නව නිර්දේශය/புதிய பாடத்திட்டம்/New Syllabus

NEW



අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2019 අගෝස්තු
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2019 ஓகஸ்ற்
General Certificate of Education (Adv. Level) Examination, August 2019

රසායන විද්‍යාව II
இரசாயனவியல் II
Chemistry II

02 E II

19.08.2019 / 0830 - 1140

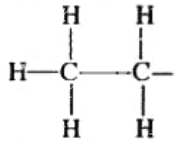
පැය තුනයි
மூன்று மணித்தியாலம்
*Three hours*

අමතර කියවීම් කාලය - මිනිත්තු 10 යි
மேலதிக வாசிப்பு நேரம் - 10 நிமிடங்கள்
Additional Reading Time - 10 minutes

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

Index No. : .....

* *A Periodic Table is provided on page 16.*
* ***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.**

Example:  group may be shown as $CH_3CH_2$–

❑ **PART A — Structured Essay (pages 2 - 8)**

* *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 PART C — Essay (pages 9 - 15)**

* *Answer **four** questions selecting **two** questions from each part. Use the papers supplied for this purpose.*
* *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 Only**

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

**Total**

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

**Code Numbers**

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

[see page two

## 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*) The following questions are related to the elements of the second row in the Periodic Table. Write the symbol of the element in the space provided in answering parts (i) to (vi).

(i) Identify the element that has the highest electronegativity (disregard the noble gas). .....

(ii) Identify the element that has an allotrope which conducts electricity. .....

(iii) Identify the element that forms the monoatomic ion largest in size (this should be a stable ion). .....

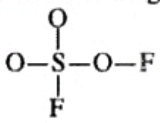
(iv) Identify the element that has no *p* electrons but has a stable *s* configuration. .....

(v) Identify the element that has the highest first ionization energy. .....

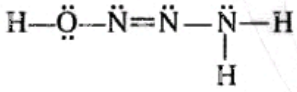
(vi) Identify the element that forms mostly electron deficient trigonal planar covalent compounds. .....

**(24 marks)**

(*b*) (i) Draw the most acceptable Lewis dot-dash structure for the molecule $SO_3F_2$. Its skeleton is given below.

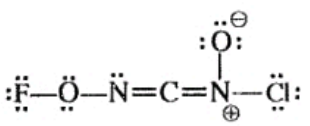


(ii) The most stable Lewis dot-dash structure for the molecule $H_3N_3O$ is shown below. Draw two more Lewis dot-dash structures (resonance structures) for this molecule. Write 'unstable' under the more unstable structure drawn by you.

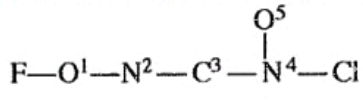


(iii) Based on the Lewis dot-dash structure given below, state the following regarding the C, N and O atoms given in the table.

I. VSEPR pairs around the atom
II. electron pair geometry around the atom
III. shape around the atom
IV. hybridization of the atom



The atoms are numbered as follows.



| | | $O^1$ | $N^2$ | $C^3$ | $N^4$ |
|---|---|---|---|---|---|
| I. | VSEPR pairs | | | | |
| II. | electron pair geometry | | | | |
| III. | shape | | | | |
| IV. | hybridization | | | | |

[see page three

Do not write in this column.

(iv) Identify the atomic/hybrid orbitals involved in the formation of the following $\sigma$ bonds in the Lewis dot-dash structure given in part (iii) above. (Numbering of atoms is as in part (iii).)

| | | | |
|---|---|---|---|
| I. | $F—O^1$ | F ..... | $O^1$ ..... |
| II. | $O^1—N^2$ | $O^1$ ..... | $N^2$ ..... |
| III. | $N^2—C^3$ | $N^2$ ..... | $C^3$ ..... |
| IV. | $C^3—N^4$ | $C^3$ ..... | $N^4$ ..... |
| V. | $N^4—O^5$ | $N^4$ ..... | $O^5$ ..... |
| VI. | $N^4—Cl$ | $N^4$ ..... | Cl ..... |

(v) Identify the atomic orbitals involved in the formation of the following $\pi$ bonds in the Lewis dot-dash structure given in part (iii) above. (Numbering of atoms is as in part (iii).)

| | | | |
|---|---|---|---|
| I. | $N^2—C^3$ | $N^2$ ..... | $C^3$ ..... |
| II. | $C^3—N^4$ | $C^3$ ..... | $N^4$ ..... |

(vi) I. How are the two double bonds oriented in the Lewis dot-dash structure given in part (iii)?

.....

II. Give an example of a molecule/ion that has a similar orientation of double bonds.

.....

Note: Your example should not contain more than 3 atoms.
The elements in your example should be restricted to the first and second periods of the Periodic Table. **(52 marks)**

(c) (i) An atomic orbital is described by three quantum numbers $n$, $l$ and $m_l$.

Write the appropriate quantum numbers and the name of the atomic orbital in the boxes given below.

| | $n$ | $l$ | $m_l$ | atomic orbital |
|---|---|---|---|---|
| I. | | | +1 | 3*p* |
| II. | 3 | 2 | –2 | |
| III | | | | 2*s* |

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

I. LiF, LiI, KF (melting point)

..... < ..... < .....

II. $NO_2^-$, $NO_4^{3-}$, $NF_5$ (stability)

..... < ..... < .....

III. NOCl, $NOCl_3$, $NO_2F$ (N—O bond distance)

..... < ..... < .....

**(24 marks)**

100

[see page four

Do not write in this column.

2.(*a*) X is an *s*-block element in the Periodic Table. The first, second and third ionization energies of X, in kJ $mol^{-1}$ are 738, 1451 and 7733 respectively. X reacts slowly with hot water, liberating $H_2(g)$ and forming its hydroxide. The hydroxide is basic. X also liberates $H_2(g)$ on reaction with dilute acids. X burns in air with a bright white light. The cation of X contributes to hardness of water.

(i) Identify X. X: .....

(ii) Write the ground state electronic configuration of X. .....

(iii) Write the chemical formulae of the two compounds formed when X burns in air.

..... and .....

(iv) Consider the given compounds of the elements in the group in the Periodic Table to which X belongs. In the given boxes, write whether the indicated property increases or decreases down the group.

I. Solubility of sulphates in water

II. Solubility of hydroxides in water

III. Thermal stability of metal carbonates

Give reasons for your answer in III.

.....

.....

.....

(v) Identify the element in the *s*-block of the Periodic Table, which reacts in a similar manner to X with $H_2(g)$, $O_2(g)$ and $N_2(g)$, but does not belong to the same group as X.

.....

(vi) Identify another metal ion that contributes to hardness of water.

.....

(vii) Identify the compound most commonly used to remove hardness of water.

.....

(viii) X is a component of a well-known reagent used in organic chemistry. Give the name of this reagent.

.....

**(50 *marks*)**

[*see page five*

Do not write in this column.

(*b*) Test tubes labelled A to E contain aqueous solutions of $Na_2S_2O_3$, $Na_2CO_3$, $KNO_2$, KBr and $Na_2S$ (not in order). The characteristics of the solutions obtained and gases evolved on addition of dil. HCl (warming if required) to each of the test-tubes A to E are given in the table below.

| Test-tube | Appearance of solution | Gas |
|---|---|---|
| A | colourless | colourless and odourless |
| B | colourless | reddish-brown with a pungent odour |
| C | colourless | colourless with a rotten egg odour |
| D | turbid | colourless with a pungent odour |
| E | colourless | not evolved |

(i) Identify the solutions in each of the test-tubes A to E.

A : ..... C : ..... E : .....

B : ..... D : .....

(ii) Write balanced chemical equations for the reactions that take place in test-tubes A, B, C and D.

In A : .....

In B : .....

In C : .....

In D : .....

(iii) Write a chemical test to identify each of the gases evolved in A, C and D.
**Note:** Observations are also required.

In A : .....

.....

In C : .....

.....

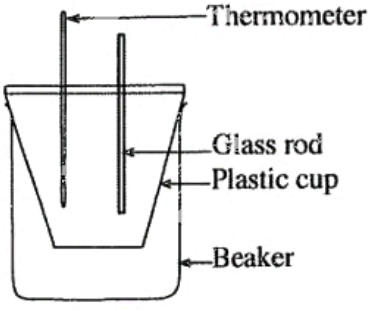
In D : .....

.....

**(50 *marks*)**

100

3. The set up shown in the figure was used to calculate the heat change associated with the dissolution of MX(s) in water. 100.00 $cm^3$ of distilled water was added to the cup. The initial temperature of distilled water was measured to be 25.0 °C. Then 0.10 mol of MX(s) was added to the water and stirred continuously. It was observed that the temperature of the solution decreased gradually. The lowest temperature measured was 17.0 °C. The amount of water used was sufficient to completely dissolve MX(s). Density and specific heat capacity of water are 1.00 g $cm^{-3}$ and 4.20 J $g^{-1}$ $°C^{-1}$ respectively. Assume that the density and the specific heat capacity of water are not changed due to the dissolution of MX(s).




(i) Calculate the amount of heat that should be supplied to bring the system (solution) back to 25.0 °C.

.....

.....

.....

[*see page six*

Do not write in this column.

(ii) Is the dissolution of MX(s) in water an endothermic or exothermic process? Explain your answer.

.....

.....

(iii) Calculate the enthalpy change (in kJ $mol^{-1}$) associated with reaction

$MX(s) + H_2O(l) \rightarrow M^+(aq) + X^-(aq)$.

.....

.....

.....

.....

.....

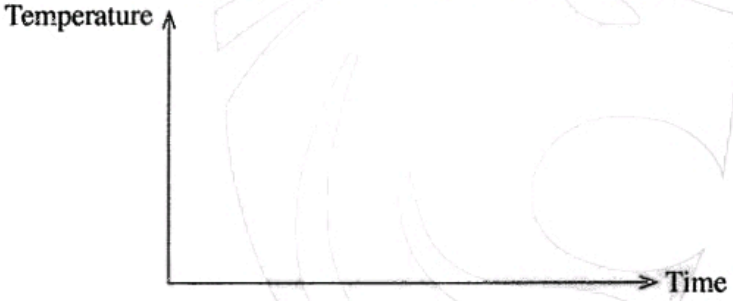
(iv) If this experiment was conducted using 200.00 $cm^3$ of water, would you expect the temperature change to be larger than the above value? Explain your answer.

.....

.....

(v) Show the variation of temperature of the system (solution) by drawing the temperature – time curve.

Note: Eventually the system reaches the room temperature (25.0 °C).




(vi) In this experiment, explain why a plastic cup is used instead of a metal cup.

.....

.....

.....

(vii) Gibbs energy change ($\Delta G$) for the dissolution of MX(s) in water at the temperature of 25.0 °C and pressure of 1.0 atm was calculated to be –26.0 kJ $mol^{-1}$. Calculate the entropy change ($\Delta S$) of dissolution of MX(s) in water at 25.0 °C using the enthalpy change calculated above.

.....

.....

.....

.....

.....

(viii) Would you expect the solubility of MX(s) to increase or decrease with increasing temperature? Give reasons for your answer.

.....

.....

.....

(100 marks)

100

[see page seven

Do not write in this column.

4. (*a*) Compounds A and B both have the same molecular formula $C_5H_{10}O$. Both A and B give orange/red precipitates with 2,4-dinitrophenylhydrazine. When A and B are reacted separately with $NaBH_4$ in methanol, compound A gives C and compound B gives D. When C is heated with $Al_2O_3$, two alkenes E ($C_5H_{10}$) and F ($C_5H_{10}$) are formed. When E and F are reacted separately with conc. $H_2SO_4$ and the products obtained are hydrolysed, compound E gives G, while compound F gives H. G gives a turbidity immediately with the Lucas reagent. H also gives a turbidity with the Lucas reagent but not immediately.

(i) Draw the structures of G and H.

G H

(ii) Draw the structures of A, C, E and F.

A C

E F

When heated with $Al_2O_3$, D gives alkene I ($C_5H_{10}$). When I is reacted with conc. $H_2SO_4$ and the product obtained hydrolysed, G is obtained.

(iii) Draw the structures of B, D and I.

B D I

(iv) Describe a test/reaction to distinguish between A and B.

.....

.....

.....

.....

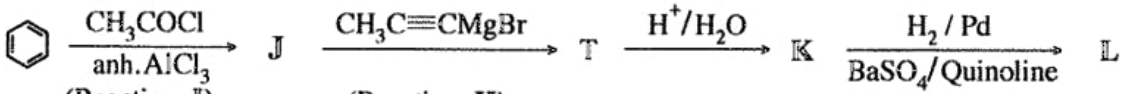
.....

**(50 *marks*)**

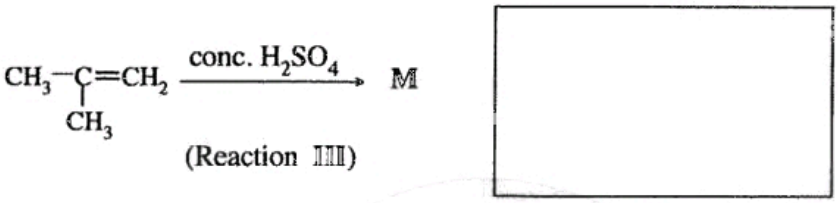
[*see page eight*

Do not write in this column.

(*b*) (i) Give the structures of J, K, L and M in the following reaction sequences.




J K L




M

(ii) Selecting from the list given below, write the type of reaction taking place in reactions I, II and III.

| Nucleophilic Addition, Nucleophilic Substitution, Electrophilic Addition, Electrophilic Substitution, Elimination |
|---|

Reaction I: .....

Reaction II: .....

Reaction III: .....

(iii) Using your knowledge of the mechanism of the reaction between alkenes and HBr, give the mechanism of reaction III.

**(50 *marks*)**

100

* *

[*see page nine*

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NEW



අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2019 අගෝස්තු
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2019 ஓகஸ்ற்
General Certificate of Education (Adv. Level) Examination, August 2019

| | |
|---|---|
| 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*) A titration between the mono acidic weak base **B** (0.15 mol $dm^{-3}$) and HCl (0.10 mol $dm^{-3}$) was carried out using a suitable indicator as described below.

The HCl solution (25.00 $cm^3$) was kept in the titration flask and the weak base **B** was added using a burette. The dissociation constant, $K_b$ of the weak base at 25 °C is $1.00 \times 10^{-5}$ mol $dm^{-3}$. All the experiments were conducted at 25 °C.

(i) Calculate the pH of the acid solution in the titration flask, before the addition of the base, **B**.

(ii) Calculate the pH of the solution in the titration flask, after the addition of 10.00 $cm^3$ of the solution of **B**. Can the solution in the titration flask act as a buffer solution? Explain your answer.

(iii) Calculate the volume of the weak base solution required to reach the equivalence point.

(iv) Another 10.00 $cm^3$ volume of the weak base was added to the titration flask after reaching the equivalence point. Calculate the pH of the solution in the titration flask.

(v) Can the solution obtained in (iv) above act as a buffer solution? Explain your answer.

(vi) Sketch the variation in pH of the mixture in the titration flask with the volume of the weak base solution added (titration curve). Label the axes, indicate pH on the *y*-axis and the volume of weak base solution added on the *x*-axis. Mark the equivalence point approximately. [Calculation of pH at equivalence point is not expected.] **(75 *marks*)**

(*b*) The following two experiments were carried out at a constant temperature using the volatile liquids **C** and **D** which form an ideal solution.

**Experiment I:** The liquids **C** and **D** were introduced in to an evacuated rigid container and allowed to reach equilibrium. When the system was at equilibrium, it was observed that the mole fractions of **C** and **D** in the liquid phase ($L_I$) were 0.3 and 0.7 respectively. Total pressure in the container was $2.70 \times 10^4$ Pa.

**Experiment II:** This experiment was conducted using different amounts of **C** and **D**. When the equilibrium was established, it was observed that the mole fractions of **C** and **D** in the liquid phase ($L_{II}$) were 0.6 and 0.4 respectively. Total pressure of the container was $2.40 \times 10^4$ Pa.

(i) Give the relationship between the partial pressure of **C** in the vapour phase ($P_C$), its saturated vapour pressure $\left(P_C^\circ\right)$ and its mole fraction in the liquid phase ($X_C$) in the form of an equation. This equation states a commonly used law in physical chemistry. Write the name of the law.

(ii) Calculate the saturated vapour pressures of **C** and **D**.

(iii) Calculate the mole fractions of **C** and **D** in the vapour phase ($V_I$) of experiment I.

(iv) Calculate the mole fractions of **C** and **D** in the vapour phase ($V_{II}$) of experiment II.

(v) Show the compositions of liquid and vapour phases ($L_I$, $L_{II}$, $V_I$ and $V_{II}$) and relevant pressures in the above two experiments on a pressure-composition phase diagram drawn at constant temperature. **(75 *marks*)**

[*see page ten*

6. (*a*) An organic solvent (org-1) and water(aq) are immiscible and form a biphasic system. Partition coefficient for the distribution of X between org-1 and water at temperature T is, $K_D = \frac{[X]_{org\text{-}1}}{[X]_{aq}} = 4.0$

An amount of 0.50 mol of X was added to a system containing 100.00 $cm^3$ of org-1 and 100.00 $cm^3$ of water. The system was allowed to reach equilibrium at temperature T.

(i) Calculate the concentration of X in org-1.

(ii) Calculate the concentration of X in water.

**(20 *marks*)**

(*b*) The compound Y is soluble only in the aqueous phase. In the aqueous phase, X and Y react to form Z. The presence of Y and Z does not affect the distribution of X between org-1 and water.

A series of biphasic systems containing org-1 and water were prepared. Then different amounts of X were distributed in the biphasic systems and the systems were allowed to reach equilibrium. The initial rate of the reaction between X and Y in the aqueous phase was measured after adding Y into the aqueous phase of these biphasic systems. Results of these experiments conducted at temperature T are given in the table.

| Experiment Number | Volume of water ($cm^3$) | Volume of org-1 ($cm^3$) | Total amount of X added (mol) | Total amount of Y added (mol) | Initial rate of the reaction (mol $dm^{-3}$ $s^{-1}$) |
|---|---|---|---|---|---|
| 1 | 100.00 | 100.00 | 0.05 | 0.02 | $2.00 \times 10^{-6}$ |
| 2 | 100.00 | 100.00 | 0.10 | 0.04 | $1.60 \times 10^{-5}$ |
| 3 | 50.00 | 50.00 | 0.25 | 0.02 | $4.00 \times 10^{-4}$ |

Orders of the reaction with respect to X and Y are $m$ and $n$ respectively. The rate constant of the reaction at temperature T is $k$.

(i) Given that the concentrations of X and Y in the aqueous phase are $[X]_{aq}$ and $[Y]_{aq}$ respectively, write the rate expression for the reaction in terms of $[X]_{aq}$, $[Y]_{aq}$, $m$, $n$ and $k$.

(ii) Calculate the initial concentration of X in the aqueous phase in each experiment.

(iii) Calculate the initial concentration of Y in the aqueous phase in each experiment.

(iv) Calculate the orders $m$ and $n$ of the reaction with respect to X and Y respectively.

(v) Calculate the rate constant of the reaction.

(vi) An experiment is designed to study the effect of temperature on the reaction rate using the partition coefficient given above.

Is this a suitable experiment to study the effect of temperature on the rate of the reaction? Explain your answer.

**(105 *marks*)**

(*c*) The organic solvent org-2 and water are also immiscible and form a biphasic system. X (0.20 mol) was added to a system containing 100.00 $cm^3$ of org-2 and 100.00 $cm^3$ of water and allowed to reach equilibrium at the temperature T. Then Y (0.01 mol) was added to the aqueous phase and the initial rate of the reaction was measured. Y does not dissolve in org-2. The initial rate of the reaction between X and Y in the aqueous phase was found to be $6.40 \times 10^{-7}$ mol $dm^{-3}$ $s^{-1}$.

Calculate the partition coefficient $\frac{[X]_{org\text{-}2}}{[X]_{aq}}$ for the distribution of X between org-2 and water.

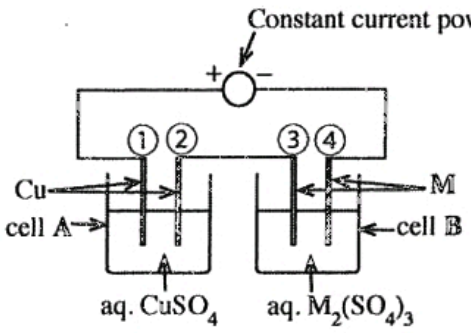
$[X]_{org\text{-}2}$ is the concentration of X in the org-2 phase.

**(25 *marks*)**

[*see page eleven*

7. (*a*) The setup shown in the figure was used to find the relative atomic mass of the metal, M.

The electrolysis was carried out for 10 minutes using a constant current. The mass of the cathode in cell A was increased by 31.75 mg whereas the mass of the cathode in cell B increased by 147.60 mg during this time period. (Assume that the electrolysis of water does not take place in cells A and B.)




(i) Identify the anode and cathode in each of the cells A and B (in terms of the numbers ①, ②, ③, and ④).

(ii) Write the half reaction taking place at each electrode in each cell.

(iii) Calculate the constant current used in electrolysis.

(iv) Calculate the relative atomic mass of metal, M.

***(75 marks)***

(*b*) (i) A, B and C are coordination compounds. They have an octahedral geometry. In each compound, two types of ligands are coordinated to the metal ion. The molecular formulae of the compounds are (not in order): $NiCl_2H_{12}N_4$, $NiI_2H_{16}N_4O_2$ and $NiCl_2H_{15}N_3O_3$.

Given below are the observations when aqueous solutions of the compounds are treated with $Pb(CH_3COO)_2(aq)$.

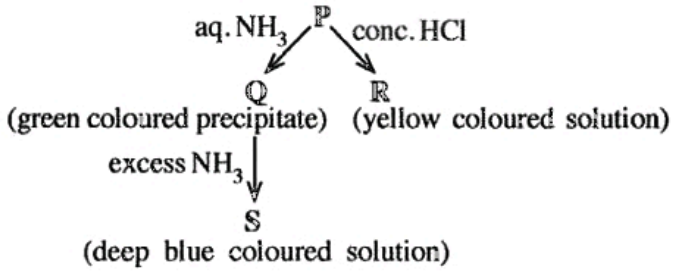
| Compound | $Pb(CH_3COO)_2(aq)$ |
|---|---|
| A | A white precipitate that is soluble in hot water |
| B | No precipitate |
| C | A yellow precipitate that is soluble in hot water |

I. Give the structures of A, B and C.

II. Write the chemical formulae of the precipitates formed on treatment of the compounds with $Pb(CH_3COO)_2(aq)$.
(Note: Indicate compound and reagent)

III. State a chemical test, together with the observation, to identify each of the anion/s if present, that is/are not coordinated to the metal ion in the compounds given above.
(Note: The tests given by you should not be a test stated here.)

(ii) A transition metal M forms a coloured complex ion P in aqueous medium. It has the general formula $[M(H_2O)_n]^{m+}$. It undergoes the reactions given below.




I. Identify the metal M. Give the oxidation state of M in complex ion P.

II. Give the electronic configuration of M in the complex ion P.

III. Give the values of n and m.

IV. Give the geometry of P.

V. Give the structures of Q, R and S.

VI. Give the IUPAC names of the complex ions, P, R and S.

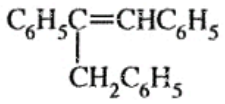
***(75 marks)***

[*see page twelve*

## PART C — ESSAY

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

**8.** (*a*) Using $C_6H_5CO_2CH_3$ as the only organic starting material and as reagents only those given in the list, show how you would synthesize the following compound in **not** more than **seven** (7) steps.

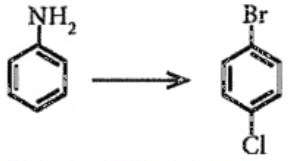


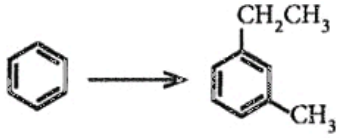
**List of reagents**

$PCl_3$, Mg/dry ether, $H^+/H_2O$, $LiAlH_4$, conc. $H_2SO_4$

**(60 *marks*)**

(*b*) Show how you would carry out each of the following conversions in **not** more than **three** (3) steps.

(i) 

(ii) 

**(60 *marks*)**

(*c*) The following reaction gives two products.

$$CH_3CH_2CH_2Br \xrightarrow{C_2H_5O^-}$$

(i) Write the structures of the two products.

(ii) Write the mechanisms for the formation of these two products.

**(30 *marks*)**

**9.** (*a*) Solution **X** contains **four** metal cations. The following tests were carried out to identify these cations.

| | Test | Observation |
|---|---|---|
| ① | Dilute HCl was added to a small portion of **X**. | No precipitate. |
| ② | $H_2S$ was bubbled through the solution from ① above. | A black precipitate ($\mathbb{P}_1$) |
| ③ | $\mathbb{P}_1$ was separated by filtration. The filtrate was boiled to remove the $H_2S$, cooled, and $NH_4Cl/NH_4OH$ was added. | A green precipitate ($\mathbb{P}_2$) |
| ④ | $\mathbb{P}_2$ was separated by filtration and $H_2S$ was bubbled through the filtrate. | A white precipitate ($\mathbb{P}_3$) |
| ⑤ | $\mathbb{P}_3$ was separated by filtration. The filtrate was boiled to remove the $H_2S$, cooled, and $(NH_4)_2CO_3$ was added. | A white precipitate ($\mathbb{P}_4$) |

The following tests were carried out on precipitates $\mathbb{P}_1$, $\mathbb{P}_2$, $\mathbb{P}_3$ and $\mathbb{P}_4$.

| Precipitate | Test | Observation |
|---|---|---|
| $\mathbb{P}_1$ | $\mathbb{P}_1$ was dissolved in hot dil. $HNO_3$ and conc. $NH_4OH$ was added in excess. | A deep blue coloured solution (**solution 1**) |
| $\mathbb{P}_2$ | * Excess dil. NaOH was added to $\mathbb{P}_2$ followed by $H_2O_2$. | A yellow coloured solution (**solution 2**) |
| | * Dilute $H_2SO_4$ was added to **solution 2**. | An orange coloured solution (**solution 3**) |
| $\mathbb{P}_3$ | * $\mathbb{P}_3$ was dissolved in dil. HCl and dil. NaOH was added gradually. | A white precipitate ($\mathbb{P}_5$) |
| | * Addition of dil. NaOH was continued. | $\mathbb{P}_5$ dissolved to give a colourless solution (**solution 4**) |
| $\mathbb{P}_4$ | $\mathbb{P}_4$ was dissolved in conc. HCl and subjected to the flame test. | A brick-red flame |

[*see page thirteen*

(i) Identify the four metal cations in solution X (**Reasons are not required.**)

(ii) Identify the precipitates $P_1$, $P_2$, $P_3$, $P_4$ and $P_5$ and the chemical species responsible for the colours of solutions 1, 2, 3 and 4.

(Note: Write chemical formulae only.)

**(75 *marks*)**

(*b*) The water sample Y contains the anions $SO_3^{2-}$, $SO_4^{2-}$ and $NO_3^-$. The following procedures were carried out for the quantitative analysis of the anions present in the water sample.

**Procedure 1**

To 25.00 $cm^3$ of sample Y, an excess of a dilute solution of $BaCl_2$ was added with stirring. Thereafter, excess dilute HCl was added with stirring to the precipitate formed until there was no further evolution of a gas with pungent odour. The solution was allowed to stand for 10 minutes and filtered. The precipitate was washed with distilled water and dried in an oven at 105 °C until a constant mass was obtained. The mass of the precipitate was 0.174 g. The filtrate obtained was kept for further analysis (see procedure 3).

**Procedure 2**

To 25.00 $cm^3$ of sample Y, an excess of dilute $H_2SO_4$ and acidified 5% $KIO_3$ solutions were added. The liberated $I_2$ was immediately titrated with 0.020 mol $dm^{-3}$ $Na_2S_2O_3$ solution using starch as the indicator. The volume of $Na_2S_2O_3$ used was 20.00 $cm^3$. (Assume that in this procedure, $SO_3^{2-}$ ions are oxidized to sulphate ions $\left(SO_4^{2-}\right)$ without any loss to the atmosphere.)

**Procedure 3**

The filtrate from procedure 1 was neutralized with dilute NaOH and to it excess Al powder and dilute NaOH were added. The solution was heated and the gas evolved was transferred quantitatively to react with a 20.00 $cm^3$ volume of 0.11 mol $dm^{-3}$ HCl solution. Completion of the reaction was tested with litmus. The HCl remaining after reacting with the gas evolved was titrated with 0.10 mol $dm^{-3}$ NaOH solution using methyl orange as the indicator. The volume of NaOH required was 10.00 $cm^3$.

(i) Write balanced ionic/non-ionic equations for the reactions taking place in procedures 1, 2 and 3.

(ii) Determine the concentrations (mol $dm^{-3}$) of $SO_3^{2-}$, $SO_4^{2-}$ and $NO_3^-$ in water sample Y. (Ba = 137; S = 32; O = 16)

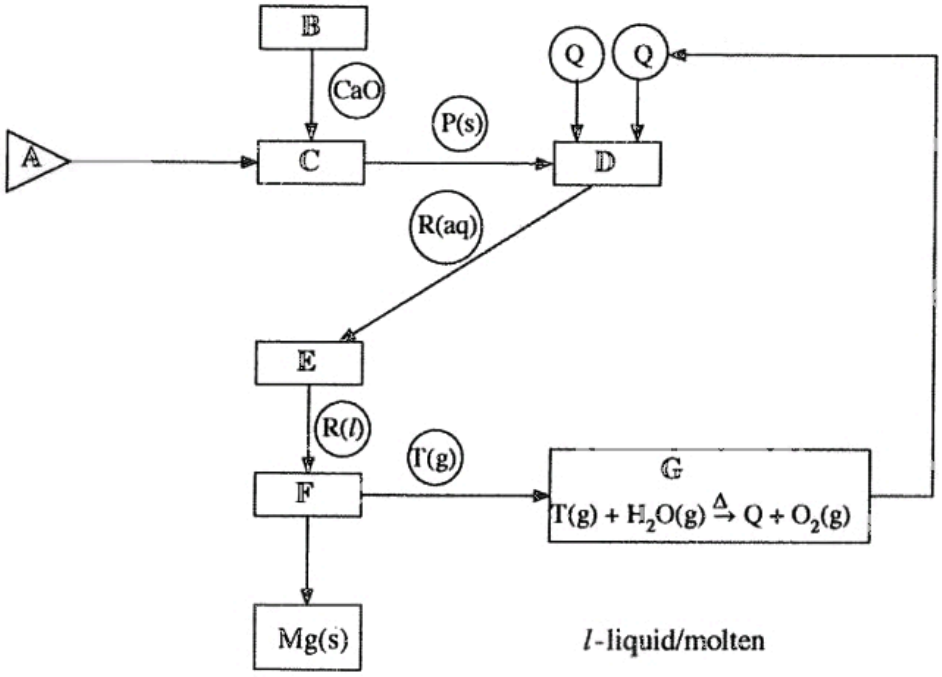
(iii) Give colour changes that would be observed in the titrations in procedures 2 and 3.

(Note: Assume that other ions that may interfere with the analysis are not present in sample Y.)

**(75 *marks*)**

[*see page fourteen*

10. *(a)*




The flow chart given above indicates the production of metal magnesium (Mg) using the Dow Process.

Answer the following questions based on the flow chart.

(i) Identify the starting material A.

(ii) Identify the processes employed at B, C, D, E, F and G from the list below.

evaporation, dissolution, thermal decomposition, electrolysis, recycling of a reagent, precipitation

(iii) Identify the chemical compound used in B.

(iv) Identify the chemical species P, Q, R and T.

(v) Give balanced chemical equations/half reactions for the processes taking place in B, C, D, and F.
(Note: When writing half reactions, identify the anode and cathode where applicable.)

(vi) State the importance of the reaction occurring in G. **(50 *marks*)**

*(b)* (i) Consider the industries given below.

Coal power plants
Refrigeration and air conditioning
Transport
Agriculture
Animal farming

I. All five industries given above contribute to global warming. Identify the gaseous chemical species associated with each of these industries that contribute to global warming.

II. State three adverse climate changes that could occur due to global warming.

(ii) Identify the main industry/industries given in (i) above that contribute to

I. photochemical smog,

II. acid rain,

III. eutrophication.

[*see page fifteen*

(iii) Due to the reduction in rainfall in Sri Lanka, inducing artificial rain has been tested near catchment areas of reservoirs that are used for hydro-power generation. In this process, fine particles of hygroscopic salts (NaCl, $CaCl_2$, NaBr) are sprayed to induce cloud formation by condensation of water vapour.

From the list given below, select the water quality parameters that are directly

I. affected

II. unaffected

due to salts entering water around catchment areas. Give reasons for your choice briefly.

List of water quality parameters:

pH, conductivity, turbidity, dissolved oxygen

**(50 *marks*)**

(c) The following questions are based on biodiesel production.

(i) State the raw materials used in the manufacture of biodiesel.

(ii) Name the main chemical compound present in each raw material where applicable.

(iii) State the name of the chemical compound used as the catalyst in the manufacture of biodiesel in the school laboratory.

(iv) Give a balanced chemical equation to show the synthesis of biodiesel using the chemical compounds stated in part (ii) above.

(v) Identify a side reaction that would take place, along with its products, if the catalyst is used in excess.

**(50 *marks*)**

* * *

[see page sixteen

## 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 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 |
| 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 Ds | 111 Rg | 112 Cn | 113 Nh | 114 Fl | 115 Mc | 116 Lv | 117 Ts | 118 Og |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |