PART A — STRUCTURED ESSAY

*Answer **all four** questions on this paper itself. (Each question carries **100** marks.)*

Do not write in this column.

1. (*a*) Write the answers to the questions given below on the dotted lines.

(i) Of the following sets of quantum numbers I, II and III, which one is **not** acceptable in describing an atomic orbital?
(I) $n=2$ $l=1$ $m_l=-1$ (II) $n=3$ $l=1$ $m_l=+2$ (III) $n=4$ $l=3$ $m_l=-3$ .....

(ii) Of the three ions Na^+, K^+ and Ca^{2+}, which one has the **largest** ionic radius? .....

(iii) Of the three cations Li^+, Na^+ and Mg^{2+}, which one has the **least** polarizing power? .....

(iv) Of the three elements Li, Be and B, which one has **the lowest** second ionization energy? .....

(v) Of the three elements Li, C and Na, which **one has** the **most** negative value for electron gain energy? .....

(vi) Of the **three** compounds CH_3OH, CH_3CH_2OH and $CH_3CH_2CH_2OH$, which **one has the strongest** intermolecular forces? .....

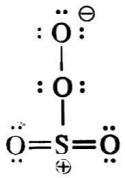
(24 *marks*)

(*b*) **(i) Draw the most** acceptable Lewis **dot-dash structure** for the **molecule** $FBrO_3$.

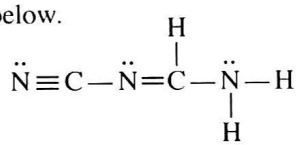
(ii) Give (I) the shape around the central atom **and (II)** the oxidation number of the central **atom** of the structure drawn in (i) above.

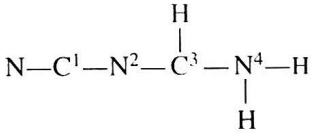
(I) ..... **(shape)** **(II)** ..... (oxidation number)

(iii) The compound SO_4 **can be prepared by the reaction of** SO_3 and O_3. An acceptable (stable) **Lewis** dot-dash structure for the molecule SO_4 is given below. Draw **three** more Lewis **dot-dash** structures (resonance structures) for this molecule and indicate their stabilities **relative to** the structure given by writing **stable or less stable or unstable** under **these structures.**



(iv) Complete the given table based on the Lewis dot-dash structure and its labelled skeleton given below.





		C^1	N^2	C^3	N^4
I.	the number of VSEPR pairs around the atom				
II.	electron pair geometry around the atom				
III.	shape around the atom				
IV.	hybridization of the atom				

[*see page three*

Do not write in this column.

- Parts (v) to (viii) are based on the Lewis dot-dash structure given in part (iv) above. Labelling of atoms is as in part (iv).

(v) Identify the atomic/hybrid orbitals involved in the formation of σ bonds between the two atoms given below.

I.	$N-C^1$	N	C^1 .....
II.	C^1-N^2	C^1	N^2 .....
III.	N^2-C^3	N^2	C^3 .....
IV.	C^3-N^4	C^3	N^4 .....
V.	N^4-H	N^4	**H** .....
VI.	C^3-H	C^3	**H** .....

(vi) Identify the orbitals involved in the formation of π bonds between the two atoms given below.

I.	**$N-C^1$**	**N**	C^1 .....
		N	C^1 .....
II.	**N^2-C^3**	**N^2**	**C^3** .....

(vii) State the approximate bond angles around the C^1, N^2, C^3 and N^4 atoms.

C^1....., N^2 ....., **C^3** ....., N^4.....

(viii) Arrange the atoms C^1, N^2, C^3 and N^4 in **the increasing** order of electronegativity.

..... **<** ..... **<** ..... **<** ..... **(56 *marks*)**

(c) State whether the following statements are **true** or **false**. Give reasons for your choice.

(i) **An acceptable** Lewis dot-dash structure **cannot** be drawn for the OF_4 molecule.

(ii) **The increasing** order of **electronegativity** of nitrogen in NO_2^+, **NBr_3,** NO_2Cl **and** HNO_2 is **$NBr_3 < NO_2Cl < HNO_2 < NO_2^+$**.

(20 *marks*)

100

[*see page four*

Do not write in this column.

2. (*a*) **A** is a *s*-block element in the Periodic Table. Its atomic number is less than 20. When **A** is heated with nitrogen and oxygen separately, two stable compounds **B** and **C** are formed respectively. **B** reacts with water to give the basic compound **D**, and a colourless gas **E** with a pungent odour that turns red litmus blue. Reaction of **A** with water at room temperature also gives **D**, and liberates a colourless, odourless, homonuclear diatomic gas **F**. **A** reacts with dil. H_2SO_4 and gives salt **G** and gas **F**. Compound **H** is formed on reaction of **D** with CO_2. **H** decomposes on heating to give compound **C** and CO_2.

(i) Identify species **A** to **H**. (Give chemical formulae.)

A ..... **E** .....

B ..... **F** .....

C ..... **G** .....

D ..... **H** .....

(ii) Write balanced chemical equations for the following reactions.

I. **A with water** .....

II. **A with dil.** H_2SO_4 .....

III. **B** with **water** .....

IV. **Decomposition** of **H** .....

(iii) Write the colour of the flame given by **salts of A** in the flame test.

..... **(65 *marks*)**

***(b)* Write the** chemical **formulae of P, Q, R and S.**

(i) **P is a** colourless solution. When CO_2 is bubbled through **P**, the solution turns milky. **When excess** CO_2 is bubbled through the milky solution, a clear colourless solution **is obtained. P** gives an orange-red flame when **subjected to the flame test. Identify P.**

P .....

(ii) **The metal M belongs to the third row** of the **Periodic** Table. **M** reacts **with** dilute **aqueous strong** acids **and** bases. **When M** reacts **with** a certain **dilute** aqueous strong acid, **it gives the salt Q as one of the** products. **When aqueous** $BaCl_2$ **is added to** this **solution, a white precipitate is** formed. The precipitate is insoluble in dilute acids. Identify **Q**.

Q .....

(iii) **R** is an ionic compound. When **R** is reacted with dil HCl, a colourless, odourless, linear triatomic gas is evolved as one of the products. **R** gives a yellow colour flame when subjected to the flame test. The metal ion in **R** is found in borax. Identify **R**.

R .....

(iv) **S** is an ionic compound. When **S** is heated, a red-brown gas is evolved. The metal in **S** burns with a bright light in air. The metal reacts slowly with hot water, to give a basic compound and $H_2(g)$. The metal ion contributes to hardness of water. Identify **S**.

S .....

[*see page five*

Do not write in this column.

(v) Give balanced chemical equations for the following reactions. Indicate precipitates with the symbol ↓.

I. **P** with **Q** .....

II. **P** with **R** .....

III. **R** with **S** .....

(35 *marks*)

100

3. (*a*) (i) A closed non-rigid container contains n moles of an ideal gas at a given temperature (T) and pressure (P). Write the relationship between the number of moles of the gas and volume V.

(ii) A closed non-rigid container of volume 150 cm^3, contains 3.75 g of $O_2(g)$ at a given temperature and pressure. If another 1.25 g of $O_2(g)$ is introduced into this container at the same temperature and pressure, what will be the new volume of the container? (O = 16)

(iii) At constant temperature and pressure, show that the molar mass (M) of an ideal gas is directly proportional to its density (d).

(40 *marks*)

[*see page six*

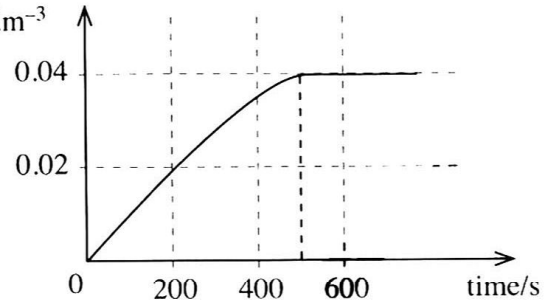
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(*b*) Consider the reversible reaction given below.

$$BF_4^-(aq) + H_2O(l) \rightleftharpoons BF_3OH^-(aq) + HF(aq)$$

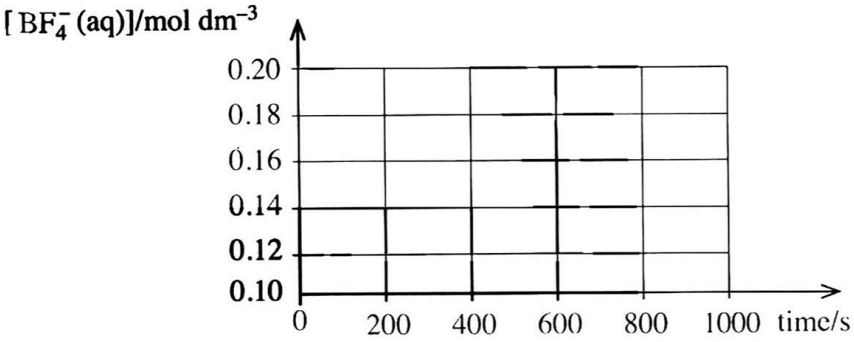
(**Note**: Neglect the ionization of HF.)

In an experiment carried out to study the kinetics of the above reaction, 0.20 mol dm^{-3} $BF_4^-(aq)$ was used and the concentration of the product HF(aq) was measured with time, at a constant temperature. The results obtained are shown in the graph below.



Concentration of HF(aq) reached the constant value of 0.04 mol dm^{-3} at the equilibrium. It was found that the forward reaction follows the rate law, rate = $k_f[BF_4^-(aq)]$ and the value of k_f is $1.0 \times 10^{-5}\ s^{-1}$.

(i) Draw a graph to show the variation of $[BF_4^-(aq)]$ with time.



(ii) At this temperature, calculate the rate of the forward reaction after 600 s.

(iii) It was found that the reverse reaction is first order with respect to $[BF_3OH^-(aq)]$ and first order with respect to [HF(aq)]. Taking k_r as the rate constant of the reverse reaction, write the rate law of the reverse reaction and calculate the value of k_r at this temperature.

(iv) State whether the initial rate method can be used to find the rate law of the reverse reaction in the above experiment. Give reasons for your answer.

(60 *marks*)

100

[*see page seven*

Do not write in this column.

4. (*a*) **A**, **B** and **C** are structural isomers having the molecular formula $C_5H_{10}O$. None of them show optical isomerism. All three compounds **A**, **B** and **C** give coloured precipitates with 2,4-dinitrophenylhydrazine (2,4-DNP). Of the three compounds **A**, **B** and **C**, only **B** gives a silver mirror with ammonical $AgNO_3$. When **A**, **B** and **C** are reacted separately with $NaBH_4/CH_3OH$, compounds **D**, **E** and **F** are produced respectively. When **D** is heated with conc. H_2SO_4, compounds **G** and **H**, which are diastereomers of each other are formed. When **E** and **F** are heated separately with conc. H_2SO_4, compound **E** gives **I** while compound **F** gives all three compounds **G**, **H** and **I**. Compounds **G**, **H** and **I** decolourize Br_2/H_2O.

Draw the structures of **A**, **B**, **C**, **D**, **E**, **F**, **G**, **H** and **I** in the boxes given below.

A

B

C

D

E

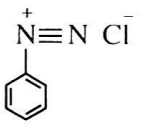
F

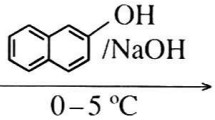
G and **H**

I

(54 *marks)*

(*b*) (i) **Draw the structures of the products J, K, L, M and N of the following reactions (I – V) in the given boxes.**

(I) 



J

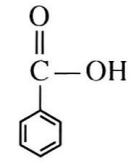
(II) $CH_3—C\equiv C—CH_3$ $\xrightarrow[\text{Quinoline}]{H_2/\text{Pd-BaSO}_4}$

K

[*see page eight*

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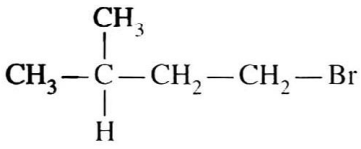
(III) $CH_3-\overset{\overset{O}{\|}}{C}-CH_3$ $\xrightarrow[(2)\ H^+/H_2O]{(1)\ C_2H_5MgBr/\text{dry ether}}$ **L**

(IV)  $\xrightarrow{PCl_3}$ **M**

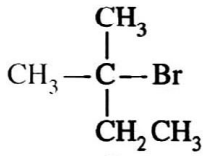
(V) $CH_3-CH_2-\overset{\overset{O}{\|}}{C}-NH_2$ $\xrightarrow[(2)\ H^+/H_2O]{(1)\ LiAlH_4/\text{dry ether}}$ **N**

(25 *marks*)

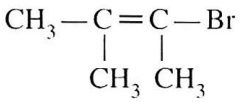
(*c*) **Consider the compounds P, Q and R given below.**



P



Q



R

(i) When compounds **P**, **Q** and **R** are separately treated with aqueous NaOH;

I. Which compound is least likely to undergo a nucleophilic substitution reaction?

.....

II. Which compound is most likely to undergo a nucleophilic substitution reaction which takes place in one step?

.....

III. Which **compound is** most likely to undergo a **nucleophilic substitution reaction** which takes place in **two steps**?

..... **(12 *marks*)**

(ii) Give the mechanism and the structure of the product formed relevant to the reaction in (*c*)(i)III above.

(09 *marks*)

100

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ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව
இலங்கைப் பரீட்சைத் திணைக்களம்
Department of Examinations, Sri Lanka

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2023(2024)
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2023(2024)
General Certificate of Education (Adv. Level) Examination, 2023(2024)

රසායන විද්‍යාව II இரசாயனவியல் II Chemistry II	02 E II

* Universal gas constant $R = 8.314$ J K^{-1} mol^{-1}
* Avogadro constant $N_A = 6.022 \times 10^{23}$ mol^{-1}

PART B — ESSAY

Answer ***two*** *questions only.* (*Each question carries* **150** ***marks.***)

5. (*a*) CaO(s) reacts with water as shown below.

$$CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(s) \quad \Delta H^\circ = -64 \text{ kJ mol}^{-1}$$

The following questions are based on the reaction given above.

(i) When 200 g of $H_2O(l)$ was reacted with a certain mass of CaO(s), the temperature of water changed from 25 °C to 75 °C. Calculate the amount of heat (in kJ) absorbed by water. Specific heat capacity of water is 4.2 J g^{-1} °C^{-1}.
(**Note**: Disregard the change in the mass of water due to the formation of $Ca(OH)_2$.)

(ii) What is the minimum mass of CaO(s) needed to make the temperature change that occurred in (i) above? (O = 16, Ca = 40)

(iii) Standard entropy values of CaO(s), $H_2O(l)$ and $Ca(OH)_2(s)$ are 40, 70 and 80 J K^{-1} mol^{-1} respectively. Calculate the entropy change of the reaction.

(iv) Predict the spontaneity of the reaction at 300 K. State any assumptions made.

(v) Predict the spontaneity of the reaction at 400 K if steam ($H_2O(g)$) is used instead of liquid water.

$$H_2O(g) \longrightarrow H_2O(l) \quad \Delta H^\circ = -44 \text{ kJ mol}^{-1}$$
$$S^\circ_{H_2O(g)} = 190 \text{ J K}^{-1} \text{ mol}^{-1}$$

(80 *marks*)

(*b*) (i) At temperature 570 °C, the equilibrium given below exists in a closed rigid container.

$$Ca(OH)_2(s) \rightleftharpoons CaO(s) + H_2O(g)$$

The pressure of the container was found to be 7.0×10^5 Pa.
Calculate K_P and K_C for the reaction at the temperature 570 °C (at 570 °C, RT = 7000 J mol^{-1}).

(ii) Giving reasons briefly explain the effect on the equilibrium in (*b*)(i) above when the following changes are done.

I. When $Ca(OH)_2(s)$ is added.

II. When some amount of $H_2O(g)$ is removed.

(iii) To determine the relationship between the pressure of the water vapour produced (P_{H_2O}) and the mass of $Ca(OH)_2(s)$ introduced into the container ($M_{Ca(OH)_2}$), the pressure was measured introducing small quantities of $Ca(OH)_2(s)$ into an evacuated rigid container at 570 °C. Draw the expected graph for the variation of P_{H_2O} with $M_{Ca(OH)_2}$ and briefly describe it.

(40 *marks*)

(*c*) (i) Write the reversible reaction for the dissolution of $Ca(OH)_2(s)$ in water at temperature 25 °C.

(ii) At temperature 25 °C the solubility product (K_{sp}) of $Ca(OH)_2(s)$ is 4.0×10^{-6} mol^3 dm^{-9}. Calculate the molar solubility of $Ca(OH)_2(s)$ at this temperature.

(iii) State giving reasons whether the solubility of $Ca(OH)_2(s)$ will be higher, lower or the same in aqueous solutions of NaOH, NaCl and $Ca(NO_3)_2$ (concentrations of solutions 0.1 mol dm^{-3}) when compared with the solubility of $Ca(OH)_2(s)$ in water. **(30 *marks*)**

[*see page ten*

6. (*a*) At 25 °C the methanoate ion, $HCOO^-(aq)$ reacts with water to form methanoic acid, $HCOOH(aq)$ and $OH^-(aq)$ as shown below.

$$HCOO^-(aq) + H_2O(l) \rightleftharpoons HCOOH(aq) + OH^-(aq)$$

(i) Given that $[OH^-(aq)] = 1.0 \times 10^{-6}$ mol dm^{-3} in a solution prepared by dissolving 0.10 mol of HCO_2Na in 1.0 dm^3 of water, calculate the following at 25 °C.

I. The value of K_b of methanoate ion.

II. The value of K_a of methanoic acid.

($K_w = 1.0 \times 10^{-14}$ mol^2 dm^{-6} at 25 °C)

(ii) Calculate the pH of a methanoic acid solution of concentration 0.10 mol dm^{-3}.

(iii) When 3.40 g of HCO_2Na was dissolved in 50.00 cm^3 of 0.10 mol dm^{-3} $HCOOH(aq)$ solution, it was observed that there was no change in volume.
(H = 1, C = 12, O = 16, Na = 23)

I. Determine the pH of this solution.

II. Explain how this solution acts as a buffer solution. **(80 *marks*)**

(*b*) (i) This question is in respect of a solution that could be made by mixing two completely miscible liquids **A** and **B**. Copy the following table on to your answer script and fill in the blanks. Different types of solutions (ideal, non-ideal/positive deviation, non-ideal/negative deviation) that could be made are given in the table.

While the mole fractions of **A** and **B** in the solution are X_A and X_B, and the vapour pressures of **A** and **B** at a given temperature are P_A and P_B respectively.

The saturated vapour pressures of **A** and **B** at this temperature are P_A° and P_B° respectively. Intermolecular forces between **A** and **A**, **B** and **B** and **A** and **B** are f_{A-A}, f_{B-B} and f_{A-B} respectively.

Property	Ideal solution	Non-ideal solution	
		Positive deviation from Raoults law	Negative deviation from Raoults law
ΔH of mixing			
relationship among f_{A-A}, f_{B-B} and f_{A-B}			
relationship among P_A°, P_A and X_A			

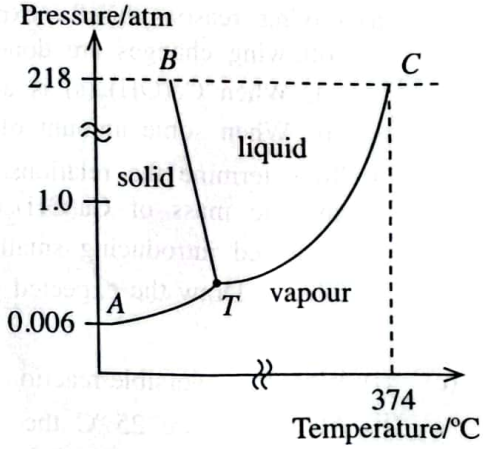
(ii) The phase diagram of pure water is given below.

Copy the diagram on to your answer script and answer the following questions.

I. Mark the normal boiling point (V) and melting point (L) of pure water.

II. What are represented by lines BT, TC and point T?

III. Assume that a small amount of salt (NaCl) is added to the pure water sample. After the addition of salt, positions of the lines BT and TC in the phase diagram were changed. Their new positions are $B'T'$ and $T'C'$ respectively. Draw their new positions on the phase diagram you have copied and label them as $B'T'$ and $T'C'$. Mark the new boiling point (V') and the new melting point (L') on the phase diagram.



(70 *marks*)

[*see page eleven*

7. (*a*) A Daniel cell consists of Zn and Cu rods immersed in $ZnSO_4$(aq, 1.0 mol dm^{-3}) and $CuSO_4$(aq, 1.0 mol dm^{-3}) respectively. The solutions are separated by a porous membrane. The overall cell reaction when the cell is operating is given below.

$$Zn(s) + Cu^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cu(s)$$

(i) Identify the anode and the cathode.

(ii) Write the anodic half reaction of the cell.

(iii) Write the cathodic half reaction of the cell.

(iv) Give the cell notation of the cell above.

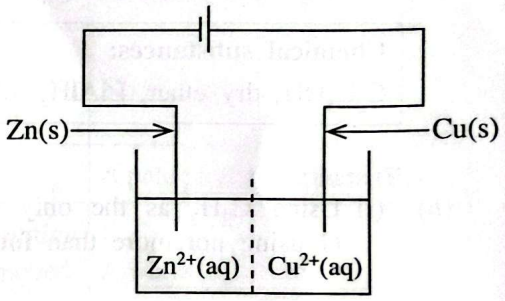
(v) Calculate the electromotive force (E°_{cell}) of the Daniel cell given above at 25 °C.
$E^{\circ}_{Cu^{2+}(aq)/Cu(s)} = 0.34$ V $\quad E^{\circ}_{Zn^{2+}(aq)/Zn(s)} = -0.76$ V

(vi) Calculate the time in seconds required to deposit 3.175 g of Cu(s) when a current of 5.0 A flows through the cell. (Cu = 63.5, 1 F = 96500 C mol^{-1})

(vii) How does the conductivity of the solution in the cell compartment containing the Zn-rod change when a current is drawn from the cell? Explain giving reasons.

(viii) It was observed that when a current is drawn from the cell, the intensity of the colour of the solution in the cell compartment containing the Cu-rod changes. Explain this observation.

(ix) As shown in the diagram, an external voltage higher than the calculated electromotive force in (v) above, was applied to the Daniel cell using another electrochemical cell. Write the overall cell reaction of the Daniel cell under this condition.



(75 *marks*)

(*b*) **A**, **B**, **C** and **D** are coordination compounds of iron with an octahedral geometry. The molecular formulae of the compounds are (**not in order**) $FeH_{14}N_2O_4Br_3$, $FeH_{15}N_5Br_2$, $FeKH_4O_2Br_4$ and $FeH_{15}N_3O_3Br_2$.

In each compound **two** types of ligands are coordinated to the metal ion.

Compound **A** : Gives three ions in aqueous solution. When $AgNO_3$(aq) is added to an aqueous solution of **A**, two moles of a yellow precipitate are formed per mole of **A**.

Compound **B** : Gives four ions in aqueous solution. When $AgNO_3$(aq) is added to an aqueous solution of **B**, three moles of a yellow precipitate are formed per mole of **B**.

Compound **C** : Gives two ions in aqueous solution. When $AgNO_3$(aq) is added to an aqueous solution of **C** one mole of a yellow precipitate is formed per mole of **C**.

Compound **D** : Gives two ions in aqueous solution. A yellow precipitate is not formed when $AgNO_3$(aq) is added to an aqueous solution of **D**.

(i) What are the common oxidation states of iron (Fe)?

(ii) Identify the yellow precipitate. (Give chemical formula.) Name a chemical reagent that can dissolve this precipitate.

(iii) Identify the ligands coordinated to the metal ion in each compound **A**, **B**, **C** and **D**.

(iv) In each of the compounds **A**, **B**, **C** and **D**,

I. write the oxidation state of iron.

II. write the electronic configuration of iron.

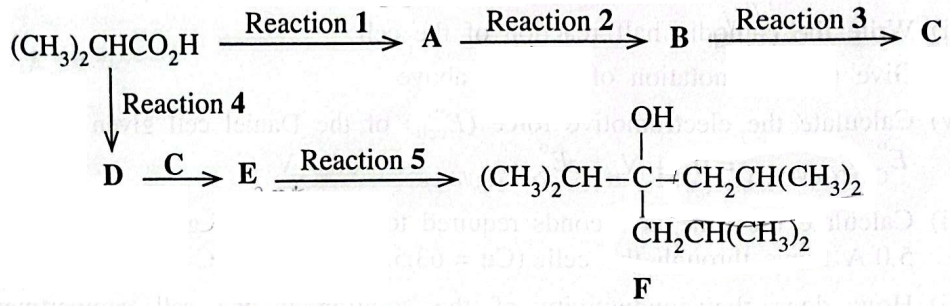
(v) Give the structures of **A**, **B**, **C** and **D**. **(75 *marks*)**

[*see page twelve*

PART C — ESSAY

Answer two questions only. (*Each question carries* **150** ***marks.***)

8. (*a*) $(CH_3)_2CHCO_2H$ has been converted to compound **F** by using the reaction scheme given below.



F

Complete the above reaction scheme by giving the structures of compounds **A**, **B**, **C**, **D** and **E** and the reagents required for the reactions **1** - **5**. Only the chemical substances given below should be used (either singly or as combinations) as reagents.

Chemical substances:
C_2H_5OH, dry ether, $LiAlH_4$, Mg, PBr_3, conc. H_2SO_4, dil. H_2SO_4

(45 ***marks)***

(*b*) (i) Using C_2H_2 as the only starting compound, show how you would prepare compound **G** using not more than **four (04)** steps.

$CH_3CH_2–C\equiv CH$

G

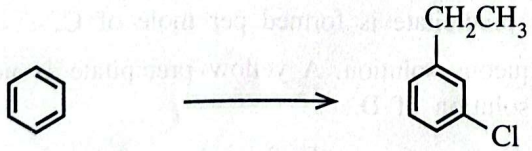
(ii) Give the structure of the compound **H** which is formed when compound **G** is reacted with excess Cl_2.

(30 ***marks)***

(*c*) Write the product and the mechanism of the reaction of benzene with conc. HNO_3/conc. H_2SO_4.

(25 ***marks)***

(*d*) Show how you would carry out each of the following conversions in not more than **three (03)** steps.

(i) 

(ii) $CH_3CH(OH)CH_3 \longrightarrow CH_3CH_2CH_2OH$

(50 ***marks)***

[*see page thirteen*

9. (*a*) (i) Aqueous solutions of compounds $MgSO_4$, $NaOH$, $BaCl_2$, Na_2SO_4 and $Zn(NO_3)_2$ are contained in five 100 cm^3 beakers labelled **A**, **B**, **C**, **D** and **E** (**not in order**). Identify **A**, **B**, **C**, **D** and **E** based on the observations given below. (Reasons **not** required.)

Note : Small portions of the solutions are mixed in test tubes.

On mixing **D** and **E** a white precipitate is formed. When excess **E** is added to the precipitate, the precipitate dissolves giving a colourless solution. A white precipitate is formed when **E** is added to **C**. Precipitates are not formed when **E** is added to **A** and when **E** is added to **B**. On mixing **A** and **B** a white precipitate is formed. When **C** is added to **A**, a white precipitate is formed. However, a precipitate is not formed when **C** is added to **B**.

(25 *marks*)

(ii) An aqueous solution **M** contains **three** cations. The following tests (1-5) were carried out to identify these cations.

Test No.	Test	Observation
1	Dilute HCl was added to solution **M**.	A white precipitate ($\mathbf{P_1}$)
2	$\mathbf{P_1}$ was separated by filtration and H_2S was bubbled through the solution.	No precipitate
3	The solution was boiled until all the H_2S was removed and then cooled. NH_4Cl/NH_4OH was added.	No precipitate
4	H_2S was bubbled through this solution.	A pale pink precipitate ($\mathbf{P_2}$)
5	$\mathbf{P_2}$ was separated by filtration and the solution was boiled until all the H_2S was removed. $(NH_4)_2CO_3$ solution was added.	A white precipitate ($\mathbf{P_3}$)

The following tests were carried out for the precipitates $\mathbf{P_1}$, $\mathbf{P_2}$ and $\mathbf{P_3}$.

Precipitate	Test	Observation
$\mathbf{P_1}$	Dilute ammonia solution was added to $\mathbf{P_1}$.	$\mathbf{P_1}$ dissolved.
$\mathbf{P_2}$	$\mathbf{P_2}$ was dissolved in dil. HNO_3 and excess dilute NaOH was added to the solution.	A white precipitate which turns brown on standing
$\mathbf{P_3}$	$\mathbf{P_3}$ was dissolved in conc. HCl and the solution was subjected to the flame test.	A green colour flame

I. Identify the **three** cations in solution **M**. (Reasons **not** required.)

II. Write the chemical formulae of the precipitates $\mathbf{P_1}$, $\mathbf{P_2}$ and $\mathbf{P_3}$. **(24 *marks*)**

(iii) **X**, **Y** and **Z** are ionic solids. Sodium is the cation in all three compounds. The following tests were carried out to identify the anions in **X**, **Y** and **Z**.

Test No.	Test	Observation
1	(i) A portion of **X** was dissolved in water in a test tube.	A colourless solution
	(ii) $Pb(CH_3COO)_2$ solution was added to the colourless solution.	A yellow precipitate
	(iii) The resulting mixture (yellow precipitate and solution) was heated.	The precipitate dissolved giving a colourless solution.
	(iv) This colourless solution was cooled.	A yellow precipitate (as golden yellow plates)

[*see page fourteen*

2	(i) A portion of **Y** was dissolved in water in a test tube.	A colourless solution
	(ii) A $BaCl_2$ solution was added to the colourless solution.	A white precipitate
	(iii) Dilute HCl was added to the resulting mixture (white precipitate and solution).	A clear colourless solution with the evolution of a gas
	(iv) The gas evolved was tested by holding a filter paper moistened with acidified $K_2Cr_2O_7$ over the mouth of the test tube.	Orange filter paper turned green.
3	(i) A portion of **Z** was dissolved in water in a test tube.	A colourless solution
	(ii) $AgNO_3$ solution was added to the colourless solution.	A black precipitate
	(iii) Dilute HCl was added to a portion of **Z** in a test tube.	A colourless gas evolved.
	(iv) The gas evolved was tested by holding a filter paper moistened with $Pb(CH_3COO)_2$ solution over the mouth of the test tube.	Filter paper turned black

I. Identify the anions in **X**, **Y** and **Z**. (Reasons **not** required.)

II. Write balanced chemical equations for the reactions taking place in the above tests.

(26 *marks*)

(*b*) A solid sample **X** contains the compounds **P**, **Q** and an inert substance. Here **P** = Fe_2O_3 and **Q** = Fe_3O_4. **Q** is a **single** compound and contains iron in Fe^{2+} and Fe^{3+} oxidation states. It reacts with I^- in an acidic medium as follows.

$$Fe_3O_4 + 2I^- + 8H^+ \longrightarrow 3Fe^{2+} + 4H_2O + I_2$$

The following experimental procedure was used to determine the mass percentages of **P** and **Q** in **X**.

When 3.2 g of sample **X** was treated with excess KI solution in the presence of dilute H_2SO_4, all the Fe^{3+} in it was converted to Fe^{2+} with the liberation of iodine. The resulting solution was diluted to 100.00 cm^3 (labelled as S). To convert the iodine to iodide in a 25.00 cm^3 volume of this diluted solution (S), 15.00 cm^3 of 0.50 mol dm^{-3} $Na_2S_2O_3$ was required.
After complete removal of iodine from another 50.00 cm^3 volume of the diluted solution (S), in dil. H_2SO_4 medium, 14.00 cm^3 of 0.25 mol dm^{-3} $KMnO_4$ was required to oxidize all the Fe^{2+} contained in it.

(i) Write balanced chemical equations for the reactions taking place in the above procedure.

(ii) Calculate the mass percentages of **P** and **Q** in **X**.
(O = 16, Fe = 56)

(75 *marks*)

[*see page fifteen*

10. (*a*) The following questions are based on the extraction of magnesium by the Dow process.

(i) State the raw materials used.

(ii) Give balanced chemical equations/half reactions in the sequence they occur in the Dow process. Appropriate conditions must be stated as required.

(iii) Give **two** industrial uses of magnesium.

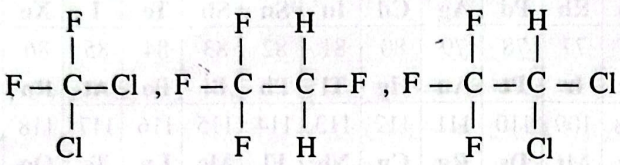
(iv) Give **two** ways in which the Dow process has a **negative** impact on the environment.

(50 *marks*)

(*b*) Given below are some pollutants that exist in the atmosphere.

Pollutant List

$CH_4, CO_2, NO, NO_2, N_2O, SO_2, SO_3, CH_3CH_2CH_2CH_2CH_3,$



The following questions are based on the pollutant list given above.

(i) Identify the pollutant that directly contributes towards increasing the level of ozone in the atmosphere.

(ii) Explain using balanced chemical equations how the pollutant you identified in (i) above increases the ozone level in the atmosphere.

(iii) Identify **two** pollutants that contribute to the reduction of ozone level in the upper atmosphere.

(iv) Briefly explain using balanced chemical equations how one of the pollutants you identified in (iii) above contributes to the reduction of ozone level in the upper atmosphere.

(v) Identify **two** pollutants that cause photochemical smog.

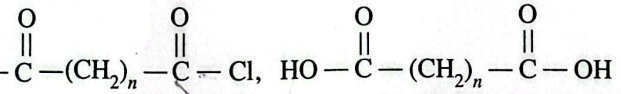
(vi) Identify **four** pollutants that can absorb infrared radiation in the atmosphere and remain stable in the atmosphere for a long period of time.

(vii) What is the commonly used name that describes the behaviour of the pollutants you identified in (vi) above?

(viii) Identify **two** pollutants that contribute to make a significant change in some water quality parameters when dissolved in water. State the water quality parameter(s) that will be affected by the pollutants you identified.

(50 *marks*)

(*c*) Consider the polymerization reactions between one monomer from group A and one monomer from group B given below.

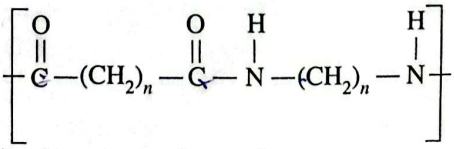
Group A monomers : 

Group B monomers : 

where *n* is an integer.

(i) Write the pair/pairs of monomers that would release an acidic molecule during the polymerization reaction.

(ii) Write the pair/pairs of monomers that would release a neutral molecule during the polymerization reaction.

(iii) The molar mass of the repeating unit  is 226 g mol^{-1}.

Calculate the number of $-CH_2-$ units in a repeating unit.

(50 *marks*)

* * *

[*see page sixteen*

The Periodic Table

	1 H																2 He
1																	
	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
2																		
	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
3																		
	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
4																		
	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
5																		
	55 Cs	56 Ba	La-Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
6																		
	87 Fr	88 Ra	Ac-Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
7																		

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr