

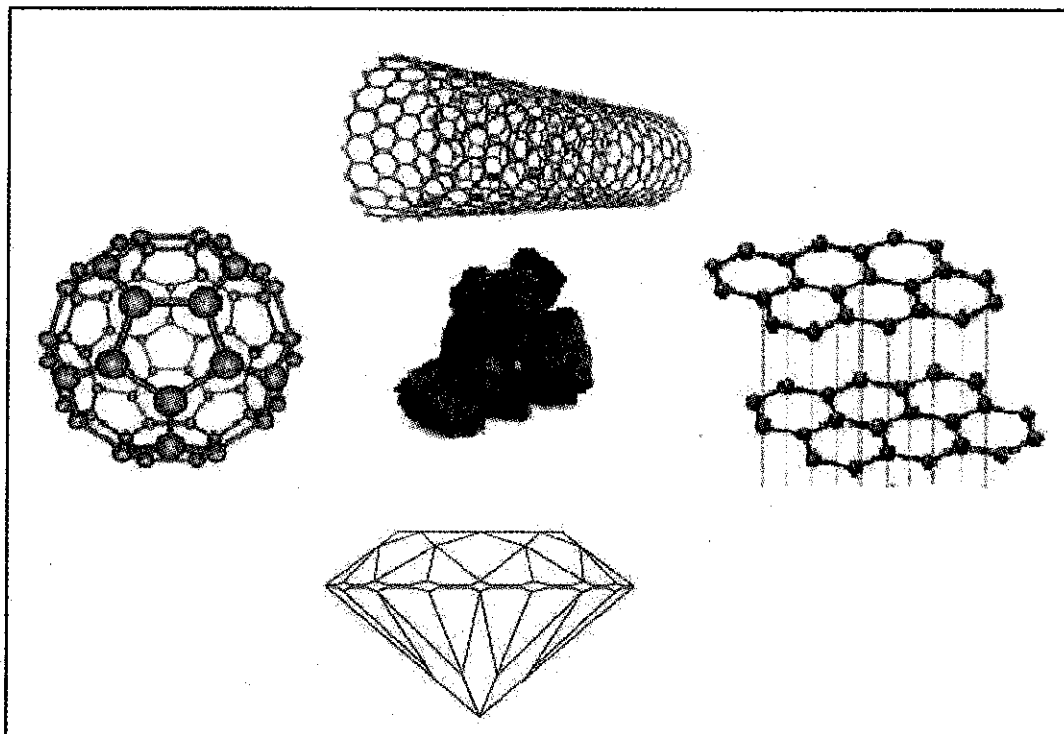


Department of Examinations – Sri Lanka

G.C.E. (A/L) Examination – 2026

02 – Chemistry

Marking Scheme



This has been prepared for the use of marking examiners. Some changes would be made according to the views presented at the Chief Examiners' meeting.

Amendments to be included

ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව

Department of Examinations – Sri Lanka
අ.පො.ස. (උ.පෙළ) විභාගය/ G.C.E. (A/L) - 2026

විෂය අංකය
Subject No

02

විෂය
Subject

Chemistry

ලකුණු දීමේ පටිපාටිය/ Marking Scheme
I පත්‍රය/ Paper I

ප්‍රශ්න අංකය Question No.	පිළිතුරු අංකය Answer No.	ප්‍රශ්න අංකය Question No.	පිළිතුරු අංකය Answer No.	ප්‍රශ්න අංකය Question No.	පිළිතුරු අංකය Answer No.	ප්‍රශ්න අංකය Question No.	පිළිතුරු අංකය Answer No.	ප්‍රශ්න අංකය Question No.	පිළිතුරු අංකය Answer No.
01.	4	11.	3	21.	4	31.	4	41.	1/3/4/5
02.	3	12.	4	22.	2	32.	4	42.	3
03.	5	13.	3	23.	3	33.	3	43.	2
04.	2	14.	2	24.	1	34.	1	44.	1
05.	5	15.	4	25.	3	35.	5	45.	2
06.	2	16.	3	26.	2	36.	5	46.	4
07.	2	17.	3	27.	4	37.	5	47.	1
08.	1	18.	1	28.	5	38.	5	48.	5
09.	3	19.	4	29.	5	39.	2	49.	1
10.	5	20.	2	30.	2	40.	5	50.	1

විශේෂ උපදෙස්/Special Instructions:

එක් පිළිතුරකට ලකුණු 01 බැගින්/ 01 Mark for each question

මුළු ලකුණු/Total Marks 01 × 50 = 50

G. C. E. (A/L) 2026 Chemistry – Paper II – Marks Distribution

1	(a)			(b)			(c)			(d)							
	(i) – (vii)			(i)	(ii)	(i)		(ii)	I	II	III						
	04 × 8 = 32			07	07 + 07	02×8 = 16		02×8 = 16	05	05	05						
	32			21			32			15							
2	(a)						(b)						(c)		(d)		
	(i)	(ii)			(iii)			(i)		(ii)	(iii)		(i)	(ii)		(i)	(ii)
		I	II	III	I	II	III	I	II		I	II		I	II		
	12	04	08	14	04	08	04	04	09	04	04	03	08	03	03	04	04
	54						24						14		08		
3	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)									
	21	09	26	18	06	10	04	06									
	100																
4	(a)			(b)			(c)										
	(i)	(ii)	(iii)	(i) - (iv)			(i)	(ii)									
	10	10	35	03 × 8 = 24			05	16									
	55			24			21										
5	(a)								(b)								
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(i)	(ii)	(iii)						
	12	12	20	4	12	24	08	28	03	17	10						
	120								30								
6	(a)				(b)			(c)									
	(i)	(ii)	(iii)	(iv)	(i)		(ii)	(i)	(ii)								
	30	12	33	15	20		10	03	27								
	90				30			30									
7	(a)					(b)					(c)						
	(i)	(ii)	(iii)	(iv)	(v)	(i)	(ii)			(iii)	(i)	(ii)	(iii)				
							I	II	III								
	18	18	09	24	06	23	10	05	05	04	19	05	04				
	75					47					28						
8	(a)		(b)			(c)			(d)								
			(i)	(ii)	(iii)	(i)		(ii)	(i)		(ii)						
	06 × 5 = 30		10	10	10	05		15	25		45						
	30		30			20			70								
9	(a)		(b)														
			(i)	(ii)	(iii)	(iv)											
	75		10	13	24	28											
	75		75														
10	(a)						(b)				(c)						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(i)	(ii)	(iii)		(i)	(ii)	(iii)	(iv)			
									I	II							
	16	08	20	06	06	04	10	15	12	13	08	16	06	10			
	60						50				40						

PART A — STRUCTURED ESSAY

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

1. (a) You are provided with the following list of chemical species (elements, ions and compounds). Selecting from the list, write the answers to the questions on the relevant dotted lines.

Li⁺, Cs⁺, Br⁻, I⁻, CCl₄, ICl, C, Al, SO₃, SO₂, S true

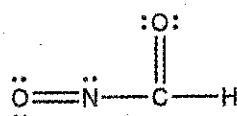
- (i) element which as the central atom in a compound, can display *sp*, *sp*², *sp*³ hybridizations C
- (ii) ion having the highest polarizability I⁻
- (iii) ion having the highest polarizing power Li⁺
- (iv) element which can form electron deficient compounds Al
- (v) compound having the strongest London forces All CCl₄*
- (vi) compound which displays the strongest dipole-dipole interactions ICl or SO₂
- (vii) compound displaying bond angles of 120° SO₃
- (viii) element which can form compounds by exceeding 8 valence electrons S

(04 Marks X 8)

* Due to a discrepancy amongst the papers in the three languages award 04 marks for all the students for part (v).

1(a): 32 Marks

- (b) (i) Draw the most acceptable Lewis dot-dash structure for the molecule HCNO₂. Its skeleton is given below.



(07 Marks)

- (ii) Draw two Lewis dot-dash structures (resonance structures) for HCNO₂, excluding the Lewis structure you have drawn above.

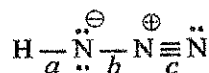


(07 marks)

(07 marks)

1(b): 21 Marks

- (c) (i) In the given HN₃ molecule, identify the bonds (as a, b, c) formed by the overlap of the following atomic/hybrid orbitals. Indicate whether the bond is σ or π type.
Note: c is a triple bond.



orbitals	bond	σ or π
s — <i>sp</i> ³	a	σ
<i>sp</i> — <i>sp</i>	c	σ
<i>sp</i> — <i>sp</i> ³	b	σ
<i>p</i> — <i>p</i>	c	π

Mark the bond type only if the bonds have been correctly identified in column 2 as a, b, or c.

(02 Marks X 8 = 16 Marks)

- (ii) Write the number of VSEPR pairs, electron pair geometry, shape and hybridization of the central sulfur atom in each of the following molecules.

molecule	number of VSEPR pairs	electron pair geometry	shape around central atom	hybridization
SF ₃ N	4	tetrahedral	tetrahedral	sp ³
Cl ₂ SO	4	tetrahedral	trigonal pyramidal	sp ³

(02 Marks X 8 = 16 Marks)

1(c): 32 Marks

- (d) Arrange the following species in increasing order of the property given in parenthesis.

I. Li₂CO₃ , Na₂CO₃ , MgCO₃ (decomposition temperature)

MgCO₃ < Li₂CO₃ < Na₂CO₃

Entire series has to be correct

II. Li , Na , B (atomic radius)

B < Li < Na

III. SO₃²⁻ , SO₄²⁻ , SO₃ (electronegativity of S)

SO₃²⁻ < SO₄²⁻ < SO₃

(05 Marks X 3)

1(d): 15 Marks

2. (a) (i) W is a p-block element in the Periodic Table. Its atomic number is less than 20. It has two allotropes; one of them (A) is odourless and the other (B), has a pungent smell. In many countries B is used to disinfect water.

Identify W O / oxygen A O₂ / dioxygen / oxygen gas B O₃ / ozone / trioxygen

(04 Marks x 3 = 12 Marks)

- (ii) W and the other elements in the group which W belongs to, form simple covalent hydrides. C is the hydride formed by W. Except for C, the other hydrides in the group are poisonous.

I. Identify C. H₂O / water (04 Marks)

- II. C has remarkably different properties to those of the other hydrides. List three such properties (other than being non-poisonous) and give the reason for those differences.

Properties: (1) high boiling point (02 Marks)
 (2) high melting point (02 Marks)
 (3) high specific heat capacity, high latent heat capacity, high viscosity, high surface tension maximum density at 4 °C (anomalous expansion of water) or low density of solid compared to liquid state (02 Marks)

Reason: hydrogen bonding or presence of hydrogen bonds (02 Marks)

- III. On going down the group;

● Does the covalent bond angle of these hydrides increase or decrease? decrease (04 Marks)

Briefly explain your answer.

Due to less repulsion between bond pairs or due to decrease of electronegativity (03 Marks)

● Does the bond length of these hydrides increase or decrease? Increase (04 Marks)

Briefly explain your answer.

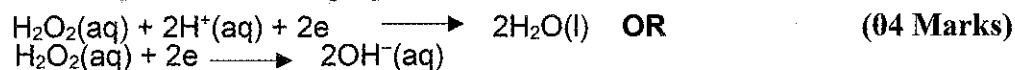
Due to increase in size/radius of central atom (03 Marks)

- (iii) **D** is a compound composed of the same elements as **C** (ratio of elements is different). It is a viscous liquid. It can act as both an oxidizing agent as well as a reducing agent. It also undergoes disproportionation.

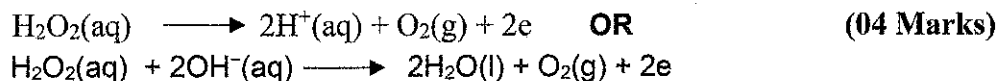
I. Identify **D**. H_2O_2 / hydrogen peroxide (04 Marks)

II. Write balanced half reactions for the following.

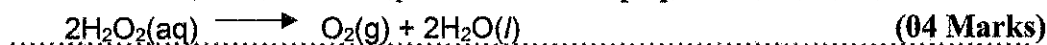
- **D** acting as an oxidizing agent



- **D** acting as a reducing agent



III. Write the balanced chemical equation for the disproportionation of **D**.



2(a): 54 Marks

- (b) (i) **X** is also a *p*-block element of the Periodic Table with an atomic number less than 20. It also exists as allotropes. One of the allotropes is a thermal and electrical conductor.

I. Identify **X**. C / Carbon (04 Marks)

II. Name three allotropes of **X**.

diamond (03 Marks)

graphite (03 Marks)

fullerene (buckyball)/nanotubes/charcoal (03 Marks)

- (ii) **E** is a compound of **X** and **W**, in the ratio 1:1. It is an odourless, poisonous gas.

Identify **E**. CO / Carbon monoxide (04 Marks)

- (iii) **F** is a compound of **X** and **W**, in the ratio 1:2. It contributes to global warming. Its solid form is used as a freezing agent in the food industry.

I. Identify **F**. CO_2 / Carbon dioxide (04 Marks)

II. What is the common name used for the solid form of **F**? dry ice (03 Marks)

2(b): 24 Marks

- (c) **M** is a *s*-block element in the Periodic Table. Its first three successive ionization energies in kJ mol^{-1} are respectively; 589, 1145 and 4912. **M** reacts readily with cold water to give compound **G** and a gas. The cation of **M** is a major contributor to hardness of water.

(i) Identify **M** and **G**.

M: Ca / Calcium (04 Marks)

G: $\text{Ca}(\text{OH})_2$ / Calcium hydroxide (04 Marks)

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

I. The initial reaction of **G** with **F** $\text{Ca}(\text{OH})_2(\text{aq}) + \text{CO}_2(\text{g}) \longrightarrow \text{CaCO}_3(\text{s}) + \text{H}_2\text{O}(\text{l})$ (03 Marks)

II. The reaction of **G** with excess **F** $\text{Ca}(\text{OH})_2(\text{aq}) + 2\text{CO}_2(\text{g}) (\text{excess}) \longrightarrow \text{Ca}(\text{HCO}_3)_2(\text{aq})$ (03 Marks)

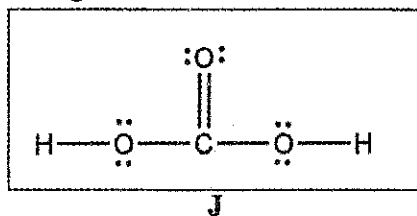
(Physical states are not required)

2(c): 14 Marks

(d) J is a common oxoacid of X. It can be prepared by dissolving F in C under pressure.

(i) Write the chemical formula of J. H_2CO_3 (04 Marks)

(ii) Draw the structure of J showing all the bonds.



(04 Marks)

(Lone pairs are not required)

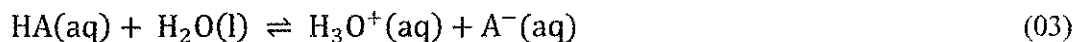
2(d): 08 Marks

3. HA(aq) is a weak acid with $K_a = 4.0 \times 10^{-4} \text{ mol dm}^{-3}$ at 25°C . In an experiment, 20.00 cm^3 of 0.25 mol dm^{-3} HA(aq) solution was titrated with 0.10 mol dm^{-3} KOH(aq) solution at 25°C .

(i) Calculate the initial pH value of the HA(aq) solution at 25°C . (log values for 1–10 are given below.)

number	1	2	3	4	5	6	7	8	9	10
log value	0.00	0.30	0.48	0.60	0.70	0.78	0.85	0.90	0.95	1.00

NOTE: PHYSICAL STATES ARE NECESSARY FOR THE ANSWER OF QUESTION 03.
The symbol of equilibrium $\rightleftharpoons$ also needed for all the reactions as indicated.



Can accept above even without water

	$\text{HA(aq)} + \text{H}_2\text{O(l)} \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{A}^-(\text{aq})$				
Initial con.	0.25	0	0	mol dm^{-3}	
Change con.	-x	x	x	mol dm^{-3}	
Equi. con.	$0.25 - x$	x	x	mol dm^{-3}	(02+01)

$$K_a = \frac{[\text{H}_3\text{O}^+(\text{aq})][\text{A}^-(\text{aq})]}{[\text{HA(aq)}]} \quad (03)$$

$$4.0 \times 10^{-4} = \frac{x \cdot x}{0.25 - x} \approx \frac{x^2}{0.25} \quad (03)$$

$$x^2 = 1.0 \times 10^{-4}$$

$$x = [\text{H}_3\text{O}^+(\text{aq})] = 1.0 \times 10^{-2} \text{ mol dm}^{-3} \quad (02+01)$$

$$\text{pH} = -\log[\text{H}_3\text{O}^+(\text{aq})] = 2 \quad (03+03)$$

$$\text{Or } \text{pH} = -\log[\text{H}^+(\text{aq})] = 2$$

(i) (21 Marks)

(ii) Calculate the volume of KOH(aq) solution needed to reach the equivalence point.



Stoichiometry; HA(aq) : KOH(aq) = 1 : 1

$$\begin{aligned} \text{Number of HA(aq) moles present} &= 0.25 \text{ mol dm}^{-3} \times 20.00 \times 10^{-3} \text{ dm}^3 \\ &= 5.0 \times 10^{-3} \text{ mol} \end{aligned} \quad (03)^*$$

$$\therefore \text{Number of moles of } 0.10 \text{ mol dm}^{-3} \text{ KOH(aq) reacted} = 5.0 \times 10^{-3} \text{ mol}$$

* 03 marks can be awarded for either number of HA moles or KOH moles

$$\begin{aligned} \therefore \text{Volume of KOH(aq)} &= (5.0 \times 10^{-3} \text{ mol}) / 0.10 \text{ mol dm}^{-3} = 5.0 \times 10^{-2} \text{ dm}^3 \\ &= 50.00 \text{ cm}^3 \end{aligned} \quad (03)$$

(OR * use; $C_1V_1 = C_2V_2$ or any other correct method to obtain 06 marks)

(ii) (09 Marks)

(iii) State whether the mixture at the equivalence point is acidic, basic or neutral.

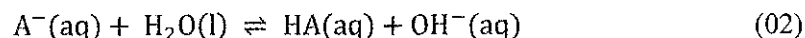
Basic (03)

At the equivalence point pH of the mixture is determined by the hydrolysis of KA(aq) salt.

Concentration of KA(aq) or $\text{A}^-(\text{aq})$ at the equivalence point

$$= 5.0 \times 10^{-3} \text{ mol} / (70 \times 10^{-3} \text{ dm}^3) = 0.07 \text{ mol dm}^{-3} \quad (02)$$

Consider the hydrolysis reaction:



Initial con.	0.07	0	0	mol dm ⁻³
Change con.	-x	x	x	mol dm ⁻³
Equi. con.	0.07 - x	x	x	mol dm ⁻³ (01+01)

Justify your answer using an appropriate calculation.

For the above hydrolysis

$$K_b = \frac{[\text{HA(aq)}][\text{OH}^-(\text{aq})]}{[\text{A}^-(\text{aq})]} \quad (02)$$

$$K_b = \frac{K_w}{K_a} \quad (02)$$

$$= 2.5 \times 10^{-11} \text{ mol dm}^{-3} \quad (02+01)$$

$$2.5 \times 10^{-11} = \frac{x \cdot x}{0.07 - x} \approx \frac{x^2}{0.07}$$

$$x^2 = 1.75 \times 10^{-12}$$

$$x = [\text{OH}^-(\text{aq})] = (1.75)^{1/2} \times 10^{-6} \text{ mol dm}^{-3} \quad (01+01)$$

$$\therefore \text{pOH} = 5.88 \quad (02)$$

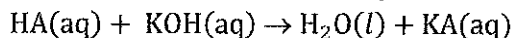
$$\text{And pH} = 8.12 \text{ (or } > 8) \quad (02)$$

$\therefore$ The mixture is basic.

(iii) (26 Marks)

- (iv) It was found that the pH value of the mixture after the addition of 80.00 cm³ of KOH(aq) was between 12 and 13. Explain this observation with an appropriate calculation.

80.00 cm³ addition of KOH(aq) means we are beyond the equivalence point and therefore the pH of the mixture is determined by the excess OH⁻(aq)/KOH(aq). (03)*



$$\text{Added amount of KOH(aq)} = 80 \times 0.10 \times 10^{-3} \text{ mol} \quad (02+01)$$

$$\text{Reacted amount of KOH(aq)} = 50 \times 0.10 \times 10^{-3} \text{ mol}$$

$$\text{Excess amount of KOH(aq)} = 30 \times 0.10 \times 10^{-3} \text{ mol} \quad (02+01)$$

$$[\text{OH}^-(\text{aq})] = 3 \times 10^{-3} / (100 \times 10^{-3}) = 3 \times 10^{-2} \text{ mol dm}^{-3} \quad (02+01)$$

$$\therefore \text{pOH} = 2 - \log(3) = 1.52 \quad (03)$$

$$\therefore \text{pH} = 12.48 \quad (03)$$

* If the words excess ^{OH⁻(aq)} O(aq)/KOH(aq) are mentioned anywhere in the answer this three marks can be awarded **iv) (18 Marks)**

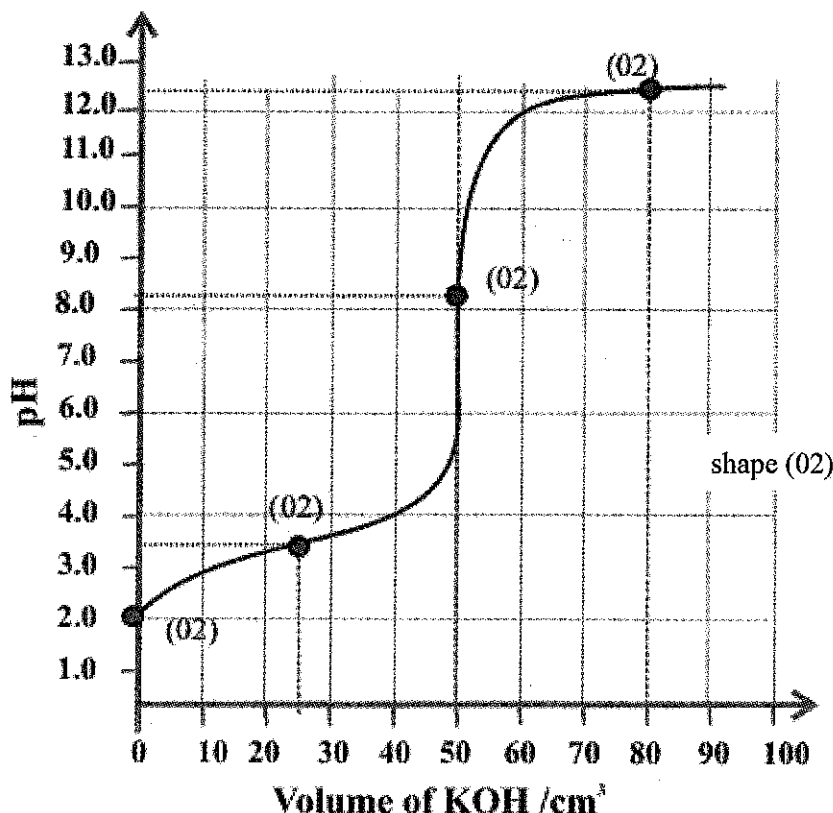
- (v) Calculate the pH value of the mixture at the half-equivalence point.

$$\text{At the half equivalence point; } \text{pH} = \text{pK}_a \quad \text{OR} \quad [\text{H}^+] = K_a \quad (03)$$

$$\therefore \text{pH} = -\log(4 \times 10^{-4}) = 3.4 \quad (03)$$

(v) (06 Marks)

- (vi) Sketch the titration curve below for this titration. Mark the points of pH values and corresponding volumes of KOH(aq) obtained in (i)–(v) above on the titration curve.



Note: Each data point should have correct X and Y coordinates to award marks.
For shape, steep change at 50 cm³ needed.

(vi) (10 Marks)

- (vii) Explain why the pH of the solution is acidic in the range of 10–40 cm³ volume of KOH added, and basic after the equivalence point.

In 10 – 40 cm³ region there is an acid present and hence the mixture is acidic. (02)

After the equivalence point, there are OH⁻(aq)/KOH (aq) present and hence the mixture is basic. (02)

(vii) (04 Marks)

- (viii) pK_a values of acid-base indicators of methyl red and bromothymol blue are 5.1 and 7.1, respectively. Identify, giving reasons which indicator is the most suitable to observe a sharp end point of the above titration.

Bromothymol-blue (02)

The equivalence point pH of the indicator should be within the indicator range $pK_{in} \pm 1$. (02)

In this titration, equivalence point pH is 8.12. (02)

(viii) (06 Marks)

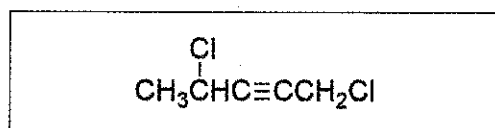
4. (a) The compound A having five (05) carbon atoms contains only C, H, and Cl. Its relative molecular mass is 137. When A reacts with aqueous NaOH, compound B having a relative molecular mass of 100 is formed. (C = 12, H = 1, O = 16, Cl = 35.5)

(i) Write the molecular formula of A. $C_5H_6Cl_2$ (10 Marks)

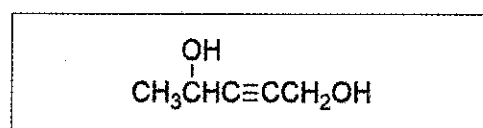
(ii) Write the molecular formula of B. $C_5H_8O_2$ $C_5H_6(OH)_2$ is wrong (10 Marks)

When A is hydrogenated with H₂/Pd in the presence of BaSO₄/quinoline, compound C having a relative molecular mass of 139 is formed. Both compounds A and B exhibit optical isomerism. A and B do not give precipitates with ammoniacal AgNO₃. When B is oxidised with pyridinium chlorochromate, compound D (C₅H₄O₂) is formed. When treated with aqueous NaOH, D undergoes a self condensation reaction. Compound B is converted to E (C₅H₇OCl) when treated with conc. HCl and ZnCl₂.

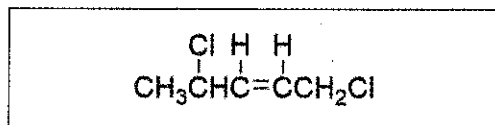
- (iii) Draw the structures of A, B, C, D and E in the relevant boxes.



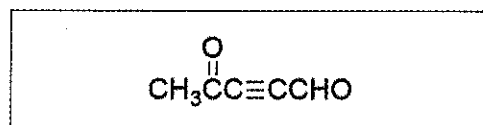
A



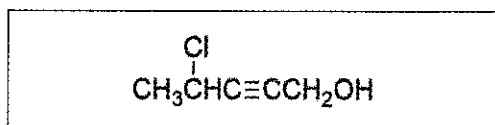
B



C



D



E

(07 × 5 = 35 Marks)

4(a) 55 Marks

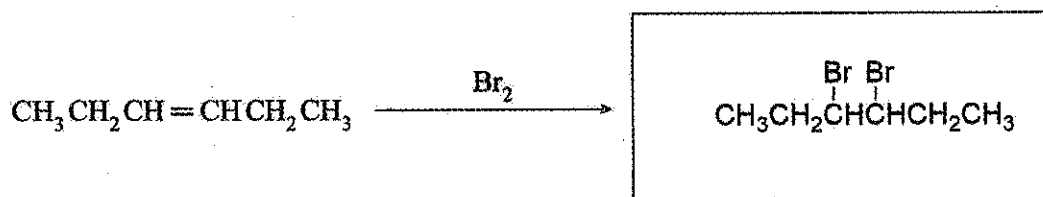
- (b) For the reactions given below, write the type of reaction [Nucleophilic addition (A_N), Nucleophilic substitution (S_N), Electrophilic addition (A_E), Electrophilic substitution (S_E), Elimination (E), acid-base (AB)] and draw the structure of the major product in the relevant box in the table.

Reaction	Type of reaction	Major product
(i) $\text{CH}_3\text{CH}_2\text{C}\equiv\text{C}-\text{H} + \text{HBr}$ (excess) $\longrightarrow$	A_E	$\text{CH}_3\text{CH}_2\text{C}(\text{Br})_2\text{CH}_3$
(ii) $\text{CH}_3\text{CH}_2\text{MgBr} + \text{H}_2\text{O} \longrightarrow$	AB	C_2H_6 or CH_3CH_3
(iii) $\text{CH}_3-\text{CH}(\text{CH}_3)-\text{Br} + \text{alcoholic KOH} \longrightarrow$	E	$\text{H}_2\text{C}=\text{CHCH}_3$
(iv) $\text{C}_6\text{H}_5-\text{C}(=\text{O})-\text{CH}_3 + \text{CH}_3\text{C}\equiv\text{C}^-\text{Na}^+ \longrightarrow$	A_N	$\text{C}_6\text{H}_5-\text{C}(\text{O}^-\text{Na}^+)(\text{CH}_3)-\text{C}\equiv\text{CCH}_3$ Award 03 marks even without Na^+

(03 × 8 = 24 Marks)

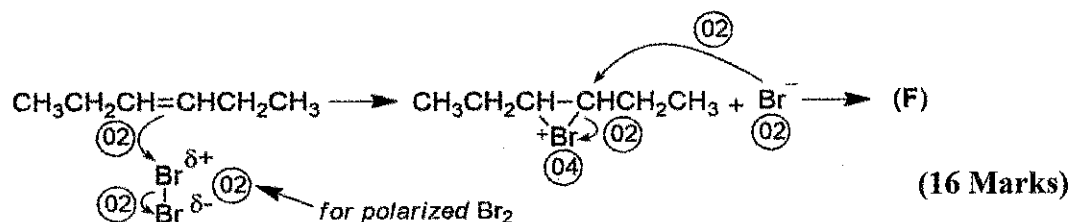
4(b) 24 Marks

- (c) (i) Draw the structure of the major product F of the following reaction in the given box.



F (05 Marks)

- (ii) Write the mechanism of the reaction stated above.



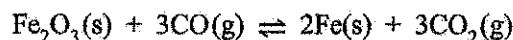
If structure F is wrong, no marks for part (ii)

If the bromonium ion is incorrect, award marks only for Br^- ion (02) and electron movement (arrow) from the Br^- ion towards the intermediate (02).

4(c) 21 Marks

NOTE: PHYSICAL STATES ARE NECESSARY

5. (a) Consider the reaction shown below at 300 K and 1 atm.



The following thermodynamic data at 300 K and 1 atm are given.

	CO(g)	CO ₂ (g)	Fe(s)	Fe ₂ O ₃ (s)
$\Delta H_f^\circ / \text{kJ mol}^{-1}$	-111	-394	0	-824
$S^\circ / \text{J K}^{-1} \text{mol}^{-1}$	197	213	27	87

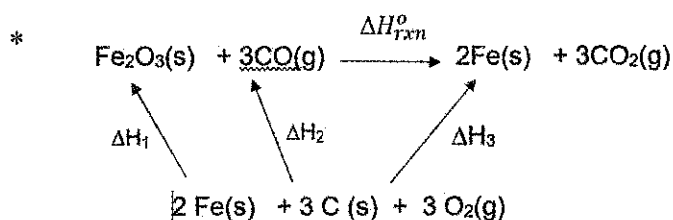
- (i) Calculate the $\Delta H_{\text{rxn}}^\circ$ of the reaction at 300 K.

i.
$$\Delta H_{\text{rxn}}^\circ = \sum \Delta_f H_{\text{products}}^\circ - \sum \Delta_f H_{\text{reactants}}^\circ \text{ or thermochemical cycle } (04)^*$$

$$= \{ [0 + 3 \times (-394)] - [-824 + 3 \times (-111)] \} \text{ kJ mol}^{-1} \quad (03+01)$$

$$= \{-1182 - (-1157)\} \text{ kJ mol}^{-1}$$

$$= -25 \text{ kJ mol}^{-1} \quad (03+01)$$



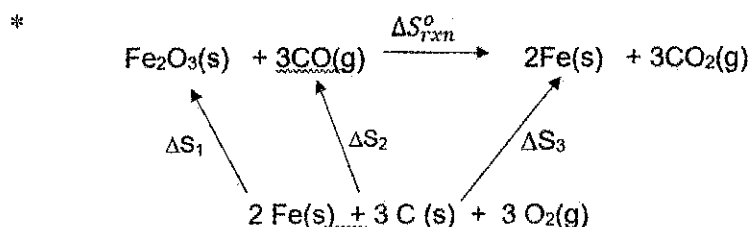
(i) (12 Marks)

- (ii) Calculate the $\Delta S_{\text{rxn}}^\circ$ of the reaction at 300 K.

$$\Delta S_{\text{rxn}}^\circ = \sum S_{\text{products}}^\circ - \sum S_{\text{reactants}}^\circ \text{ or thermochemical cycle } (04)^*$$

$$= \{ [2 \times 27 + 3 \times (213)] - [87 + 3 \times (197)] \} \text{ J K}^{-1} \text{mol}^{-1} \quad (03+01)$$

$$= 15 \text{ J K}^{-1} \text{mol}^{-1} \quad (03+01)$$



(ii) (12 Marks)

- (iii) Show that the reaction is "Theoretically possible at any temperature". State the assumption you made.

Consider the Gibbs free energy change of the reaction;

$$\Delta G_{\text{rxn}}^\circ = \Delta H_{\text{rxn}}^\circ - T \Delta S_{\text{rxn}}^\circ \quad (04)$$

$$= -\text{ve} - (+\text{ve}) \quad (04)$$

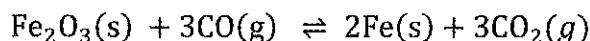
$$\therefore \Delta G_{\text{rxn}}^\circ \text{ is negative at all temperatures} \quad (04)$$

indicating that the reaction is theoretically possible at all temperatures. (04)

Assumption: $\Delta H_{\text{rxn}}^\circ$ and $\Delta S_{\text{rxn}}^\circ$ are independent of temperature. (04)

(iii) (20 Marks)

(iv) Write the expression for the equilibrium constant, K_p of the reaction at 300 K.



$$K_p = \frac{(P_{\text{CO}_2(\text{g})})^3}{(P_{\text{CO}(\text{g})})^3} \quad (04)$$

(iv) (04 Marks)

(v) Derive the expression for the equilibrium constant, K_C of the reaction, in terms of K_p at 300 K.

$$K_p = K_C (RT)^{\Delta n} \quad (04)^*$$

$$\Delta n = 3 - 3 = 0 \quad (04)^*$$

$$\therefore K_C = K_p \quad (04)^*$$

(v) (12 Marks)

*** Alternate answer**

Assuming ideal behaviour,

$$\left. \begin{array}{l} PV = nRT \\ P = CRT \end{array} \right\} \quad (03)$$

$$K_p = \frac{(P_{\text{CO}_2(\text{g})})^3}{(P_{\text{CO}(\text{g})})^3}$$

$$K_p = \frac{([\text{CO}_2(\text{g})] RT)^3}{([\text{CO}(\text{g})] RT)^3} = \frac{[\text{CO}_2(\text{g})]^3}{[\text{CO}(\text{g})]^3} \quad (03)$$

$$K_C = \frac{[\text{CO}_2(\text{g})]^3}{[\text{CO}(\text{g})]^3} \quad (03)$$

$$\therefore K_p = K_C \quad (03)$$

(vi) It was found that the K_p value of the reaction is 125 at 300 K, while the value is 27 at 900 K.

I. Calculate the ratios of partial pressures of $\text{CO}_2(\text{g})$ and $\text{CO}(\text{g})$, $(P_{\text{CO}_2(\text{g})}/P_{\text{CO}(\text{g})})$ at these two temperatures.

$$\text{At 300 K, } K_p = \frac{(P_{\text{CO}_2(\text{g})})^3}{(P_{\text{CO}(\text{g})})^3} = 125 \quad \therefore \frac{(P_{\text{CO}_2(\text{g})})}{(P_{\text{CO}(\text{g})})} = 5 \quad (1) \quad (04)$$

$$\text{At 900 K, } K_p = \frac{(P_{\text{CO}_2(\text{g})})^3}{(P_{\text{CO}(\text{g})})^3} = 27 \quad \therefore \frac{(P_{\text{CO}_2(\text{g})})}{(P_{\text{CO}(\text{g})})} = 3 \quad (2) \quad (04)$$

(08 Marks)

II. Give reasons for the difference in the two values obtained in I above.

$$\text{From (1) and (2) above; } (K_p)_{300\text{ K}} > (K_p)_{900\text{ K}} \quad (04)$$

The reaction is exothermic (04)

At high temperature favours the backward reaction (04)

$\therefore$ The increase of $\text{CO}(\text{g})$ / decrease of $\text{CO}_2(\text{g})$ result in the decrease in the value of K_p . (04)

(16 Marks)

(vi) (24 Marks)

- (vii) Explain the effect on the equilibrium position when the total pressure of the system is increased at a given temperature.

$$\Delta n = 3 - 3 = 0 \text{ for the reaction} \quad (04)$$

or equal number of gaseous species are present in the both sides.

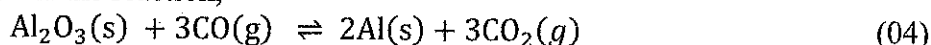
Therefore, there will be no significant change in the equilibrium position upon increasing the pressure of the system. (04)

(vii) (08 Marks)

- (viii) The reduction of $\text{Fe}_2\text{O}_3(\text{s})$ to $\text{Fe}(\text{s})$ can be carried out in a blast furnace by using $\text{CO}(\text{g})$. The maximum temperature achievable in a blast furnace is 2300 K. Even though $\text{Al}_2\text{O}_3(\text{s})$ can be reduced to $\text{Al}(\text{s})$ in a similar reaction using $\text{CO}(\text{g})$, explain by means of a suitable calculation why it is **not** carried out in a blast furnace. Use the data given below for your calculation.

	$\text{CO}(\text{g})$	$\text{CO}_2(\text{g})$	$\text{Al}(\text{s})$	$\text{Al}_2\text{O}_3(\text{s})$
$\Delta H_f^\circ / \text{kJ mol}^{-1}$	-111	-394	0	-1676
$S^\circ / \text{J K}^{-1} \text{mol}^{-1}$	197	213	28	51

Consider the reaction,



$$\begin{aligned} \Delta H_{\text{rxn}}^\circ &= \sum \Delta_f H_{\text{products}}^\circ - \sum \Delta_f H_{\text{reactants}}^\circ \\ &= \{ [0 + 3 \times (-394)] - [-1676 + 3 \times (-111)] \} \text{ kJ mol}^{-1} \quad (02) \\ &= 827 \text{ kJ mol}^{-1} \quad (03+01) \end{aligned}$$

$\therefore$ The reaction is endothermic.

$$\begin{aligned} \Delta S_{\text{rxn}}^\circ &= \sum S_{\text{products}}^\circ - \sum S_{\text{reactants}}^\circ \\ &= \{ [2 \times 28 + 3 \times (213)] - [51 + 3 \times (197)] \} \text{ J K}^{-1} \text{mol}^{-1} \quad (02) \\ &= 53 \text{ J K}^{-1} \text{mol}^{-1} \quad (03+01) \end{aligned}$$

Consider the Gibbs free energy change of the reaction;

$$\Delta G_{\text{rxn}}^\circ = \Delta H_{\text{rxn}}^\circ - T \Delta S_{\text{rxn}}^\circ$$

The temperature needed to reach the equilibrium position:

$$\Delta H_{\text{rxn}}^\circ - T \Delta S_{\text{rxn}}^\circ = 0 \quad (04) *$$

$$\therefore T = \frac{\Delta H_{\text{rxn}}^\circ}{\Delta S_{\text{rxn}}^\circ} = 15,600 \text{ K} \quad (04) *$$

$\therefore$ This temperature cannot be reached in the blast furnace. (04) *

$\therefore$ The reduction of $\text{Al}_2\text{O}_3(\text{s})$ to $\text{Al}(\text{s})$ cannot be achieved in the blast furnace.

(viii) (28 Marks)

* Alternate answer

$$\Delta G_{\text{rxn}}^\circ = \Delta H_{\text{rxn}}^\circ - T \Delta S_{\text{rxn}}^\circ$$

For the reaction to be theoretically possible,

$$\Delta G_{\text{rxn}}^\circ < 0 \quad \text{or}$$

$$\Delta H_{\text{rxn}}^\circ - T \Delta S_{\text{rxn}}^\circ < 0 \quad (04)$$

$$T \Delta S_{\text{rxn}}^\circ > \Delta H_{\text{rxn}}^\circ$$

$$T > \frac{827 \times 10^3 \text{ J mol}^{-1}}{53 \text{ J K}^{-1} \text{mol}^{-1}}$$

$$T > 15,600 \text{ K} \quad (04)$$

$\therefore$ This temperature cannot be reached in the blast furnace. (04)

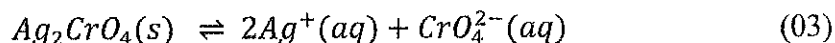
$\therefore$ The reduction of $\text{Al}_2\text{O}_3(\text{s})$ to $\text{Al}(\text{s})$ cannot be achieved in the blast furnace.

*If the student write only at 2300 K
 ΔG is (+)ve award only 08 marks*

5(a) (120 Marks)

(b) $\text{Ag}_2\text{CrO}_4(\text{s})$ is a sparingly soluble salt in water with $K_{\text{sp}} = 4.0 \times 10^{-12} \text{ mol}^3 \text{ dm}^{-9}$ at 25°C .

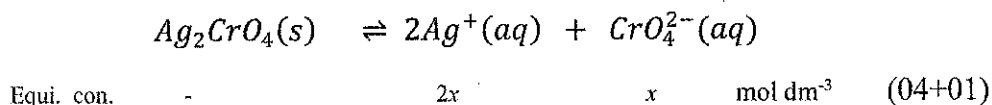
(i) Write the equilibrium reaction that exists in a saturated aqueous solution of $\text{Ag}_2\text{CrO}_4(\text{s})$ at 25°C .



(i) (03 Marks)

(ii) Calculate the concentration of $\text{Ag}^+(\text{aq})$ in a saturated aqueous solution of $\text{Ag}_2\text{CrO}_4(\text{s})$ at 25°C .

Consider the equilibrium;



$$K_{\text{sp}} = [\text{Ag}^+(\text{aq})]^2 [\text{CrO}_4^{2-}(\text{aq})] = 4.0 \times 10^{-12} \text{ mol}^3 \text{ dm}^{-9} \quad (04)$$

$$4.0 \times 10^{-12} = (2x)^2 x = 4x^3$$

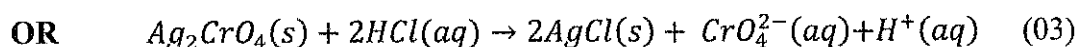
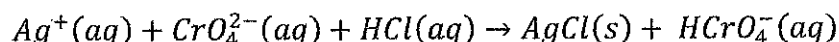
$$x = 1.0 \times 10^{-4} \text{ mol dm}^{-3} \quad (03+01)$$

$$[\text{Ag}^+(\text{aq})] = 2x = 2.0 \times 10^{-4} \text{ mol dm}^{-3} \quad (03+01)$$

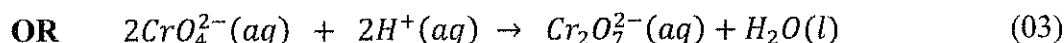
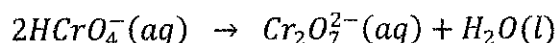
(ii) (17 Marks)

(iii) When dil. HCl was added dropwise to a saturated Ag_2CrO_4 solution in a beaker, first the reddish-colour of the solution decreased and turned yellow with formation of a precipitate on the bottom of the beaker. When the addition of HCl is further continued, the colour of the solution turned to an intense-orange. Explain these observations using appropriate chemical reactions.

At the beginning the reddish-color of the solution decreases due to the dissolution of Ag_2CrO_4 and formation of white $\text{AgCl}(\text{s})$ precipitate and yellow color CrO_4^{2-} .
(02)



Further addition of acid converts $\text{HCrO}_4^-(\text{aq})$ ions or $\text{CrO}_4^{2-}(\text{aq})$ into intense orange-colored $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$ ions. (02)



(iii) (10 Marks)

5(b) (30 Marks)

NOTE: PHYSICAL STATES ARE NECESSARY

6. (a) At a given temperature, the rate law of a first-order reaction $A \rightarrow P$ can be expressed as $2.303 \log \left(\frac{A_0}{A_t} \right) = kt$, where A_0 is the concentration of A at time, $t = 0$, A_t is the concentration of A at time, $t = t$, and k is the rate constant.

Note: partial pressures can also be used instead of concentrations.

- (i) In an experiment carried out for a gas-phase first order reaction, the time required to complete 99% of the reaction was t_1 , and that for the 90% completion was t_2 . Show that $t_1 = 2t_2$.

Consider the first order reaction,

	A	→	P		
Initial($t=0$)	100				
After($t=t_1$)	(100-99)			99% completion (1)	(03)
After($t=t_2$)	(100-90)			90% completion (2)	(02)

The rate equation given is:

$$2.303 \log \left(\frac{A_0}{A_t} \right) = k t$$

$$\text{For (1): } 2.303 \log \left(\frac{100}{1} \right) = k t_1 \quad (05)$$

$$2.303 \times 2 = k t_1 \quad (1) \quad (05)$$

$$\text{For (2): } 2.303 \log \left(\frac{100}{10} \right) = k t_2 \quad (05)$$

$$2.303 \times 1 = k t_2 \quad (2) \quad (05)$$

$$(1)/(2) ; t_1 = 2 t_2 \quad (05)$$

Steps can be combined.

(i) (30 Marks)

- (ii) Show that the half-life ($t_{1/2}$) of the above reaction is given by the expression $t_{1/2} = \frac{0.693}{k}$.
 k is the rate constant. ($\log_{10} 2 = 0.301$)

If the initial concentration is $[A]_0$,

The concentration at half-life, $t_{1/2}$ is $[A]_0/2$ (03)

Substituting this in rate equation;

$$2.303 \log \left(\frac{A_0}{A_0/2} \right) = k t_{1/2} \quad (03)$$

$$2.303 \log(2) = k t_{1/2} \quad (03)$$

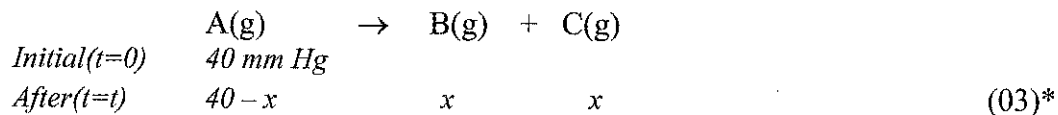
$$2.303 \times 0.301 = k t_{1/2} \quad (03)$$

$$t_{1/2} = \frac{0.693}{k}$$

(ii) (12 Marks)

- (iii) A first-order gas phase elementary decomposition reaction $A(g) \rightarrow B(g) + C(g)$ occurs in a closed-rigid container at a given temperature. When pure $A(g)$ was placed initially in the empty container, the pressure of the system was 40 mmHg. The pressure of the system was 76 mmHg, when $t = 300$ s. Calculate the rate constant (k) and half-life ($t_{1/2}$) of the reaction at this temperature.

Consider the reaction,



$$\therefore \text{Total pressure at time } t \text{ is } 40 + x \quad (03)$$

$$76 = 40 + x \quad (03)$$

$$x = 76 - 40 = 36 \text{ mmHg} \quad (03)^*$$

* pressure can be expressed in concentration terms. $P = \frac{1}{RT} \propto RT$

$$\text{At time } t, P_A = 40 - 36 = 4 \text{ mmHg} \quad (03)^*$$

$$k = \frac{2.303}{300 \text{ s}} \log \left(\frac{40}{4} \right) \quad (06)$$

$$k = \frac{2.303}{300 \text{ s}} \log(10) \quad (03)$$

$$k = 7.7 \times 10^{-3} \text{ s}^{-1} \quad (02+01)$$

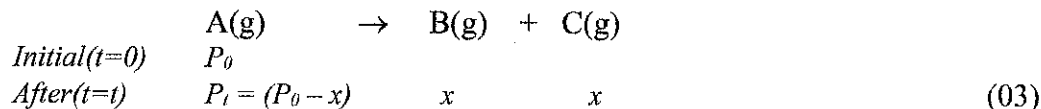
$$\text{And } t_{1/2} = \frac{0.693}{k} = \frac{0.693}{7.7 \times 10^{-3} \text{ s}^{-1}} \quad (03)$$

$$t_{1/2} = 90 \text{ s} \quad (02+01)$$

Alternate method

(iii) (33 Marks)

Consider the reaction,



$$\therefore \text{Total pressure at time } t \text{ is } (P_0 + x) \quad (03)$$

If the pressure of the system at time t is P_t , then we can write

$$x = P_t - P_0 \quad (03)$$

$$\therefore (P_0 - x) = 2P_0 - P_t \quad (03)$$

$$\text{From (i) above, we can write } k = \frac{2.303}{t} \log \left(\frac{P_0}{(P_0 - x)} \right) \quad (03)$$

Since $t = 300$ s

$$k = \frac{2.303}{300 \text{ s}} \log \left(\frac{P_0}{(2P_0 - P_t)} \right) = \frac{2.303}{300 \text{ s}} \log \left(\frac{40}{(2 \times 40 - 76)} \right) \quad (03+03)$$

$$k = \frac{2.303}{300 \text{ s}} \log(10) \quad (03)$$

$$k = 7.7 \times 10^{-3} \text{ s}^{-1} \quad (02+01)$$

$$\text{And } t_{1/2} = \frac{0.693}{k} = \frac{0.693}{7.7 \times 10^{-3} \text{ s}^{-1}} \quad (03)$$

$$t_{1/2} = 90 \text{ s} \quad (02+01)$$

- (iv) Calculate the rate of the reaction given in part (iii) above in mmHg s^{-1} when the pressure of the system is 50 mmHg.

Given, $P_t = 50 \text{ mmHg}$ (and we know that $P_0 = 40 \text{ mmHg}$)

$$\therefore x = (50 - 40) \text{ mmHg} = 10 \text{ mmHg} \quad (02+01)$$

If the pressure of A(g) at any time is P_A , $P_A = (P_0 - x)$

$$= (40 - 10) = 30 \text{ mmHg} \quad (02+01)$$

Since the reaction is first order, Rate of the reaction is given by,

$$\text{Rate} = k P_A \quad (03)$$

$$\text{Rate} = 7.7 \times 10^{-3} \text{ s}^{-1} \times 30 \text{ mmHg} \quad (02+01)$$

$$= 0.23 \text{ mmHg s}^{-1} \quad (02+01)$$

(iv) (15 Marks)

6(a) (90 Marks)

- (b) (i) Explain the following observation.

The boiling point of a liquid mixture prepared by mixing two completely miscible liquids A and B in a specified ratio was greater than the boiling points of each of the two liquids A and B.

Given : Boiling point of a mixture AB > boiling points of A and B

$$\therefore \text{Vapor pressure of AB} < \text{vapor pressures of A and B} \quad (05)$$

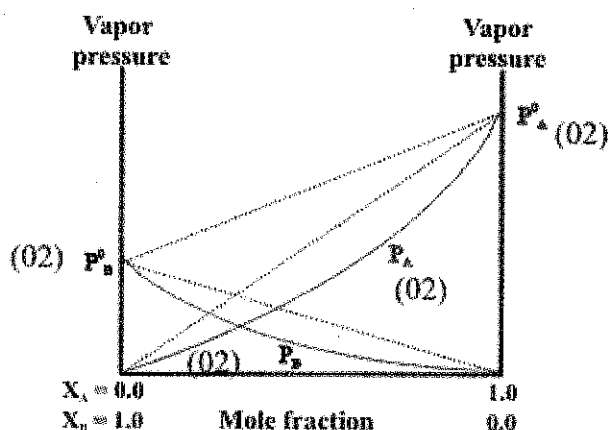
$$\text{And } P_{AB} < P_{AB(\text{ideal})} \quad (05)$$

$$\therefore \text{Intermolecular forces; } f_{A-B} > f_{A-A}, f_{B-B} \quad (05)$$

$$\therefore \text{Mixture has the negative deviation from Raoult's law.} \quad (05)$$

(i) (20 Marks)

- (ii) Sketch the diagram for the variation of partial pressures of A and B against composition of liquid mixtures of A and B. Pure liquid B has a higher boiling point than pure liquid A.



(02) for correct axes

Note: Award marks with or without dotted lines.

(ii) (10 Marks)

6 (b) (30 Marks)

- (c) (i) Define the partition coefficient (K_D) of a substance which distributes in two immiscible liquid phases.

When a substance distributes in two immiscible liquid phases, the partition coefficient (K_D) is the ratio of concentrations of the substance between two immiscible phases at dynamic equilibrium.

Or $K_D = \frac{[C]_1}{[C]_2}$; $[C]_1$ and $[C]_2$ are the concentrations of the substance in phase 1 and phase 2, respectively at dynamic equilibrium. (03)

(i) (03 Marks)

- (ii) In an experiment to evaluate the partition coefficient of ammonia between trichloromethane and water, at a given temperature the following procedure was carried out. A given amount of liquid ammonia was added to a given volume of water and then a given volume of trichloromethane was added and shaken vigorously. After reaching the equilibrium, 10.00 cm³ of aqueous layer required 12.00 cm³ of 0.25 mol dm⁻³ HCl(aq) for the complete neutralization, while 25.00 cm³ of trichloromethane layer required 6.00 cm³ of 0.05 mol dm⁻³ HCl(aq). Calculate K_D of ammonia between trichloromethane and aqueous layers at this temperature.

$$K_D = \frac{[NH_3]_{CHCl_3}}{[NH_3]_{H_2O}} \quad (03)^*$$

$$NH_3 : HCl \text{ stoichiometry is } 1 : 1 \quad (03)$$

For the aqueous layer;

$$\text{Number of HCl moles reacted} = \text{number of } NH_3 \text{ moles present in } 10 \text{ cm}^3 \quad (03)$$

$$\begin{aligned} \text{Number of } NH_3 \text{ moles present in } 10 \text{ cm}^3 &= 0.25 \text{ mol dm}^{-3} \times 12 \times 10^{-3} \text{ dm}^3 \\ &= 3.00 \times 10^{-3} \text{ mol} \end{aligned} \quad (02+01)$$

$$[NH_3]_{H_2O} = \frac{3.00 \times 10^{-3}}{10.00} \text{ mol cm}^{-3} \quad (02+01)$$

For the organic layer;

$$\text{Number of HCl moles reacted} = \text{number of } NH_3 \text{ moles present in } 25.00 \text{ cm}^3$$

$$\begin{aligned} \text{Number of } NH_3 \text{ moles present in } 25 \text{ cm}^3 &= 0.05 \text{ mol dm}^{-3} \times 6 \times 10^{-3} \text{ dm}^3 \\ &= 3.00 \times 10^{-4} \text{ mol} \end{aligned} \quad (02+01)$$

$$[NH_3]_{CHCl_3} = \frac{3.00 \times 10^{-4}}{25.00} \text{ mol cm}^{-3} \quad (02+01)$$

$$\begin{aligned} K_D &= \frac{[NH_3]_{CHCl_3}}{[NH_3]_{H_2O}} \\ &= \frac{\frac{3.00 \times 10^{-4}}{25.00} \text{ mol cm}^{-3}}{\frac{3.00 \times 10^{-3}}{10.00} \text{ mol cm}^{-3}} = \frac{1}{25} = 0.04 \end{aligned} \quad (02+01+03)^*$$

*If student has defined as

$$K_D = \frac{[NH_3]_{H_2O}}{[NH_3]_{CHCl_3}} \text{ may accept } 25 \text{ as the answer to receive these } 03 + 06 \text{ marks.}$$

(ii) (27 Marks)

6 (b) (30 Marks)

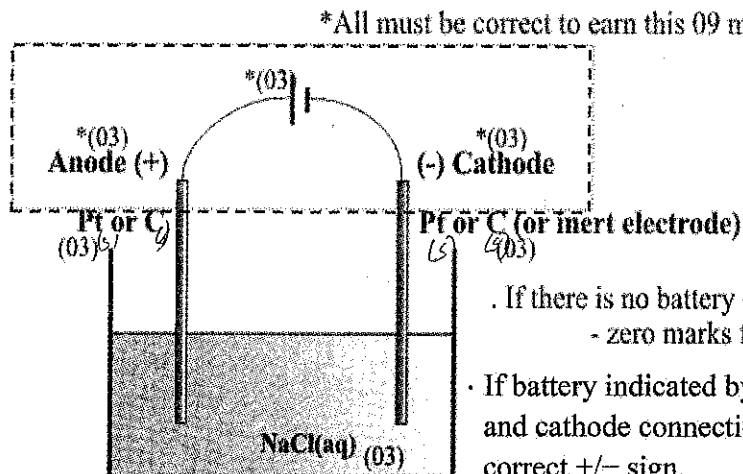
PHYSICAL STATES ARE NECESSARY

7. (a) Consider the following reduction potentials at 25 °C.

$$E^\circ_{\text{H}^+(\text{aq})/\text{H}_2(\text{g})} = 0.00 \text{ V} , E^\circ_{\text{H}_2\text{O}(\text{l})/\text{H}_2(\text{g})} = -0.83 \text{ V} , E^\circ_{\text{Na}^+(\text{aq})/\text{Na}(\text{s})} = -2.71 \text{ V}$$

$$E^\circ_{\text{Cl}_2(\text{g})/\text{Cl}^-(\text{aq})} = 1.36 \text{ V} , E^\circ_{\text{O}_2(\text{g})/\text{H}_2\text{O}(\text{l})} = 1.23 \text{ V}$$

(i) Sketch a labelled diagram of an electrochemical cell that can be used to electrolyse an aqueous NaCl solution using inert electrodes.



- If there is no battery or voltmeter, ammeter etc given - zero marks for the diagram(part i)
- If battery indicated by a different symbol, anode and cathode connections must be given with correct +/- sign.
- If battery (external power supply) is correct, signs of anode and cathode are not necessary.

(i) (18 Marks)

(ii) Write **all the possible** half reactions that can take place at the anode and the cathode.

At Cathode: reduction



At Anode: Oxidation



(ii) (18 Marks)

(iii) Giving reasons, identify the half reactions actually occurring at the anode and the cathode.

The half reaction relevant for the highest reduction potential (E^0) takes place at the cathode.

But reduction of H^+ does not take place due to very low concentration. (03)

Exact reaction at the cathode is;



The half reaction relevant for the lowest reduction potential (E^0) takes place at the anode.

But oxidation of H_2O does not take place due to higher overpotential. (02)

Exact reaction at the anode is;



(iii) (09 Marks)

- (iv) If the gas formed at the anode is collected at 1 atm and 25 °C by passing a constant current of 1.2 A for 2 hours through the cell, calculate the volume of the gas. (1 F = 96 500 C mol⁻¹)

Note: Assume that the gas does not react with or dissolve in the electrolyte solution.

State any other assumptions made in your calculation. (1 atm = 101 kPa)

$$Q = It \quad (03)$$

$$Q = (1.2 \times 2 \times 60 \times 60) \text{ C} \quad (03)$$

$$\text{Moles of electrons} = (1.2 \times 2 \times 60 \times 60) \text{ C} / 96500 \text{ C mol}^{-1} \approx 0.09 \text{ mol} \quad (03)$$

$$2 \text{ mol of electrons} \equiv 1 \text{ mol of Cl}_2(\text{g}) \quad (03)$$

$$\text{Moles of Cl}_2(\text{g}) \text{ produced} = 0.045 \text{ mol} \quad (03)$$

$$\text{Assuming an ideal gas behavior: } PV = nRT \quad (03)$$

$$V = \frac{nRT}{P} = \frac{0.045 \text{ mol} \times 8.314 \text{ J K}^{-1} \text{ mol}^{-1} \times 298 \text{ K}}{1 \times 10^5 \text{ Pa}} \quad (03)$$

$$= 109 \times 10^{-5} \text{ m}^3 - 112 \times 10^{-5} \text{ m}^3$$

$$\text{or } 1.09 - 1.12 \text{ dm}^3 \quad (03)$$

(iv) (24 Marks)

- (v) Write the half reactions occurring at the anode and the cathode, when molten NaCl(l) is used as the electrolyte in the above cell.

When molten NaCl(l) is used:

At cathode:



At anode:



(v) (06 Marks)

7(a) 75 Marks

- (b) X is a *d*-block element that belongs to the fourth period of the Periodic Table. X forms an amphoteric oxide X_1 . The most common ion of X is X^{n+} . In dilute aqueous solution, X^{n+} forms the coloured species X_2 .

On treatment of the solution containing X_2 separately with:

- aqueous NH_3 , the blue-green gelatinous precipitate X_3 is formed.
- excess dil. $NaOH$, followed by H_2O_2 , the yellow species X_4 is formed.

In acidic medium X_4 gives species X_5 .

On bubbling $SO_2(g)$ through an acidic solution containing X_5 , the ions X^{n+} and SO_4^{2-} are formed.

- (i) Identify X, X^{n+} , X_1 , X_2 , X_3 , X_4 and X_5 . (Give chemical formulae. Reasons are **not** required.)

X: Cr (04)

X^{n+} : Cr^{3+} (04)

X_1 : Cr_2O_3 (03)

X_2 : $[Cr(H_2O)_6]^{3+}$ (03)

X_3 : $Cr(OH)_3$ (03)

X_4 : CrO_4^{2-} or Na_2CrO_4 (03)

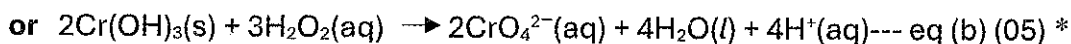
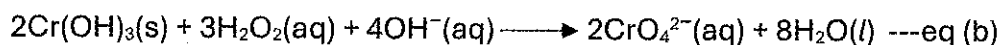
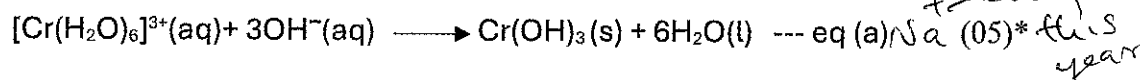
X_5 : $Cr_2O_7^{2-}$ or $Na_2Cr_2O_7$ (03)

[No marks for names of species.]

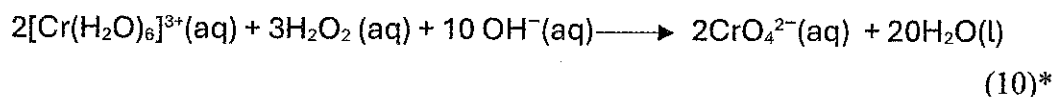
(i) (23 Marks)

- (ii) Write balanced ionic equations for I, II and III given below.

I. Formation of X_4 from X_2 on treatment with excess dil. $NaOH$ followed by H_2O_2

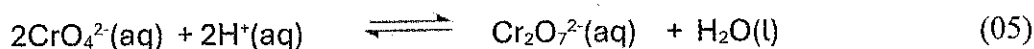


(*If students combine the two equations, (a) and (b), award the 10 marks.)

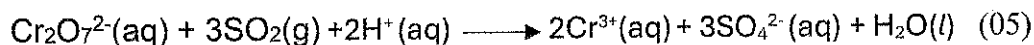


Note: Marks may be awarded for $Cr^{3+}(aq)$ in place of $[Cr(H_2O)_6]^{3+}(aq)$ if equations are balanced correctly.

II. Formation of X_5 from X_4 in acidic medium



III. Reaction of X_5 with $\text{SO}_2(\text{g})$ in acidic medium



(Physical states are not required)

(ii) 20 Marks

(iii) Write the IUPAC name of X_2 .

hexaaquachromium(III) ion

(iii) 04 Marks

7 (b) (47 Marks)

(c) **Y** is also a *d*-block element, which belongs to the fourth period in the Periodic Table. **Y** has two common oxidation numbers, **p** and **q**. **q** is greater than **p**. Y^{p+} forms the dirty-green precipitate Y_1 with dil. NaOH. Y^{q+} forms a yellow/yellow-brown species Y_2 in aqueous solution. On reaction of Y^{q+} with $\text{NH}_4\text{SCN}(\text{aq})$, a red complex Y_3 is formed.

(i) Identify **Y**, Y_1 , Y_2 and Y_3 . (Give chemical formulae). Write the oxidation numbers **p** and **q**. (Reasons are not required.)

Y: Fe (04)

p: $2+ / 2 / +2 / \text{II}$ (03)

q: $3+ / 3 / +3 / \text{III}$ (03)

Y_1 : $\text{Fe}(\text{OH})_2$ (03)

Y_2 : $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ no marks for Fe^{3+} (03)

Y_3 : $[\text{Fe}(\text{SCN})(\text{H}_2\text{O})_5]^{2+}$ (03)*

*Marks may be awarded for $n=1-6$ and appropriate charges
 $[\text{Fe}(\text{SCN})_n(\text{H}_2\text{O})_{6-n}]^{m+}$, no marks if H_2O ligands are not shown.

(i) 19 Marks

(ii) Give the balanced ionic equation for the reaction of Y^{p+} with an acidic solution of MnO_4^- ions.



(ii) 05 Marks

(iii) Write the IUPAC name of Y_2 .

hexaaquairon(III) ion

(iii) 04 Marks

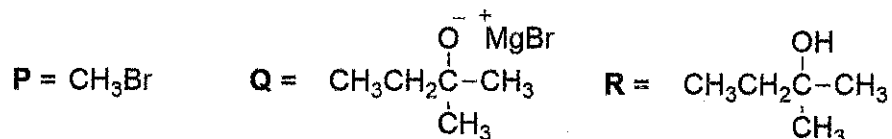
7(c) 28 Marks

8. (a) Identify the reagents **K** and **L**, and the products **P**, **Q** and **R** of the following reaction scheme.



K = PBr_3 or HBr

L = Mg/dry ether

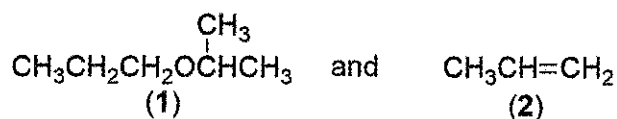


If the word dry is not written in **L** deduct 02 marks

(a) $06 \times 5 = 30$ Marks

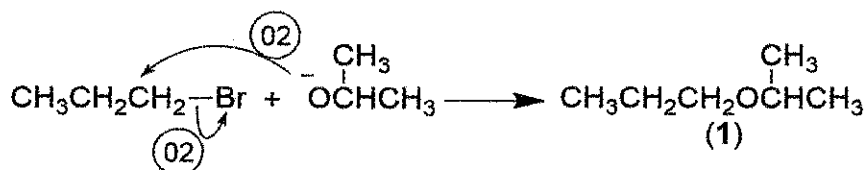
- (b) Two products are obtained from the compound $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$ when it reacts with $\text{CH}_3\overset{\text{CH}_3}{\underset{|}{\text{CHO}}}^-$ ion.

- (i) Draw the structures of these **two** products.

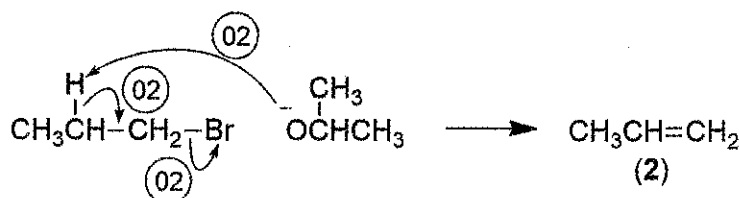


(i) $05 \times 2 = 10$ Marks

- (ii) Write the mechanisms of the reactions giving these **two** products.



04 Marks



06 Marks

(ii) 10 Marks

(iii) Give reasons as to why **both** these mechanisms take place.

(Due to the higher electronegativity of the Br atom relative to the C atom) the C – Br bond is polarized. (02)

As a result, there is an electron deficiency in that C atom. (02)

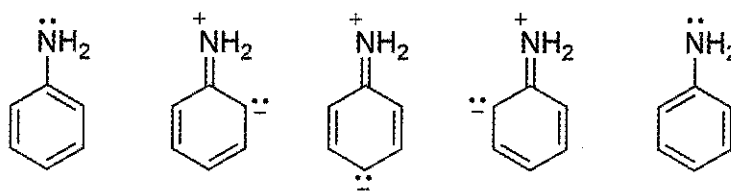
Therefore, the nucleophile $[(\text{CH}_3)_2\text{CH-O}^-]$ attacks on that C atom resulting the product (1) (02)

Due to the polarity of the C – Br bond, the H atoms attached to the adjacent C atom bearing Br atom are slightly acidic. (02)

$(\text{CH}_3)_2\text{CH-O}^-$ ion acts as a base and removes a H atom as H^+ resulting the product(2). (02)

(iii) 10 Marks
8 (b) 30 Marks

(c) (i) Draw the resonance structures of aniline.



(i) (01 × 5 = 05 Marks)

Lone pair is required

(ii) Consider the two compounds aniline and ethylamine. Giving reasons, state which of these two compounds is more basic.

Ethyl amine is more basic than aniline. (06)

In aniline, the lone pair of electrons on the N atom is delocalized on to the benzene ring by resonance. (03)

Therefore, it is not easily available (less available) for the donation to a proton. (03)

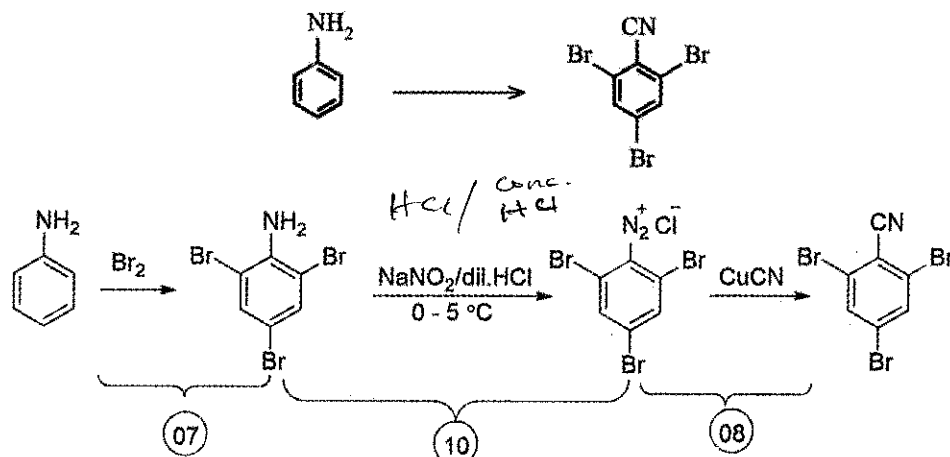
In contrast, the lone pair of electrons on the N atom in ethylamine is not delocalized and therefore is more available for donation to a proton. (03)

(ii) (15 Marks)

8 (c) 20 Marks

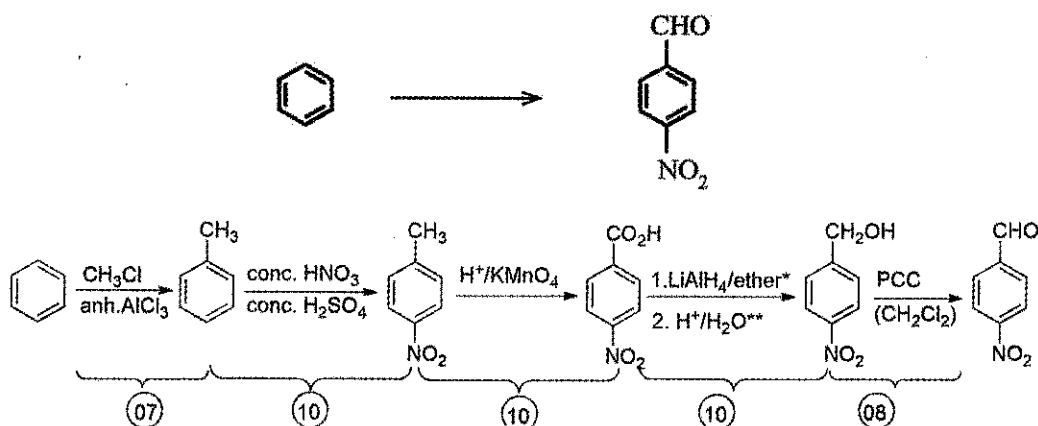
(d) Answer the following parts.

(i) Show how you would carry out the following conversion using not more than **three** steps.



Note: Do not award marks if the number of steps is more than three (i) (25 Marks)

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

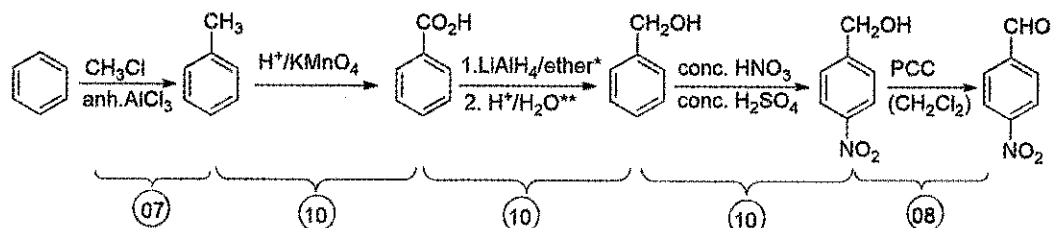


*deduct 02 marks if ether is not given,

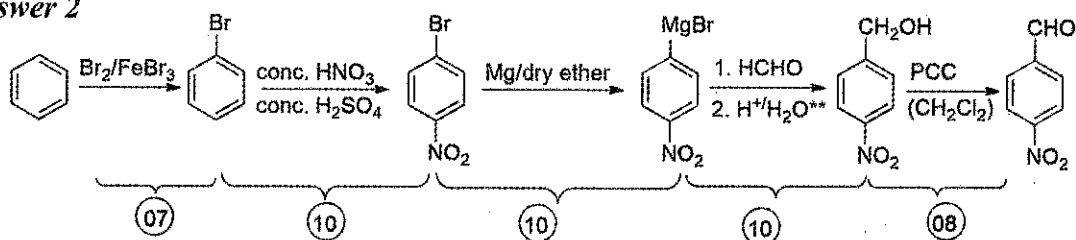
Note: Do not award marks if the number of steps is more than five. (45 Marks)

Alternative marking schemes

Answer 1



Answer 2



8 (d) 70 Marks

9. (a) A, B, C and D are water soluble inorganic compounds. Only two of these compounds contain *d*-block elements. A and B are white solids, while C and D are coloured solids. When aqueous solutions of A and B are mixed together the white precipitate E is formed. E is insoluble in hot water and in dil. HCl. When E is separated by filtration and dil. NaOH is added to the filtrate, the white gelatinous precipitate F is formed. F dissolves in excess dil. NaOH and gives G.

Mixing aqueous solutions of B and C gives the white precipitate H. H, is soluble in hot water. H is separated by filtration and the filtrate is divided into two portions. On addition of dil. NH_4OH to one portion of the filtrate a light-blue precipitate, I is formed. On addition of more dil. NH_4OH to the precipitate I, a deep blue solution J is formed.

To the other portion of the filtrate, when a saturated solution of D is added, followed by the slow addition of conc. H_2SO_4 along the wall of the test tube, a brown ring is formed.

On mixing B and D the white precipitate E is formed.

Identify the compounds A, B, C, D, E, F, G, H, I and J. (Give chemical formulae. Explanations are not required.)

A: $\text{Al}_2(\text{SO}_4)_3$ (08)

B: $\text{Pb}(\text{NO}_3)_2$ (08)

C: CuCl_2 (08)

D: FeSO_4 (08)

E: PbSO_4 (08)

F: $\text{Al}(\text{OH})_3$ (07)

G: NaAlO_2 or $\text{Na}[\text{Al}(\text{OH})_4]$ (07)

H: PbCl_2 (07)

I: $\text{Cu}(\text{OH})_2$ (07)

J: $[\text{Cu}(\text{NH}_3)_4](\text{OH})_2$ or $[\text{Cu}(\text{NH}_3)_4](\text{NO}_3)_2$ or $[\text{Cu}(\text{NH}_3)_4]^{+2} + 2(\text{NO}_3)^- \text{ or } 2\text{OH}^-$ (07)*

(No marks for names and if any part of the formulae are wrong.)

9(a) (75 marks)

*If only $[\text{Cu}(\text{NH}_3)_4]^{+2}$ is given award 04 marks.

- (b) A sample of 5.00 g of white brass [Cu–Zn–Sn alloy] used to make inexpensive jewellery, was dissolved in 10.00 cm^3 of conc. HNO_3 acid and diluted to 1.00 dm^3 in a volumetric flask with water.

The resultant solution X, contains Cu^{2+} , Zn^{2+} and Sn^{2+} as the only metal ions.

(Sn = 118.7, Zn = 65.3, Cu = 63.5, O = 16.0, C = 12.0, H = 1.0)

Experiment A

Upon adding dilute NaOH to 50.00 cm^3 of solution X, a precipitate is formed. On the addition of excess NaOH, part of the precipitate dissolves, resulting in a precipitate having a mass of 0.0925 g.

Note: Consider that Sn^{2+} reacts with dil. NaOH in a manner similar to that of Zn^{2+} .

Experiment B

To 25.00 cm³ portion of solution X, solid Na₂CO₃ was added to reduce the acidity of the medium. Then excess 5% KI solution was added.

Upon adding I⁻, Cu²⁺ reduces to CuI(s), producing I₂. A certain amount of the total I₂ formed is reduced back to I⁻ by Sn²⁺, which completely oxidizes to Sn⁴⁺. The remaining I₂ was titrated with standard 0.05 mol dm⁻³ Na₂S₂O₃ solution using a few drops of starch solution as the indicator. The volume of Na₂S₂O₃ consumed was 8.00 cm³.

Note: Consider that NO₃⁻ ions do not react under the above conditions.

Experiment C

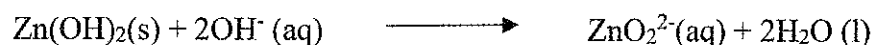
To a 50.00 cm³ portion of solution X, excess saturated Na₂CO₃ was added resulting in a precipitate having a mass of 0.4380 g.

Note: Saturated Na₂CO₃ will precipitate all metal ions except Li⁺, Na⁺ and K⁺.

(i) Write balanced ionic equations for all the reactions relevant to **experiment A**.



Or



Or



(physical states are not required for any of the above equations)

(i) (10 Marks)

(ii) Calculate the percentage of Cu in the solid white brass sample.

Only Cu(OH)₂ is in the precipitate,

$$\text{molar mass of Cu}(\text{OH})_2 = 63.5 + (16 \times 2) + (1 \times 2) = 97.5 \text{ g mol}^{-1} \quad (02)$$

Mass of precipitate from 50.00 cm³ of solution X = 0.0925 g

$$\text{therefore, moles of Cu}(\text{OH})_2 = \text{moles of Cu}^{2+} \text{ in X} = \frac{0.0925 \text{ g}}{97.5 \text{ g mol}^{-1}} = 9.5 \times 10^{-4} \text{ mol} \quad (03)$$

Mass of Cu in alloy sample (since final volume of X is 1.00 L)

$$= \frac{9.5 \times 10^{-4} \text{ mol} \times 1000 \text{ cm}^3 \times 63.5 \text{ g mol}^{-1}}{50.00 \text{ cm}^3} = 1.21 \text{ g} \quad (04)$$

$$\text{Cu\% in alloy sample} = \frac{1.21 \text{ g}}{5.00 \text{ g}} \times 100 = 24.2\% \quad (04)$$

Note *

$$\text{moles of Cu(OH)}_2 = \text{moles of Cu}^{2+} \text{ in X} = \frac{0.0925 \text{ g}}{97.5 \text{ g mol}^{-1}} = 9.5 \times 10^{-4} \text{ mol}$$

(give marks if the value is approximated as $1 \times 10^{-3} \text{ mol}$) (03)

Then the Cu^{2+} moles to 1×10^{-3} the value will be

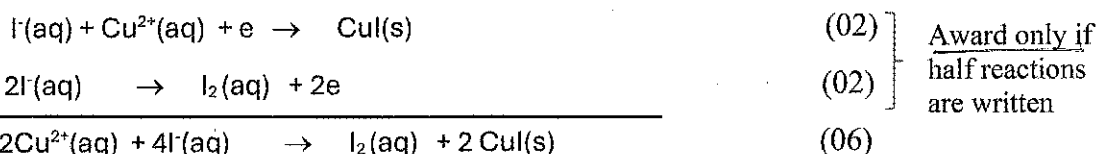
$$= \frac{1.0 \times 10^{-3} \text{ mol} \times 1000 \text{ cm}^3 \times 63.5 \text{ g mol}^{-1}}{50.00 \text{ cm}^3} = 1.27 \text{ g} \quad (04)$$

$$\text{Cu\% in alloy sample} = \frac{1.27 \text{ g}}{5.00 \text{ g}} \times 100 = 25.4\% \quad (04)$$

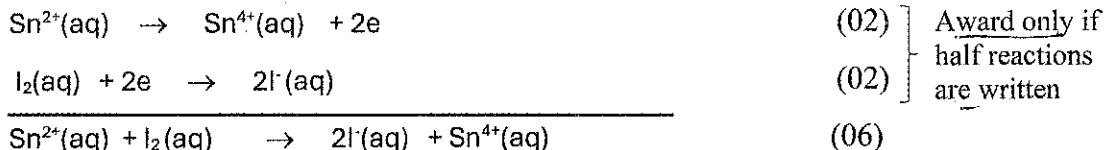
(ii) (13 Marks)

(iii) Write balanced chemical or ionic equations for all the reactions relevant to **experiments B and C**.

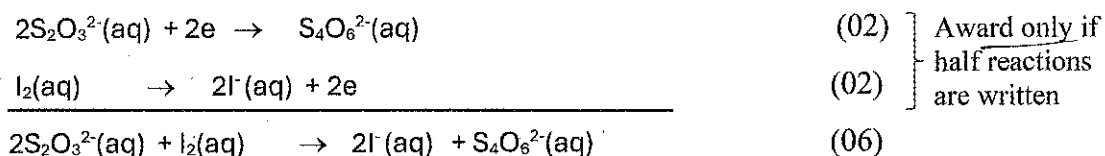
Experiment B

Production of I_2 

Award only if
half reactions
are written

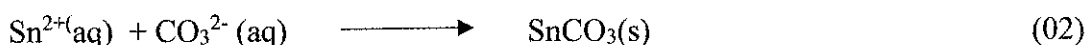
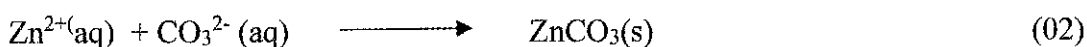
Partial consumption of I_2 

Award only if
half reactions
are written

Excess I_2 determination

Award only if
half reactions
are written

Experiment C



(Physical states are not required for any of the above equations)

(iii) (24 Marks)

(iv) Calculate the mass ratio between Sn and Zn (Sn/Zn) in the white brass sample.

Moles of Cu^{2+} in 25.00 cm^3 of solution X = $9.5 \times 10^{-4}/2$ – from part (ii)

Therefore, I_2 produced = $9.5 \times 10^{-4}/4 \text{ mol}$ (02)

I_2 consumed by Sn^{2+} = moles of Sn^{2+} in 25.00 cm^3 of solution X.

$\therefore \text{I}_2$ produced by Cu^{2+} - I_2 consumed by Sn^{2+} = excess I_2 (02)

2 x excess I_2 moles = $\text{S}_2\text{O}_3^{2-}$ reacted

$$= \frac{0.05 \text{ mol dm}^{-3} \times 8.00 \text{ cm}^3}{1000} = 4.0 \times 10^{-4} \text{ mol} \quad (03)$$

$\therefore$ excess I_2 moles = $4.0 \times 10^{-4}/2 \text{ mol} = 2.0 \times 10^{-4} \text{ mol}$ (02)

Moles of Sn^{2+} in 25.00 cm^3 of solution X = I_2 produced by Cu^{2+} - excess I_2 (in 25.00 cm^3)

$$= 9.50 \times 10^{-4}/4 - 2.0 \times 10^{-4}$$

$$= 2.38 \times 10^{-4} - 2.0 \times 10^{-4} \text{ mol} \quad (03)$$

$$= 0.38 \times 10^{-4} \text{ mol}$$

Mass of Sn in alloy sample = mass of Sn^{2+} in 50.00 cm^3 of solution X

$$= \frac{0.38 \times 10^{-4} \text{ mol} \times 50.00 \text{ cm}^3}{25.00 \text{ cm}^3} \times 118.7 \text{ g mol}^{-1} \quad (03)$$

$$= 0.009 \text{ g}$$

Moles of Cu^{2+} in 25.00 cm^3 of solution X = $1 \times 10^{-3}/2$ – from part (ii)

Therefore, I_2 produced = $1 \times 10^{-3}/4 \text{ mol}$ (02)

I_2 consumed by Sn^{2+} = moles of Sn^{2+} in 25.00 cm^3 of solution X.

$\therefore \text{I}_2$ produced by Cu^{2+} - I_2 consumed by Sn^{2+} = excess I_2 (02)

2 x excess I_2 moles = $\text{S}_2\text{O}_3^{2-}$ reacted

$$= \frac{0.05 \text{ mol dm}^{-3} \times 8.00 \text{ cm}^3}{1000} = 4.0 \times 10^{-4} \text{ mol} \quad (03)$$

$\therefore$ excess I_2 moles = $4.0 \times 10^{-4}/2 \text{ mol} = 2.0 \times 10^{-4} \text{ mol}$ (02)

Moles of Sn^{2+} in 25.00 cm^3 of solution X = I_2 produced by Cu^{2+} - excess I_2 (in 25.00 cm^3)

$$= 1 \times 10^{-3}/4 - 2.0 \times 10^{-4}$$

$$= 2.5 \times 10^{-4} - 2.0 \times 10^{-4} \text{ mol} \quad (03)$$

$$= 0.5 \times 10^{-4} \text{ mol}$$

Mass of Sn in alloy sample = mass of Sn^{2+} in 50.00 cm^3 of solution X

$$= \frac{0.50 \times 10^{-4} \text{ mol} \times 50.00 \text{ cm}^3}{25.00 \text{ cm}^3} \times 118.7 \text{ g mol}^{-1} \quad (03)$$

$$= 0.0119 \text{ g}$$

In experiment C,

Mass of $\text{CuCO}_3 + \text{SnCO}_3 + \text{ZnCO}_3$ (in 50.00 cm^3) = 0.438 g

Molar mass $\text{CuCO}_3 = 63.5 + 12 + 3 \times 16 = 123.5 \text{ g mol}^{-1}$ (01)

$\text{SnCO}_3 = 118.7 + 12 + 3 \times 16 = 178.7 \text{ g mol}^{-1}$ (01)

$\text{ZnCO}_3 = 65.3 + 12 + 3 \times 16 = 125.3 \text{ g mol}^{-1}$ (01)

Moles of CuCO_3 = moles of Cu^{2+} in solution X (in 50.00 cm^3)

From part (ii) = $9.5 \times 10^{-4} \text{ mol}$

$\therefore$ Mass of $\text{CuCO}_3 = 9.5 \times 10^{-4} \text{ mol} \times 123.5 \text{ g mol}^{-1} = 0.117 \text{ g}$ (02)

Moles of SnCO_3 = moles of Sn^{2+} in solution X (in 50.00 cm^3)

From part (iv) = $2 \times [0.38 \times 10^{-4}] \text{ mol}$

$\therefore$ Mass of $\text{SnCO}_3 = 0.76 \times 10^{-4} \text{ mol} \times 178.7 \text{ g mol}^{-1} = 0.0135 \text{ g}$ (02)

Mass of ZnCO_3 (from 50.00 cm^3 of solution X)

= mass of precipitate - mass of CuCO_3 - mass of SnCO_3

= $0.438 \text{ g} - 0.117 \text{ g} - 0.0135 \text{ g}$

= 0.308 g (02)

$\therefore$ Mass of Zn (in 50.00 cm^3 of X)

= $\frac{0.308 \text{ g} \times 65.3 \text{ g mol}^{-1}}{125.3 \text{ g mol}^{-1}} = 0.161 \text{ g}$ (02)

Mass ratio Sn/Zn = $\frac{0.009 \text{ g}}{0.161 \text{ g}} = 0.056$ (02)

Moles of CuCO_3 = moles of Cu^{2+} in solution X (in 50.00 cm^3)

From part (ii) $\sim 1 \times 10^{-3} \text{ mol}$

$\therefore$ Mass of $\text{CuCO}_3 = 1.0 \times 10^{-3} \text{ mol} \times 123.5 \text{ g mol}^{-1} = 0.1235 \text{ g}$ (02)

Moles of SnCO_3 = moles of Sn^{2+} in solution X (in 50.00 cm^3)

From part (iv) = $2 \times [0.5 \times 10^{-4}] \text{ mol}$

$\therefore$ Mass of $\text{SnCO}_3 = 1.0 \times 10^{-4} \text{ mol} \times 178.7 \text{ g mol}^{-1} = 0.0179 \text{ g}$ (02)

Mass of ZnCO_3 (from 50.00 cm^3 of solution X)

= mass of precipitate - mass of CuCO_3 - mass of SnCO_3

= $0.1235 \text{ g} - 0.0179 \text{ g}$

= 0.297 g (02)

$\therefore$ mass of Zn (in 50.00 cm^3 of X)

= $\frac{(0.297) \text{ g} \times 65.3 \text{ g mol}^{-1}}{125.3 \text{ g mol}^{-1}} = 0.155 \text{ g}$ (02)

Mass ratio Sn/Zn = $\frac{0.012 \text{ g}}{0.155 \text{ g}} = 0.077$ (02)

(iv) (28 Marks)

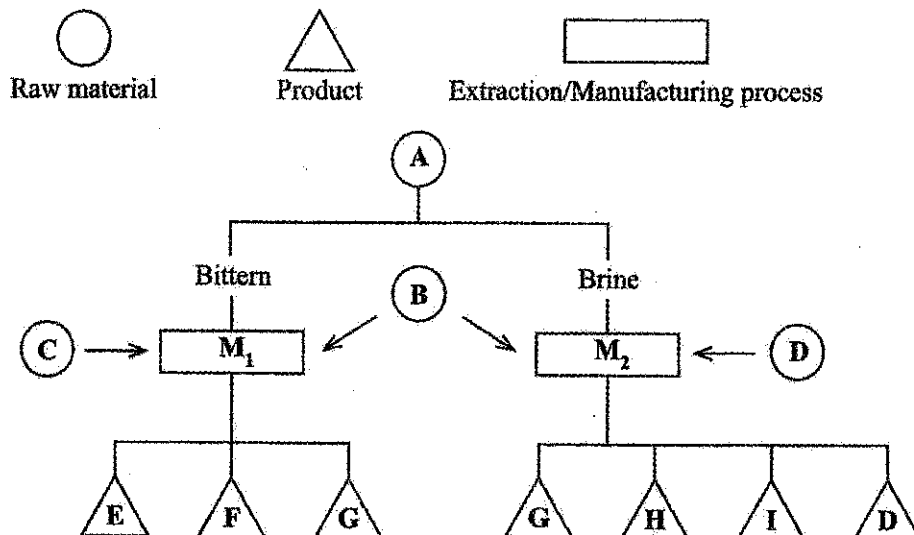
(For the calculation of mass ratio, the students may have used (a) mass of metal in 25.00 cm^3

(b) mass of metals in solid sample or 1 dm^3 of solution X or metal percentages in solid.

However, the calculation steps should be the same.)

9(b) (75 Marks)

- 10.(a) The following flow chart shows the industrial extraction/manufacturing process of an element and a compound. The following symbols are used to represent raw materials, products, and extraction/manufacturing processes.



A and B are naturally occurring while C and D are produced by other industrial processes. C can be regenerated by reacting E with water. D is regenerated in M_2 . H is used to remove hardness of water.

G is a gaseous pollutant, which can be reused in M_2 .

- (i) Write the raw materials A, B, C and D.

A: sea water (04)

B: CaCO_3 / limestone (04)

C: (conc) HCl (04)

D: NH_3 / ammonia (04)

(i) (16 Marks)

- (ii) Name the extraction/manufacturing processes M_1 and M_2 .

M_1 : Mg extraction / Dow Process (04)

M_2 : Na_2CO_3 production / Solvay Process / ammonia soda process (04)

(ii) (08 Marks)

- (iii) Write the products E, F, G, H and I.

E: Cl_2 (04)

F: Mg (04)

G: CO_2 (04)

H: Na_2CO_3 (04)

I: CaCl_2 (04)

(iii) (20 Marks)

(iv) State **two** ways in which the efficiency of the M_2 process can be increased.

- Carrying out ammonification prior to carbonation
- Introducing NH_3 from the bottom of the ammonification tower, in opposite direction to that of brine *
- Maintaining low temperature in the towers
- Introducing CO_2 from bottom of the carbonation tower while brine saturated with ammonia is introduced from the top.*

Any two of the above

(iv) (03x2 = 06)

**Student may state as counter current principle is utilized for gaseous reactants*

(v) State the importance of regenerating **C** and **D**.

Reducing manufacturing cost

Reducing environment pollution

(v) (03x2 = 06)

Note : Award marks if either HCl or NH_3 is identify.

(vi) Give **two** uses each for **D** and **E** (other than what is indicated in the flow chart or given in the question).

Cl_2 : water purification, TiO_2 production

NH_3 : fertilizer production, HNO_3 production, for pH control in water treatment, to prevent coagulation of rubber latex.

(vi) (01x4= 04)

Note : E and **D should be correctly identified to award marks for (iv).**

10(a): 60 Marks

(b) Oxygen is essential for life. Aquatic organisms depend on dissolved oxygen in water. Dissolved oxygen is an important indicator of water quality, commonly measured using the Winkler method. ($H = 1$, $O = 16$, $S = 32$, $I = 127$)

(i) Explain briefly why, oxygen has a poor solubility in water.

Oxygen is a non-polar gas **(03)** and water is a polar solvent **(03)**.

The interaction between oxygen molecules and water molecules is weak **(04)**, so only a small amount of oxygen can dissolve in water.

(i) (10 Marks)

(ii) I. State **two** processes that increase dissolved oxygen in a waterbody.

Two processes that increase dissolved oxygen

(03 x 2)

Dissolution from air

Photosynthesis within the water body

II. State **three** processes that decrease dissolved oxygen in a waterbody.

Three processes that decrease dissolved oxygen

(any, 03 x 3)

Respiration of aquatic animals

Decomposition of organic matter (dead plants and animals)

Consumption of oxygen by organic pollutants and reduced substances

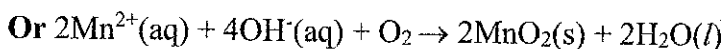
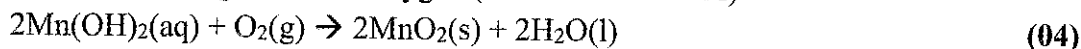
Eutrophication reduces light penetration, reducing photosynthesis

(ii) (15 Marks)

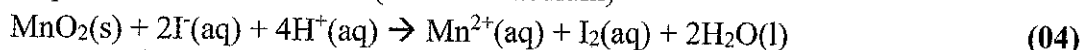
- (iii) In the Winkler method, determination of dissolved oxygen is done in three steps. First, dissolved oxygen is fixed by oxidizing Mn(OH)_2 to MnO_2 . Next, excess KI is added in an acidic medium to reduce MnO_2 to Mn^{2+} liberating iodine. Finally, the released iodine is titrated with a standard thiosulfate solution.

I. Write balanced ionic equations to represent the above three steps in the Winkler method.

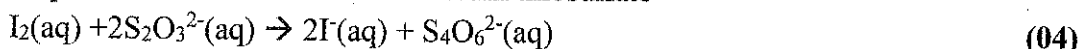
I Step 1: Fixing dissolved oxygen (formation of MnO_2)



Step 2: Liberation of iodine (in acidic medium)



Step 3: Titration of iodine with sodium thiosulfate



Physical states not required.

(12 Marks)

- II. If 12.40 cm^3 of $0.015 \text{ mol dm}^{-3}$ thiosulfate solution was required for the determination of the amount of dissolved oxygen in a 100.00 cm^3 water sample, calculate the amount of dissolved oxygen in water in mg dm^{-3} .

$$\text{Thiosulphate used} = 0.015 \text{ mol S}_2\text{O}_3^{2-} \text{ dm}^{-3} \times 0.01240 \text{ dm}^3 = 1.86 \times 10^{-4} \text{ mol S}_2\text{O}_3^{2-} \quad (03)$$

$$\text{I}_2 \text{ produced} = 1.86 \times 10^{-4} \text{ mol S}_2\text{O}_3^{2-} \times (1 \text{ mol I}_2 / 2 \text{ mol S}_2\text{O}_3^{2-}) = 9.3 \times 10^{-5} \text{ mol I}_2 \quad (03)$$

$$\text{O}_2 \text{ present} = 9.3 \times 10^{-5} \text{ mol I}_2 \times (1 \text{ mol O}_2 / 2 \text{ mol I}_2) = 4.65 \times 10^{-5} \text{ mol O}_2 \quad (03)$$

$$\text{DO concentration} = 4.65 \times 10^{-5} \text{ mol O}_2 / 0.100 \text{ dm}^3 = 4.65 \times 10^{-4} \text{ mol dm}^{-3}$$

$$= 4.65 \times 10^{-4} \text{ mol dm}^{-3} \times 32 \text{ g / 1 mol O}_2 = 1.49 \times 10^{-2} \text{ g dm}^{-3}$$

$$= 1.49 \times 10^{-2} \text{ g dm}^{-3} \times (1000 \text{ mg/g}) = 14.9 \text{ mg dm}^{-3} \quad (04)$$

(13 Marks)

(iii) (25 Marks)

10 (b) 50 Marks

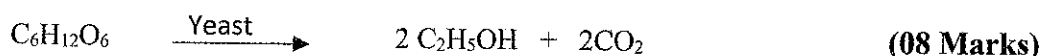
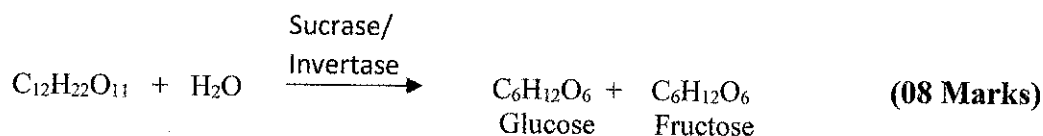
- (c) The questions given below are related to the process of manufacturing coconut toddy from sweet toddy.

- (i) Write the main compound produced by the fermentation of sweet toddy.

Ethanol

(i) (08 Marks)

- (ii) Write balanced chemical equations to show the chemical changes that take place in sweet toddy during the formation of the main compound you stated in (i) above.



(ii) (16 Marks)

- (iii) Name the method used to separate the main compound given by you in (i) above, from coconut toddy.

Fractional Distillation

(iii) (06 Marks)

- (iv) State why the method named in (iii) above is used to separate the main compound.

This technique is used to separate components, which are miscible and have different boiling points. The boiling points of ethanol and water are different from each other.

Note: All 4 points must be written to award the 10 marks

(iv) (10 Marks)

10 (c) 40 Marks
