

**G.C.E. (A/L) Examination
2008 August
Chemistry I / Two hours**

Important :

- * This paper consists of 10 pages (Periodic Table is also provided)
 - * Answer all the questions.
 - * Use of calculators is not allowed.
 - * Write your Index Number in the space provided in the answer sheet.
 - * Instructions are given on the back of the answer sheet. Follow those carefully.
 - * In each of the questions 1 to 60, pick one of the alternatives, from (1), (2), (3), (4), (5) which is correct or most appropriate and mark your response on the answer sheet with a cross (x) on the number of the correct option in accordance with the instructions given on the back of the answer sheet.

Universal gas constant. $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$
 Avogadro Constant $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

- Which period in the periodic table contains the highest number of non-metallic elements?
 (1) 1 (2) 2 (3) 3 (4) 4 (5) 5
 - Of the molecules/ions given below, which one has a shape different from the shape of the others?
 (1) SO_4^{2-} (2) $\text{S}_2\text{O}_3^{2-}$ (3) PCl_4^+
 (4) NH_4^+ (5) SF_4
 - A gas **not** likely to be present in the emission of an automobile engine is
 (1) CO_2 (2) SO_2 (3) H_2S
 (4) NO (5) CO
 - $\text{MSO}_x \cdot x\text{H}_2\text{O}$ has 36% of H_2O by mass. The value of x is
 ($H = 1.0, O = 16.0, S = 32.0, M = 64.0$)
 (1) 3 (2) 4 (3) 5 (4) 6 (5) 7
 - Which one of the following does not react with sodium metal?
 (1) $\text{CH}_3-\text{C} \equiv \text{CH}$ (2) $\text{HC} \equiv \text{CH}$ (3) $\text{CH}_3\text{CH}_2\text{OH}$
 (4) CH_3CHO (5) $\text{C}_6\text{H}_5\text{OH}$
 - The oxidation states of the $\text{S}_{(1)}$ and $\text{S}_{(2)}$ atoms in the following molecule are respectively,

$$\begin{array}{c} \text{F} \\ | \\ \text{F}-\text{S}_{(1)}-\text{S}_{(2)}-\text{F} \\ | \\ \text{F} \end{array}$$

 (1) +1 and +3 (2) +4 and +2 (3) +3 and +1
 (4) -3 and -1 (5) +2 and +2
 - The following equilibrium occurs between A(g) and B(g)

$$\text{A(g)} \rightleftharpoons x\text{B(g)}$$

 When 3 moles of A(g) are placed initially in an evacuated container, an equimolar mixture of A and B is formed at equilibrium. The value of x is
 (1) 1 (2) 2 (3) 3 (4) 4 (5) 5
 - The partition coefficient of compound A between CHCl_3 and water is 9 with A more soluble in CHCl_3 . 100 cm^3 of an aqueous solution of A initially contains 2.00 g of A. The total mass of A extracted into CHCl_3 , when the solution of A is extracted twice with two, 100 cm^3 portions of CHCl_3 , is
 (1) 1.80g (2) 0.198g (3) 1.89g
 (4) 1.09g (5) 1.98g

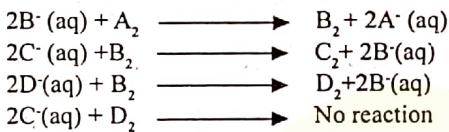
20. The correct **decreasing** order of the radii of the ions S^{2-} , Cl^- , K^+ and Ca^{2+} is

(1) $S^{2-} > Cl^- > K^+ > Ca^{2+}$ (2) $Cl^- > S^{2-} > K^+ > Ca^{2+}$
 (3) $S^{2-} > Cl^- > Ca^{2+} > K^+$ (4) $Ca^{2+} > K^+ > S^{2-} > Cl^-$
 (5) $K^+ > Ca^{2+} > Cl^- > S^{2-}$

21. A metal M was converted to its sulphate $M_2(SO_4)_3$. A solution of this sulphate was treated with $Pb(NO_3)_2$ to give $PbSO_4$. If 1.04 g of M gave 9.09 g (dry mass) of $PbSO_4$, the metal M is (Al=27.0, Cr=52.0, Fe=55.8, Co=58.9 Ga=69.7, $PbSO_4$ =303.0)

(1) Al (2) Cr (3) Fe (4) Co (5) Ga

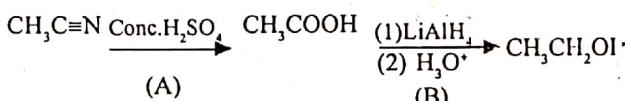
22. A,B,C and D are non-metallic elements.



The correct **increasing** order of the oxidizing ability of these elements is

- | | |
|---|--|
| (1) A < B < C < D
(3) D < C < B < A
(5) A < B < D < C | (2) B < A < C < D
(4) A < C < D < B |
|---|--|

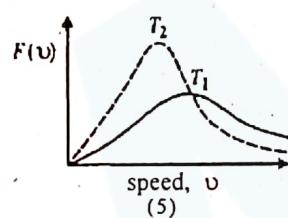
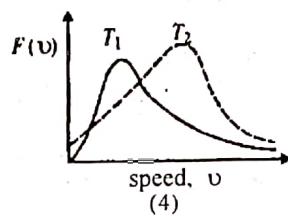
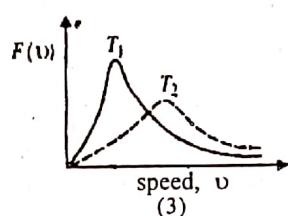
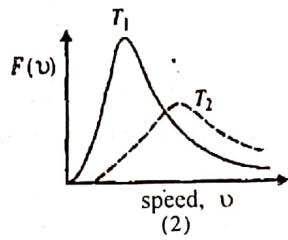
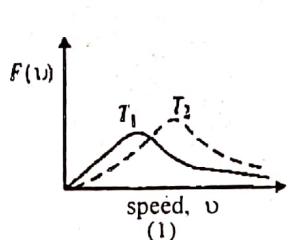
24. Consider the following reaction scheme,



Reaction steps (A) and (B) are respectively,

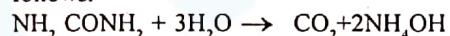
- (1) Oxidation and reduction.
 (2) Oxidation and oxidation.
 (3) Oxidation and hydrolysis.
 (4) hydrolysis and reduction.
 (5) reduction and reduction.

25. The distributions of molecular speeds are shown below for a gas at two temperatures T_1 and T_2 with $T_2 > T_1$. Which of the graphs 1-5 shows the most likely variations of the molecular speeds at T_1 and T_2 ?
 $[F(v) = \text{fraction of molecules with speed, } v]$



26. The salt X evolves a gas when warmed with dil. H_2SO_4 . An aqueous solution of X gives a white precipitate with $Ba(NO_3)_2$ which is soluble in dil. HNO_3 . However, when X is treated with H_2O_2 and $Ba(NO_3)_2$ added thereafter to the solution, a white precipitate insoluble in dil. HNO_3 is formed. The anion in salt X is

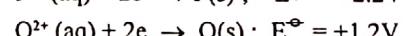
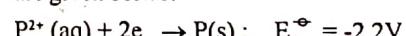
27. A solution of urea (NH_2CONH_2) is decomposed on heating as follows.



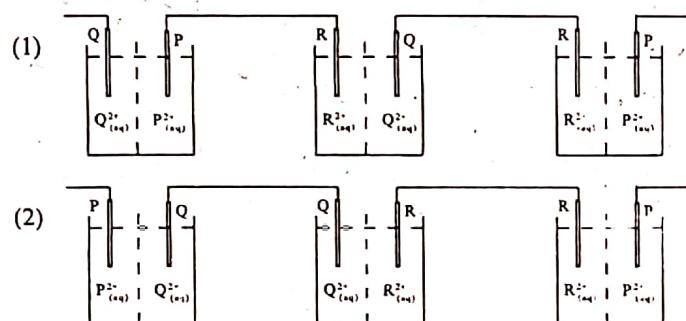
The mass of urea required to precipitate Al present in 100.0 cm^3 of 0.20 mol dm^{-3} $\text{Al}(\text{NO}_3)_3$ solution is
 $(\text{H} = 1.0, \text{C} = 12.0, \text{N} = 14.0, \text{O} = 16.0)$

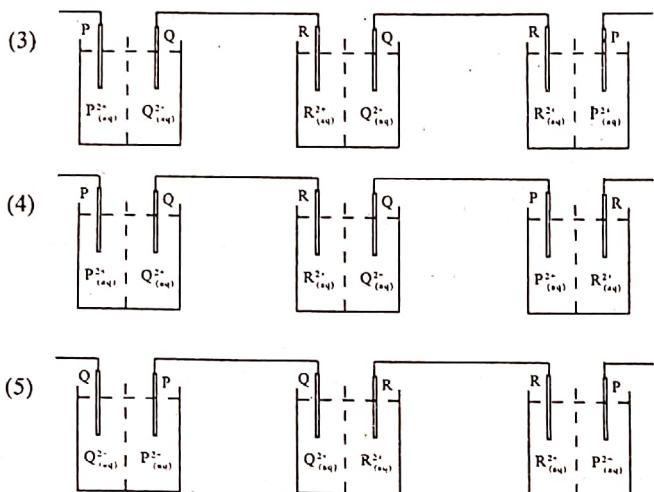
- (1) 1.80g (2) 0.90g (3) 2.70g
 (4) 3.60g (5) 1.20g

28. Standard electrode potentials for the metals P, Q and R at 25°C are given below.



Which combination of the three electrochemical cells given below constructed using half cells of P,Q and R metals at their standard states produce an electromotive force of 8.0 V?





29. The IUPAC name of $[\text{Fe}(\text{H}_2\text{O})_5\text{OH}]^{2+}$ is

- Hydroxopentaquairon (III) ion
- Pentaaquahydroxyliron (III) ion
- Pentaaquahydroxoferrous (II) ion
- Hydroxopentaquairon (II) ion
- Pentaaquahydroxoiron (III) ion

30. CO_2 was passed through 25.00 cm^3 of a 0.10 mol dm^{-3} NaOH solution until 50% of NaOH was converted to Na_2CO_3 . This solution was titrated with 0.10 mol dm^{-3} HCl solution using phenolphthalein as the indicator.

The end-point of the titration would be,

- 18.75 cm^3
- 20.00 cm^3
- 37.50 cm^3
- 25.00 cm^3
- 12.50 cm^3

31. $m_1 \text{ g}$ of NaCl and $m_2 \text{ g}$ MgCl_2 were dissolved in water add diluted upto 1.00 dm^3 . 25.00 cm^3 of this solution was treated with excess AgNO_3 solution. The mass of AgCl precipitate obtained was $m_3 \text{ g}$.

(Relative molar mass : $\text{NaCl} = M_1$, $\text{MgCl}_2 = M_2$, $\text{AgCl} = M_3$)

Which of the following expressions is correct?

$$(1) m_3 = \frac{m_1}{M_1} + \frac{2m_2}{M_2} \times M_3$$

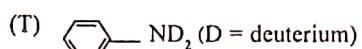
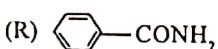
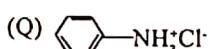
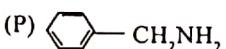
$$(2) m_3 = \left(\frac{m_1}{M_1} + \frac{2m_2}{M_2} \right) \times M_3$$

$$(3) m_3 = \frac{25}{1000} \times \left(\frac{m_1}{M_1} + \frac{m_2}{M_2} \right) \times M_3$$

$$(4) m_3 = \frac{1}{1000} \times \left(\frac{m_1}{M_1} + \frac{m_2}{M_2} \right) \times M_3$$

$$(5) m_3 = \frac{25}{1000} \left(\frac{m_1}{M_1} + \frac{2m_2}{M_2} \right) \times M_3$$

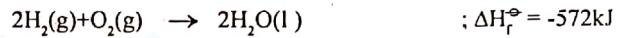
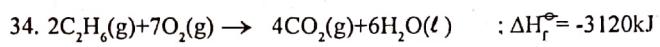
32. Which of the following compounds P,Q,R, S and T will form a diazonium salt when treated with dil. HCl and NaNO_2 at 5°C ?



- P and Q
- Q and R
- R and T
- Q and T
- S and T

33. Which of the following statements is incorrect?

- Fractional distillation is used in refining petroleum.
- Raoult's law can be used to explain the process of fractional distillation.
- Steam distillation is used to extract citronella oil.
- Raoult's law can be used to explain the process of steam distillation.
- A binary mixture of pure liquids A and B shows a negative deviation from Raoult's law when the strength of molecular interactions $A, A < A, B > B, B$

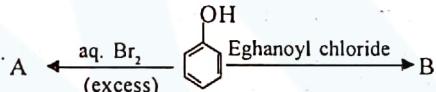


The standard enthalpy change ΔH_f^\ominus for the reaction,
 $2\text{C}(\text{s}) + 3\text{H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_6(\text{g})$

Calculated using the data given above is

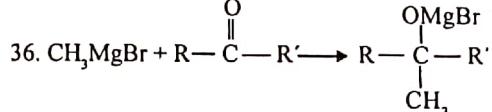
- +25 kJ
- 58 kJ
- +86 kJ
- 86 kJ
- 52 kJ

35. Consider the following reactions of phenol,



The structures of A and B respectively are,

- | | |
|----------------|----------------|
| (1)
and
 | (2)
and
 |
| (3)
and
 | (4)
and
 |
| (5)
and
 | |



The rate of the above reaction under identical conditions follows the order, (Ph stands for C_6H_5)

- $\text{R} = \text{R}' = \text{Ph} > \text{R} = \text{R}' = \text{CH}_3 > \text{R} = \text{R}' = \text{H}$
- $\text{R} = \text{CH}_3, \text{R}' = \text{Ph} > \text{R} = \text{H}, \text{R}' = \text{CH}_3 > \text{R} = \text{R}' = \text{H}$
- $\text{R} = \text{R}' = \text{CH}_3 > \text{R} = \text{H}, \text{R}' = \text{CH}_3 > \text{R} = \text{CH}_3, \text{R}' = \text{Ph}$
- $\text{R} = \text{H}, \text{R}' = \text{CH}_3 > \text{R} = \text{R}' = \text{H} > \text{R} = \text{R}' = \text{CH}_3$
- $\text{R} = \text{R}' = \text{H} > \text{R} = \text{R}' = \text{CH}_3 > \text{R} = \text{R}' = \text{Ph}$

37. Which of the following statements is not true?
- Polluted water contains a lower amount of dissolved O₂ than pure water.
 - Bleaching powder is manufactured by passing Cl₂ into slaked lime.
 - Calcium carbide is manufactured by heating Ca metal with coke.
 - Natural rubber is cis-poly (isoprene).
 - (NH₄)₂SO₄ can be made by reacting an aqueous solution of (NH₄)₂CO₃ with CaSO₄.
38. Which of the following statements are true regarding hydrocarbons?
- All the carbon atoms in a hydrocarbon molecule may be sp³ hybridised.
 - The number of sp² hybridised carbon atoms, if any, should be even.
 - The number of sp hybridised carbon atoms, if any, should be odd.
 - They may be solids, liquids or gases at room temperature.
- (A), (B) and (D)
 - (A), (B) and (C)
 - (B) and (C)
 - (A), (B), (C) and (D)
 - (C) and (D)
39. Consider the following tests,
- Addition of FeCl₃ to a solution of salicylic acid.
 - Addition of Conc. HCl to a CoCl₂ solution.
 - Addition of KI to a Pb(NO₃)₂ solution.
 - Addition of ethanol to acidified K₂Cr₂O₇.
- The colours of solutions/ precipitates obtained in A, B, C and D are respectively.
- purple, blue, yellow, green
 - green, yellow, blue, purple
 - blue, yellow, purple, green
 - purple, blue, yellow, orange
 - green, blue, yellow, green
40. The molar concentration of an ammonium molybdate (NH₄)₂MoO₄, solution which contains 48 ppm of Mo is (1 ppm = 1 mg dm⁻³, Mo = 96)
- 2.5 × 10⁻⁵ mol dm⁻³
 - 7.5 × 10⁻⁵ mol dm⁻³
 - 5.0 × 10⁻³ mol dm⁻³
 - 2.5 × 10⁻⁴ mol dm⁻³
 - 5.0 × 10⁻³ mol dm⁻³
- Instructions for questions No. 41 to 50 :
- For each of the questions 41 to 50, four responses (a), (b), (c) and (d) are given; out of which, one or more of these is/ are correct. Select the correct response/responses. In accordance with the instructions given on your answer sheet, mark.
- if only (a) and (b) are correct.
 - if only (b) and (c) are correct.
 - if only (c) and (d) are correct.
 - if only (d) and (a) are correct.
 - if any other number or combination of responses is/are correct.

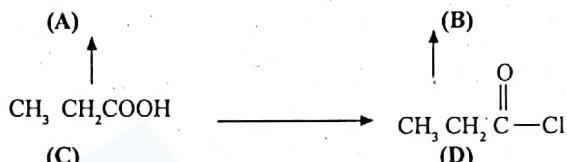
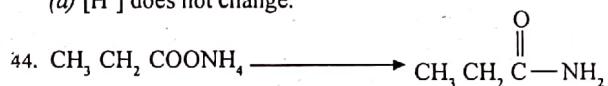
Summary of above Instructions

(1)	(2)	(3)	(4)	(5)
Only (a) and (b) correct.	Only (b) and (c) correct.	Only (c) and (d) correct.	Only (d) and (a) correct.	Any other number or combination of responses correct.

41. An element shows the stable oxidation states +3, +5 and +7. The other stable oxidation state/states shown by this element is/are
- +1
 - +2
 - +6
 - 1

42. Which of the following is not a green-house gas/are not green-house gases?
- CH₄
 - CO₂
 - O₂
 - N₂

43. Which of the following statements is/are true in relation to addition of some amount of CaCl₂(s) to a saturated aqueous solution of Ca(OH)₂?
- [OH⁻] does not change.
 - Some amount of Ca(OH)₂ is precipitated.
 - [Ca²⁺] will increase.
 - [H⁺] does not change.



Which of the following statements is/are true regarding the reaction scheme given above?

- The same reagent can be used to convert C to A as well as D to B.
- Heating A produces NH₃ and C as main products.
- C is a stronger acid than CH₃COOH.
- D forms CH₃CH₂CO⁺AlCl₄⁻ with AlCl₃

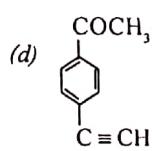
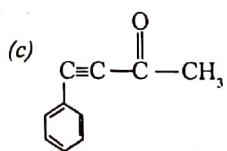
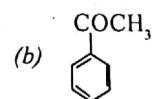
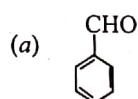
45. Which of the following reacts/react with atmospheric oxygen?

- aqueous LiI solution
- Mn(OH)₂ suspension in water.
- aqueous Ca(OH)₂ solution
- Cr(OH)₂ suspension in water

46. Which of the following statements is/are true regarding Al(OH)₃ and Zn(OH)₂? Both of them are,

- soluble in excess of aqueous NH₄OH solution.
- insoluble in excess of aqueous NH₄OH solution.
- precipitated by adding NH₄Cl and NH₄OH to a solution containing Al³⁺ and Zn²⁺ ions.
- amphoteric

47. Which of the following compounds react/reacts separately with (i) ammoniacal AgNO₃ and (ii) 2,4 - diritrophenylhydrazine



48. Which of the following statements is/are true regarding Le Chatelier's principle?

- It can be applied to any homogeneous equilibrium system.
- It can be used to explain the dependence of rate on concentration of chemical reactions.
- It does not provide correct information on equilibrium reactions involving gas evolution.
- It can be applied to explain the effect of the addition of an inert gas on a gas phase equilibrium system.

49. Which of the following pairs of lines has(have) a difference(s) between them which is equal to that between the 3rd (H_3) and 4th (H_4) lines of the Lyman series of the atomic spectrum of hydrogen?

- (a) 3rd and 4th lines of Balmer series
- (b) 1st and 2nd lines of Paschen series
- (c) 2nd and 3rd lines of Balmer series
- (d) 3rd and 4th lines of Paschen series

50. Which of the following statements is/are true about the compound ?

- (a) When reduced with NaBH_4 the product molecules formed are optically active.
- (b) When brominated in the presence of Fe ,  is formed.
- (c) When reduced with $\text{Zn}(\text{Hg})$ and Conc. HCl, the product molecules formed are optically active.
- (d) On oxidation with KMnO_4 ,  can be formed.

• Instructions for questions No. 51 to 60.

In questions No. 51 to 60, two statements are given in respect of each question.

From the Table given below, select the response out of the responses (1), (2), (3), (4) and (5) that best fits the two statements given for each of the questions and mark appropriately on your answer sheet.

Response	First Statement	Second Statement
(1)	True	True, and correctly explains the first statement.
(2)	True	True, but does not explain the first statement correctly.
(3)	True	False
(4)	False	True
(5)	False	False

56	Solubility of gases in water increases with decreasing temperature.	Dissolution of gases in water is an exothermic process.
57.	When the temperature is increased the equilibrium of an endothermic reaction shifts in the forward direction forming more products.	For an endothermic reaction the activation energy of the forward reaction is higher than that for the reverse reaction.
58.	Zn^{2+} and Mn^{2+} are not precipitated as sulphides when H_2S is passed into a solution of these ions, acidified with dil HCl.	ZnS and MnS are soluble in dil. HCl.
59.	The compressibility factor, $Z = (pV/nRT)$ approaches unity at very low pressures for real gases.	Intermolecular forces do not affect the behaviour of gas molecules at very low pressures.
60.	Electrons behave sometimes as particles and some times as waves.	Electrons have both particle and wave properties.

	First Statement	Second Statement
51.	I_2 is more soluble in aqueous KI than in pure water.	KI reduces the polarity of water making non-polar I_2 more soluble.
52.	When a reversible reaction is at equilibrium, the rate of the forward reaction is equal to the rate of the reverse reaction.	At equilibrium, the activation energy of the forward reaction is equal to the activation energy of the reverse reaction.
53.	SO_2 , when used as a bleaching agent, acts as an oxidising agent.	Bleaching action is generally an oxidation process.
54.	$\text{CH}_3\text{CH}_2\text{COCl}$ gives a white precipitate of AgCl with aqueous AgNO_3 .	Organic compounds with ionic chlorine give a white precipitate of AgCl with aqueous AgNO_3 .
55.	Silica (SiO_2) has a very high melting point.	Si-O bonds are strong covalent bonds.

**G.C.E. (A/L) Examination
2008 August
Chemistry II / Three hours**

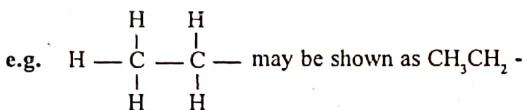
- Periodic Table is provided on page 8.
- Use of calculators is not allowed.

PART A - Structured Essay (Pages 2-7)

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

N.B : INSTRUCTION BOX

- In answering questions 3 and 4, you may represent alkyl groups in a condensed manner.



PART B and PART C - Essay (pages 9-12)

Answer four questions selecting not more than two questions from each part. Use the paper supplied for this purpose.

At the end of the time allotted for this paper, tie the answers to three parts A, B and C together so that Part A is on top and hand them over to the Supervisor.

You are permitted to remove only Parts B and C of the question paper from the Examination Hall.

$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$
$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

PART A - STRUCTURED ESSAY

Answer all four questions. Each question carries 10 marks.

- I (a) The 3d transition element M shows the highest oxidation state of +7.
- Identify M
 - Write the complete electronic configuration of M.
 - Give the chemical formula and the colour of the most stable oxide of M.
- (2.2 marks)

- (b) Fill in the blanks in the following table selecting the most appropriate words/ phrases from only those given below the table under categories A,B, C and D for the respective columns.

Material	A Type of material	B Particles occupying lattice positions	C Interactions between particles	D Electrical properties
Diamond				
KF (s)				
Ice				
Li(s)				

A : Ionic lattice, giant covalent lattice, metallic lattice, molecular lattice, amorphous material

B : Atoms, positive ions, negative ions, positive ions and negative ions, molecules electrons

C : Covalent bonds, van der waals interactions, hydrogen bonds, metallic bonds, electrostatic interactions

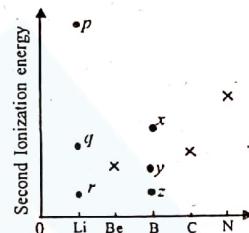
D : Conductor, nonconductor, electrolyte

(4.8 marks)

(c) the points corresponding to the second ionization energy of Be, C and N are shown by x in the figure given below.

(i) Select the most appropriate point corresponding to the second ionization energy of Li out of the points p, q and r, and mark it with a circle (◎)

(ii) Select the most appropriate point corresponding to the second ionization energy of B out of the points x,y and z and mark it with a square (◻)



(3.0 marks)

2. (a) A sample of Na_2SO_4 is contaminated with some NaCl . The following procedure was used to determine the percentage of NaCl in the sample.

1.000 g of the sample was dissolved in water in a 250 cm^3 volumetric flask and diluted upto the mark to form the solution A.

The following solutions (1) - (5) were prepared by diluting a $4.0 \times 10^{-4} \text{ mol dm}^{-3} \text{ Cl}^-$ ion solution.

(1) (2) (3) (4) (5)

$4.0 \times 10^{-4} \text{ mol dm}^{-3} \text{ Cl}^-$ ion solution/cm³ 1.00 2.00 3.00 4.00 5.00

Distilled water/cm³ 9.00 8.00 7.00 6.00 5.00

Into each of the solutions (1)-(5), 1.00 cm³ of dil. HNO_3 and 1.00 cm³ of AgNO_3 were added. Similarly into 10.00 cm³ of solution A, 1.00 cm³ dil. HNO_3 and 1.00 cm³ AgNO_3 were added.

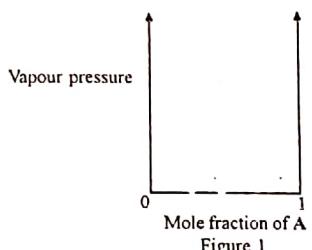
It was observed that the turbidity produced by solution A was equal to that of solution (3).

Calculate the mass percentage of NaCl in the sample of Na_2SO_4 . ($\text{Na} = 23.0$, $\text{Cl} = 35.5$)

(5.0 marks)

- (b) A and B are pure liquids miscible in all proportions forming ideal solutions at temperature T. The boiling point of A is higher than that of B. Mark/draw the following in Figure 1.

- P_A^0 and P_B^0 : Relative points representing vapour pressures of pure A and Pure B respectively.
- P_A : Line/curve showing the variation of the vapour pressure of A with composition.
- P_B : Line/curve showing the variation of the vapour pressure of B with composition.
- P_T : Line/curve showing the variation of the total vapour pressure with composition.



(v) Show that for an equimolar solution of A and B in equilibrium with its vapour, the mole fraction of A in the vapour phase is,

$$\frac{P_A^0}{P_A^0 + P_B^0}$$

(vi) Draw the temperature - composition phase diagram for the solutions of A and B in Figure 2. Mark in your diagram,

- I. the boiling point, T_A^0 , of pure A.
- II. the boiling point, T_B^0 , of pure B and
- III. the regions where the following phases exist.

liquid, vapour and liquid + vapour together.

(5.0 marks)

3. Complete the following synthesis, schemes A and B selecting reagents and solvents only from those given with each scheme.
 * Write the structure of appropriate compounds in the boxes and the reagents / solvents in the circles.

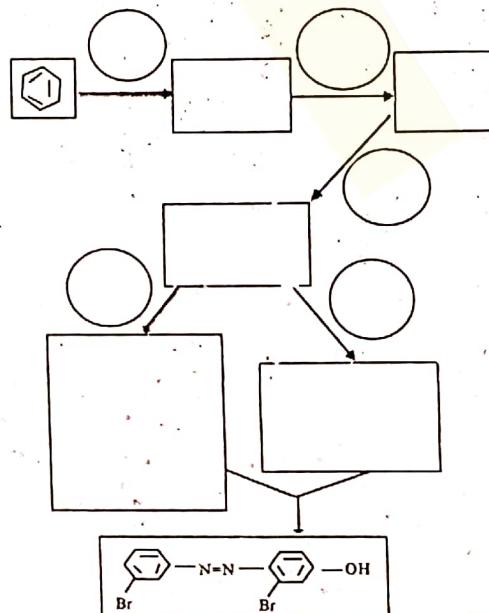
* Indicate temperature where important.

(j) Scheme A:

Reagents and solvents:

dil HCl, conc.HCl, conc.H₂SO₄, conc.HNO₃

aq. NaOH, NaNO₂, CuBr, Br₂, FeBr₃, Fe, PBr₃, LiAlH₄, Sn

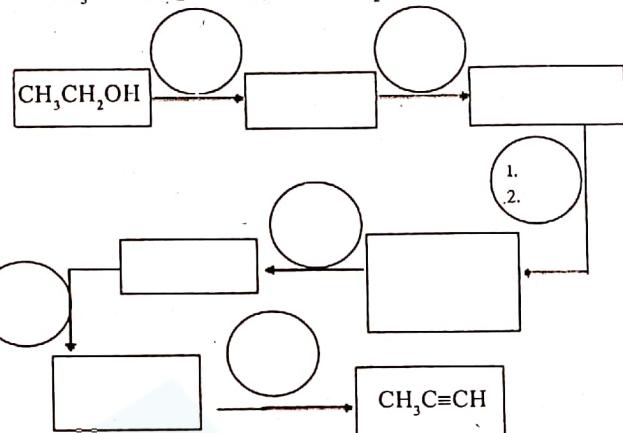


(5.0 marks)

(ii) Scheme B:

Reagents and solvents:

conc. H_2SO_4 , Br_2 , FeBr_3 , PBr_3 , HCHO , alcoholic KOH, CH_3CHO , Mg , Fe , dry ether, H_2O



(5.0 marks)

4 (a) Cinnamaldehyde is the main constituent of cinnamon oil. It has the following structure.
 $\text{C}_6\text{H}_5\text{-CH=CH CHO}$
(i) Suggest a test, to show that cinnamaldehyde contains a double bond. Give the expected observation/s.

Test **Observation/s**

(ii) Cinnamaldehyde is reacted with LiAlH_4 and reaction mixture is treated with dil. acid.

I. Draw the structure of the final organic product obtained.

II. Name the type of reaction occurring between Cinnamaldehyde and LiAlH₄.

(iii) Cinnamaldehyde reacts with isopropyl magnesium bromide, $(\text{CH}_3)_2\text{CHMgBr}$

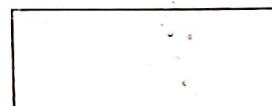
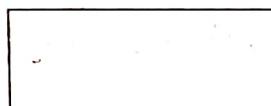
I. Give the name of a solvent used on this reaction.

II. Why is it important to keep the solvent dry?

III Write the structural formula of the product obtained when cinnamaldehyde is reacted with $(CH_3)_2CHMgBr$ and the intermediate hydrolysed.

IV. Recall the condensation reaction that occurs between two molecules of CH_3CHO in the presence of aqueous NaOH .

Write the structures of the two molecules that would undergo a similar reaction under the same conditions forming cinnamaldehyde.



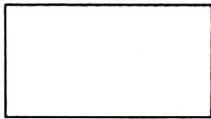
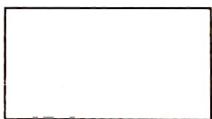
(5.0 marks)

- (b) The two compounds A and B have the same molecular formula C_3H_6O . Both A and B react with Brady's reagent giving orange coloured precipitates.

A reacts with HCN forming a single product C.

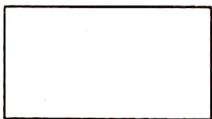
B reacts with HCN forming a mixture of two stereo-isomers D and E.

- (i) Write the structures of A, B, C, D and E in the appropriate boxes.



A

B



C

D

E

- (ii) State the specific type of isomerism shown by D and E.

.....

- (iii) State a physical property that can be used to distinguish between D and E?

.....

- (iv) What difference is shown by D and E in respect of the physical property given by you in (iii) above?

.....

(5.0 marks)

PART B - ESSAY

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

$$R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$$

$$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

- 5 (a) NH_4SH undergoes decomposition at 27°C as follows :



The equilibrium constant, K_c , for this reaction at 27°C is $1.44 \times 10^2 \text{ mol}^2 \text{ m}^{-6}$

- (i) Calculate the equilibrium constant, K_p , for the above reaction at 27°C .

Note : • Derivation of the relevant equations is not necessary.
• Assume that $\text{NH}_3(\text{g})$ and $\text{H}_2\text{S}(\text{g})$ behave ideally.
• At 27°C , $RT = 2.5 \text{ kJ mol}^{-1}$

- (ii) Calculate the minimum mass of NH_4SH that must be placed in an evacuated vessel of volume $1.0 \times 10^{-2} \text{ m}^3$ to attain the state of equilibrium at 27°C .

(The relative molecular mass of $\text{NH}_4\text{SH} = 51$)

(7.5 marks)

- (b) Using the descriptions provided for solutions A to G, answer the questions (i) - (vi)

Solution

Description

- A Freshly distilled water in a stoppered bottle.
- B An aqueous solution of 0.20 mol dm^{-3} HCl.
- C An aqueous solution of 0.10 mol dm^{-3} CH_3COOH .
- D An aqueous solution of 0.01 mol dm^{-3} CH_3COOH .
- E An aqueous solution which is 0.10 mol dm^{-3} in CH_3COOH and 0.10 mol dm^{-3} in CH_3COONa .
- F An aqueous solution which is 0.10 mol dm^{-3} in CH_3COOH and 0.05 mol dm^{-3} in CH_3COONa .
- G An aqueous solution which is $C_1 \text{ mol dm}^{-3}$ in CH_3COOH (dissociation constant K_1) and $C_2 \text{ mol dm}^{-3}$ in HCOOH dissociation constant K_2 .

- (i) Arrange solutions A to E in the order of increasing their pH. No explanation is necessary.

- (ii) Solution E was diluted 10 times. Would the pH change? Explain your answer in brief.

- (iii) Which of the solutions E or F would resist more to a change in pH upon addition of a small quantity of an HCl acid solution? Explain your answer in brief.

- (iv) Solution I was prepared by mixing 50.0 cm^3 of B and 50.0 cm^3 of C. What is the pH of I? State assumptions, if any, you used in this estimation.

- (v) What change in pH would you expect when A is exposed to air? Explain your answer in brief.

- (vi) Derive an expression for the total H^+ ion concentration of solution G in terms of the initial concentrations (C_1 , C_2) and the acid dissociation constants (K_1 , K_2) of acetic acid and formic acid respectively.

(7.5 marks)

6. (a) Calculate the lattice energy of $\text{CaBr}_2(\text{s})$ by constructing an appropriate enthalpy level diagram. Necessary thermochemical data are given below. (Physical states of all chemical species must be given for full marks)

Enthalpy of evaporation of $\text{Br}_2(\text{l})$	= 31 kJ mol ⁻¹
Bond dissociation enthalpy of $\text{Br}_2(\text{g})$	= 193 kJ mol ⁻¹
Electron affinity of $\text{Br}(\text{g})$	= -331 kJ mol ⁻¹
Enthalpy of atomization of $\text{Ca}(\text{s})$	= 177 kJ mol ⁻¹
Sum of first and second ionization energies of $\text{Ca}(\text{g})$	= 1740 kJ mol ⁻¹
Enthalpy of formation of $\text{CaBr}_2(\text{s})$	= -683 kJ mol ⁻¹

(6.0 marks)

- (b) A 20.0 g sample of dry clay was thoroughly stirred with 100.0 cm³ of 0.100 mol dm⁻³ KNO_3 solution, and the resulting clay suspension was allowed to settle. The supernatant solution was then separated, and to 50.0 cm³ of this solution, 100.0 cm³ of 0.0500 mol dm⁻³ ammonium oxalate solution was added. The resulting solution was filtered, and the precipitate was dried and weighed. The mass of the dry precipitate was 256 mg.

- (i) Calculate the concentration of Ca^{2+} in this filtrate.
(ii) Calculate the quantity of Ca in the clay sample in mg/kg. State assumptions, if any, you used in these calculations.
 $(C = 12, O = 16.0, \text{Ca} = 40.0)$
Solubility product of calcium oxalate (CaC_2O_4) at the relevant temperature = 2.30×10^{-9} mol² dm⁻⁶

(9.0 marks)

- 7 (a) Few drops of phenolphthalein were added to a freshly prepared aqueous solution of 0.10 mol dm⁻³ KI. This solution was well stirred, and thereafter, it was electrolysed using carbon electrodes for a specific period of time. The current passed through the solution was kept constant.

- (i) What was the colour of the solution before electrolysis?
(ii) Write the balanced chemical equations for
I. the anode reaction
II. the cathode reaction, and
III. the cell reaction
(iii) Indicate the colour changes that would occur around the electrodes with the start of electrolysis.
(iv) Propose a method to determine the fraction of I^- ions left at the end of electrolysis. (No experimental details necessary)
(v) Would the fraction of remaining I^- be different from the value in (iv) if 0.50 mol dm⁻³ KI was used instead of 0.10 mol dm⁻³ KI? Briefly explain your answer.

- (vi) In a separate experiment, a solution of CuSO_4 was electrolysed using carbon electrodes. What changes would you observe,
I. On the electrodes
II. in solution?
Write down the relevant electrode reactions.

(9.0 marks)

- (b) (i) "The order of a particular reactant appearing in the rate expression of a given chemical reaction may not necessarily be the same as the stoichiometric coefficient of that reactant in the balanced chemical equation." Clarify this statement in brief.

- (ii) FeCl_3 is reduced by SnCl_2 according to the following reaction.



A 50.0 cm³ sample of 0.0360 mol dm⁻³ FeCl_3 solution was mixed with a SnCl_2 solution of the concentration and of the same volume. It was found that, after 4.00 minutes, 24% of the initial quantity of Fe(III) had been converted to Fe(II). Calculate

- I. the rate of reduction of Fe (III).
II. the rate of oxidation of Sn (II).

(6.0 marks)

PART C - ESSAY

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

- 8 (a) X_2Y and YZ_2 are two gases formed by the element Y. Y is a solid at room temperature where as X_2Y and YZ_2 are gases

- (A) X_2Y and YZ_2 dissolve in water giving acidic solutions.
(B) The oxidation state of Y in X_2Y is -2 and in YZ_2 it is +4.
(C) X_2Y and YZ_2 (moist) react together forming Y and H_2O .
(D) When X_2Y is passed into an acidified CuSO_4 solution, a black precipitate is formed.
(E) When YZ_2 is passed into an acidified CuSO_4 solution, the solution turns colourless.

- (i) Identify the gases X_2Y and YZ_2 .
(ii) Write balanced chemical equations for reactions occurring in (C), (D) and (E).
(iii) Give two industrial uses of the gas YZ_2 .
(iv) Describe briefly a chemical method to identify each of these gases when present as a mixture.
Give the relevant balanced chemical equations.

(9.0 marks)

- (b) A solution B contains $\text{C}_2\text{O}_4^{2-}$ and CO_3^{2-} ions. A 25.00 cm³ portion of this solution was treated with excess $\text{Ca}(\text{NO}_3)_2$ solution to completely precipitate $\text{C}_2\text{O}_4^{2-}$ and CO_3^{2-} ions. The precipitate so obtained after drying had a mass of 0.820 g. This precipitate was then dissolved in dil. H_2SO_4 and titrated with 0.05 mol dm⁻³ KMnO_4 solution. The titration required 20.00 cm³ of the KMnO_4 solution.

Calculate the concentrations of $\text{C}_2\text{O}_4^{2-}$ and CO_3^{2-} ions in the solution B.

$(\text{Ca} = 40, \text{O} = 16.0, \text{C} = 12.0)$

(6.0 marks)

9. (a) (i) The density of an aqueous solution prepared using pure Na_2CO_3 was found to be 1.0212 g cm⁻³. Calculate the concentration of this solution. Assume that the density of water at the very same temperature is 1.000 g cm⁻³ and that there is no change in volume during the dissolution of Na_2CO_3 .

- (ii) With the solution in (i) above (in the burette) 25.00 cm³ aliquots of a H_2SO_4 solution were titrated using phenolphthalein as the indicator. The average of three appropriate end points obtained was 12.50 cm³.

Calculate the concentration of the H_2SO_4 solution.

(iii) Would it be possible to carry out the above titration in the same way using methyl orange as the indicator?
If yes, what is the end-point you expect? If no, give reasons.
(Na = 23.0, C = 12.0, O = 16.0)

(6.0 marks)

(b) The 3d transition element M reacts with dil. H_2SO_4 forming a pale green solution. On addition of NH_4OH this solution gives a light green precipitate. This precipitate turns yellow-brown with time when kept exposed to air.

- Identify M.
- What are the most common (positive) oxidation states of M?
- Give one test to distinguish between the oxidation states given in (ii).
- Outline a method to determine quantitatively the concentrations of M in each of the oxidation states given in (ii) when present together in a sample.
- Identify the species responsible for the light green and the yellow-brown precipitates mentioned above.
- Give one instance where M is used as a catalyst in chemical industry.
- Give the chemical formulae and the names of two ores used for the extraction of M.

(9.0 marks)

- 10 (a) (i) I. What is meant by the temporary hardness of water?
II. What chemical species are responsible for the temporary hardness?
III. Give two domestic problems caused by the temporary hardness.
IV. Give two methods by which temporary hardness can be removed. Write chemical equations where appropriate.
- (ii) Briefly explain the variation of the acids strength of the following.
 $HClO$, $HClO_2$, $HClO_3$, $HClO_4$

(7.0 marks)

(b) Ostwald process is used for the manufacture of HNO_3 acid.

- What are the starting materials used in this process?
- State the sources/ methods of obtaining these starting materials.
- Give the chemical steps involved in the Ostwald process together with balanced chemical equations and the necessary conditions (temperature, pressure, catalyst)
- In the manufacture of HNO_3 , rather than oxidizing $N_2(g)$ directly to $NO(g)$, It is first reduced and the product obtained then oxidized.

Explain the reason for this briefly using the thermochemical data given below.

Values of standard enthalpy of formation, (ΔH_f), of $NO(g)$, $NH_3(g)$ and $H_2O(g)$ are respectively +90 kJ mol⁻¹, -46 kJ mol⁻¹ and -242 kJ mol⁻¹.

(8.0 marks)

1	1 H	The Periodic Table												2 He				
2	3 Li	4 Be																
3	11 Na	12 Mg																
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	La-Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	Ac-Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub	113 Uut				

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

**G.C.E. (A/L) Examination
Chemistry - 2008**

M.C.Q. Answers

- | | | | |
|-----------|----------|------------|----------|
| (1) - 2 | (16) - 1 | (31) - 5 | (46) - 5 |
| (2) - 5 | (17) - 2 | (32) - 4 | (47) - 4 |
| (3) - 3 | (18) - 2 | (33) - 4 | (48) - 4 |
| (4) - 3 | (19) - 4 | (34) - all | (49) - 2 |
| (5) - 4 | (20) - 1 | (35) - 5 | (50) - 1 |
| (6) - 3 | (21) - 2 | (36) - 5 | (51) - 3 |
| (7) - all | (22) - 3 | (37) - 3 | (52) - 3 |
| (8) - 5 | (23) - 5 | (38) - 1 | (53) - 5 |
| (9) - 3 | (24) - 4 | (39) - 1 | (54) - 2 |
| (10) - 4 | (25) - 3 | (40) - 5 | (55) - 2 |
| (11) - 4 | (26) - 3 | (41) - 4 | (56) - 1 |
| (12) - 5 | (27) - 1 | (42) - 3 | (57) - 2 |
| (13) - 2 | (28) - 3 | (43) - 2 | (58) - 2 |
| (14) - 1 | (29) - 5 | (44) - 4 | (59) - 1 |
| (15) - 5 | (30) - 1 | (45) - 1 | (60) - 4 |

PART A - STRUCTURED ESSAY

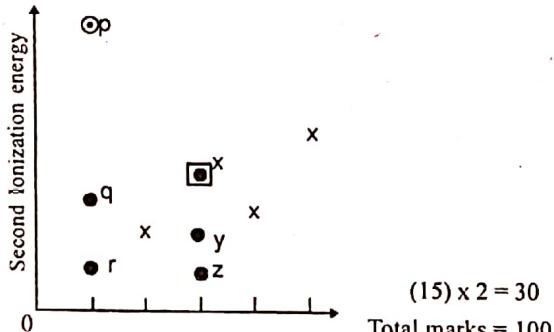
Answer all four questions. Each question carries 10 marks

1. (a)
- Mn / Manganese (10)
 - $1s^2 2S^2 2P^6 3S^2 3p^6 4S^2 3d^5$ or..... $3d^5 4S^2$ (6)
 - MnO_2 Black (or Brown) (3+3)
- 22 marks

(b)

Material	A Type of Material	B Particles Occupying Lattice Positions	C Interactions between particles	D Electrical properties
Diamond	Giant covalent lattice	atoms	covalent bonds	non-conduct
KF (s)	Ionic lattice	+8 - ions	Electrostatic	non-conduct
Ice	Molecular Lattice	molecules	H bonds	non-conduct
Li(s)	Metallic Lattice	+ive ions	metallic bonds	Conductor

(c) (3) x 16 = 48



2 (a) Concentration of Cl^- in solution No. 3

$$= \frac{4.0 \times 10^{-4}}{10} \times 3 \text{ mol dm}^{-3} \quad (13+2)$$

$$= 1.2 \times 10^{-4} \text{ mol dm}^{-3}$$

$$\text{Molar mass of NaCl} = 23.0 + 35.5 \text{ g mol}^{-1}$$

$$= 58.5 \text{ g mol}^{-1} \quad (3+2)$$

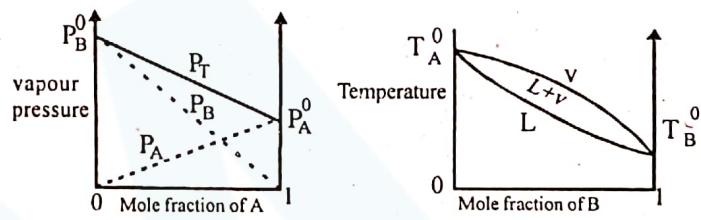
$$\therefore \text{The mass of NaCl in } 1.0 \text{ dm}^3 \text{ of solution} \\ = 1.2 \times 10^{-4} \times 58.5 \text{ g} \quad (8+2)$$

$$\text{The mass of sample in } 1.0 \text{ dm}^3 = 4.00 \text{ g} \quad (3+2)$$

$$\% \text{ of NaCl in the sample} = \frac{1.2 \times 10^{-4} \times 58.5 \text{ g} \times 100}{4.00 \text{ g}} \quad (8+2)$$

$$= 0.1755 \quad (5)$$

Part (a) = 50 marks



Labelling $02 \times 10 = (20)$
3 lines + 2 curves

$3 \times 5 = 15$

(b) (v) $P_x = P_x^0 \times X_{(\text{soln})}$ (2)

$P_{\text{Total}} = P_A + P_B$ (2)

$P_A = P_A^0 \times 0.5$ (2)

$0.5P_A^0 + 0.5P_B^0$ (2)

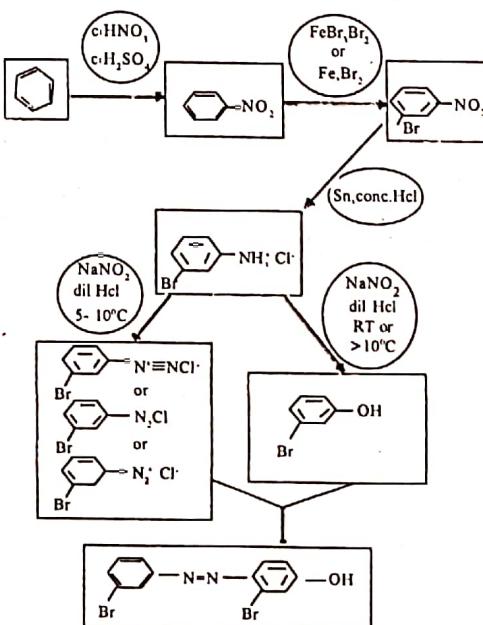
$P_B = P_B^0 \times 0.5$ (2)

$$X_A(\text{vapour}) = \frac{P_A}{P_{\text{Total}}} = \frac{0.5P_A^0}{0.5(P_A^0 + P_B^0)} = \frac{P_A^0}{P_A^0 + P_B^0} \quad (2) \quad (3)$$

(vi) 50 marks for all candidates

Total marks (100)

3. (i) Scheme A



(5) x 10 = 50

- (b) (i) $B < C < D < E < A$ (10) (No part marks)
- (ii) No (3)
- Ratio of the concentrations of CH_3COO^- and CH_3COOH does not change with dilution (3)
 $\therefore \text{pH is not changed.}$
- (iii) E (3)
- Concentration of CH_3COO^- in E > Concentration of CH_3COO^- in F (3)
- (iv) Presence of CH_3COOH does not affect the amount of H^+ formed from HCl (or The $[\text{H}^+]$ due to CH_3COOH is negligible compared to that due to HCl) (4)
- Concentration of $\text{H}^+ = \frac{50.0\text{cm}^3 \times 0.20 \text{ mol dm}^{-3}}{100.0\text{cm}^3}$ (3+2)
 $= 0.10 \text{ mol dm}^{-3}$
 $\text{pH} = -\log(0.10)$ (3)
 $= 1.0$ (2)
- (v) pH decreases (3)
Dissolution of atmospheric CO_2 decreases the pH of water. (3)
- (vi) $\text{CH}_3\text{COOH}(\text{aq}) \rightleftharpoons \text{CH}_3\text{COO}^-(\text{aq}) + \text{H}^+(\text{aq})$ (2+1)
 $\text{HCOOH}(\text{aq}) \rightleftharpoons \text{HCOO}^-(\text{aq}) + \text{H}^+(\text{aq})$ (2+1)
 $\text{H}^+(\text{aq})$ is the total $[\text{H}^+]$ at equilibrium in the mixture. (3)
- $[\text{CH}_3\text{COO}^-]_{(\text{aq})} + [\text{HCOO}^-]_{(\text{aq})} = [\text{H}^+]_{(\text{aq})}$ (2+1)
 $K_1 = [\text{CH}_3\text{COO}^-]_{(\text{aq})} [\text{H}^+]_{(\text{aq})} / [\text{CH}_3\text{COOH}]_{(\text{aq})}$ (2+1)
 $\therefore [\text{CH}_3\text{COO}^-]_{(\text{aq})} = K_1 [\text{CH}_3\text{COOH}]_{(\text{aq})} / [\text{H}^+]_{(\text{aq})} \quad \textcircled{A}$
 $K_2 = [\text{HCOO}^-]_{(\text{aq})} [\text{H}^+]_{(\text{aq})} / [\text{HCOOH}]_{(\text{aq})}$ (2+1)
 $\therefore [\text{HCOO}^-]_{(\text{aq})} = K_2 [\text{HCOOH}]_{(\text{aq})} / [\text{H}^+]_{(\text{aq})} \quad \textcircled{B}$
- $\textcircled{A} + \textcircled{B}$ $[\text{H}^+]_{(\text{aq})} = K_1 [\text{CH}_3\text{COOH}]_{(\text{aq})} / [\text{H}^+]_{(\text{aq})} + K_2 [\text{HCOOH}]_{(\text{aq})} / [\text{H}^+]_{(\text{aq})}$ (2+1)

Multiplying by $[\text{H}^+]_{(\text{aq})}$

$$[\text{H}^+]_{(\text{aq})}^2 = K_1 [\text{CH}_3\text{COOH}]_{(\text{aq})} + K_2 [\text{HCOOH}]_{(\text{aq})}$$
 (2+1)

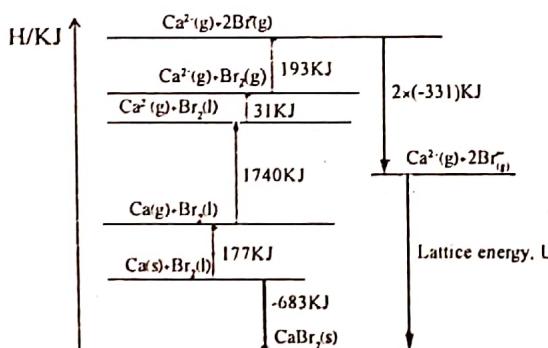
$$[\text{H}^+]_{(\text{aq})} = \sqrt{K_1 [\text{CH}_3\text{COOH}]_{(\text{aq})} + K_2 [\text{HCOOH}]_{(\text{aq})}}$$
 (2+1)

Assuming that the dissociation of these acids occurs only to a small extent (3)

$$[\text{H}^+] = \sqrt{K_1 C_1 + K_2 C_2}$$
 (3)

5 (b) = 75 marks

6. (a) Enthalpy level diagram of $\text{CaBr}_2(\text{s})$



7 steps x (2+2+2) marks

Note : 2 for substances with correct physical states.
2 for correct arrows and 2 for values or symbols of corresponding enthalpy.
06 marks for either H/kJ in the y-axis or H in the y-axis with unit kJ in all places. Units in kJ mol^{-1} may be acceptable if the process involves 1 mol of the substance of interest.

$$177\text{KJ} + 1740\text{KJ} + 31\text{KJ} + 193\text{KJ} + 2x(-331\text{KJ}) + U = -683\text{KJ} \quad (4+2)$$

$$U = -2162 \text{ KJ}$$

Lattice energy of $\text{CaBr}_2(\text{s}) = -2162 \text{ KJ mol}^{-1}$ (4+2)

6 (a) = 60 marks

(b) (i) Molar mass of $\text{CaC}_2\text{O}_4 = (40 + 2 \times 12 + 4 \times 16) \text{ g mol}^{-1} = 128 \text{ g mol}^{-1}$ (3+2)

Mass of $\text{CaC}_2\text{O}_4 = 256 \text{ mg}$
Amount of $\text{CaC}_2\text{O}_4 = \frac{0.256}{128 \text{ g mol}^{-1}} = 0.0020 \text{ mol}$ (3+2)

Amount of CaC_2O_4 in ammonium oxalate solution
 $= 0.100 \text{ dm}^3 \times 0.0500 \text{ mol dm}^{-3}$ (3+2)
 $= 0.0050 \text{ mol}$

Amount of CaC_2O_4 in solution (filterate)
 $= 0.0050 - 0.0020 \text{ mol}$
 $= 0.0030 \text{ mol}$ (3+2)

Concentration of $\text{C}_2\text{O}_4^{2-} = 0.0030 \text{ mol} / 0.150 \text{ dm}^3 = 0.0200 \text{ mol dm}^{-3}$ (3+2)

$\text{CaC}_2\text{O}_4(\text{s}) \rightleftharpoons \text{Ca}^{2+}(\text{aq}) + \text{C}_2\text{O}_4^{2-}(\text{aq})$ (3+2)

Initially $0.0200 \text{ mol dm}^{-3}$
At equilibrium S $0.0200 \text{ mol dm}^{-3}$ (3+2)

$K_{sp} = [\text{Ca}^{2+}(\text{aq})][\text{C}_2\text{O}_4^{2-}(\text{aq})]$ (5)
 $= (s)(0.0200) \text{ mol}^2 \text{ dm}^{-6}$ (3+2)

Assumption : All Ca^{2+} in the clay is exchange by K^+ (5)
 $S(0.0200) \text{ mol}^2 \text{ dm}^{-6} = 2.3 \times 10^{-9} \text{ mol}^2 \text{ dm}^{-6}$ (3+2)
 $S = 1.15 \times 10^{-7}$

Concentration of Ca^{2+} in the filterate = $1.15 \times 10^{-7} \text{ mol dm}^{-3}$ (3+2)

(i) Quantity of Ca in clay

$$= 0.002 \text{ mol } \text{CaC}_2\text{O}_4 \times \frac{1 \text{ mol Ca}}{1 \text{ mol } \text{CaC}_2\text{O}_4} \times \frac{40 \text{ g ca}}{1 \text{ mol ca}} \times \frac{1000 \text{ mg}}{1 \text{ g}} \times \frac{1}{0.020 \text{ kg}} \times \frac{100 \text{ cm}^3}{50 \text{ cm}^3}$$

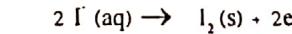
$$(3+2) \quad (3+2) \quad (3+2) \quad (3+2) \quad (3+2)$$

$$= 8000 \text{ mg / kg}$$
 (3+2)

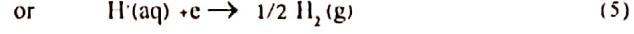
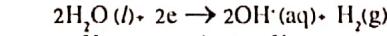
6 (b) = 90 marks

7. (a) (i) Initial colour of solution . Clourless (5)

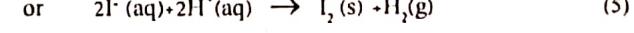
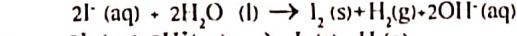
(ii) I. Anode half - reaction



II. Cathode half - reaction



II. Cell reaction



(iii) Colour changes : Near anode : Light yellow/ brown solution/ brown deposit on electrode (5)
Near cathode : Solution turning pink (5)

- (iv) Remove the electrodes, extract dissolved iodine or determine the amount of dissolved iodine using thiosulphate, add excess of an oxidizing agent ($K_2Cr_2O_7$, K_2CrO_4 , Fe^{3+} etc) (5) and titrate liberated I_2 with $S_2O_3^{2-}$ (5). If the volume of the solution used for electrolysis is known, the fraction of I^- remaining can be calculated. (5)
- OR

If the current passed and the duration are measured (5), the amount of I_2 liberated can be calculated (5) and if the volume of the solution used for electrolysis is known the fraction of I^- remaining can be determined. (5)

- (v) yes. (different) (5)

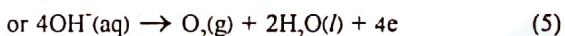
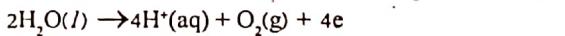
Since the amount of electricity passed is the same (5), the same amount of I_2 is liberated (5).

But since the initial amount of I^- is larger when 0.5 mol dm^{-3} KI is used (5), the fraction remaining will be different.

- (vi) i. On cathode : Deposition of Cu (5)



On anode : Evolution of gas bubbles (O_2) (5)



- ii. In solution :

The blue colour of the solution decreases (5)

7. (b) (i) For an elementary (single step) reaction, the rate expression contains concentration terms of reactants raised to their stoichiometric numbers. (10) Many chemical reactions are non-elementary and may take place via several elementary steps (in their mechanisms). The rate of overall reaction is determined by the rate of the slowest (rate-determining) elementary step. (10) Substances in the rate-determining step may not have the same stoichiometric numbers as those appearing in the overall reaction. (10)

(ii) Initial concentration of Fe (III) = $\frac{0.0360\text{ mol dm}^{-3}}{2}$ (4+2)

$$\text{Change in [Fe (III)] in 4 minutes} = \frac{0.0360\text{ mol dm}^{-3} \times 24}{2 \times 100} \quad (4+2)$$

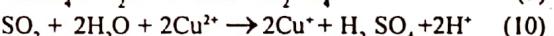
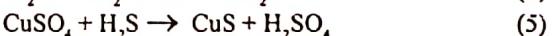
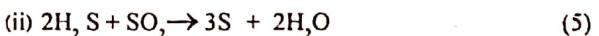
$$\text{The average rate of reduction of Fe (III)} = \frac{0.0360\text{ mol dm}^{-3} \times 24}{2 \times 100} \times \frac{1}{4\text{ min}} = 0.00108\text{ mol dm}^{-3}\text{min}^{-1} \quad (4+2)$$

Since 2 mol of Fe (III) react with 1 mol of Sn (II) the rate of oxidation of Sn(II) is half that of reduction of Fe(III) (6)

$$\text{Rate of oxidation of Sn(II)} = \frac{0.00108\text{ mol dm}^{-3}\text{min}^{-1}}{2} = 0.00054\text{ mol dm}^{-3}\text{min}^{-1} \quad (4+2)$$

7 (b) for 60 marks

8. (a) (i) $X_2 Y = H_2S$ and $YZ_2 = SO_2$ (20+20)



- (iii) Industrial uses of SO_2
For bleaching, manufacture of H_2SO_4
As a preservative
(any two industrial uses) (5+5)

- (iv) H_2S and SO_2
Pass the gases through a metal ion solution (Ni^{2+} , Cr^{3+} , Hg^{2+} , Pb^{2+} , Ag^+ , Cd^{2+} etc)
Which can be precipitated as the sulphide and which does not with SO_2 (5)
 SO_2 which comes out can be tested with acidified dichromate which turns green (5)
- $$M^{2+} + H_2S \rightarrow MS \downarrow + 2H^+ \quad (5)$$
- $$Cr_2O_7^{2-} + 3SO_2 + 8H^+ \rightarrow 2Cr^{3+} + 3SO_3 + 4H_2O \quad (5)$$

Total marks 8 (a) = 90

8. (b) $C_2O_4^{2-} \rightarrow 2CO_2 + 2e \quad (3)$

$$MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O \quad (3)$$

$$5C_2O_4^{2-} \equiv 2MnO_4^- \quad (4)$$

$$\text{Amount of } MnO_4^- \text{ reacted with } C_2O_4^{2-}$$

$$= \frac{0.05 \times 20.00}{1000} = 1.0 \times 10^{-3} \text{ mol} \quad (5)$$

$$\text{Amount of } C_2O_4^{2-} \text{ in the precipitate}$$

$$= \frac{1.0 \times 10^{-3} \times 5}{2} = 2.5 \times 10^{-3} \text{ mol} \quad (5)$$

$$\therefore \text{The conc. of } C_2O_4^{2-} \text{ in solution B}$$

$$= \frac{2.5 \times 10^{-3} \times 1000}{25.00} = 0.10 \text{ mol dm}^{-3} \quad (3+2)$$

The relative formula unit mass of CaC_2O_4 = 128

$$\text{The mass of } CaC_2O_4 \text{ in the precipitate}$$

$$= 2.50 \times 10^{-3} \text{ mol} \times 128 \text{ g mol}^{-1} = 0.320 \text{ g} \quad (5)$$

$$\therefore \text{The mass of } CaCO_3 \text{ in the ppt.}$$

$$= (0.820 - 0.320) \text{ g} = 0.500 \text{ g} \quad (5)$$

The relative formula unit mass of $CaCO_3$ = 100

$$\text{The number of mol of } CaCO_3 = \frac{0.500}{100} = 5 \times 10^{-3} \text{ mol} \quad (5)$$

$$\therefore \text{Number of moles of } CO_3^{2-} \text{ in } 25.00 \text{ cm}^3 \text{ of solution B}$$

$$= 5 \times 10^{-3} \text{ mol} \quad (5)$$

$$\therefore \text{The conc. of } CO_3^{2-} \text{ in solution B}$$

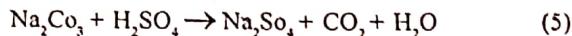
$$= \frac{5.0 \times 10^{-3} \times 1000}{25} = 0.2 \text{ mol dm}^{-3} \quad (3+2)$$

Total marks for 8 (b) = 60

9. (a) (i) Mass of Na_2CO_3 in 1.00 cm^3 of solution
- $$= 1.0212\text{ g} - 1.000\text{ g}$$
- $$= 0.0212 \text{ g} \quad (5)$$
- Mass of Na_2CO_3 in 1.000 dm^3 of solution
- $$= 0.0212 \text{ g} \times 1000$$
- $$= 21.20 \text{ g} \quad (5)$$
- Molar mass of Na_2CO_3 = 106 g mol^{-1}
- \therefore The conc. of Na_2CO_3 solution = $\frac{21.20}{106} \text{ mol dm}^{-3}$ (5)
- $$= 0.20 \text{ mol dm}^{-3} \quad (3+2)$$

- (ii) When Na_2CO_3 solution is added from burette to the H_2SO_4 solution in the flask the end point is obtained when Na_2CO_3 is completely neutralized.

OR



$$\therefore 1 \text{ mol of } \text{Na}_2\text{CO}_3 \equiv 1 \text{ mol of } \text{H}_2\text{SO}_4 \quad (5)$$

$$\begin{aligned} \text{Amount of } \text{Na}_2\text{CO}_3 \text{ in } 12.50 \text{ cm}^3 \text{ of solution} \\ = \frac{0.2 \times 12.50}{1000} = 2.5 \times 10^{-3} \text{ mol} \end{aligned} \quad (5)$$

$$\begin{aligned} \text{Amount of } \text{H}_2\text{SO}_4 \text{ reacted with } \text{Na}_2\text{CO}_3 \\ = 2.5 \times 10^{-3} \text{ mol} \end{aligned} \quad (5)$$

$$\begin{aligned} \therefore \text{The conc. of } \text{H}_2\text{SO}_4 \text{ solution} \\ = \frac{2.5 \times 10^{-3} \times 1000 \text{ mol dm}^{-3}}{25.0} \end{aligned} \quad (5)$$

$$= 0.10 \text{ mol dm}^{-3} \quad (3+2)$$

- (iii) yes. 12.5 cm^3 (5+5)

9 (a) for 60 marks

- (b) (i) Fe (Iron) (15)

$$\text{(ii) } +2 \text{ and } +3 \quad (5+5)$$

(iii) Potassium ferricyanide gives a blue ppt. with Fe^{2+} (or potassium Ferrocyanide gives blue ppt. with Fe^{3+}) or any other suitable test (eg. SCN^- gives a red coloration with Fe^{3+})

Test + observation (5+5)

(iv) Take a measured volume (5) of solution and titrate with a standard solution of KMnO_4 (05). This gives the amount of Fe^{2+} (5)

Take another portion and pass SO_2 to convert Fe^{3+} to Fe^{2+} (05)

Boil off excess SO_2 and titrate with KMnO_4

This gives the total amount of iron (5)

The difference gives the amount of Fe^{3+} (5)

(Alternative method)

Take a measured volume (5) of solution and add excess KI

Titrate the liberated I_2 with standard thiosulphate solution (5)

This gives the amount of Fe^{3+} (5)

Take another portion and react with H_2O_2 to convert Fe^{2+} to Fe^{3+} (5)

Boil off excess H_2O_2 and add excess of KI

Titrate the liberated I_2 with standard thiosulphate solution.

This gives the total amount of iron (5)

The difference gives the amount of Fe^{3+} (5)

- (v) Light green ppt : Fe(OH)_2 (5)
yellow - brown ppt : Fe(OH)_3 (5)

- (vi) Fe as catalyst : Haber process / production of ammonia (5)

- (vii) Hematite (Fe_2O_3) (2+3)
Magnetite (Fe_3O_4) (2+3)

Limonite ($2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$)

Siderite (FeCO_3 , also acceptable)

10. (a) (i) (I) Temporary hardness : that which can be removed by boiling (5)
(II) Bicarbonate of calcium and bicarbonate of magnesium (5+5)

- (III) Domestic problems : Difficulty in using soap
Scale formation in kettles etc....
Unpleasant taste in drinking water (any two 5+5)

- (IV) 1. By boiling
 $\text{Ca}^{2+} + 2\text{HCO}_3^- \rightarrow \text{CaCO}_3 + \text{CO}_2 + \text{H}_2\text{O}$ (5)
2. Using ion exchange resins/zeolites / clays (5)

- (ii) The formulae of acids are
 $\text{Cl}-\text{O}-\text{H}$, $\text{O}=\text{Cl}-\text{O}-\text{H}$, $\text{O}=\overset{\parallel}{\text{Cl}}-\overset{\parallel}{\text{O}}-\text{H}$, $\text{O}=\overset{\parallel}{\text{Cl}}-\overset{\parallel}{\text{O}}-\overset{\parallel}{\text{O}}-\text{H}$ (10)

(02 for each correct structure, 10 if all structures correct)

Oxygen is more electronegative than Cl (5)

As more Oxygen atoms get attached to the Cl atom, its positive character increases (5)

This makes the ionization of the H atom as H^+ easier (5)

\therefore The acidity increases in the order

$\text{HClO} < \text{HClO}_2 < \text{HClO}_3 < \text{HClO}_4$ (5) OR
Oxidation number of Cl increases from HCl (+1), HOCl_2 (+3), HOCl_3 (+5), HOCl_4 (+7) (5)

\therefore The positive character of the H atom as H^+ easier (5)

\therefore The acidity increases in the order

$\text{HClO} < \text{HClO}_2 < \text{HClO}_3 < \text{HClO}_4$ (5) 10 (a) for 70 marks

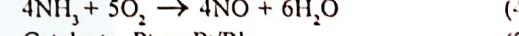
- (b) (i) Ammonia (NH_3) and Oxygen (O_2) (4+4)

- (ii) NH_3 : by the reaction between $\text{H}_2(\text{g})$ and $\text{N}_2(\text{g})$ (4)

(Or Haber process)

O_2 : From air (4)

- (iii) Step I : Reaction between $\text{NH}_3(\text{g})$ and $\text{O}_2(\text{g})$ air (2)



Catalyst : Pt or Pt/Rh (2)

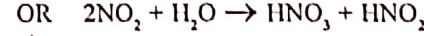
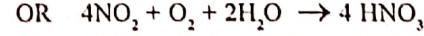
Temperature : about 850°C (2)

Pressure : near atmospheric pressure (2)

Step II : NO is reacted with O_2 to form NO (2)



Step III : NO_2 gas is dissolved in water in form HNO_3 (2)



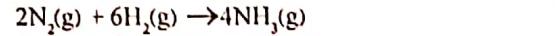
(iv) For direct oxidation of N_2 to NO,



$$\Delta H = 4x(+90 \text{ KJ}) = +360 \text{ KJ} \quad (4)$$

This process (A) is endothermic (4)

For reduction of $\text{N}_2(\text{g})$ followed by oxidation,



$$\Delta H = 4x(-46 \text{ KJ}) = -184 \text{ KJ} \quad (4)$$



$$\Delta H = 6x(-242 \text{ KJ}) + 4x(+90 \text{ KJ}) - 4x(-46 \text{ KJ}) = -908 \text{ KJ} \quad (4)$$

For reduction of $\text{N}_2(\text{g})$ to $\text{NH}_3(\text{g})$ followed by oxidation,

$$\Delta H = -184 \text{ KJ} + (-908 \text{ KJ}) = -1092 \text{ KJ} \quad (4)$$

[For the production of 4 mol of NO (g)]

This process (B) is exothermic (4)

Therefore process B is likely to be more feasible compared to process A

10 (b) for 80 marks

9 (b) for 90 marks