

Second Term Evaluation - 2025

Grade

13

Subject

Chemistry II

Time

03 hours

Name

Part A - Structured Essay

★ Answer all the questions.

★ Universal gas constant $R = 8.314 \text{ J K}^{-1}\text{mol}^{-1}$ ★ Plank's constant $h = 6.626 \times 10^{-34} \text{ J s}$ ★ Avogadro constant $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$ ★ Velocity of light $C = 3 \times 10^8 \text{ ms}^{-1}$

(01) (a) Select the suitable answer from the species given within brackets.

(i) Element with the lowest value for first ionization energy

(C , N , O)

(ii) Molecule with a tetrahedral shape

(SF_4 , XeO_2F_2 , POCl_3)

(iii) Species with the highest boiling point

(CH_3OH , H_2O_2 , H_2O)

(iv) Ionic compound with the highest melting point.

(NaCl , BaF_2 , MgBr_2)

(v) The green colour aqueous solution

($[\text{Ni}(\text{NH}_3)_6]^{2+}$, $[\text{CuCl}_4]^{2-}$, $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]^+$)

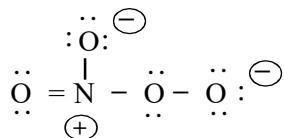
(vi) Species with the most electronegative central N atom.

(NO_3^- , N_2H_2 , HCN)(b) (i) Draw the most stable Lewis structure for SF_3OCl molecule.

(ii) Mention the oxidation number and the shape of the central atom of the above molecule.

Oxidation number shape

- (iii) Most stable Lewis structure of NO_4^- ion is given below. Draw three other resonance structures for this molecule and label them as "stable", "unstable" or "less stable"

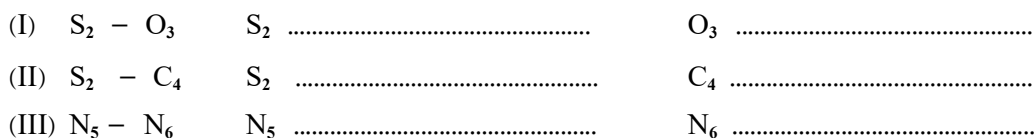


- (iv) Complete the table based on the Lewis structure and the atomic skeleton of it given below.

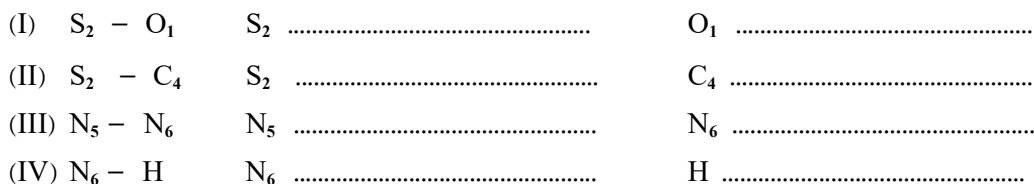


		O_1	S_2	C_4	N_5	N_6
1	Number of VSEPR pairs around the atom.					
2	Electron pair geometry around the atom					
3	Bond angle around the atom					
4	Oxidation number of the atom					
5	Hybridization of the atom					

- (v) Identify atomic / hybrid orbitals that form the pi (π) bond between the two atoms given below.



- (vi) Identify atomic / hybrid orbitals that form the sigma (σ) bond between the two atoms given below.

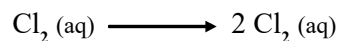


- (vii) Arrange the atoms given below that belong to the above structure, in the ascending order of the electronegativity $\text{S}_2 / \text{O}_3 / \text{C}_4 / \text{N}_5 / \text{N}_6$

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(c) Do the following calculations.

- (i) If Cl – Cl bond energy of $\text{Cl}_2(\text{aq})$ is 240 kJ mol^{-1} , what is the minimum frequency required to break as below ?



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- (ii) What is the De Broglie wave length of an electron that travels at a speed of $1 \times 10^5 \text{ m s}^{-1}$?

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(02) (a) In the p block of the periodic table, four elements that belongs to two short periods are symbolized as **A, B, C, D**. **A** and **B**, **C** and **D** are consecutive elements.

The oxides of **A, B, C, D** formed with the highest oxidation number are **E, F, G, H**.

Hydrides of **A, B, C, D** are **I, J, K, L**. When **E, F, G, H** are dissolved in water **M, N, O, P** are formed.

A and **C** are solid elements and **B** and **D** are gaseous elements when oxidation numbers of **A** are considered it has equal numbers of oxidation states above and below zero (0).

- (i) Identify **A, B, C, D** elements

A **C**

B **D**

- (ii) Write balanced equations for reactions of producing **M, N, O, P** by dissolving **E, F, G, H** in water.

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(iii) Plot the graph of boiling points of I, J, K, L against their mass number.

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(iv) Sodium (Na^+) salt solutions of oxoanions of M, N, O, P are found in four test tubes. Explain an experimental procedure to distinguish the above solutions.

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(b) A solution includes SO_4^{2-} and CO_3^{2-} anions. In order to find the ion concentrations, 100.00 cm^3 of the initial solution was decanted and excess $\text{BaCl}_2 (\text{aq})$ was added. The formed precipitate was filtered washed with water and dried and mass was measured as 8.60 g. The above precipitate was taken in to a beaker, dissolved using dilute HNO_3 . Then the obtained gas volume under S.T.P. was $V_1 \text{ cm}^3$. Remaining solid residue was filtered, dried to obtain a mass of 4.66 g.

(i) Write all the balanced equations for the above reactions.

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(ii) Calculate CO_3^{2-} and SO_4^{2-} ion concentrations of the solutions.

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(iii) What is the V_1 volume under S.T.P. ?

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(iv) Is it possible to follow the above procedure to find out ion concentrations in a solution that includes PO_4^{3-} and SO_3^{2-} ion ? Explain your answer.

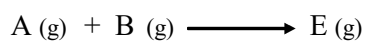
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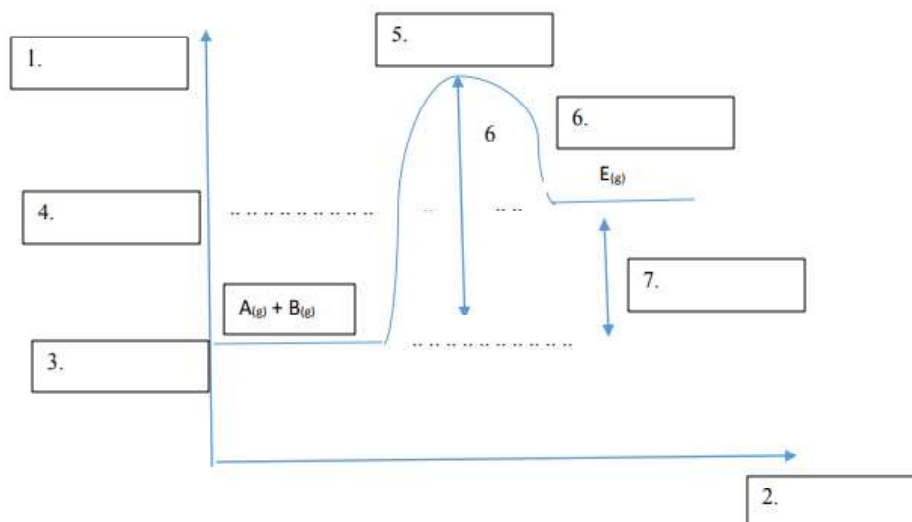
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(03) (a) Energy profile of the reaction,

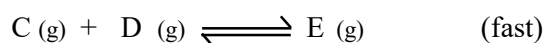
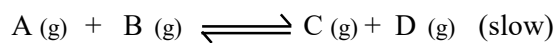


is given below.



(i) Identify species 1 - 7 .

(ii) When A (g) and B (g) are reacted in the presence of Zn (g) , E is given through a 2 step process.

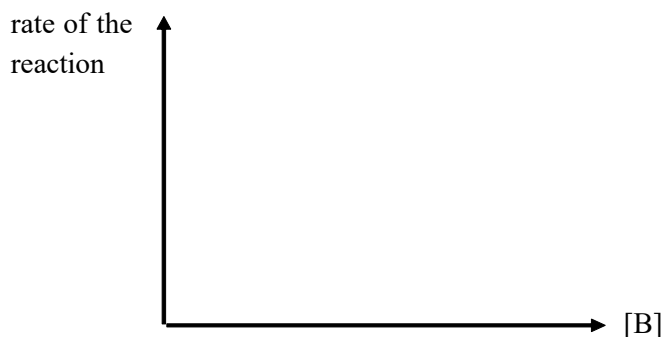


(I) Sketch this energy variation on the above plot itself.

(II) Mention the rate equation for the reaction in the presence of Zn (rate constant = K)

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- (iii) With Zn keeping concentration of the reactant A (g) at a constant high value , concentration of B (g) is increased gradually , to study the rate of the reaction. Plot the above reaction on the following graph.



- (iv) In the above reaction of A and B under Zn (s) catalyst, A and B were mixed and allowed to react. Plot the variation in the concentration of B reactant with time.



- (b) Without Zn (s) catalyst , A (g) and B (g) were mixed in different pressure values and the total pressure was studied. Then the total pressure in 40 seconds was as follow.

Experiment number	Initial pressure of A (g) (Nm ⁻²)	Initial pressure of B (g) (Nm ⁻²)	Total pressure of the system after 40 s (Nm ⁻²)	Rate of pressure change (Nm ⁻² s ⁻¹)
1.	1 x 10 ⁵	1 x 10 ⁵	1.8 x 10 ⁵	
2.	2 x 10 ⁵	1 x 10 ⁵	2.6 x 10 ⁵	
3.	2 x 10 ⁵	2 x 10 ⁵	3.6 x 10 ⁵	

- (i) Calculate the rate of pressure change in each state of the system and complete the table.

- (ii) In the above reaction, calculate the order of the reaction with respect to A (g) and B (g). Write an expression for the reaction rate using those values.

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- (iii) Mention whether the order of the reaction is changed or not in the presence of the catalyst. Briefly explain your answer.

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- (04) (a) Organic compound A is weakly basic. 1.86 g of A was dissolved in 100.00 cm³ of water and 25.00 cm³ of that was taken to the titration flask and titrated with 0.1 mol dm⁻³ HCl in the presence of methylorange as the indicator. Burette reading was 50.00 cm³. (stoichiometry of A : HCl is 1 : 1 in the reaction)

- (i) Calculate the molecular mass of A.

- (ii) A is converted to B in the presence of HNO₂ and N₂(g) is liberated. Both A and B form a white precipitate with Br₂(l). Identify the structures of A and B.

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(b) (i) Identify the structure simplest optically active alcohol.

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(ii) Write the IUPAC name of that compound.

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(iii) Identify the compound C that is formed when the above alcohol is dehydrated using conc. H_2SO_4 .

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(iv) Mention the type of isomerism depicted by C and identify the 2 forms of isomers.

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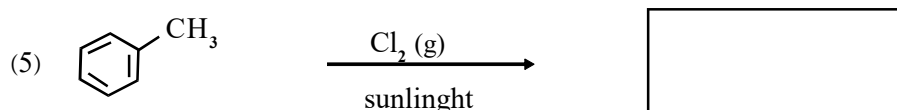
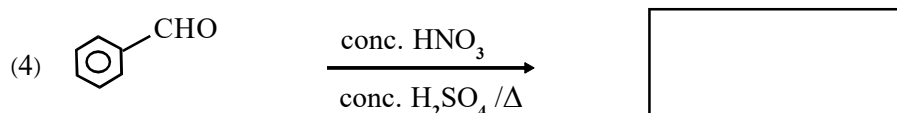
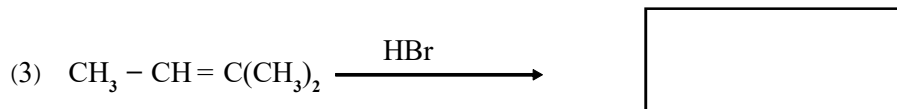
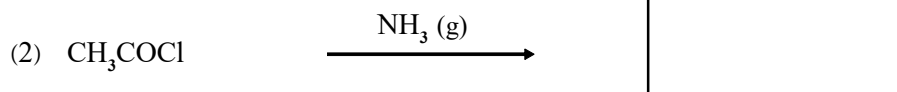
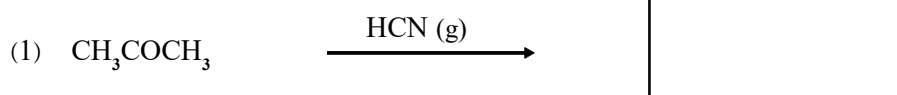
(v) Identify more polar form.

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(vi) Are boiling points of the two isomer forms equal?

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(c) (i) Identify the product species formed in the following reactions.



(ii) Sketch the mechanism of the reaction 4 above.

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Part B - Essay

★ Answer only two questions.

- (05) (a) To a glass bulb with 10 dm^3 volume, A(g) was inserted at 27°C until pressure becomes $1 \times 10^5 \text{ Nm}^{-2}$. When the above system was allowed to reach equilibrium, after three hours pressure values were constant as $6 \times 10^4 \text{ Nm}^{-2}$ for A(g), $2 \times 10^4 \text{ Nm}^{-2}$ for B(g) and $6 \times 10^4 \text{ Nm}^{-2}$ for C(g) in the system.
- After one hour, A(g) gas was inserted again to the system until the new partial pressure of A(g) became $1.6 \times 10^5 \text{ Nm}^{-2}$. Then the total pressure of the system became constant again after one hour.
- Identify the balance equation for the equilibrium among A(g), B(g) and C(g).
 - Find the equilibrium constant (K_p) for that equilibrium.
 - Calculate K_c value using K_p calculated above.
 - Calculate the reaction quotient (Q_c) at the moment when A(g) was inserted again to the system.
 - Deduce the partial pressure of A(g), B(g) and C(g) in the final equilibrium of the system.
 - Illustrate graphically, the variation of total pressure in the system for a period of 6 hours.
- (b) $\text{CH}_3\text{-NH}_2$ distributes similarly in both water and $\text{C}_6\text{H}_6(l)$. In order to obtain the distribution coefficient for the above distribution, 500 cm^3 of 0.1 mol dm^{-3} CH_3NH_2 aqueous solution was allowed to reach equilibrium with 100 cm^3 of $\text{C}_6\text{H}_6(l)$ and 25.00 cm^3 of the organic layer was separated and titrated with 0.5 mol dm^{-3} HCl and the consumed volume was 20.00 cm^3 . Determined distribution coefficient of CH_3NH_2 in water and $\text{C}_6\text{H}_6(l)$.
- (c) In a study to determine the suitable mixtures for liquid petroleum cylinders, following mixture were used. Consider that these gases exist as liquids due to high pressure inside cylinders.
- Cylinder 1 : propane (l) 100 mol + butane (l) 100 mol
 Cylinder 2 : propane (l) 150 mol + butane (l) 50 mol
 At 27°C
- $$P^0_{\text{propane}} = 6 \times 10^5 \text{ Nm}^{-2} \quad \Delta H^0_{\text{C}} \text{ propane} = -2200 \text{ kJ mol}^{-1}$$
- At 27°C
- $$P^0_{\text{butane}} = 4 \times 10^5 \text{ Nm}^{-2} \quad \Delta H^0_{\text{C}} \text{ butane} = -2800 \text{ kJ mol}^{-1}$$
- What are the masses of L.P. gases available in the cylinders?
 - Find out the thermal energies that can be obtained from the cylinders separately.
 - What are the total pressures built inside the cylinders initially?
 - Which of the two cylinders is more advantageous to the consumer?
 - If the cylinder are made in a manner that the maximum pressure to be held is 6 atm , which cylinder is safer to use?

- (06) (a) At 27 °C, a solution includes $\text{Al}^{3+}(\text{aq})$ and $\text{Ag}^+(\text{aq})$ each in 0.01 mol dm^{-3} concentration. 500 cm^3 of that solution was separated and a PO_4^{3-} solution with a high concentration was added slowly.

$$K_{\text{sp}} \text{ AlPO}_4(\text{s}) = 1 \times 10^{-20} \text{ mol}^2 \text{ dm}^{-6}$$

$$K_{\text{sp}} \text{ Ag}_3\text{PO}_4(\text{s}) = 1 \times 10^{-12} \text{ mol}^4 \text{ dm}^{-12}$$

- Identify the compound which precipitate first, as PO_4^{3-} is added if the volume change is ignored
 - Calculate concentrations of each ion when the compound precipitated secondly starts to precipitate.
 - If 0.02 mol of PO_4^{3-} ions are added to the solution, calculate the mass of the precipitate deposited at the bottom of the solution and the concentration of each ion available in the solution. ($\text{Al} = 27$, $\text{C} = 32$, $\text{Ag} = 108$, $\text{O} = 16$)
- (b) $\text{C}_2\text{H}_5\text{COOH}$ dissolved in water and behaves as a weak acid.
- $$K_{\text{a}} (\text{C}_2\text{H}_5\text{COOH}(\text{aq})) = 1.2 \times 10^{-5} \text{ mol dm}^{-3}$$
- At 25 °C, calculate the pH of 0.1 mol dm^{-3} propanoic acid solution.
 - For 25.00 cm^3 volume of that solution, 0.1 mol dm^{-3} NaOH is added. Calculate the pH value in following situations.
 - When 12.5 cm^3 of NaOH is added
 - When 25.0 cm^3 of NaOH is added
 - Out of the two situations mentioned in (ii) above, under which situation does the solution show behaviour of a buffer? Explain that buffer action.
 - Sketch roughly the variation of pOH in the solution of the titration flask as 50.00 cm^3 of NaOH (aq) is added to the solution as in (ii) above.

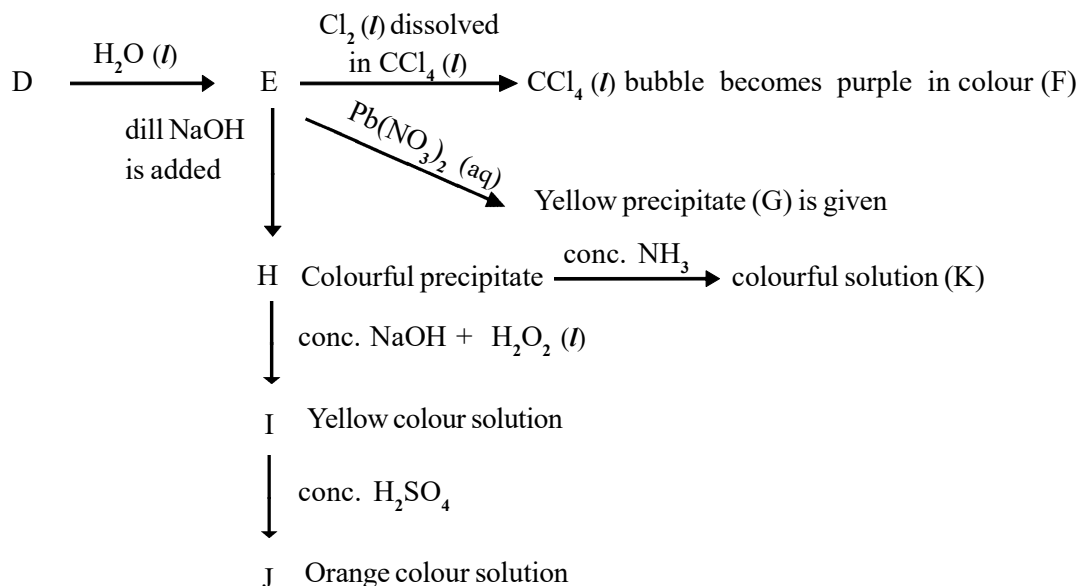
- (07) (a) A, B and C are three compounds with the molecular formula $\text{FeCl}_2\text{BrH}_8\text{O}_4$.

Fe has the same oxidation number in all three compounds. Further they are all octahedral. In order to distinguish A, B and C, three aqueous solutions were treated with AgNO_3 separately and the observations are given below.

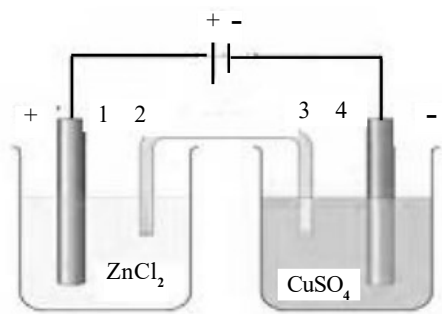
Compound	Observation when $\text{AgNO}_3(\text{aq})$ is added
A	a pale yellow precipitate is formed
B	a white precipitate is formed
C	a pale yellow precipitate is formed

- Identify A, B, C coordination spheres and write the molecular formulae.
- Write the IUPAC names of A and B.
- If A and C can be called as "cis" and "trans" based on the distribution in the space, sketch A, B, C illustrating the distribution of ligands in the space. Sketch A, B, C illustrating the distribution of ligands in the space.

- (b) Metallic salt D is converted to E in the aqueous solution. An analytical flow chart for E is given below.



- Identify the metal salt D.
 - Identify E, G, H
 - Identify I and J ions.
 - Identify E and K coordination complexes.
- (c) $ZnCl_2(aq)$ solution and $CuSO_4(aq)$ a solution were connected serially to an external potential. Rough sketch of that arrangement is given below.



Current of 1 A was supplied for a period of 8 minutes to these two solutions.

- What is amount of charge passed across the solutions ?
- What is the number of moles of electrons that passed through the solutions ?
- Identify 1, 2, 3, 4 as cathodes and anodes.
- Name two chemical species that can be used as anode and cathode in this situation.
- Identify the reactions at the cathode and the anode of each solution.
- What is the mass of metal deposited and the volume of gas liberated at the end of the electrolysis process ?
 (At 127 °C $V_m = 25.0 \text{ dm}^3 \text{ mol}^{-1}$) (Zn = 60, Cu = 63.5)


★ Answer two questions only.

$$\text{CH}_3\text{COOC}_3\text{H}_7 \xrightarrow[\text{(ii) H}_2\text{O (l)}]{\text{(i) (M)}} \text{A} \xrightarrow{\text{(N)}} \text{CH}_3-\overset{\text{O}}{\overset{\parallel}{\text{C}}}-\text{CH}_3$$

$$\text{A} + \text{B} \xrightarrow{\text{(O)}} \text{C} \xrightarrow{\text{(P)}} \text{D}$$

$$\text{D} \xrightarrow[\text{(ii) H}_2\text{O (l)}]{\text{(i) (Q)}} \text{E}$$

(i) A, B, C, D and E species and
(ii) M, N, O, P reagents.

(i)  Nc1ccccc1 \longrightarrow BrC1C(Br)C(Br)C=C(N)C1 (in less than 4 steps)

(ii) $\text{CH}_3 - \text{CH}_2 - \text{OH} \longrightarrow \text{OH} - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{OH}$
(in less than 6 steps)

(c) (i) In the reaction between $\text{CH}_3-\text{CH}=\text{C}(\text{CH}_3)_2$ and HBr , identify the major product.
(ii) Write the mechanism relevant for obtaining that product.
(iii) Briefly explain how it becomes the major product.

(09) In a solution, four metal cations are found connected to a single anion. Analytical process of that solution is given below.

Experiment number	Experiment	observations
1	Dil. HCl is added to a portion of that solution	White precipitate is obtained
2	Precipitate is filtered, decanted to a boiling tube, water is added and boiled	Part of the above precipitate dissolved
3	System in number 2 above is cooled	The total amount of the precipitate is regained
4	Dil. NH_3 is added to the system in number 3 above	Part of the precipitate dissolved
5	Filtrate in the system in number 1 above is bubbled with $\text{H}_2\text{S}(\text{g})$	No visible observation
6	Solution in number 5 is boiled, HNO_3 is added, heated again, NH_4Cl and NH_4OH is added	No visible observation
7	$\text{H}_2\text{S}(\text{g})$ is bubbled through the final solution	Black colour precipitate is obtained
8	The above precipitate is separated and conc. HCl is added to it	A blue solution is formed liberating a colourless gas
9	To the filtrate in number 7 above, Na_2CO_3 is added	No clear observation
10	8-hydroxyquinoline is added to the final solution	Turned to green-yellow colour
11	A portion of the initial solution is taken and heated with $\text{Cu}(\text{s})$ and conc H_2SO_4	Solution turns to pale blue and a brown colour gas is liberated
12	The evolved gas is bubbled through water	A colourless solution is obtained

- Identify the four cations and the anion in the solution (Not necessary to explain the reasons)
 - Mention the colour of the initial solution
 - Write the balanced chemical equation for the reaction in experiment number 11.
 - Write the balanced chemical equation for the reaction in experiment number 12.
- (b) A solid mixture includes Zn, Al and inert impurities. In order to obtain percentage masses of Zn and Al, 4.00 g of the mixture was finely powdered, $\text{H}_2\text{S}(\text{g})$ is sent over the powder for a long duration. Final residue obtained had a mass of 7.20 g. Then the solid was put into a tightly closed container and reacted in the presence of $\text{HCl}(\text{aq})$ and allowed the liberated gas to be removed. Solution was filtered and the mass of the impurity is measured and found to be 0.52 g.
- Write balanced chemical equation for all the reactions.
 - What is the percentage masses of Zn and Al in the solid mixture?
- (Zn= 60, Al=27)

(10) (a) 1. Name the elements of the third period downward on your answer script (one below the other)

2. Write their maximum oxidation number in front of them.

3. In front of them, write the hydride formed with the maximum oxidation number of the element.

4. In front of them, mention the nature of the hydride using only one or two suitable words from the terms: strongly acidic/strongly basic/ weakly acidic/ weakly basic

5. Clarify how the hydride is named as acidic or basic based on the electronegativity considering the strongly acidic and strongly basic hydroxides.

(b) CuS and FeSO₃ are included in a natural metal ore. In order to get mass percentages of CuS and

FeSO₃ in the solid mixture 10.00 g of the sample was reacted with 0.1 mol of strongly acidic KMnO₄.

Cu²⁺, Fe³⁺, SO₄²⁻, Mn²⁺ and MnO₄⁻ ions were included in the final solution obtained above.

Then the final volume of that solution was made to 100.00 cm³ and 25.0 cm³ of it was taken and the remaining MnO₄⁻ was titrated with 1 mol dm⁻³ H₂O₂. The consumed volume was 13.75 cm³.

Solution resulting from the titration was treated with excess KI and then the solution was titrated with 1 mol dm⁻³ Na₂SO₃ using starch as the indicator. The burette reading was 20.0 cm³ by then.

i. Write the balanced chemical equation for the reaction between CuS, FeSO₃ and acidic KMnO₄.

ii. Write the balanced chemical equation for the reaction between MnO₄⁻ and H₂O₂.

iii. Write the balanced chemical equation for the reaction of Cu²⁺ and Fe³⁺ with I⁻.

iv. Calculate the mass percentages of CuS and FeSO₃ in the initial solid mixture.

Periodic Table

Periodic Table																	
1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
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
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
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
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