**අ.පො.ස උසස් පෙළ උපකාරක සම්මන්ත්‍රණය – 2023**
ஆதரவு கருத்தரங்கு – 2023
G.C.E Advance level support seminar – 2023

රසායන විද්‍යාව II
,urhadtpay; II
Chemistry II

**02 E II**

පැය තුනයි
%d;W kzpj;jpahyk;
Three hours

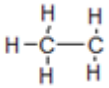
අමතර කියවීම් කාලය - මිනිත්තු 10 යි
Nkyjpf thrpg;G Neuk; - 10 epkplq;fs;
Extra Reading Time - 10 minutes

Use the **additional reading time** to go through the question paper, select the questions, and decide on the questions that you give priority in answering

**Answer all the questions.**

* A Periodic Table is provided on page 17.
* **Use of calculators is not allowed.**
* Universal gas constant, $R = 8.314\ J\ K^{-1}\ mol^{-1}$
* Avogadro constant, $N_A = 6.022 \times 10^{23}\ mol^{-1}$
* In answering this paper, you may represent alkyl groups in a condensed manner.

Index Number : .....

Example:  group may be shown as $CH_3$- $CH_2$-

➢ **Part A - Structured Essay (pages 02 - 07)**

* Answer all the questions on the question paper itself.
* Write your answer in the space provided for each question. Please note that the space provided is sufficient for the answer and that extensive answers are not expected.

➢ **Part B and C - Essay (pages 08 - 17)**

* Answer **four** questions selecting **two** questions from each part.
* At the end of the time allotted for this paper, tie the answers to the three **Parts A, B,** and **C** together so that **Part A** is on top and hand them over to the Supervisor.
* You are permitted to remove **only Parts B** and **C** of the question paper from the Examination Hall.

**For Examiner's Use**

| Part | Question No | Marks |
|---|---|---|
| A | 1 | |
| | 2 | |
| | 3 | |
| | 4 | |
| B | 5 | |
| | 6 | |
| | 7 | |
| C | 8 | |
| | 9 | |
| | 10 | |
| **Total** | | |

**Total**

| | |
|---|---|
| In Numbers | |
| In Letters | |

**Code Number**

| | |
|---|---|
| Marking Examiner 1 | |
| Marking Examiner 2 | |
| Checked by : | |
| Supervised by : | |

## Part A - STRUCTURED ESSAY

Answer all the questions on this paper itself. Each question carries 100 marks.

1. (a) Answer the following questions based on the elements in the second and third periods of the periodic table by selecting the most appropriate element.

(i) The element which has the highest first ionization energy……

(ii) The element which liberates the highest energy when an electron is gained by an atom in the gas phase …….

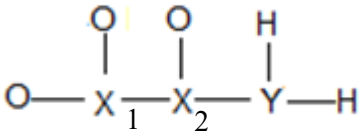
(iii) The element which has the highest hardness ……

(iv) The element which has the least electronegativity ……

(v) The element which forms an anion with the smallest radius ……

(vi) The element which gives turbidity in the solution during hydrolysis of its chloride …….

(b) X and Y are second period elements of the anion $[X_2YH_2O_3]^-$. The atomic radius of X is greater than the atomic radius of Y. The skeleton of $[X_2YH_2O_3]^-$ anion is given below.




(i) Identify X and Y.

X - …….. Y - ……..

(ii) Draw the most acceptable Lewis structure for the above anion.

(iii) Based on the structure drawn in part (ii) above write the,

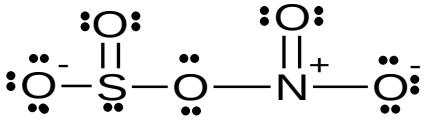
(I) Shapes around the atoms ; $X_2$ and Y

$X_2$ -…… Y - …… ( Shape )

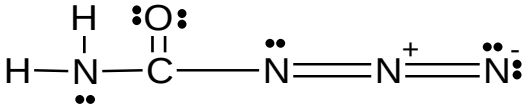
(II) Oxidation states of the atoms ; $X_2$ and Y

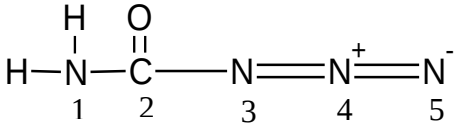
$X_2$ -…… Y - …… ( Oxidation state )

(iv) Lewis dot-dash structure of the $SNO_5^-$ ion is given below. Draw four Lewis dot-dash structures (resonance structures) for this ion, excluding the structure given. Indicate the relative stabilities of the structures drawn , by writing (**stable/unstable** ) under each of the structures.



(v) Complete the following table based on the Lewis structure and its labelled skeleton given below.





| | $N^1$ | $C^2$ | $N^3$ | $N^4$ |
|---|---|---|---|---|
| VSEPR pairs around the atom | | | | |
| Electron pair geometry around the atom | | | | |
| Shape around the atom | | | | |
| Hybridization of the atom | | | | |

- Parts(vi) to (ix) are based on the Lewis structure given in part(v) above.Numbering of atoms is as in part (v)

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

(I) $H - N^1$ H ..... $N^1$ .....

(II) $N^1 - C^2$ $N^1$ ..... $C^2$ .....

(III) $C^2 - O$ $C^2$ ..... O .....

(IV) $C^2 – N^3$ $C^2$ ..... $N^3$ .....

(V) $N^3 - N^4$ $N^3$ ..... $N^4$ .....

(VI) $N^4 - N^5$ $N^4$ ..... $N^5$ .....

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

(I) $C^2 - O$ $C^2$ ..... O .....

(II) $N^3 - N^4$ $N^3$ ..... $N^4$ .....

(III) $N^4 - N^5$ $N^4$ ..... $N^5$ .....

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

$N^1$ …… $C^2$ …… $N^3$ …… $N^4$ ……

(ix) Arrange the atoms $N^1$, $C^2$, $N^3$, $N^4$, and $N^5$ in the increasing order of the electronegativity.

……. < ……. < ……. < ……. < ……..

(c) (i) Arrange the following species in the increasing order of the property indicated in parenthesis. (Reasons are not required)

(I) $SO_2$, $SO_3$, $SO_4^{2-}$, $SOF_2$, $SOCl_2$ (Electronegativity of sulfur)

……

(II) $NO_2$, $NO_2^-$, $NO_3^-$, $NO_4^{3-}$, $NO_2^+$ (Bond angle)

……

(ii) (I) An electron with the mass 'm' is moving at a velocity 'V'. Write the expression for the De Broglie wavelength ( $\lambda$ ) of this electron.

(II) If the mass of this electron is $9.1 \times 10^{-28}$ g and the velocity of it is $2.5 \times 10^7$ $ms^{-1}$, calculate the wavelength of this electron.

2. (a) A is an element which belongs to the s block of the periodic table forms B , C and D upon combustion in air. B is the major product. The element E which is present in the right side of the same period of A , produces a reddish orange colour in the flame test. When E is burnt in the air, F and G are formed as the products. Gas H which is formed upon addition of water to the product G turns of nessler's reagent brown. When cold water is added to C, non-planer covalent molecule I and the strong base J are formed.

(i) Identify the elements or compounds given in the letter below.

A ……. B ……. C …….

D ……. E ……. F …….

G ……. H ……. I …….

J …….

(ii) Write balanced chemical equations for the following reactions (physical states are not

required).

I.Formation of B by A : ……

II.Formation of C by A : ……

III.Formation of G by E : ……

IV.Formation of H by G : ……

V.Formation of I and J by C : ……

(iii) Write balanced ionic equations for the reactions that take place when an acidic solution of I is added to the solutions given below. (Physical states are not required).

(I) With $Fe^{2+}(aq)$

(II) With $Cr_2O_7^{2-}(aq)$

(III) With $I^-(aq)$

(b) Write balanced chemical equations for the following reactions. (physical states are not required)

(i) Mg(s) and dilute $HNO_3(aq)$

……..

(ii) Mg(s) and concentrated $HNO_3(aq)$

……..

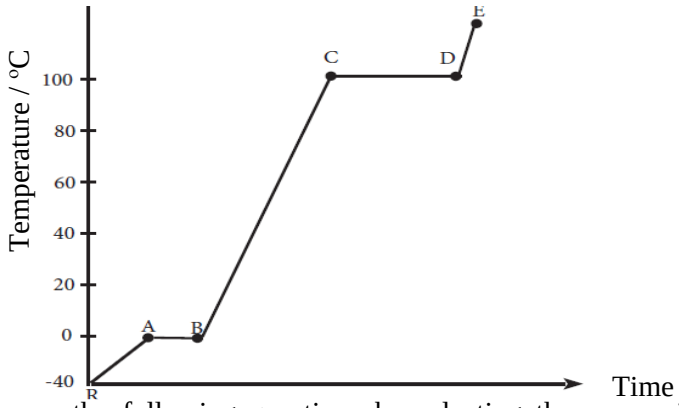
(iii) Excess of $NH_3(g)$ and $Cl_2(g)$

……..

(iv) CuO(s) and $NH_3(g)$

……..

3. (a) The typical heating curve of water is given in the diagram below




(i) Answer the following questions by selecting the appropriate formula/process from the

following,

$H_2O(g)$, $H_2O(l)$, $H_2O(s)$, $H_2O(s) \rightleftharpoons H_2O(l)$ , $H_2O(l) \rightleftharpoons H_2O(g)$

Identify what the following regions depicted.

(I) RA ..... (II) AB ..... (III) BC .....

(IV) CD ..... (V) DE .....

(ii) State the processes represented by points A, B, C, and D in the heating curve given above.

A ……. B …….

C ……. D …….

(iii) What is the reason for the AB plateau < CD plateau in the above curve?(plateaus are areas where the temperature remains constant)

(iv) Calculate the amount of heat required to convert 90 g of ice at -40 °C to water at 60 °C. (H = 1, O = 16)
Specific heat capacity of ice = 2.09 J $g^{-1}$ $^oC^{-1}$
Specific heat capacity of liquid water = 4.2 J $g^{-1}$ $^oC^{-1}$
Enthalpy of fusion of ice ($\Delta H_{fus}$) = 6.0 kJ $mol^{-1}$

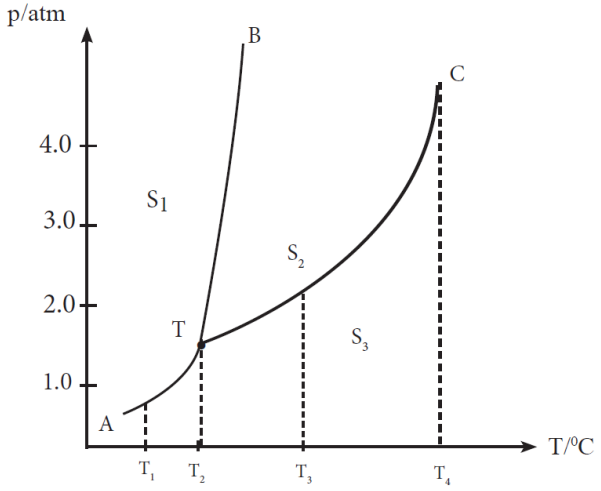
(b) An ideal binary liquid solution of A and B is in equilibrium with its vapour at temperature T K. The mole fractions of A and B in the vapour phase are $Y_A$ and $Y_B$ respectively and the mole fractions of A and B in the liquid phase are $X_A$ and $X_B$ respectively. The saturated vapour pressures of A and B respectively are $P_A^o$ and $P_B^o$ .

(i) Derive an expression for the mole fraction of $Y_A$ of A in the vapour phase.

(ii) State the laws that are used to drive the above expression.

(iii) At 300 K, the saturated vapour pressure of pure liquids A and B are 50 kPa and 75 kPa respectively. If a mixture consisting of 1.0 moles of A and 4.0 moles of B behaves as an ideal solution, calculate the mole fractions of A and B in the vapour phase.

(iv) A phase diagram of the substance X which does not have allotropic forms is given below. Answer the following questions based on the phase diagram given.




(I) Identify the phases of $S_1$, $S_2$, and $S_3$.

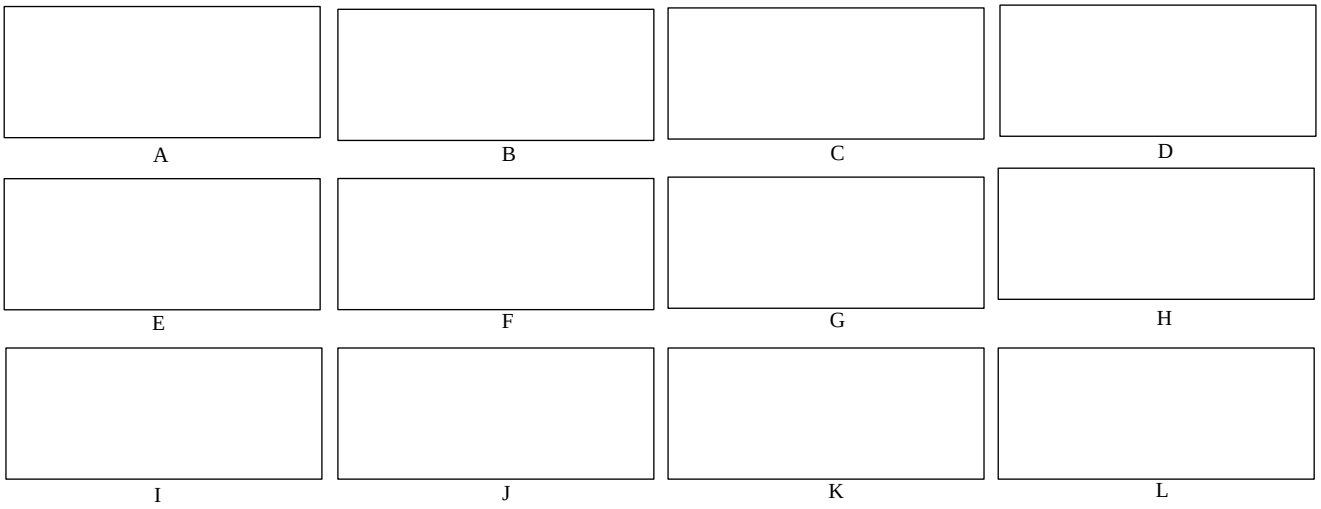
(II) What is the characteristic feature of the point T?

(III) Identify the temperature $T_4$

(IV) What is the phase transition that occurs when the temperature of X at 1 atm and temperature $T_1$ is changed to $T_2$, keeping the pressure constant?

(V) What is the phase transition that occurs when the pressure of X at 4 atm is reduced to 3 atm and the temperature is increased from $T_1$ to $T_3$ ?

4. (a) A, B, C, D, E, and F are alcohols of the molecular formula $C_5H_{10}O$. Only A, B, and C show enantiomerism (optical isomerism).
Dehydration of A, B, and C with concentrated $H_2SO_4$ form the compounds G, H, and I respectively. Only H shows geometrical isomerism. G and I form the same compound J upon addition of HBr.
When the products formed by the reaction of A, B, and C with PCC, only the product formed by A decolourises a solution of $H^+$ /$KMnO_4$.
D and F react with PCC to give the compounds K, and L respectively. E does not undergo oxidation with PCC and K does not undergo condensation reactions with aqueous NaOH. L does not decolourise a solution of $H^+$ /$KMnO_4$.
(i) Draw the structures of A, B, C, D, E, F, G, H, I, J, K, and L in the boxes given below




(ii) Describe a test to distinguish between K and L.

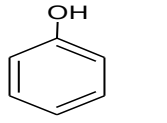
(b) (i) Draw the structures of the product of the reactions [(I) – (V)] , in the boxes given below.

(I) $CH_3-C(CH_3)=CH_2$ $\xrightarrow{\text{concentrated.}H_2SO_4}$

(II) $CH_3-C(=O)-Cl$ $\xrightarrow{NaOH(aq)}$

(III) $CH_3-C(=O)-CH_2CH_3$ $\xrightarrow[2)\ H^+ / H_2O]{1)\ C_6H_5MgBr}$

(IV) $CH_3-CH(CH_3)-C(=O)-H$ $\xrightarrow{NaOH(aq)}$

(V)  $\xrightarrow{H_3C-C(=O)-Cl}$

(ii) Write the type of the reactions given in part (i) above in words.

(I) Reaction I -

(II) Reaction II -

(III) Reaction III -

(iii) Give the mechanism of the reaction (III) in part b(i) above.

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G.C.E Advance level support seminar – **2023**

| | | |
|---|---|---|
| රසායන විද්‍යාව II<br>,urhadtpa**y;** II<br>Chemistry II | **02** **E** **II** | |
| පැය තුනයි<br>%d;W kzpj;jpahyk;<br>Three hours | | අමතර කියවීම් කාලය - මිනිත්තු 10 යි<br>Nkyjpf thrpg;G Neuk; - 10 epkplq;fs; Extra Reading Time - 10 minutes |

Use the **additional reading time** to go through the question paper, select the questions, and decide on the questions that you give priority in answering

Universal gas constant $R = 8.314\ J\ K^{-1}\ mol^{-1}$
Avogadro's constant $N_A = 6.022 \times 10^{23}\ mol^{-1}$
Speed of light $c = 3 \times 10^8\ m\ s^{-1}$

## PART B - ESSAY

Answer two questions only (Each question carries 150 marks)

5. (a) Gases $N_2(g)$ and $O_2(g)$ exist in the mole ratio 4:1 in a rigid closed container. When the temperature is increased up to $T_1$, the following equilibrium is attained in the container.

$$2NO(g) \rightleftharpoons N_2(g) + O_2(g)$$

The mole percentage of NO(g) in the system at the equilibrium is 2.0%. Answer the following questions based on this system.

(i) Write the equilibrium law in terms of partial pressures.

(ii) Calculate the equilibrium constant $K_P$ at the temperature $T_1$.

(iii) The temperature of the above system at the equilibrium at $T_1$ was changed to $T_2$. The mole percentage of oxygen gas at the equilibrium at $T_2$ was found to be 10%. The following data are provided to you.

| Bond | $\Delta_D H^0$ (kJ mol$^{-1}$) |
|---|---|
| N≡N | 946 |
| N=O | 590 |
| O=O | 498 |

(I) Calculate the standard enthalpy change of the above reaction.

(II) Using a suitable calculation, deduce the higher temperature from $T_1$ and $T_2$

(III) Compare the time taken to reach the equilibrium at $T_1$ and $T_2$?

(b) Answer the following questions based on the data given in the following table.

| Compound | Lattice dissociation enthalpy (kJ $mol^{-1}$) | $T\Delta S$ (J $mol^{-1}$) for the water solubility |
|---|---|---|
| NaCl(s) | 769 | +13 |
| NaBr(s) | 735 | +18 |

| Ion | $Cl^-$ | $Br^-$ | $Na^+$ |
|---|---|---|---|
| Hydration enthalpy (kJ $mol^{-1}$) | -381 | -351 | -399 |

(i) Calculate the solution enthalpies of NaCl(s) and NaBr(s).(related to the water solubility)

(ii) Calculate Gibb's free energy changes of the solubility (in water) of NaCl(s) and NaBr(s).

(iii) Using the $\Delta G$ values obtained above; state the compound which is more soluble in water.

(c) Excess of solid $Ca(OH)_2$ is dissolved in a 0.010 mol $dm^{-3}$ solution of aqueous NaOH. The mixture is taken and left for a few minutes. Some solid Calcium Hydroxide is deposited at the bottom of the container.

The solution was then filtered and 25.00 $cm^3$ of the filtrate was titrated using 0.050 mol $dm^{-3}$ HCl solution. The endpoint volume was 20.00 $cm^{-3}$.

(i) Calculate the total concentration of $OH^-(aq)$ in the solution.

(ii) Calculate the concentration of $Ca^{2+}(aq)$ ions in the solution.

(iii) Calculate the solubility product of $Ca(OH)_2(s)$.

6. (a) A portion of 25.00 $cm^3$ of 0.225 mol $dm^{-3}$ ethanoic acid($CH_3COOH$) was mixed with 25.00 $cm^3$ of butanol and shaken vigorously and set aside.

20.00 $cm^3$ of 0.125 mol $dm^{-3}$ NaOH was required to react with 25.00 $cm^3$ from the aqueous layer at the equilibrium. Calculate the partition coefficient of ethanoic acid between water and butanol.

(b) An aqueous solution of $H_2O_2$ decomposes forming $H_2O(l)$ and $O_2(g)$.

$$2H_2O_2(aq) \longrightarrow 2H_2O(l) + O_2(g)$$

The following experiment was performed to study the rate of decomposition of $H_2O_2(aq)$, using a 3.00 mol $dm^{-3}$ $H_2O_2(aq)$ solution kept in a bottle.

The data obtained by titrating a 10.00 $cm^3$ portion of this $H_2O_2$ solution, (by taking the 10.00 $cm^3$ portions, out of the solution) with 0.10 mol $dm^{-3}$ $H^+$ / $KMnO_4$ are given below. The stoichiometry of the reaction, $H_2O_2$ : $KMnO_4$ 5 : 2 (Ignore the amount of $H_2O_2$ decomposed during the time of titration)

| Time (min.) | Volume of the 0.10 mol $dm^{-3}$ $KMnO_4$ ($cm^3$) |
|---|---|
| 0 | 30.0 |
| 5 | 23.4 |
| 10 | 18.3 |
| 15 | 14.2 |
| 20 | 11.1 |
| 25 | 8.7 |
| 30 | 6.8 |

(i) Show that $V_{MnO_4^-} \propto [H_2O_2(aq)]$

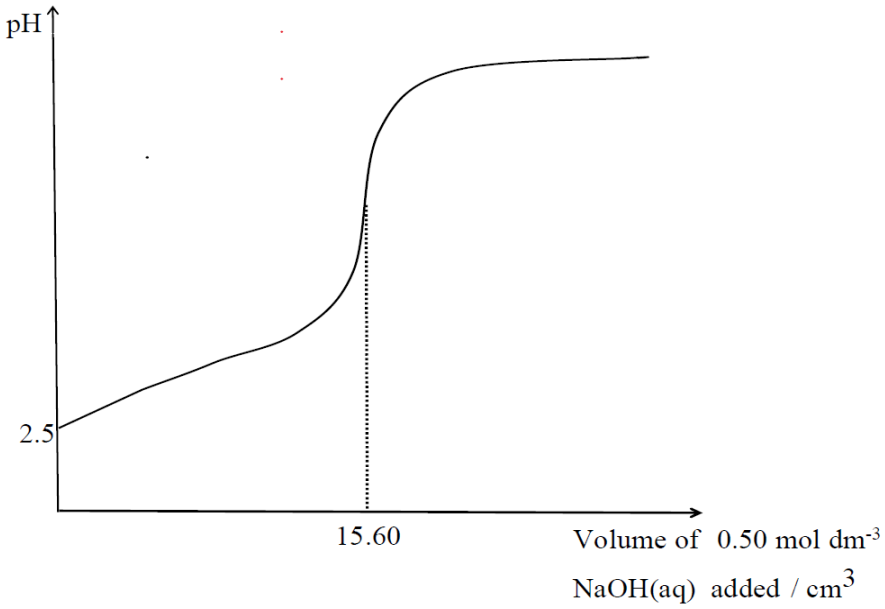
(ii) (I) Show that the order with respect to $H_2O_2(aq)$ is 1, using a volume vs time graph, of the decomposition reaction of $H_2O_2(aq)$.

(II) Mark the half-life on the graph.

(III) Calculate the rate constant of the reaction, using the half-life of the reaction.

(c) A portion of 10.00 $cm^3$ of the weak acid HA(aq) was taken into a titration flask and titrated against 0.50 mol $dm^{-3}$ solution of NaOH at 25 $^oC$ using an indicator HIn.

The variation of pH with the volume of NaOH(aq) added is shown in the graph below.




(i) What is the initial concentration of weak acid HA?

(ii) Calculate the dissociation constant($K_a$) of HA

(iii) Calculate the pH at the endpoint.

(iv) Which of the following indicators is most suitable to be used for the above titration?

| Indicator | p$K_{In}$ of the indicator |
|---|---|
| A | 8.5 |
| B | 3.7 |

(v) Explain whether this solution (Solution formed in the titration flask) functions as a buffer when the pH is 4.4.

7. (a) (i) (I) What is meant by a reference electrode?

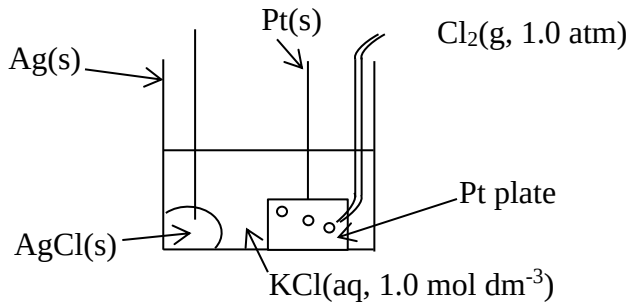
(II) State the type of reference electrodes giving an example for each type.

(III) Sketch the silver-silver chloride electrode and label it completely.

(IV) Briefly mention how the concentration of $Cl^-$ (aq) in the electrolyte of silver-silver chloride electrode is heat at a constant value.

(V) Write the equilibrium which exists in the silver-silver chloride electrode.

(ii) The following diagram shows an electrochemical cell constructed using two electrodes.




$AgCl(s) + e \rightleftharpoons Ag(s) + Cl^-(aq)$ $\quad E^\theta = +0.22$ V

$Cl_2(g) + 2e \rightleftharpoons 2Cl^-(aq)$ $\quad E^\theta = +1.36$ V

(I) Write the oxidation half reaction of the above cell.

(II) Write the reduction half reaction of the above cell.

(III) Construct the overall cell reaction.

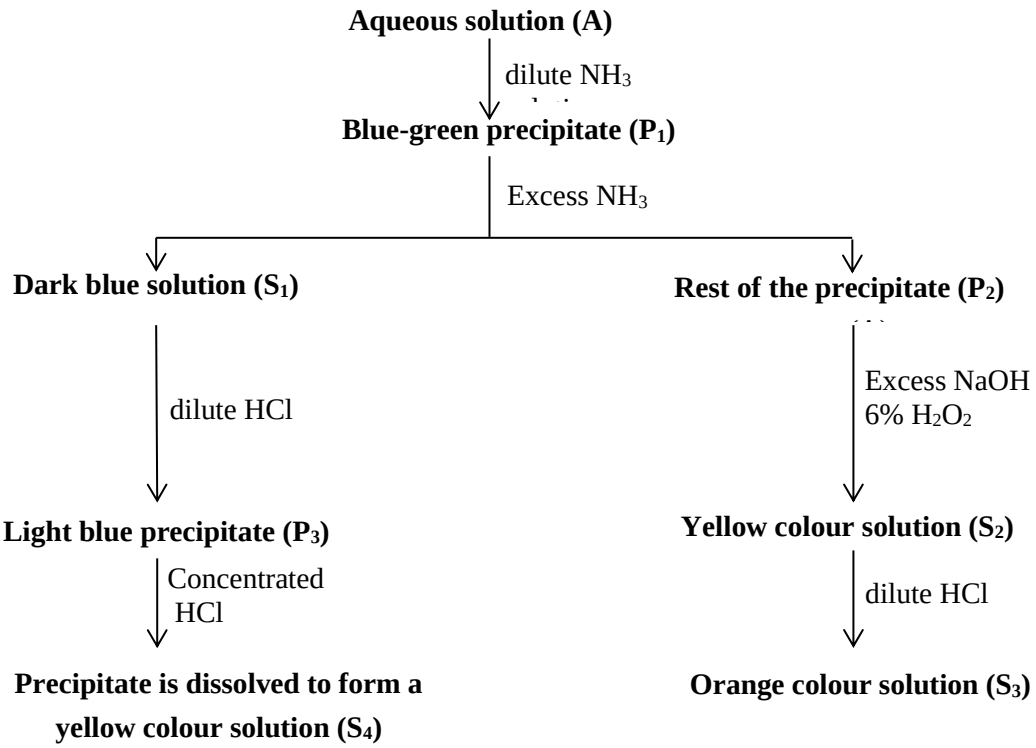
(iii) Using the standard electrode potentials given, calculate the electromotive force of the above cell.

(iv) Represent the above cell according to the standard notation.

(v) Briefly explain whether there is any effect from the KCl concentration on the electromotive force of the above cell.

(vi) A constant current of 0.15 A was drawn for 80 minutes at 25 $^oC$ from this cell. Calculate the mass of AgCl(s) formed , after drawing the current above.
(Ag = 108.0, Cl = 35.5)

(b) A series of experiments and observations to identify two cations of d block in an aqueous solution of **A** are given below,




(i) Identify the cations in the aqueous solution.

(ii) Identify the species which cause the colour of precipitates of $P_1$, $P_2$, $P_3$ and solutions of $S_1$, $S_2$, $S_3$ and $S_4$.

(iii) Write the balanced chemical equation for the reaction of $P_2 \longrightarrow S_2$

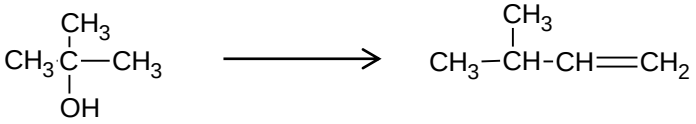
(iv) Write the balanced chemical equation for the reaction of $S_2 \longrightarrow S_3$

(v) Write the electronic configuration of the cation in $S_1$.

(vi) Write the IUPAC names of the species $S_1$ and $S_4$.

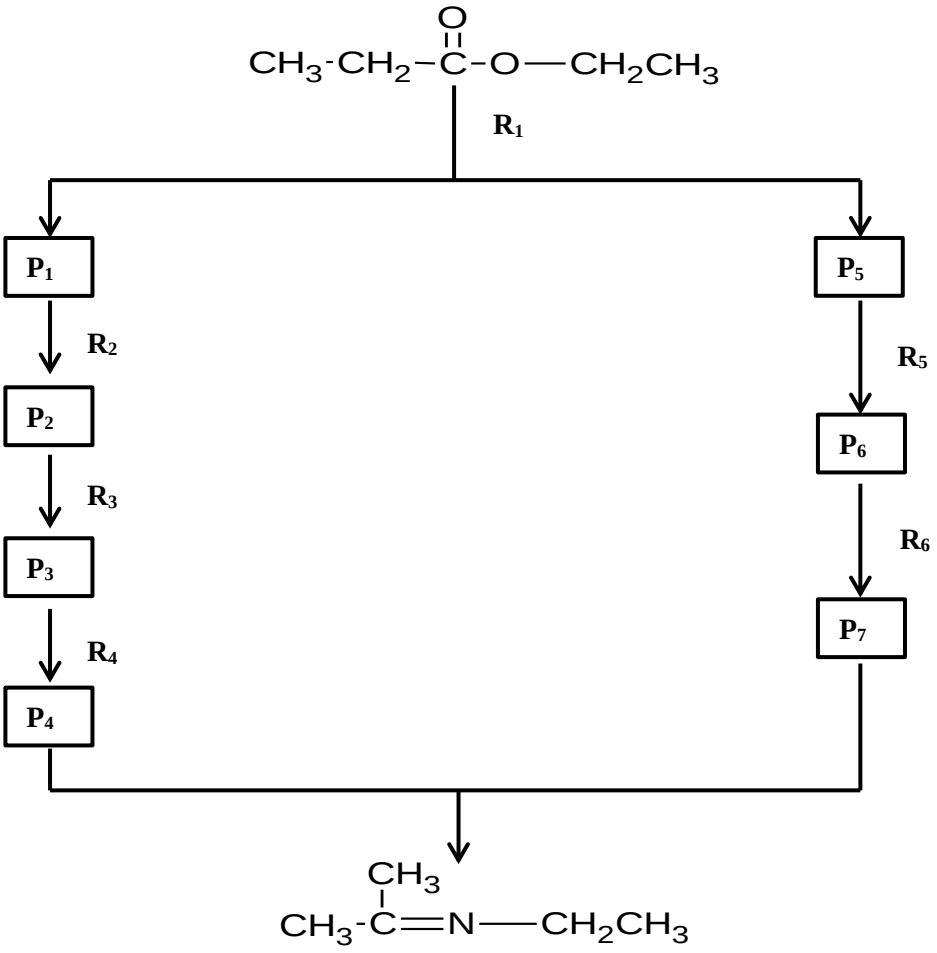
## Part C – ESSAY

8. (a) Show how you would carry out the following conversion using only the chemicals given in the list below

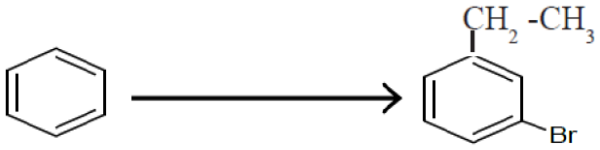



| List of chemicals, |
| --- |
| HCHO, Mg, dry ether, HBr, Organic peroxides, conc.$H_2SO_4$, $H^+/H_2O$ |

(b) (i) Complete the following reaction sequence; identify the products $P_1 - P_7$ and the reagents $R_1 - R_6$.




(ii) Show how you would carry out the following conversion in not more than 3 steps.




(c) (i) $CH_3-\underset{\displaystyle Cl}{\underset{|}{C}}H-CH_3$ shows nucleophilic substitution reactions, but $CH_2=CH-Cl$ does not show nucleophilic substitution reaction. Explain these statements based on the stability of carbonations and the resonance structures of the compounds.

(ii) Which of the above compounds are used in the production of an addition polymer?

9. (a) X is a d-block element that belongs to the fourth period of the periodic table. The ion $X^{n+}$ in the aqueous solution is coloured.

The oxyanion ($X_1$) is derived from the highest oxidation number of X. This ion $X_1$ turns into the dark green species $X_2$ , after the reaction of $X_1$ with concentrated KOH. When $H_2O_2$ is added to this green coloured solution, a brown precipitate($X_3$) is formed. $X_3$ reacts with concentrated HCl to form the colourless solution $X_4$, liberating the gas $X_5$. When dilute ammonia is added to a solution of $X^{n+}$, a cream-coloured (off white) precipitate($X_6$) is formed. This precipitate is insoluble in excess ammonia.

When concentrated HCl is added to a solution of $X^{n+}$ (aq), a green-coloured solution ($X_7$) is formed. When $H_2S$ is passed through an alkaline solution of $X^{n+}$(aq), the Pale pink precipitate ($X_8$) is formed.

(i) Identify the chemical species from $X_1$ to $X_8$.

(ii) Write the balanced chemical equation for the reaction between $X_1$ and concentrated KOH.

(iii) Write the IUPAC name of the ion $X_7$.

(iv) To analyze the anion $X_1$ quantitatively, this $X_1$ solution can be titrated with a standard solution (acidic medium) of $K_2C_2O_4$.

(I) Write the balanced chemical equations for the reaction occurring during this titration.

(II) Name the solution added to the burette and the titration flask separately.

(III) Stay the reason why it is important to warm the titration flask gently before the titration.

(IV) What is the colour change at the endpoint of this titration?

(V) The above titration was performed three times. The difference between the two burette readings was 0.50 $cm^3$. Explain whether these readings are suitable to be used for the calculation.

(VI) State two properties of $K_2C_2O_4$ that make it suitable to use as a primary standard.

(b) A solid mixture containing $KIO_3$, $Fe(NO_3)_3$, and an inert material. A 6.0 g sample of this mixture was dissolved in excess water to prepare a 250.00 $cm^3$ solution(Z).

A portion of 25.00 $cm^3$ from the solution (Z) and excess NaOH(aq) was added. The precipitate formed was heated strongly. The mass of the dry precipitate was 0.152 g.

A portion of 50.00 $cm^3$ was treated with an excess of KI(aq) and diluted $H_2SO_4$(aq). This solution was then diluted up to 100.00 $cm^3$. 25.00 $cm^3$ of this diluted solution was titrated with 0.10 mol $dm^{-3}$ solution of $Na_2S_2O_3$. The burette reading of the endpoint was 13.50 $cm^3$.

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

(ii) Calculate the mass percentage of $KIO_3$ and $Fe(NO_3)_3$ in the above sample.

(iii) What is the function of dilute $H_2SO_4$ in the experiment?

(iv) State the reason for the addition of the starch indicator, when the solution reaches the endpoint.

(v) Which of the apparatus burette, pipette, and titration flask should be rinsed with the solution to be filled into it?

10. (a) Some of the chemical reactions of the solvay process are given below,

$$NH_3(g) + H_2O(l) \rightleftharpoons NH_4OH(aq) \quad \text{—— (1)}$$

$$CO_2(g) \xrightleftharpoons{aq} CO_2(aq)$$

$$NH_4OH(aq) + CO_2(aq) \rightleftharpoons NH_4HCO_3(aq) \quad \text{—— (2)}$$

(i) Based on the relevant physicochemical principles, explain whether high temperatures or low temperatures are suitable for the reaction 1 and 2 above.

(ii) Explain the reason why carbonation is done before ammonification in the solvay process of production of $Na_2CO_3$.

(iii) Explain the reason why, $Na_2CO_3$ is obtained by the thermal decomposition of $NaHCO_3$ rather than producing it directly in the above process.

(iv) Write the net reaction for the production of $NaHCO_3$.

(v) (I) What are the gases that can be obtained by recycling of the above process?

(II) Write the chemical reactions relevant for obtaining the gases mention in (I).

(vi) State three reasons why the production of $Na_2CO_3$ from the solvay process is more economical.

(vii) Write two uses of $Na_2CO_3$.

(viii) What is the final by product of this process?

(b) (i) Consider the following species which contribute to various global environmental issues.

$SO_2, N_2O, NO, CO, CO_2, CH_4, CF_2Cl_2, NO_3^-, Mg^{2+}$

(I) Identify the compounds which contribute to global warming.

(II) Briefly explain the difference between the greenhouse effect and global warming.

(III) Identify the species which contribute to the depletion of the ozone layer.

(IV) Using four equation, show how one of the above species mention in (iii) contribute to the depletion of the ozone layer.

(V) Identify the species each contribute for the

(VI) (A) Permanent hardness of the water.

(B) Eutrophication

(ii) (I) Write 3 balanced chemical equations for how one of the species mentioned above contributes to acid rain.

(II) Write the chemical formulae of two types of ions whose concentration in water increases due to acid rain.

(III) State two human activities which contribute to acid rain.

(c) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H < 0$

(i) State the temperature, pressure, and catalyst that are used to increase the yield in the production of $NH_3$ from the Haber process.

(ii) The temperature above (i) is used as the optimum temperature. Explain the reason for this based on the physiochemical principles.

(iii) Write the methods of how raw materials of $N_2(g)$ and are obtained.

(iv) (I) Write the method for how $NH_3(g)$ is separated from the above equilibrium.

(II) What is the specific property of $NH_3(g)$, which enables it to separate from the $N_2(g)$ and $H_2(g)$?

(v) What is the reason for sending the mixture of $N_2(g)$ and $H_2(g)$ several times through the chamber of catalysts?

**The Periodic Table**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 **H** | | | | | | | | | | | | | | | | 2 **He** |
| 2 | 3 **Li** | 4 **Be** | | | | | | | | | | | 5 **B** | 6 **C** | 7 **N** | 8 **O** | 9 **F** | 10 **Ne** |
| 3 | 11 **Na** | 12 **Mg** | | | | | | | | | | | 13 **Al** | 14 **Si** | 15 **P** | 16 **S** | 17 **Cl** | 18 **Ar** |
| 4 | 19 **K** | 20 **Ca** | 21 **Se** | 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** |
| 5 | 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** |
| 6 | 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** |
| 7 | 87 **Fr** | 88 **Ra** | **Ac-Lr** | 104 **Rf** | 105 **Db** | 106 **Sg** | 107 **Bh** | 108 **Hs** | 109 **Mt** | 110 **Uun** | 111 **Uuu** | 112 **Uub** | 113 **Uut** | … | | | | |