PART A — STRUCTURED ESSAY

Answer all four questions on this paper itself. (Each question carries **10** *marks.)*

1. (*a*) State whether the following statements are **true** or **false**. (Reasons are **not** required.)

(i) The polarizability of halide ions increases with increasing size. .....

(ii) The O—N—O bond angle of NO_2 is greater than that of NO_2^-. .....

(iii) London dispersion forces among CCl_4 molecules are smaller than the London dispersion forces among SO_3 molecules. .....

(iv) The shape of the HSO_4^- ion is trigonal bipyramidal. .....

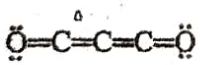
(v) All 3*d* atomic orbitals of an atom are represented by quantum numbers (n, l, m_l) 3, 2, 1. .....

(vi) The addition of an electron to a gaseous phosphorus atom is an exothermic process whereas for a gaseous nitrogen atom it is endothermic. .....

(*b*) (i) Draw the **most** acceptable Lewis structure for the molecule SF_3N.

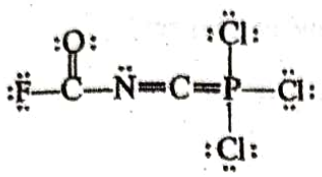
(ii) The most stable Lewis structure for the molecule C_3O_2 (carbon suboxide) is shown below. Draw another two Lewis structures (resonance structures) for this molecule.

(**Note**: Marks will not be awarded for Lewis structures drawn with octet rule violated.)

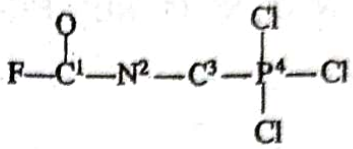


(iii) Based on the Lewis structure given below, state the following regarding the C, N and P atoms given in the table below.

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:



		C^1	N^2	C^3	P^4
I	VSEPR pairs				
II	Electron pair geometry				
III	Shape				
IV	Hybridization				

(iv) Identify the atomic/hybrid orbitals involved in the formation of the following σ bonds in the Lewis structure given in part (iii) above. (Numbering of atoms is as in part (iii).)

I. F—C^1 F....., C^1 .....
II. C^1—N^2 C^1....., N^2 .....
III. N^2—C^3 N^2....., C^3 .....
IV. C^3—P^4 C^3....., P^4 .....
V. P^4—Cl P^4....., Cl .....

(v) Identify the atomic orbitals involved in the formation of the following π bonds in the Lewis 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—P^4 C^3....., P^4 .....

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

(i) B, Na, P, Be, N (first ionization energy)

....

(ii) NH_3, NOCl, NO_2Cl, NH_4^+, F_3C-NC (electronegativity of nitrogen)

....

(iii) Quantum numbers of electrons in an atom (n, l, m_l, m_s)

$\left(3, 1, 0, -\frac{1}{2}\right), \left(3, 0, 0, +\frac{1}{2}\right), \left(2, 0, 0, +\frac{1}{2}\right), \left(2, 1, +1, +\frac{1}{2}\right), \left(3, 2, -1, +\frac{1}{2}\right)$ (energy of electron)

2. (a) **X** is a *p*-block element in the Periodic Table. It exists as a diatomic gas. **X** exhibits a wide range of oxidation states. **Y** is the most common hydride of **X**. **Y** dissolves readily in water to give a basic solution. **Y** acts as an oxidizing agent, a reducing agent, an acid and a base. The diatomic gas of **X** is used in the manufacture of **Y**.

(i) Identify **X** and **Y**.

(ii) The diatomic gas of **X** is generally considered as inert. Briefly explain.

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.....

(iii) Write the chemical formulae of three oxides of **X**, and indicate the oxidation state of **X** in each compound.

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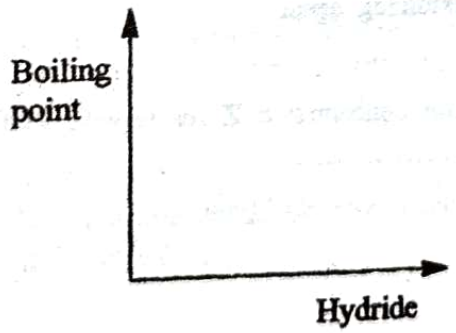
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(iv) In each of the following instances, give a balanced chemical equation to indicate action of **Y**.

I. **Y** as an oxidizing agent

II. **Y** as a reducing agent

(v) Consider the hydrides of the elements in the group to which **X** belongs, which a analogous to **Y**. Sketch the variation in boiling points of these hydrides (including in the graph below. In your sketch indicate the hydrides using their chemical formul (**Note**: Values of boiling points are **not** required.)



(vi) Give reasons for the variation in boiling points in part (v) above.

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(vii) I. Write what you would observe when an excess of an aqueous solution of **Y** is added to a solution of $Al_2(SO_4)_3$.

.....

II. Write the chemical formula of the species that gives rise to your observation in part I above.

.....

(viii) Give **one chemical** test to identify **Y**.

Test: .....

Observation: .....

(ix) **Z** is an oxo-acid of **X** and a strong oxidizing agent.

I. Identify **Z**. .....

II. State the products obtained when hot concentrated **Z** reacts with sulphur.

.....

(*b*) **A** and **B** are compounds of two *p*-block elements that belong to the same group in the Periodic Table. **A** exists as a colourless, odourless liquid at room temperature and atmospheric pressure. It is also found in the gaseous and solid states. The solid state of **A** is less dense than its liquid state. Ionic and polar compounds are readily soluble in **A**.

B is a colourless gas at room temperature and atmospheric pressure. A filter paper moistened with lead acetate turns black on treatment with **B**.

(i) Identify **A** and **B**.

(ii) Sketch the shapes of **A** and **B** showing lone pairs of electrons where necessary.

(iii) Giving reasons, state whether **A** or **B** has the larger bond angle.

(iv) In each of the following instances, give a balanced chemical equation to indicate the action of **A**.

I. **A** as an acid:

II. **A** as a base:

(v) Write the balanced chemical equation for the reaction of **B** with aqueous lead acetate.

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(vi) I. Write what you would observe when **A** and **B** are added **separately** to an acidified solution of $BiCl_3$.

with **A** (excess) -

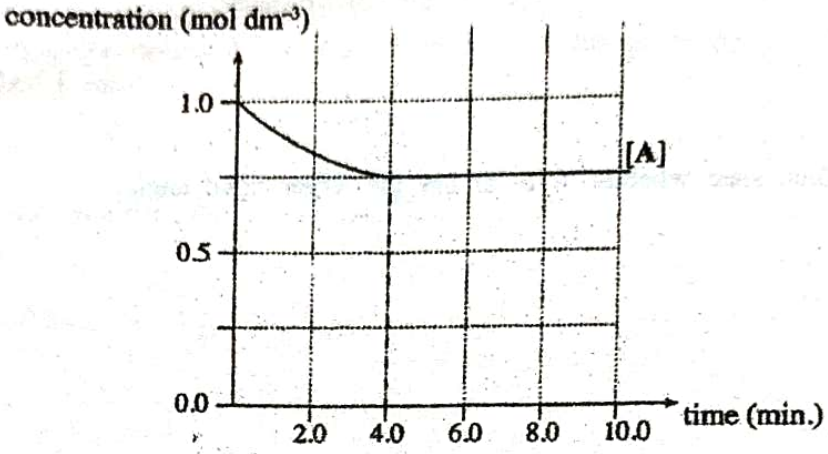
with **B**

II. Write balanced chemical equations for your observations in part I above.

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3. The reaction $A + B \rightleftharpoons 2C + D$ (elementary in both directions) was carried out at 25 °C. Initially, the reaction mixture was made by dissolving 0.10 mol of **A** and 0.10 mol of **B** in distilled water (total volume 100.00 cm^3). Variation in the concentration of **A** in this solution with time is shown in the graph.



(i) Calculate the amount of **A** (in moles) reacted during the first 4.0 minutes of the reaction.

(ii) Would the rate of the forward reaction be less than the rate of the reverse reaction after 4.0 minutes? Explain your answer.

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(iii) Given that the rate constant of the forward reaction ($k_{forward}$) is 18.57 $mol^{-1}\ dm^3\ min^{-1}$, calculate the initial rate of the forward reaction.

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.....

(iv) Calculate the concentrations of **C** and **D** at equilibrium.
Draw the relevant curves showing the variation of the concentrations of **C** and **D** with time in the above graph and **label** them.

.....

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(v) Write the expression for the equilibrium constant K_c of the above reaction and calculate it value.

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(vi) Calculate the value of the rate constant ($k_{reverse}$) of the reverse reaction.

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(vii) After reaching equilibrium, the volume of the solution was doubled by adding 100.00 of distilled water. Predict the direction of the net reaction soon after doubling the vol of the solution, by means of a suitable calculation.

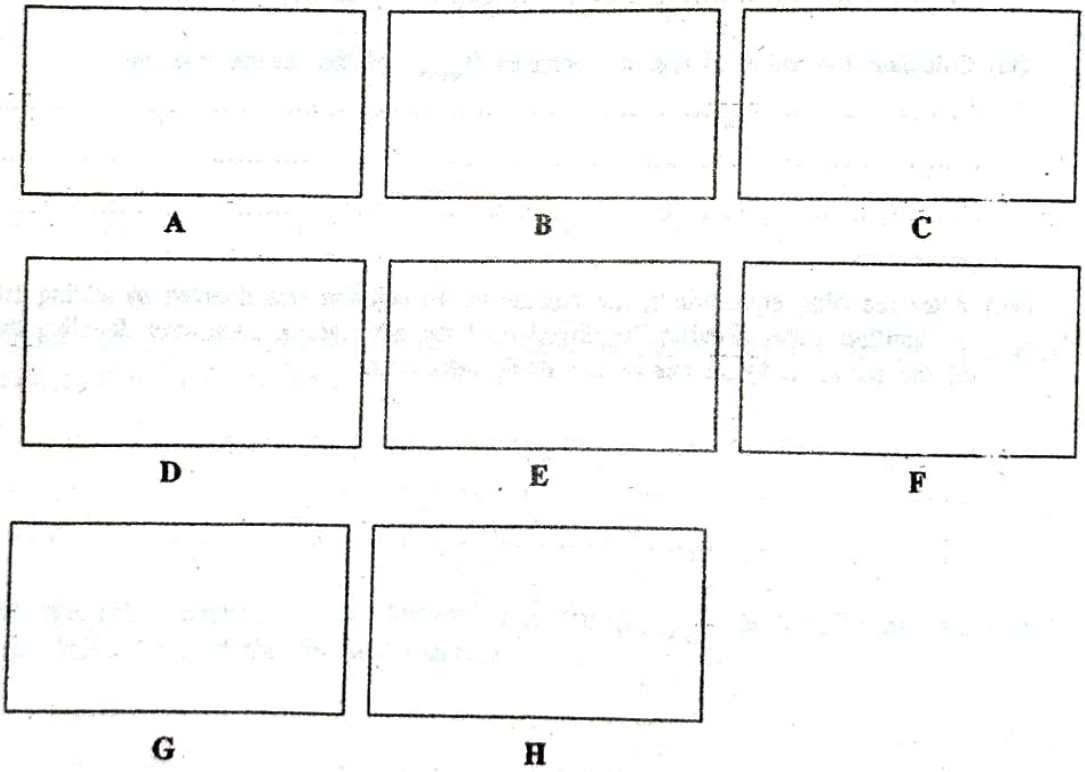
(viii) Consider that the above experiment was conducted at a temperature lower than 25 °C. How would this affect the rate of the reverse reaction? Explain your answer giving reasons.

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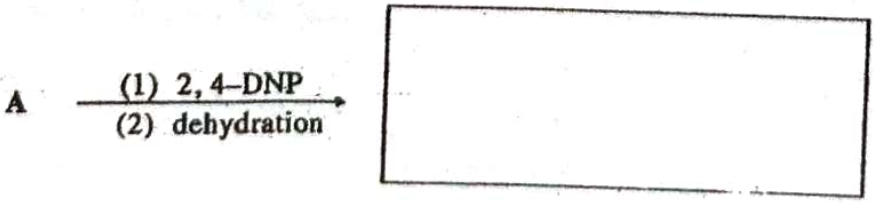
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4. (*a*) (i) Compounds **A**, **B** and **C** are structural isomers of each other having the molecular formula $C_5H_{10}O$. All three compounds give yellow-orange precipitates with 2, 4–DNP. None of them give a silver mirror in the silver mirror test. When **A**, **B** and **C** were separately reacted with $NaBH_4$, compounds **D**, **E** and **F** respectively were obtained. Only **E** and **F** showed optical isomerism. When **B** and **C** were separately reacted with $CH_3CH_2CH_2MgBr$ followed by hydrolysis, compounds **G** and **H** respectively, were obtained. Only **G** showed optical isomerism. Draw the structures of **A**, **B**, **C**, **D**, **E**, **F**, **G** and **H** in, the boxes given below. (It is **not** necessary to show stereoisomeric forms.)



(ii) Draw the structure of the product of the following reaction.



(*b*) Draw the structure of the **major** organic **product** in each of the following reactions.

(i) C_6H_6 $\xrightarrow[150\ °C]{H_2/\text{Raney Ni}}$

(ii) $C_6H_5-NH_2$ $\xrightarrow{Br_2\ \text{water}}$

(iii) CH_3CHO $\xrightarrow[(2)\ \text{dehydration}]{(1)\ \text{aqueous NaOH}}$

(iv) $C_5H_5-\overset{\oplus}{N_2}\overset{\ominus}{Cl}$ $\xrightarrow[\Delta]{H_3PO_2}$

(v) $C_2H_5CONH_2$ $\xrightarrow[\Delta]{\text{aqueous NaOH}}$

(vi) $CH_3CH=CH_2$ $\xrightarrow{\text{conc. } H_2SO_4}$

(vii) CH_3COCl $\xrightarrow{NH_3}$

(viii) $C_2H_5CO_2H$ $\xrightarrow{PCl_5}$

(ix) C_2H_5OH $\xrightarrow{H^+/KMnO_4}$

(x) $C_2H_5COCH_3$ $\xrightarrow{HCN}$

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අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2018 අගෝස්තු
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2018 ஓகஸ்ற்
General Certificate of Education (Adv. Level) Examination, August 2018
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 **15 marks**.)*

5. (*a*) Consider the following reactions.

$$M(CO_3)_2 \cdot nH_2O(s) \rightarrow M(CO_3)_2(s) + nH_2O(g)$$

$$M(CO_3)_2(s) \rightleftharpoons MO_2(s) + 2CO_2(g)$$

A small amount (0.10 mol) of $M(CO_3)_2 \cdot nH_2O(s)$ is present in an evacuated rigid container of volume 0.08314 m^3. The temperature of the container was raised to 400 K. The metal carbonate, $M(CO_3)_2$ does not decompose at this temperature but the crystalline water evaporates completely. The pressure of the container was measured to be 1.60×10^4 Pa. Volume occupied by the solids is negligible.

Determine the value of 'n' in the formula $M(CO_3)_2 \cdot nH_2O(s)$.

(2.0 *marks*)

(*b*) The temperature of the above system was then increased to 800 K. It was observed that some amount of the solid metal carbonate is decomposed and is in equilibrium with the gas phase. The pressure of the container was measured to be 4.20×10^4 Pa.

(i) Calculate the partial pressure of water vapour in the container at 800 K.

(ii) Calculate the partial pressure of CO_2 in the container at 800 K.

(iii) Write an expression for the pressure equilibrium constant, K_p for the decomposition of $M(CO_3)_2(s)$. Calculate K_p at 800 K.

(iv) Calculate the molar percentage of the metal carbonate decomposed at 800 K.

(v) Enthalpy change (ΔH) for the decomposition of the metal carbonate under the above conditions is 40.0 kJ mol^{-1}. Calculate the corresponding entropy change (ΔS).

(vi) Suggest **two** ways to drive the decomposition reaction of $M(CO_3)_2(s)$ in the forward direction.

(6.5 *marks*)

(*c*) With the aid of thermochemical cycles and the data given in the table, answer the following questions.

Species	Standard enthalpy of formation (ΔH_f°) (kJ mol^{-1})
M(s)	0.0
M(g)	800.0
$O_2(g)$	0.0
O(g)	249.2
$MO_2(g)$	– 400.0

(i) Given that $MO(g) + \frac{1}{2} O_2(g) \rightarrow MO_2(g)$ $\Delta H^\circ = -50.0$ kJ mol^{-1}, calculate the standard enthalpy of formation of MO(g).

(ii) Calculate M–O bond dissociation enthalpy in MO(g).

(iii) Calculate M–O bond dissociation enthalpy in $MO_2(g)$.

(iv) By means of a suitable calculation, predict whether the reaction, $MO_2(g) \rightarrow MO(g) + \frac{1}{2} O_2(g)$ is spontaneous under standard conditions and 2000 K. Standard entropy change of this reaction is 30.0 J K^{-1} mol^{-1}.

(6.5 *marks*)

6. (*a*) An experiment was carried out to determine the partition coefficient of iodine (I_2) between water (**A**) and an organic solvent (**B**) which form an immiscible liquid system.

20.00 cm^3 of **B** containing 'n' moles of I_2 is mixed with 20.00 cm^3 of **A** and allowed to reach equilibrium at room temperature.

The concentration of I_2 in phase **A** is determined by titrating a 5.00 cm^3 sample drawn from phase **A** with a 0.005 mol dm^{-3} solution of $Na_2S_2O_3$. The volume of $Na_2S_2O_3$ required to reach the end point was 22.00 cm^3. The concentration of I_2 in phase **B** was determined to be 0.040 mol dm^{-3}.

(i) Write the balanced chemical equation for the reaction between $Na_2S_2O_3$ and I_2.

(ii) Calculate the concentration of I_2 in phase **A**.

(iii) Calculate the value of the partition coefficient, K_D where $K_D = \frac{[I_2]_B}{[I_2]_A}$.

(iv) Calculate the total number of moles of I_2 in the two phases **A** and **B**.

(4.5 *marks*)

(*b*) The above experiment was repeated under the same conditions, that is, at the same temperature, using the same amount of I_2 and the same volumes, but with the addition of I^- ions to phase **A**. The system was then thoroughly shaken and allowed to reach equilibrium. The volume of 0.005 mol dm^{-3} $Na_2S_2O_3$ solution required to titrate the I_2 in a 5.00 cm^3 sample of phase **A** was 41.00 cm^3. The concentration of I_2 in phase **B** was then determined to be 0.030 mol dm^{-3}

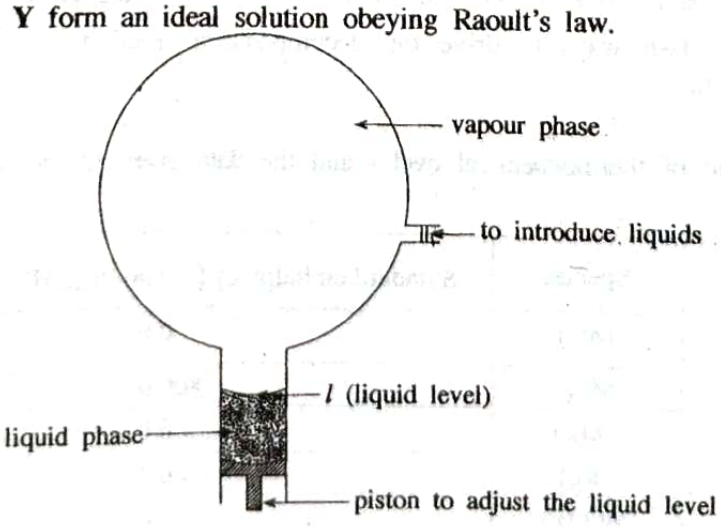
(i) Calculate the amount of I_2 (moles) expected in 5.00 cm^3 of phase **A**, based on the partition coefficient for the distribution of I_2 between the phases **A** and **B**.

(ii) Calculate the amount (moles) of I_2 reacted with $Na_2S_2O_3$ in the above titration.

(iii) Considering the different iodine species present in phase **A**, explain why the answers obtained in parts (*b*)(i) and (*b*)(ii) above are different.

(3.5 *marks*)

(*c*) Liquids **X** and **Y** form an ideal solution obeying Raoult's law.



Initially only liquid **X** was introduced in to an evacuated rigid container as shown in the figure.

Maintaining the liquid level at l, the system was allowed to reach equilibrium at 400 K. The pressure of the container was measured to be 3.00×10^4 Pa. The volume of the vapour phase when the liquid level is at l was 4.157 dm^3. Then liquid **Y** was introduced in to the container, mixed with liquid **X** and the system was allowed to reach equilibrium at 400 K. The liquid level was maintained at l. The molar ratio of **X** : **Y** in the liquid phase was found to be 1 : 3. The pressure of the container was measured to be 5.00×10^4 Pa.

(i) What is the saturated vapour pressure of **X** at 400 K?

(ii) Calculate the mole fractions of **X** and **Y** in the liquid phase at equilibrium.

(iii) Calculate the partial pressure of **X** at equilibrium after the addition of **Y**.

(iv) Calculate the partial pressure of **Y** at equilibrium.

(v) Calculate the saturated vapour pressure of **Y**.

(vi) Calculate the amounts (in moles) of **X** and **Y** in the vapour phase.

(vii) When a mixture of the liquids **X** and **Y** is subjected to fractional distillation, state which compound would distill out first from the fractional distillation column. Give reason/s for your answer.

(7.0 marks)

7. (*a*) Using only the chemicals given in the list, show how you would carry out the following conversion.

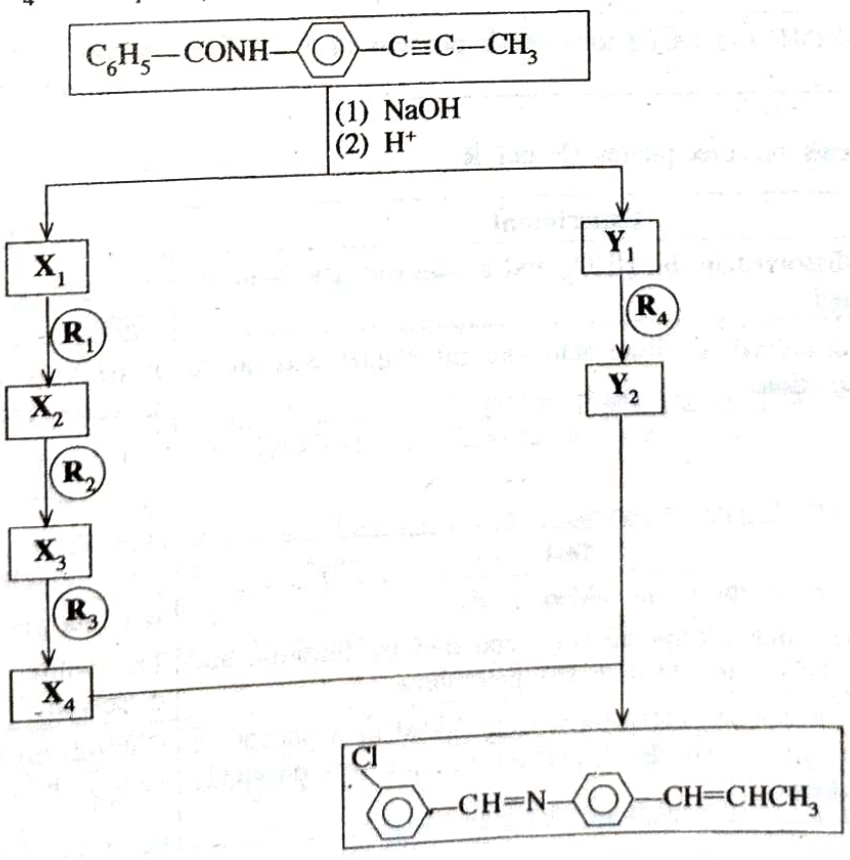
$$C_2H_5CH_2CHO \longrightarrow C_2H_5COCH_3$$

List of chemicals
aqueous NaOH, HBr, alcoholic KOH, $NaBH_4$, $H^+/KMnO_4$

Your conversion should not exceed 7 steps.

(6.0 marks)

(*b*) Identify $\mathbf{R_1}$—$\mathbf{R_4}$ and $\mathbf{X_1}$—$\mathbf{X_4}$ and $\mathbf{Y_1}$, $\mathbf{Y_2}$ in order to complete the following reaction scheme.



(6.0 marks)

(c) (i) Give the mechanism of the following reaction.

$$C_2H_5OH + HBr \longrightarrow C_2H_5Br + H_2O$$

(ii) State whether the above reaction is a nucleophilic substitution reaction or an electrophilic substitution reaction. Identify the nucleophile or electrophile as appropriate.

(iii) State giving reasons which of the two compounds, phenol (C_6H_5OH) or ethanol (C_2H_5OH) is more acidic.

(3.0 *marks*)

PART C — ESSAY

*Answer **two** questions only. (Each question carries **15 marks**.)*

8. (a) An aqueous solution **P** contains **two** cations and **two** anions. The following experiments were carried out to identify these cations and anions.

Cations

	Experiment	Observation
①	**P** was acidified with dilute HCl and H_2S was bubbled through the solution.	A clear solution was obtained.
②	The above solution was boiled till all the H_2S was removed. A few drops of conc. HNO_3 were added and the solution was heated further. The resulting solution was cooled and NH_4Cl/NH_4OH was added.	A brown precipitate (**Q**) was formed.
③	**Q** was removed by filtration and H_2S was bubbled through the filtrate.	A pale pink precipitate (**R**) was formed.
④	**R** was removed by filtration and the filtrate was boiled till all the H_2S was removed. $(NH_4)_2CO_3$ was added to the solution.	A clear solution was obtained.
⑤	Dilute NaOH was added to a **fresh portion** of **P**.	A dirty-green precipitate and a while precipitate were formed.

Experiments for precipitates **Q** and **R**:

	Experiment	Observation
⑥	**Q** was dissolved in dil. HNO_3 and a salicylic acid solution was added.	A light purple solution was obtained.
⑦	**R** was dissolved in dilute acid and dil. NaOH was added to the solution.	A white precipitate was formed. It turned brown on standing.

Anions

		Test	Observation
⑧	I.	$BaCl_2$ solution was added to **P**.	A white precipitate was formed.
	II.	The white precipitate was separated by filtration and dil. HCl was added to the precipitate.	The white precipitate was not dissolved.
⑨		Cl_2 water and chloroform were added to a portion of the filtrate from ⑧ II, and the mixture was throughly shaken.	Chloroform layer turned yellowish-brown.

(i) Identify the **two** cations and the **two** anions in solution **P**. (Reasons are **not** required.)

(ii) Write the chemical formulae of the precipitates **Q** and **R**.

(iii) Give reasons for the following:

I. Removal of H_2S in experiment ② for cations.

II. Heating with conc. HNO_3 in experiment ② for cations.

(7.5 *marks*)

(*b*) The sample **X** contains lead, copper and an inert material. The following procedure was carried out to analyse lead and copper in **X**.

Procedure:

A mass of 0.285 g of **X** was dissolved in a slight excess of dil. HNO_3. A clear solution was obtained. A NaCl solution was added to the resulting clear solution. A white precipitate (**Y**) was formed. The precipitate was separated by filtration and the precipitate (**Y**) and filtrate (**Z**) were analysed separately.

Precipitate (Y)

The precipitate was dissolved in hot water. A solution of K_2CrO_4 was added in excess. A yellow precipitate was formed. The precipitate was separated by filtration and dissolved in dil. HNO_3. An orange coloured solution was obtained. Excess KI was added to this solution and the liberated I_2 was titrated with 0.100 mol dm^{-3} $Na_2S_2O_3$, with starch as the indicator. The volume of $Na_2S_2O_3$ required to reach the end point was 27.00 cm^3.

(Assume that the NO_3^- ions do **not** interfere with the titration.)

Filtrate (Z)

The filtrate was neutralized and excess KI was added to it. The liberated I_2 was titrated with 0.100 mol dm^{-3} $Na_2S_2O_3$, with starch as the indicator. The volume of $Na_2S_2O_3$ required to reach the end point was 15.00 cm^3.

(**Note**: Assume that the inert material was soluble in dil. HNO_3 and did **not** interfere with the experiment.)

(i) Calculate the mass percentages of lead and copper in **X**. Write balanced chemical equations where relevant.

(ii) What is the colour change at the end point in the titration carried out in the analysis of precipitate **Y**?

(Cu = 63.5, Pb = 207)

(7.5 *marks*)

9. (*a*) The following questions are based on the environment and related issues.

(i) Identify **three** greenhouse gases that contribute to global warming. State **two** consequences of global warming.

(ii) Global environmental issues caused by coal power plants are well known. Identify **one** such issue that contributes **significantly** to change in certain water quality parameters in rivers and lakes.

(iii) Name the chemical species responsible for the environmental issue identified in (ii) above and state **three** water quality parameters that are likely to be affected by this issue.

(iv) Identify **two** environmental issues that change (increase or decrease) the ozone level in the atmosphere and explain briefly how these changes take place with the aid of balanced chemical equations.

(v) I. "Most of the harmful gases in vehicle exhausts are converted to relatively harmless gases by catalytic converters." Briefly explain this statement.

II. Name the harmful gas (except CO_2) that is not converted to a less harmful gas by the catalytic converter. State briefly how this harmful gas is formed in the vehicle engine.

(7.5 *marks*)

(*b*) The flow chart given below shows the production of two important compounds P_1 and P_2 and three other important compounds P_3, P_4 and P_5 derived from them. P_1 is used as a raw material in the manufacture of Na_2CO_3. P_3 can be manufactured by the reaction between P_1 and P_2. P_3 is used as a fertilizer and as an explosive. P_1 is also used in the manufacture of P_4 which is a widely used fertilizer. P_4 is used to synthesize an important thermosetting polymer P_5.

M — Manufacturing process

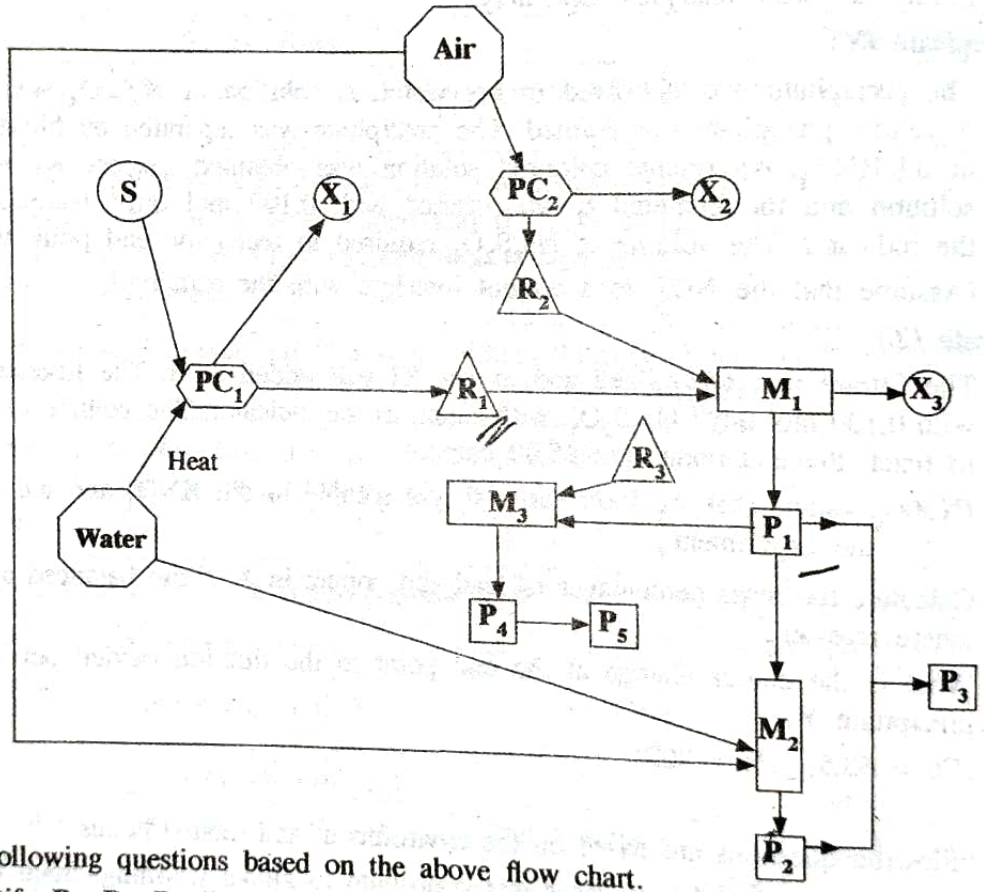
PC — Physical/chemical process to obtain raw material

R — Raw material

P — Product

S — Source of raw material

X — Unreacted raw material(s) / substance discharged to the atmosphere during physical and/or chemical process



Answer the following questions based on the above flow chart.

(i) Identify P_1, P_2, P_3, P_4 and P_5

(ii) Identify R_1, R_2 and R_3

(iii) Identify X_1, X_2 and X_3

(iv) Identify S.

(v) Briefly state the processes taking place in PC_1 and PC_2 giving balanced chemical equations where applicable.

(vi) Identify manufacturing processes M_1, M_2 and M_3. (e.g. contact process or manufacture of H_2SO_4.)

(vii) Give balanced chemical equations with appropriate conditions, for reactions taking place in M_1, M_2 and M_3.

(viii) I. Give one use of each compound P_1 and P_2 other than those mentioned above.

II. Give one use of R_1 in the manufacturing process P_1 other than being used as a raw material.

(7.5 marks)

10. (a) **A** and **B** are **complex ions**, (i.e. metal ion and ligands coordinated to it) with an octahedral geometry. They have the same atomic composition of $MnC_5H_3N_6$. In each complex ion, **two** types of ligands are coordinated to the metal ion. When an aqueous solution containing **A** is treated with a potassium salt, the **coordination compound C** is formed. **C** gives four ions in aqueous solution. When an aqueous solution containing **B** is treated with a potassium salt the **coordination compound D** is formed. **D** gives three ions in aqueous solution. Both **C** and **D** have an octahedral geometry.

(**Note**: The oxidation states of manganese in **A** and **B** do not change on treatment with the potassium salt).

(i) Identify the ligands coordinated to manganese in **A** and **B**.

(ii) Give the structures of **A**, **B**, **C** and **D**.

(iii) Write the electronic configurations of the manganese ions in **A** and **B**.

(iv) Write the IUPAC names of **C** and **D**.

(7.5 marks)

(b) (i) I. Write the reduction half reaction corresponding to the electrode, $Ag(s)\,|\,AgCl(s)\,|\,Cl^-(aq)$.

II. State whether the electrode potential of $Ag(s)\,|\,AgCl(s)\,|\,Cl^-(aq)$ depends on the Ag^+ concentration in the solution. Explain your answer.

(ii) Consider the following reaction.

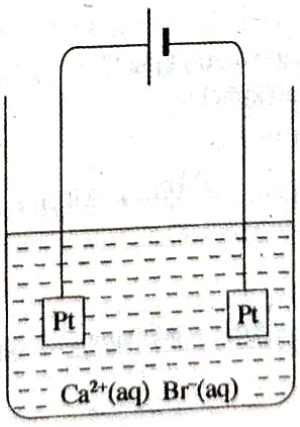
$$Fe(s) + 2H^+(aq) + \frac{1}{2}O_2(g) \longrightarrow Fe^{2+}(aq) + H_2O(l)$$

I. Write the oxidation and reduction half reactions relevant to the above reaction.

II. Given that the above reaction is the cell reaction of an electrochemical cell, determine the standard electromotive force of the cell.

$$E^\circ_{Fe^{2+}(aq)/Fe(s)} = -0.44\ V \qquad E^\circ_{H^+(aq)/O_2(g)/H_2O(l)} = 1.23\ V$$

(iii) A constant current of 100 mA was passed through 100.00 cm^3 of a 0.10 mol dm^{-3} aqueous $CaBr_2$ solution as shown in the diagram. The temperature of the system was maintained at 25 °C.



I. Write the oxidation and reduction reactions that take place at the electrodes.

II. Calculate the time taken for the commencement of precipitation of $Ca(OH)_2(s)$. Solubility product of $Ca(OH)_2$ at 25 °C is 1.0×10^{-5} $mol^3\ dm^{-9}$. Neglect the ionization of water. Assume that the volume of the aqueous phase remains constant.

(7.5 marks)

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