na_2S0_4 solution. The height of barium sulphate precipitate formed in the test-tube was measured.

(a) Write the balanced molecular and net ionic reaction involved in the experiment. **(2marks)**

(b) Identify the limiting reagent. Justify your answer by appropriate calculations. **(7 marks)**

(c) Calculate the mass of barium sulphate (molar mass =233.40 g/mol) formed. **(4marks)**

(d) What was the main source of error in the experiment? **(2marks)**

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1.00 cm of the diluted white wine and left until all the ethanol had been completely oxidised.

tep 3 10 cm^3 (an excess) of potassium iodide solution was added to the flask to react with the remaining potassium dichromate (VI) solution.

tep 4 The iodine produced was titrated with 0.0300 mol dm^{-3} sodium thiosulfate solution.

tep 5 The procedure was repeated twice more. The mean titre of sodium thiosulfate solution was 9.20 cm^3. The equations for the reactions taking place are

$$2Cr_2O_7^{2-}(aq) + 3C_2H_5OH(l) + + 16H^+(aq) + \rightarrow 4Cr^{3+}(aq) + 11H_2O(l) + 3CH_3COOH(aq)$$

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6I^-(aq) \rightarrow 2Cr^{3+}(aq) + 3I_2(aq) + 7H_2O(l)$$

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

(i) Use the equations to determine the mole ratio of $S_2O_3^{2-}$ to $Cr_2O_7^{2-}$ in this series of reactions. **[2 marks]**

(ii) Calculate the mass of ethanol in 5.00 cm^3 of the original white wine. **[7 marks]**

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Question A3

Consider the following data:

Half equation	E/V
$Fe^{3+}(aq) + 3e^- \leftrightharpoons Fe(s)$	- 0.04
$Fe^{2+}(aq) + 2e^- \leftrightharpoons Fe(s)$	- 0.44

Use the data above to construct a redox equation for the reaction between Fe^{3+} (aq) and $Fe(s)$, and whether or not this reaction is feasible. Show your work. [4]

Question A4

Nitrogen monoxide reacts with hydrogen gas to produce nitrogen gas and water. The mechanism is believed to be:

Step 1 : $2NO \longrightarrow N_2O_2$

Step 2 : $N_2O_2 + H_2 \longrightarrow N_2O + H_2O$

Step 3 : $N_2O + H_2 \longrightarrow N_2 + H_2O$

(a) What is the molecularity of Step 2?
(b) What is the balanced net reaction?
(c) Identify any reaction intermediate(s). [4]

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SECTION A

ANSWER ALL QUESTIONS IN THIS SECTION IN THE MAINBOOKLET

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.

(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]

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estion B 2

(i) Draw a ground state electronic orbital energy diagram of nitrogen and Oxygen atoms using orbital box notation. **(3 marks)**

(ii) Explain in two sentences why the first ionization energy of $O(1320\ KJ\ mol^{-1})$ is less than that $N(1410\ KJ\ mol^{-1})$ despite the fact the highest orbitals in N and O are in the same energy level.

(2 marks)

(iii) Calculate the ionization energy of $^{1}_{1}H$ IN $KJ\ mol^{-1}$. **(4 marks)**

(i) Explain trend in boiling points of the following: **(2 marks)**

$I, -85°C;\ HBr, -67°C;\ HL, -15°C$

(ii) Use Lewis diagrams to illustrate the formation Of HCl from its elements

Use Hess's Law to determine ΔH for the reaction $C_3H_4(g) + 2H_2(g) \rightarrow C_3H_8(g)$ **(2 marks)**

(1) $H_2(g) + {}^{1}/_{2}\,O_2(g) \rightarrow H_2O(l) \Delta H = -1\,285.8\ kj$

(2) $C_2H_4(g) + 4O_2(g) \rightarrow 3CO_2(g) + 2H_2O(L) \quad \Delta H = -1937\ kj$

(3) $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)\ \Delta H = -2219.1\ kj$

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v) Write the conventional representation for this cell. (2marks)

vi) Write an equation for the overall cell reaction that would occur.

vii) The voltmeter V shown in the diagram of the cell was replaced by an ammeter. (2marks)

viii) Explain why the ammeter reading would fall to zero after sometime time. (1 mark)

(b) A curious CHEM 1000 student analysed the 10.00 mL sample of the solution D to determine the concentration of Fe^{2+} ions by titrating the acidified solution with a standard potassium permanganate solution

$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$

10.0 mL the solution was titrated potassium permanganate solution of concentration 0.0200 mol^{-1}. Volume of potassium permanganate used for complete reaction was 37.5 mL.

Calculate the following:

(i) oxidation state of Mn in potassium permanganate. (1 mark)
(ii) number of moles of permanganate ions used (2 mark)
(iii) number of moles of iron(ii) ions in 10.0mL of solution. (1 mark)

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SECTION B

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

Question B1

A CHE 1000 Student, Lydia, trying to determine the concentration of HCl by titrating it with 0.525mol dm^3 NaOH. It takes 83 ml, of a 0.525 mol dm^3 NaOH solution to neutralize 235 mL of an HCl solution.

(a) Another student, Joseph, carefully pipettes 10.0 mL of mol drn•3 NaOH into a test tube. He places the test tube into a small beaker and then pipettes 7.50 ml, of 0.355 mol dm^{-3} HCl into another test tube. He accidentally knocked the test tubes, while placing, contents combined in the beaker.

(i) Is the solution formed from the contents of the two test tubes acidic or basic?

(ii) If he added few drops of Methyl Orange indicator what would be the colour of the solution?

(7 marks)

(b) You are carrying out an acid base titration to determine the concentration, of the acid. The endpoint of the neutralization is reached but the stopcock on the burette sticks slightly and allows a few more drops of acid to fall into the solution. Will this small amount of acid any effect on the determined value for the concentration of the acid? If so, how is it affected (Not more than 4 lines)? **(4 marks)**

(c) A few small drops of water are left in a burette that is then used to titrate a base into an acid solution to determine the concentration of the acid. Will this small amount of water have any effect on the determined value for the concentration of the acid? If so, how is it affected (Not more than 4 lines)? **(4 marks)**

[TOTAL: 15 Marks]

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SECTION A — ANSWER ALL QUESTIONS

Question A1

A sample contains 27. 1 g of calcium oxide.

(a) Give the formula of calcium oxide.
(b) Calculate the number of moles of calcium oxide in the sample.

Question A2

(a) How many grams of carbon dioxide are there in a container with a volume of 4.50 L at STP?
(b) How many oxygen atoms are there in this amount of carbon dioxide?

Question A3

Consider the following redox reaction.

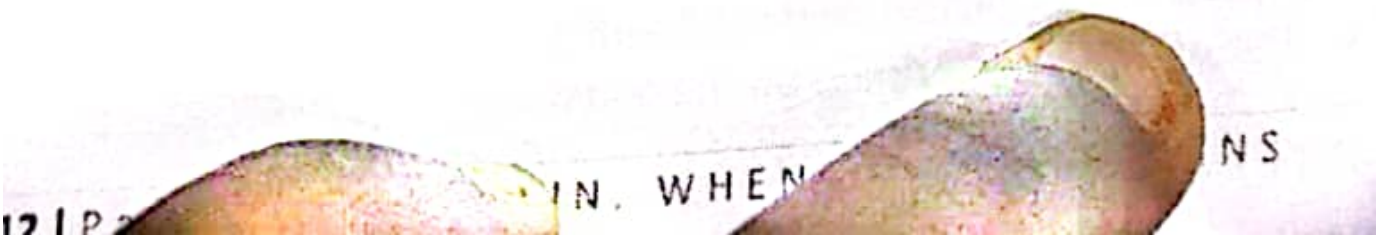
$$Br_2(aq) + 2V^{3+}(aq) + 2H_2O(l) \rightarrow 2V^{2+}(aq) + 4H^+(aq) + 2Br^-(aq)$$

Given that $E^\circ_{cell} = +1.39\,V$ and $E^\circ_{Br_2/Br^-} = +1.07$

(a) Calculate E° for V^{3+}
(b) Is the reaction spontaneous?

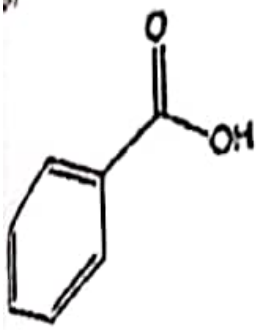
Question A4

(a) Draw a fully labeled diagram that shows the transition of an electron in the hydrogen atom from n = 4 to n = 2.
(b) Does the transition represent an emission or absorption?



Question B 5

a) A frequent used food preservative, P, is made as shown below:



+ NaOH ⟶ P + Q

(i) Name the type of reaction. (1 mark)

(ii) What is the structure of P? (1 mark)

(iii) Give IUPAC name for P. (1 mark)

(b) Several constitutional (structural) isomers can be written for the molecular formula C_5H_9OBr.

(i) Calculate the DBE (IHD) and state all possible interpretations.

(ii) One of the isomers decolorizes bromine water. Does this isomer has a ring? Give a reason. (2 marks)

(iii) Give a line formula for another isomer that is a <u>straight chain acyl bromide</u> (acid bromide). (2 marks)

TEAM WINS

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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

1 J = 1 kg m^{2}s^{-2}

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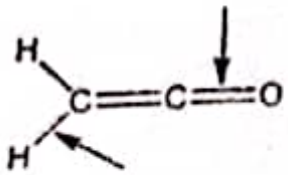
Question B5

(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 $C_4H_8O_2$. **[3 Marks]**

(i) Calculate the IHD and state all possible interpretations.

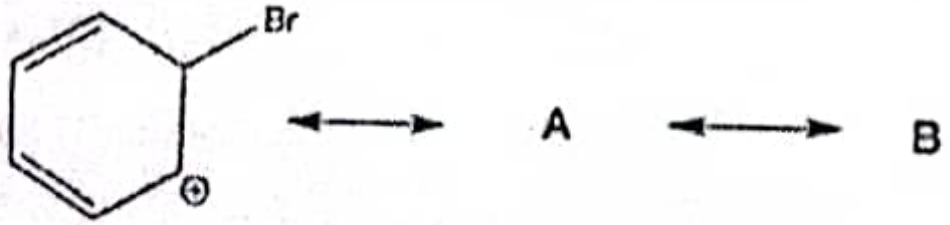
(ii) One of the isomers, B, decolorizes bromine water. Does this isomer has a ring? Give a reason. **[2 Marks]**

(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]

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Question B3

(a) Write an equilibrium reaction equation for the ionization of acetic acid (CH_3COOH) in water and Identify the conjugate acid-base pairs.

(b) Some solid sodium acetate (CH_3COOH Na) is dissolved in 1 mol dm^3 solution of acetic acid.

(i) Write the equilibrium reaction.

(ii) Explain the effect of the pH 0 n the pH of the 1 mol dm^3 solution of acetic acid when the [4]

(c) sodium acetate is dissolved.

$$SO_2Cl_2(g) \rightarrow SO_2(g) + Cl_2(g)$$

At 380 K, the equilibrium constant $K_p = 2.5\ bar$

(i) Write the expression for K_p for the equilibrium. [2]

(II) A sample of S02C12 is introduced in an evacuated reaction vessel and brought to - 0.1 equilibrium at 380 K. Ifthe sample and vessel are of such size that psoact2 — bar at equilibrium; calculate the equilibrium values of p_{so_2} and p_{cl_2}. What is total gas pressure in the vessel? [6]

Question B4

(a) Calculate the ionisation energy of a hydrogen atom in its ground state i.e. when the hydrogen's electron is at level 1.

(b) (i) Draw the Lewis structure for the water Ha O molecule and use V SEP R theory to sketch the arrangement of electron pair in space. Name the geometrical shape illustrated.

(ii) For the molecule described in b (i) above show whether the molecule is polar or non-polar. Justify your answer.

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Question A7

(a) The vapor pressure above a solution of a nonvolatile solute at 25.0°C is 19.3 mm Hg.

What is the mole fraction of the solute? (The vapor pressure of pure water is 23.8 torr at

25.0 oc.)

(b) List the following molecules in order of increasing surface tension: C_3H_8, CH_4, CH_8COOH and C_2H_6.

(c) Which substance has the higher vapor pressure: $C_{20}H_{42}$ or $C_{30}H_{62}$?

[4 Marks]

Question A8

(a) Identify the strongest intermolecular force present in the following molecules:

(i) CH_3CH_2OH

(ii) CH_3CH_2Cl

(b) Predict which will have the higher boiling point: ICl or Br_2 Explain your answer in not more than two lines. **[4 Marks]**

Question A9

(a) For compound A, 5-isopropyl-2,3-dimethyloct-2-ene:

(i) Draw a line-bond formula.

(ii) Give molecular formula.

(iii) State the number of allylic hydrogens in A.

OUR TEAM WINS

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[4 Marks]

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(i) CH_3CH_2OH

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Question A9

(a) For compound A, 5-isopropyl-2,3-dimethyloct-2-ene:

(i) Draw a line-bond formula.

(ii) Give molecular formula.

(iii) State the number of allylic hydrogens in A.

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Question B4

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

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

$[I^-]_o$ (M)	$[S_2O_8^{2-}]_o$ (M)	Initial rates (mol $L^{-1}.s^{-1}$)
0.080	0.040	12.5×10^{-4}
0.040	0.040	6.25×10^{-4}
0.080	0.020	6.25×10^{-4}
0.032	0.040	5.00×10^{-4}
0.060	0.030	7.00×10^{-4}

(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:

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

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 x $10^{-7} L/mol.s$. 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 $6.2 \times 10^{-12} mol/L$. **[3 Marks]**

[Total: 15 Marks]

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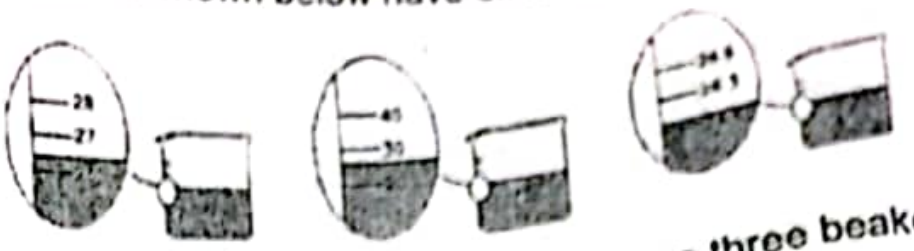
SECTION A

ANSWER ALL QUESTIONS IN THIS SECTION IN THE MAIN BOOKLET

QUESTION A1

(a) The beakers shown below have different precisions as shown.



Suppose you pour the water from these three beakers into on container. What would be the volume in the container reported to the correct number of significant figures?

(b) Roundup, a herbicide manufactured by Monsanto, has the formu $C_3H_8NO_5P$. How many molecules are there in a 304.3 g sample Roundup?

[4 Ma

QUESTION A2

A flammable gas made up of only carbon and hydrogen is found t effuse through a porous barrier in 1.50 min. Under the same cond of temperature and pressure, it takes an equal volume of bromine vapor 4.73 min to effuse through the same barrier.

(a) Calculate the molar mass of the unknown gas.

(b) Suggest the name of this gas.

[4

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Question B2

Given the following galvanic cell at 25°C and K_{eq} for this reaction is 2.79×10^7, $Pt(s)|Cr^{2+}(0.3M),\ Cr^{3+}(2.0M)||CO^{2+}(0.30M)|CO(s)$

(a) Draw a fully labeled cell diagram for the above notation. [6]
(b) Write a balanced overall cell reaction. [3]
(c) Calculate the cell potential ε and [3]
(d) ΔG for this reaction at the given temperature. [3]

Question B3

(a) Hydrogen has a red emission line at 656.3 nm, what is the energy and frequency of a photon of this light? [4]
(b) Refer to the periodic table arrange the following in order of increasing atomic radius: Al, C, Si. [3]
(c) Show using appropriate orbital energy diagram that the elements C and Si have similar chemical Properties. Justify in one Sentence. [3]

(d) Consider the molecule H_2O:
(i) Draw the Lewis structure of the molecule and determine its geometry about the central atom using the VSEPR model. [2]

(ii) Determine the hybrid orbitals on the oxygen atom using an appropriate hybridization scheme to justify the geometry identified in d(i) above. [2]

Question B4

(a) Pure ethanoic acid (CH_3COOH, also known as glacial acetic acid) has a concentration of 17.54 M. If 8.55 mL of pure acid are diluted to 770 mL, what is the ethanoic acid concentration? [3]
(b) If 26 mL of this diluted ethanoic acid in (a) has pH of 2.74.
(i) What is the hydrogen ion concentration in the solution? [2]
(ii) Calculate Ka for ethanoic acid. [4]
(c) If 13.2 g CH_3COOHNa are added to the 800 mL, of solution in (b) what is resulting pH?

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USEFUL DATA

Physical constants

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

Standard Reduction potentials

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

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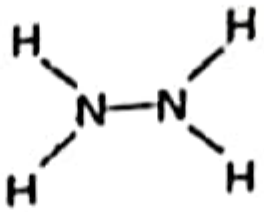
QUESTION A5

The compound hydrazine, N_2H_4 (structure shown below), is a liquid which is used as a rocket fuel.



Some bond enthalpies are given in the table.

Bond	Bond enthalpy/kJ mol
N–N	158
O–O	498
N≡N	945
H–O	464
N–H	391

Calculate the enthalpy change for the oxidation of hydrazine (equation shown below), using the bond enthalpy values in the table.

$$N_2H_{4(l)} + O_{2(g)} \rightarrow N_{2(g)} + 2H_2O_{(l)}$$

[4 Marks]

QUESTION A6

If the radiator of an automobile contains 12.00 L of water, how much would the freezing point be lowered by the addition of 5 kg of Preston (glycol, C_2H_4, 32.0 g/mol). How many Kg of zerone (methyl alcohol, CH_3OH, $M_r = 32.0\ g/mol$) would be required to produce the same result? Molar freezing point depression constant, $K_f = 1.86°C/m$. Assume the density of water $= 1\ kg/L$.

[4 Marks]

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QUESTION B3

(a) A voltaic cell is based on the following

$VO^{+}_{2(aq)} + 2H^{+}_{(aq)} + e^{-} \rightleftharpoons VO^{+}_{2(aq)} + H_2O_{(l)}$, $E^{\circ} = +1.00\,V$

$Zn^{2+}_{(aq)} + e^{-} \rightleftharpoons Zn_{(s)}$ $E^{\circ} = -0.70\,V$

The conditions in the cell were temperature 25°C, $[VO^{+}_{2} = 2.0\,M]$, $[H^{+}] = 0.05\,M$, $[VO]^{2+} = 0.01$ and $[Zn^{2+}] = 0.1\,M$.

(i) Calculate the E_{cell} **[2 Marks]**

(ii) Calculate the reaction quotient. **[2 Marks]**

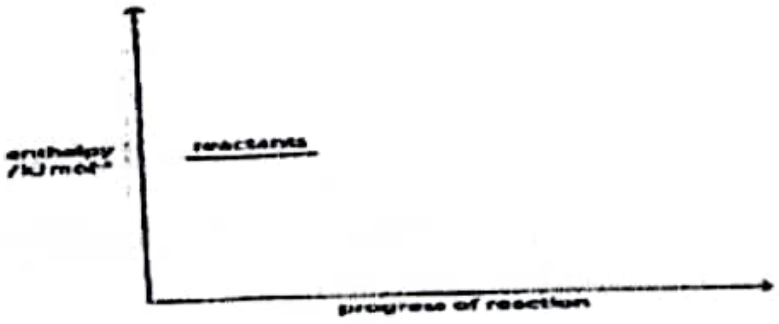
(iii) Draw a fully labelled cell diagram of this voltaic cell. **[2 Marks]**

[4 Marks]

(b) When 25.0 ml of 0.025 mol of HCl at 25.0°C is added to 25.0 ml of 0.025 mol of NaOH at 25.0°C in a foam cup calorimeter, a reaction occurs.

(i) Calculate the enthalpy change (in kJ) during this reaction if the highest temperature observed is 32.0°C. Assume the density of the solution is 1.00 g/ml and C_p, of the solution is 4.184 J/g°C. **[4 Marks]**

(ii) Redraw and complete the reaction profile diagram for the above reaction. Include labels showing the standard enthalpy change of the reaction, , and the activation energy, E_a. **[3 Marks]**



[Total: 15 Marks]

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SECTION B

ANSWER QUESTION B1 AND ANY THREE QUESTIONS IN ANOTHER SEPARATE MAIN ANSWER BOOKLET

QUESTION B1

(a) In a volumetric analysis experiment, a 22.5 cm^3 aqueous solution of sodium hydroxide of concentration O. 12 mol/dm^3 is titrated against an aqueous solution of ethanoic (acetic) acid of unknown concentration.

(i) Write a balanced equation for the reaction between sodium hydroxide and ethanoic (acetic) acid including state symbols.

[3 Marks]

(ii) Calculate the number of moles of sodium hydroxide in the titrated 22.5 cm^3.

[2 Marks]

(iii) Determine the concentration of ethanoic (acetic) acid if the following set of titres was obtained: (1) 8.82 (2) 8.50 and (3) 8.63 cm^3. Give your final answer to three significant figures.

[4 Marks]

(b) It is not advised to put sodium hydroxide solution into the burette when conducting a volumetric analysis experiment. However, it was put in the burette during the back titration experiment.

(i) State the risk that putting sodium hydroxide in the burette poses.

[1 Marks]

(ii) Mention why this risk arises.

[1 Marks]

(iii) Write an equation for the reaction that produces this risk.

[1 Marks]

(c) In the experiment to determine molar mass of a volatile liquid, draw a fully labelled apparatus set up for this experiment.

[3 Marks]

[Total: 15 Marks]

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Question A6

Use the following data to answer the questions about this reaction $A(g) + 3B(g) \rightarrow + 2C(g)$, 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 I, 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 ΔH^0 values;

$2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(g)$ $\quad \Delta H^0 = -305.4\ kJ$

$HCO_3H(l) + {}^1/_2\, O_2(g) \rightarrow CO_2(g) + H_2O(g)$ $\quad \Delta H^0 = -65.2\ kJ$

Calculate ΔH^0 for the reaction:

$CH_3OH(l) + O_2(g) \rightarrow HO_2H(g) + H_2O(g)$

[4 Marks]

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_2OK_f =1.86°C kg/mol] **[4 Marks]**

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USEFUL DATA

Physical constants

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

Question A6

A first-order reaction has a rate constant, k, of $2.00 \times 10^{-3} s^{-1}$. Calculate the time when only 1 percent of reactant remains.

Question A7

A saturated solution of Ag2Cr04 has the following equilibrium reaction:

$$Ag_2CrO_4(s) + H_2O(l) \rightleftharpoons 2Ag^+(aq) + Cr_4^{2-}(aq)$$

The solubility product of Ag_2CrO_4 is 9.0×10^{-12} at 25°C. Calculate the solubility of Ag_2CrO_4 in 0.0100 M k_2CrO_4 solution.

Question A8

NH4Cl is an acidic salt, K_b 0f NH_3 is 1.8×10^{-5}. Calculate the pH of 0.010 M NH_4Cl solution.

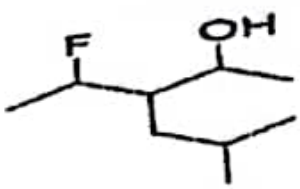
Question A9

Calculate the freezing point in Kelvin of a solution containing 18 g glucose (Mr 180 g/mol) and 68.4 g of sucrose (Mr 324 g/mol) in 200 g water. The freezing point of pure water is 0.0 °C and K_f of water is 1.86K/m.

Question A10

(a) Draw the structure for the following compound: 2-Bromo-8-chloro-4-(1 -methylpropyl) nonane

(b) Provide the TUPAC name for the following compound:



QUESTION B2

(a) A photon has both wave-like and particle-like properties. What do we call this phenomenon?

[1 Mark]

(b) What are the possible values of the magnetic quantum number for an electron in a **3p** subshell?

[2 Marks]

(c) For sodium metal to emit electrons, the metal must be irradiated with electromagnetic radiation that possesses energy of at least 220 kJ/mol. What is the wavelength of this radiation in meters?

[4 Marks]

(d) Using noble gas configuration (short hand notation), give the electron configuration for arsenic.

[2 Marks]

(e) From the list of molecules below, select all the polar molecules and list them from left to right in order of increasing molecular dipole moment.

[3 Marks]

$$CH_3Cl, CH_3F,\ CH_4\ CO_2, CH_3Br$$

(f) Using VSEPR theory, draw and name the molecular shape of the SO_4^{2-} ion (Central atom listed first).

[Total: 15 Marks]

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Question B4

Use the following information to answer questions below.

1	$SO_4^{2-}(aq) + H_2O(l) + 2e^- \rightleftharpoons SO_3^{2-}(aq) + 2OH^-(aq)$	- 0.93 V
2	$MnO_4^-(aq) + e^- \rightleftharpoons MnO_4^{2-}(aq)$	+ 0.56 V
3	$MnO_4^{2-}(aq) + H_2O(l) + 2e^- \rightleftharpoons MnO_2(aq) + 4OH^-(aq)$	+ 0.59 V
4	$Cr_2O_7^{2-}(aq) + 8H^+(aq) + 5e^- \rightleftharpoons 2Cr^{3+}(aq) + 7H_2O(l)$	+ 1.33 V
5	$2H^+(aq) + O_2(g) + 2e^- \rightleftharpoons H_2O_2(aq)$	+ 0.68V
6	$MnO_4^-(aq) + 8H^+(aq) + e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$	+ 1.51 V
7	$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightleftharpoons 2H_2O(l)$	+ 1.77 V
8	$FeO_4^{2-}(aq) + 8H^+(aq) + 3e^- \rightleftharpoons Fe^{3+}(aq) + 4H_2O(l)$	+ 2.20 V

(a)

(i) Give the formula of the species which, under standard conditions, is the strongest oxidising agent. [2 marks]

(ii) Calculate the standard cell potential, E^0 cell, for the following reaction.

$$2MnO_4^-(aq) + 6H^+(aq) + 5H_2O_2(aq) \rightleftharpoons 2Mn^{2+}(aq) + 5O_2(g) + 8H_2O(l)$$

[4 marks]

(b) The mass of ethanol in 5.00 cm ofwhite wine is found by oxidising the ethanol to ethanoic acid using acidified potassium dichromate(VI) solution. The excess acidified potassium dichromate(VI) solution is then determined.

Step 1 5.00 cm^3 of white wine Was diluted to 100.0 crn3 with distilled water.

tep 2 10.0 cm^3 of acidified potassium dichromate (VI) solution, of concentration 0.0150 mol dm^{-3}, was placed in a conical flask with

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QUESTION A7

The liquid-solid equilibrium line in the phase diagram of water has a negative slope and that for CO_2 slope is positive. What does this imply?

[4 Marks]

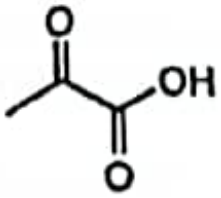
QUESTION A8

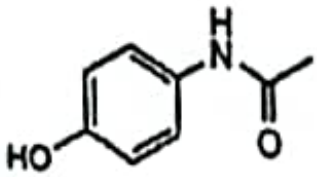
If 3.0 g of substance A decomposes for 36 min, the mass of A remaining unreacted is found to be 0.375 g. What is the half-life of this reaction if it follows first-order kinetics?

[4 Marks]

QUESTION A9

Name the functional groups in the following structures.

(i) 

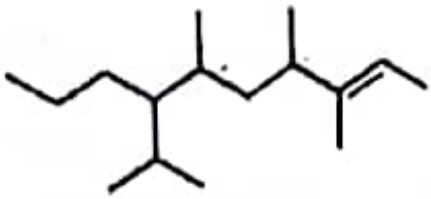
(ii) 

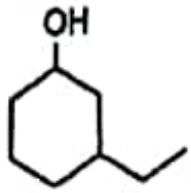
An analgesic

[4 Marks]

QUESTION A10

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

a) 

b) 

[4 Marks]

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Question A5

For the simple decomposition reaction

$$AB(g) \rightarrow A(g) + B(g)$$

the rate law is rate = k[AB]^2, and the rate constant, k, is 0.200 $M^{-1}s^{-1}$. How long will it take for [AB] to reach 1/3 of its initial concentration of 1.500 M?

Question A6 L

(a) Explain why ethanol (C_2H_5OH) dissolves in water.
(b) Name the two intermolecular forces involved when ethanol dissolves in water.

Question A7

For the reaction: $NO_2Cl(g) + NO(g)\, NO_2(g) + NOCl(g)$

the pre-exponential factor, A, is 1.00 x 10^{10} $M^{-1}s^{-1}$ and the activation energy of 40.00 k J mol^{-1}

The rate equation is first order in NO_2Cl and first order in NO.

(a) Write the rate law for the reaction.
(b) Calculate the value of the rate constant, k, at 500.0 K and its units.

Question A8

Soft drink fizz opening. Calculate the concentration of CO_2 when a drink is bottled at 455.76 kPa. For CO_2 in water, Henry's constant, K_H, is $3.356 \times 10^{-4}\ M/kPa$.

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Question A 6

(a) What are the units of the rate constant for the following reaction?

$2NO_2(g) \longrightarrow N_2O_4(g)$ $\qquad Rate = k\,[NO_2]^2$

(b) Calculate the rate at which N_2O_4 is formed in the following reaction at the moment in time when NO_2 is being consumed at rate of $0.0592\ mol\ dm^{-3}s^{-1}$.

Question A 7

Consider the following reaction:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

If a 10.00 l vessel has 2.50 mol CO_2 and 5.00 mol CO_2 and H_2 gas at 588 k, which way will the reaction proceed? ($k_c = 31.4$ at 588 k)

Question A 8

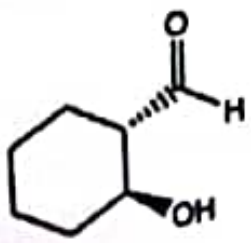
If 152g of Na_2So_4 are dissolved in 875g of H_2O, what will be the freezing point resulting solution. Assume 100% ionization

$K_f = 1.86°C/m$

Question A 9

Provide the IUPAC name for each of the following compounds:

(a)



(b)

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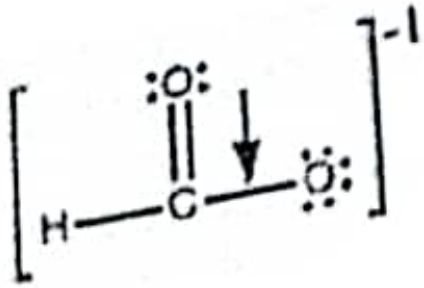
(iii) Calculate the cell potential after 10.0 A Of current ... [3 mark]
for 10,0 hours.
(Assume each half-cell contains 1.00 L of solution.)
(iv) Calculate the mass of each electrode after 10.0 hours. [3 mark]
(v) What will cause the battery to die after some time? [2 mark]

(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]

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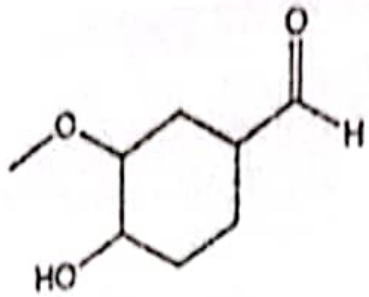
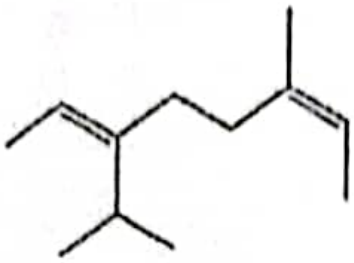
Question A9

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

(a)



(b)

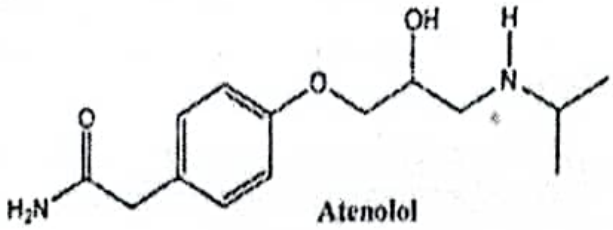


[4 Marks]

Question A10

(a) Write the bond line formulae corresponding to TUPAC 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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Question B3

(a) Use standard electrode potential, ED, data to calculate the celi potential for the following reaction:

$Cl_2 + 2OH^- \rightleftharpoons Cl^- + ClO^- + H_2O$

(2 marks)

(b) The chlorate(I) ion is unstable and decomposes when heated as shown.

$3Cl^- \rightleftharpoons 2Cl^-(aq) + ClO_3^-(aq)$

(I) Calculate the oxidation number of chlorine in each species.

(3 marks)

(ii) terms of electron transfer. State what happens to chlorine in die

(1 marks)

(c) A half equation involving bromate (V) ions, BrO_3^-, and bromide ions is shown.

$Br_3^-(aq) + 3H_2O(l) + 6e^- \rightleftharpoons Br^-(aq) + 6OH^-(aq)\ E^0 = +0.58\,V$

(i) An alkali solution of chlorate (I), Cl^-, can be used to oxidize bromide ins to bromated (V) ions. Write the equation for the spontaneous reaction.

(2 marks)

(ii) Draw a cell in which this reaction will occur and label all the parts.

(5 marks)

(iii) Write the shorthand notation for the cell. **(2 marks)**

(TOTAL: 15 Marks)

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(c) The experiment on the effect of temperature on the rate Of reaction was performed in the laboratory. The rate law for the reaction is given below:

$$\frac{constant}{t} = k[H^+]^m[S_2SO_3^{2-}(aq)]^n$$

(i) In the rate law equation, what is the name of the term on the left-hand side of the equation. [1]

(ii) What mathematical rule or manipulation is done on the rate law to obtain a linear equation with y = -ln t and x = 1/T? [2]

(iii) Write the Arrhenius equation. [2]

(iv) Given that E_a =.801 x 10^4 J mol^{-1} [3]

Calculate the slope b in the linear equation.

Question B2

(a) State Grahams Law using the formula format.

(b) Nickel forms a gaseous compound of the formula Ni(CO)x. If methane (CH_4) effuses 3.3 times faster than the compound, under the same conditions of temperature and pressure, calculate the value of x. [5]

(c) A flammable gas made up only of carbon and hydrogen is found to effuse through a porous barrier in 1.50 min. Under the same conditions of temperature and pressure, it takes an equal volume of bromine vapor 4.73 min to effuse through the same barrier.

(i) Calculate the molar mass of the unknown gas. [5]

(ii) Suggest the name of this gas. [1]

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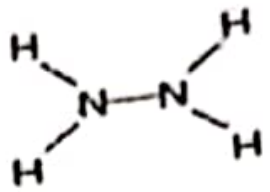
QUESTION A5

The compound hydrazine, N_2H_4 (structure shown below), is a liquid which is used as a rocket fuel.



Some bond enthalpies are given in the table.

Bond	Bond enthalpy / kJ mol⁻¹
N—N	158
O—O	498
N≡N	945
H—O	464
N—H	391

Calculate the enthalpy change for the oxidation of hydrazine (equation shown below), using the bond enthalpy values in the table.

$$N_2H_{4(l)} + O_{2(g)} \rightarrow N_{2(g)} + 2H_2O_{(l)}$$

[4 Marks]

QUESTION A6

If the radiator of an automobile contains 12.00 L of water, how much would the freezing point be lowered by the addition of 5 kg of Prestone (glycol, C_2H_4, 32.0 g/mol). How many Kg of zerone (methyl alcohol CH_3OH, $M_r = 32.0\ g/mol$) would be required to produce the same result? Molar freezing point depression constant, $K_f = 1.86°C/m$. Assume the density of water = $1\ kg/L$.

[4 Ma

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Question A5

Consider the following gaseous reaction:

$SO_2Cl_{2(g)} \rightarrow SO_2(g) + Cl_2(g)$

Experiment	Initial concentration (mol dm^{-3})	Initial rate of formation of SO_2, R_0 (mol $dm^{-3}s^{-1}$)
1	0.100	2.2×10^{-6}
2	0.200	4.4×10^{-6}
3	0.300	6.6×10^{-6}

(a) Determine the rate Law for the reaction

(b) Calculate the rate constant for the reaction solution.

Question A6

Calculate the enthalpy change, AHR for the reaction

$2NH_3(g) + CO_2(g) \rightarrow NH_2CONH_2(s) + H_2O(l)$

Substance	Enthalpies of formation ΔH_f / k.J mol^{-1}
$NH_3(g)$	−46.2
$CO_2(g)$	− 393.5
$NH_2CONH_2(s)$	− 632.2
$H_2O(l)$	− 285.8

[4]

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THE UNIVERSITY OF NATURAL SCIENCES
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTY
2020/2021 ACADEMIC YEAR
FINAL EXAMINATIONS

CHEM 1000: 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 ONE SEPERATE MAIN ANSWER BOOKLET

4. Section B has five (5) long answer questions. Questions carry equal marks.
   $(Total\ marks\ -\ 60)$.

   ANSWER QUESTION B1 AND ANY THREE QUESTIONS IN ANOTHER SEPARATE MAIN ANSWER BOOKLET.

5. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.**
6. Please be reminded that it is your responsibility to **ENSURE** that you have Ten (10) printed pages containing questions Al to A10 and B1 to B5.

ADDITIONAL INF RMATION TO THE CANDIDATES:

Useful data is provided on page 11
Periodic Table of Elements is on page 12.

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QUESTION B5

(a) Natural gas, a widely used energy resource, is a combustible mixture of hydrocarbons including largely methane and a small proportion of propane. Give a balanced equation for complete combustion of propane in excess oxygen. **[3 Marks]**

(b) Several constitutional isomers can be written for molecular formula $C_5H_{10}O$.

(i) Calculate the IHD for $C_5H_{10}O$ and state all possible interpretations, include possible functional groups as well.

(ii) Draw a cyclic secondary alcohol with the molecular formula, $C_5H_{10}O$. **[2 Marks]**

(iii) Draw a ketone with one methyl group as a substituent with the molecular formula, $C_5H_{10}O$. **[2 Marks]**

(c) A compound with a general formula, C_nH_{2n} may be either an alkene or a cycloalkane. Some of these compounds exhibit **cis** & **trans** isomerism. Write down **3D**-structures of the isomers (include the stereochemistry) and give IUPAC names for 2-butene. **[3 Marks]**

[Total: 15 Marks]

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Question A7

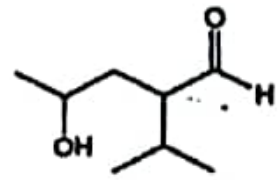
What is the vapour pressure of a solution at 298 K containing 68 g of glucose (M, 180 g/mol) in 600 g of water? The vapor pressure of pure water at 298 K is 0.03173 bar. [4]

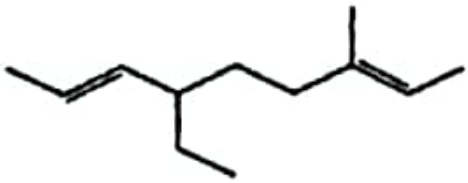
Question A8

Calculate ΔH_{vap} for ethanol, given vapor pressure at 313 K = 0.19999 bar. The normal boiling point for ethanol is 351 K.

Question A9

Provide the IUPAC name for each of the following compounds:

(a) 

(b) 

[4]

Question A10

(a) Write the line formula for 4-aminobutanoic acid.

(b) Describe the highlighted carbon oxygen double bond of the ketene, $CH_2 = C = O$.

(c) Provide the stereochemical structure for the Cis-alkene, C_4H_8, which has two vinylic and six allylic hydrogens. [4]

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Question B 4

(a) For a first order reaction, $A\ C \rightarrow + D$, at 300.0 K, the concentration of A was reduced to one half of its initial value after 5000.0 s. At 310.0 K, the concentration of A was halved after 1000.0 s.

(i) Calculate the rate constant for the reaction at 300.0 K and 310.0 K. **(3marks)**

(ii) Determine the activation energy of the reaction **(5marks)**

(b) Consider the equilibrium reaction below with a K_{sp} of $4.68\times\ 10^{-6}$ at 25°C

$$Ca(OH)_2(s) + H_2O(l \rightleftharpoons Ca^{2+}(aq) + OH^-(aq)$$

(i) Calculate the soulubity of $Ca(OH)_2$ in $mol\ L^{-1}$ **(4 marks)**

(ii) Determine the PH of the saturated solution. **(2 marks)**

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(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 $moldm^{-3}$ potassium manganate (VII) which had average titer 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.

$$Fe^{2+} \longrightarrow Fe^{3+} + e^-$$

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

(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 B2

(a) Explain the decrease in the atomic radii across the periodic from *Na* to *Cl*. [2 Marks]

(b) Modern plasma television screens emit light when mixtures noble gases, such as neon and xenon, are ionized. The first ionization energies of neon and xenon are shown in the table below.

Element	1st ionization energy / $kJmol^{-1}$
Neon	+2081
Xenon	+1170

Give three reasons why xenon has lower first ionization energy than neon.
[3 Marks]

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THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2015 ACADEMIC YEAR

FINAL EXAMINATIONS

CHE 1000: INTRODUCTION TO CHEMISTRY

TIME: THREE (3) HOURS

INSTRUCTIONS TO THE CANDIDATES

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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 THREE QUESTIONS, EACH IN A SEPARATE ANSWER BOOKLET.

5. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.**
6. **ENSURE** that you have eight (7) printed pages and Periodic Table.

ADDITIONAL INFORMATION TO THE CANDIDATES:

3. **Useful data** is printed on **page 7 and 8.**
   Periodic table is printed on the last page

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Question A9

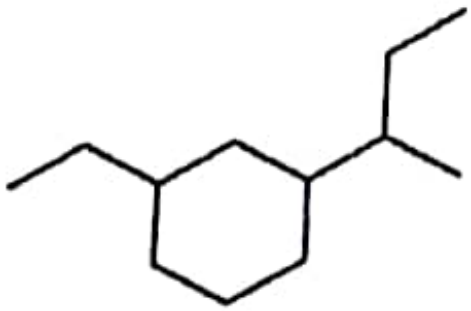
A sample of 0.500 g Of hemoglobin, a non-electrolyte, was dissolved in water in a volumetric

flask to give I .00 L of solution. The osmotic pressure of this solution was then measured at 250C and found to be 1.776 x10-3atm. Calculate molar mass of hemoglobin.

Question A10

(a) Provide a line-bond structure for 4-tert-butyl-7-methylnona-1 ,3-dien-8-yne.

(b) Give the IUPAC name for the following molecule:



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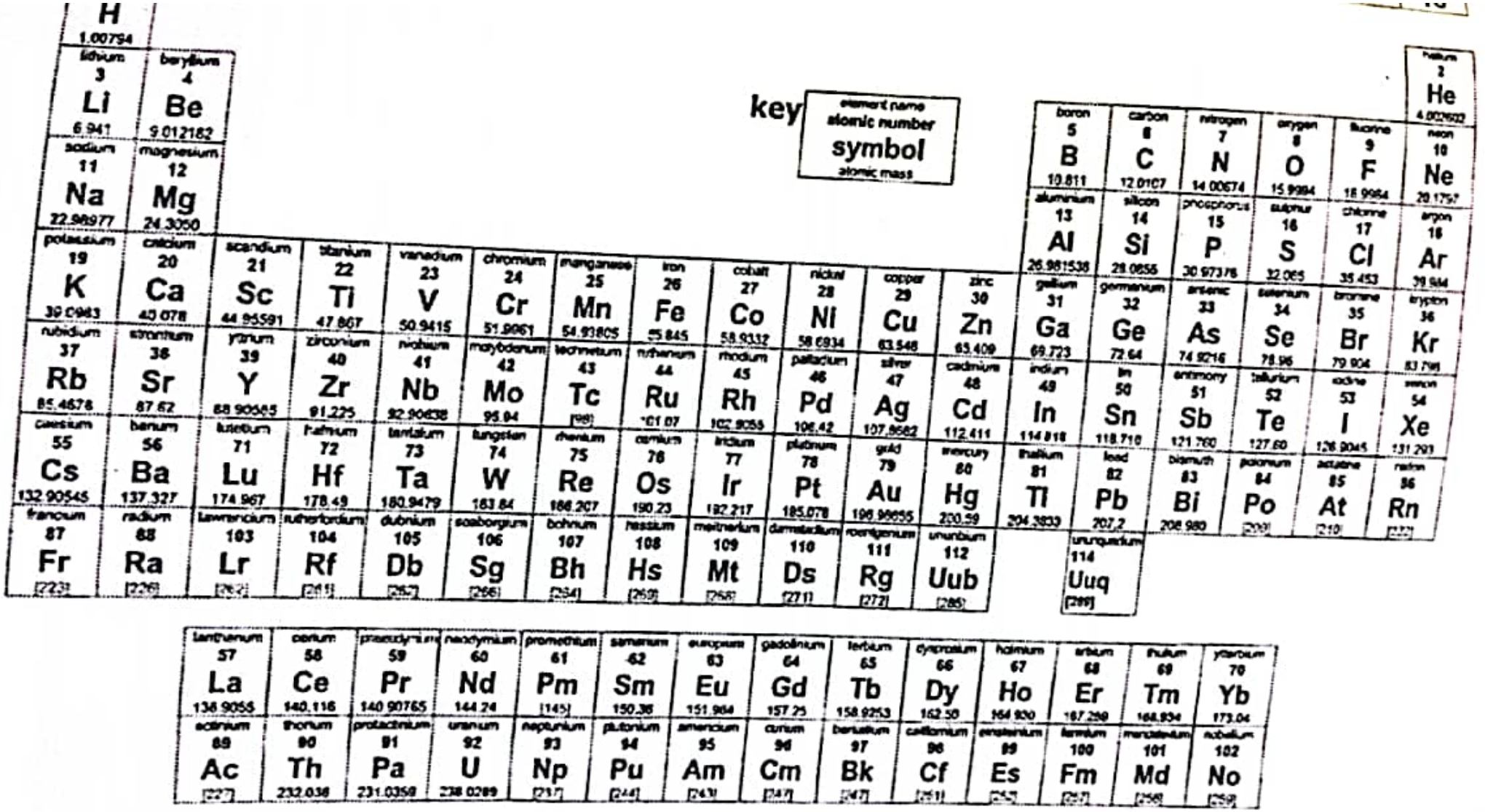
key
element name
atomic number
symbol
atomic mass
H 1.00794
He 4.002602
Li 6.941
Be 9.012182
B 10.811
C 12.0107
N 14.00674
O 15.9994
F 18.9984
Ne 20.1797
Na 22.98977
Mg 24.3050
Al 26.981538
Si 28.0855
P 30.973761
S 32.065
Cl 35.453
Ar 39.948
K 39.0983
Ca 40.078
Sc 44.95591
Ti 47.867
V 50.9415
Cr 51.9961
Mn 54.93805
Fe 55.845
Co 58.9332
Ni 58.6934
Cu 63.546
Zn 65.409
Ga 69.723
Ge 72.64
As 74.9216
Se 78.96
Br 79.904
Kr 83.798
Rb 85.4678
Sr 87.62
Y 88.90585
Zr 91.225
Nb 92.90638
Mo 95.94
Tc [98]
Ru 101.07
Rh 102.9055
Pd 106.42
Ag 107.8682
Cd 112.411
In 114.818
Sn 118.710
Sb 121.760
Te 127.60
I 126.9045
Xe 131.293
Cs 132.90545
Ba 137.327
Lu 174.967
Hf 178.49
Ta 180.9479
W 183.84
Re 186.207
Os 190.23
Ir 192.217
Pt 195.078
Au 196.96655
Hg 200.59
Tl 204.3833
Pb 207.2
Bi 208.980
Po [209]
At [210]
Rn [222]
Fr [223]
Ra [226]
Lr [262]
Rf [261]
Db [262]
Sg [266]
Bh [264]
Hs [269]
Mt [268]
Ds [271]
Rg [272]
Uub [285]
Uuq [289]
La 138.9055
Ce 140.116
Pr 140.90765
Nd 144.24
Pm [145]
Sm 150.36
Eu 151.964
Gd 157.25
Tb 158.9253
Dy 162.50
Ho 164.930
Er 167.259
Tm 168.934
Yb 173.04
Ac [227]
Th 232.038
Pa 231.0359
U 238.0289
Np [237]
Pu [244]
Am [243]
Cm [247]
Bk [247]
Cf [251]
Es [252]
Fm [257]
Md [258]
No [259]

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SECTION B ANSWER QUESTION B1 AND ANY THREE QUESTIONS

Question B1

In the Lab you performed a chemical kinetics experiment on the effect of temperature on the rate of reaction. In the experiment, the rate of reaction at different temperatures was given by

$$Rate_0 = \frac{constant}{t} = k[H^+(aq)]_0^m[S_2SO_3^{2-}(aq)]_0^n$$

(a) In the experiment, how was the reaction time, t. changing with the increase in temperature? [3]

(b) What parameter in the rate equation was responsible for the increase in the rate of reaction When temperature was increased?

(c) Write an equation that relates the parameter identified in (b) with temperature, T and define the terms in the equation.

(d) A plot of a graph of - ln (t) versus 1/T gave a gradient of -4.710×10^3 Calculate the activation energy of the reaction. [5]

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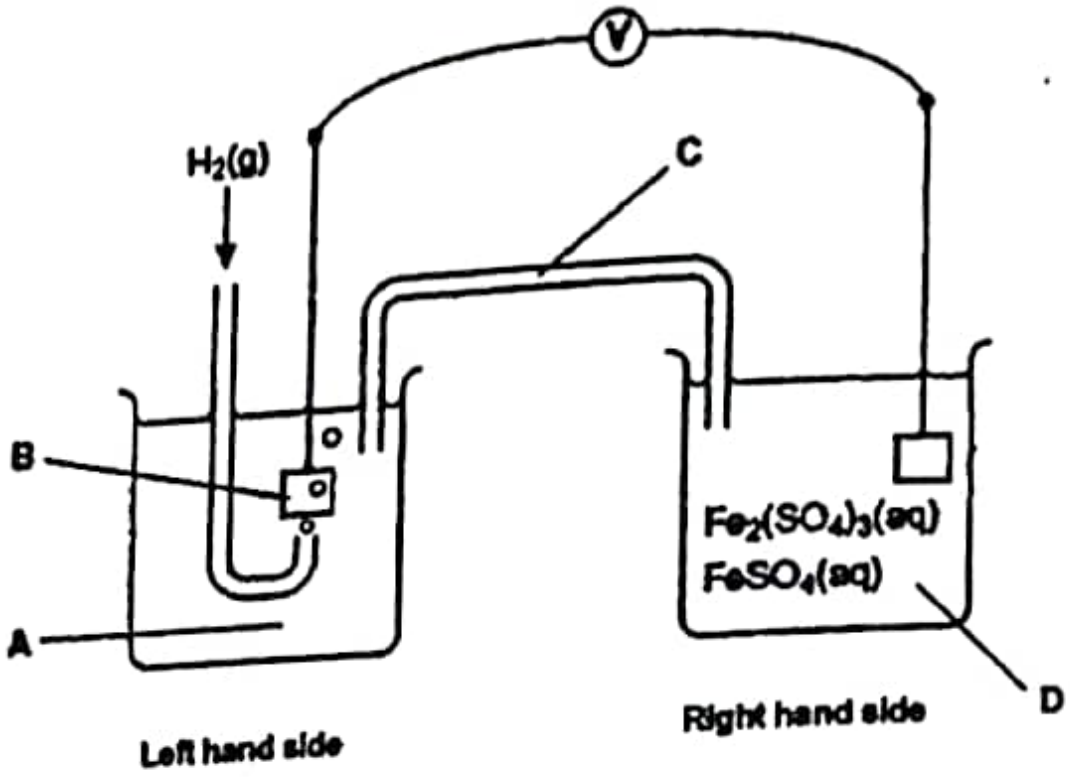
Question B 3

(a) The diagram below shows a cell that can be used to measure the standard electrode potential for the half-reaction $Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$. In this cell, the electrode on the right-hand side is positive.



(i) Identify solution A and give its concentration. State one other essential condition for the operation of the standard electrode that forms the left-hand side of the cell. **(2 marks)**

(ii) Identify the material from which electrodes B is made. Give two reasons why this material is suitable for its purpose. **(2marks)**

(iii) Identify a solution that could be used in C to complete the circuit. Give two reasons why this solution is suitable for its purpose.

(2marks)

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Question B2

(a) Using the VSEPR model, write the molecular geometry of ozone, O_3. [2 marks]

(b) On solving the Schrödinger's wave equation for hydrogen atom, we get a number of wave functions which are characterized by three quantum numbers. **In brief**, state and explain the meaning of these three quantum numbers. [6 marks]

(c) Use the spdf notation (condensed) to write the configurations Of Chromium (Cr). [1 mark]

(d) **Briefly** State and explain the trend in ionization energy and atomic radius across a period and down a group. [6 marks]

Question B3

(a)

(i) The normal boiling points of diethyl ether, ethanol and water are given below:

Diethyl ether 34.6 °C

Ethanol 78.3 °C

Water 100.0 °C

Give an explanation based on intermolecular forces for the observed trend in the boiling points of the liquids. [6 marks]

(ii) An unknown compound exhibits a vapor pressure of 193,800 Pa at 25.5 °C and 329,840 Pa at 48.8 °C. What is AvapH of this substance? [3 marks]

(b) The osmotic pressure of a 0.010 mol dm^{-3} aqueous solution of $CaCl_2$ is found to be 68,293 Pa at 25°C. [3 marks]

(i) Calculate the van't Hoff factor, **i**, for the solution.

(ii) How would you expect the value of **i** to change as the solution becomes more concentrated? Explain. [3 marks]

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ADDITIONAL INFORMATION TO THE CANDIDATES:

1. **Useful data is printed on page 8.**
2. **Periodic table is printed on the last page**

SECTION A — ANSWER ALL QUESTIONS

Question A 1

Calculate the mass of sodium hydroxide needed to make a 5.00 L solution with a molarity of 0.400 M.

Question A 2

What is the de Broglie wavelength of a helium atom of atomic mass of 4.003 amu travelling at a velocity of 1000.0 $m\ s^{-1}$?

Question A 3

In an atom of an element, state the quantum numbers that defines an atomic orbital and their allowed values.

Question A 4

A 500. g copper forceps was accidentally left on a heating mantle until it had a temperature of 35°C. A student then placed the forceps in 70 g ofwater at 22°C to cool it off. Calculate the specific heat capacity of the copper forceps if the final temperature of the water was 27°C. (Specific heat capacity of water is 4.18 J/g. °C).

Question A 5

Calculate the cell potential ($E°$) for the reaction below and determine whether it will proceed in the direction in which it is written under standard conditions.

$$2NaClO_2(aq) + Cl_2(g) \rightleftharpoons 2ClO_2(g) + 2NaCl(aq)$$

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Question A4

Consider the reaction known to be zero order in A and have a rate constant of $5.0 \times 10^{-2}\ Ms^{-1}$ at 25°C. An experiment was run at 25°C, where $[A]_0 = 1.0 \times 10 - 3\ M$.

(a) Write the integrated rate law for this reaction.
(b) Calculate the half-life for this reaction.
(c) Find the concentration after $1.0\ X\ 10^{-3}$ s has elapsed. **[4 Marks]**

Question A5

A solution contains 1.0×10^{-5} mol dm^{-3} of Na_3PO_4 . What is the required concentration of AgN03 that would cause precipitation of Ag3P04 (K_{sp} 1.8×10^{-18})? **[4 Marks]**

Question A6

(a) The enthalpy of formation of NH_3 is $-46\ kJ/mol$. Calculate the enthalpy change for the reaction $2NH_{3(g)} \longrightarrow N_2(g) + 3H_2(g)$
(b) When 285 J of heat is added to 33.6 g of hexane, (M_r 86.06 g/mol) the temperature increases by 3.74°C. Calculate the molar heat capacity of hexane. **[4 Marks]**

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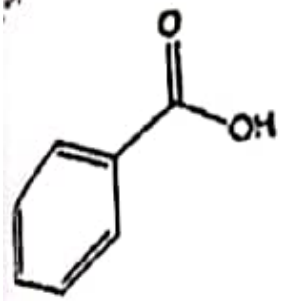
Question B 5

(a) A frequent used food preservative, P, is made as shown below:



+ NaOH ⟶ P + Q

(i) Name the type of reaction. (1 mark)

(ii) What is the structure of P? (1 mark)

(iii) Give IUPAC name for P. (1 mark)

(b) Several constitutional (structural) isomers can be written for the molecular formula C_5H_9OBr.

(i) Calculate the DBE (IHD) and state all possible interpretations.

(ii) One of the isomers decolorizes bromine water. Does this isomer has a ring? Give a reason. (2 marks)

(iii) Give a line formula for another isomer that is a <u>straight chain acyl bromide</u> (acid bromide). (2 marks)

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SECTION B

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

Question B1

(a) The reaction of concentrated sulphuric acid with water is highly exothermic. Describe in one sentence how to dilute the acid.

(b) In the laboratory, redox titration was performed involving the following reaction:

$$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$$

The reduction reaction takes place in an acidic medium (H^+). In the experiment sulphuric acid was added to Fe^{2+} solution in the conical flask. At the stoichiometric point or equivalent point, Fe^{2+} completely reacted with potassium permanganate. The same redox reaction above can be used in a galvanic cell under condition of dynamic equilibrium.

(i) Describe in one sentence, in terms of number of moles, the effect of adding sulphuric acid to Fe^{2+} solution in the conical flask. [2]

(ii) Name the indicator in the titrate on and how the end-po int is detected? [2]

(iii) List three chemicals in the half cell reduction reaction below, required for the half cell to be in dynamic equilibrium. [2]

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

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SECTION A — ANSWER ALL QUESTIONS

Question A1

A sample of nitrogen gas, N_2, is collected in a 100 cm^3 container at a pressure of 91,726 Pa and a temperature of 565 °C. How many grams of nitrogen gas are present in this sample?

Question A2

A balloon is filled with 35.0 dm^3 of helium in the morning when the temperature is 20.0°C . By noon the temperature has risen to 45.0°C What is the new volume of the balloon?

Question A3

Calculate the energy and the wavelength of light required to excite the hydrogen atom from level n=1 to level n=2.

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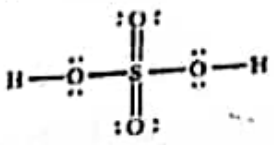
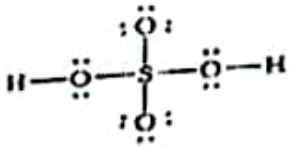
Question A4

Two structures of sulphuric acid (a) and (b) are shown below. Which structure is the correct One? Justify in one line.

(a)



(b)



Question A5

The rate law for the reaction, $2Cl_2O \rightarrow 2Cl_2 + O_2$ at 200°C is found to be, rate = $k[Cl_2O]^2$. Let the initial concentration of Cl_2O to be 0.10M

(a) Calculate the rate of the reaction, if the concentration of $[Cl_2O]$ is reduced to one-third of its original value?

(b) Determine the concentration of $[Cl_2O]$, if the rate is doubled.

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