

**G.C.E (A/L) Examination**  
**New Syllabus**  
**2013 August – Chemistry I/**  
**Two hours**

- \* Periodic Table is provided
- \* This paper consists of 09 pages
- \* Answer all the questions.
- \* Use of calculators is not allowed.
- \* Write your Index Number in the space provided in the answer sheet.
- \* Follow the instructions given on the back of the answer sheet carefully.
- \* In each of the questions 1 to 50, 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) 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  $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$   
 Planck's constant  $h = 6.626 \times 10^{-34} \text{ J s}$   
 Velocity of light  $c = 3 \times 10^8 \text{ m s}^{-1}$

1. The highest oxidation state and the outer electron configuration of the ground state of chromium respectively are  
 (1) +3 and [Ar]3d<sup>4</sup>4s<sup>2</sup>      (2) +4 and [Ar]3d<sup>8</sup>4s<sup>1</sup>  
 (3) +6 and [Ar]3d<sup>4</sup>4s<sup>2</sup>      (4) +4 and [Ar]3d<sup>6</sup>4s<sup>0</sup>  
 (5) +6 and [Ar]3d<sup>4</sup>s<sup>1</sup>
2. The increasing order of the first ionization energy of atoms N, Ne, Na, P, Ar and K is  
 (1) Na < K < P < N < Ar < Ne      (2) Na < K < Ar < N < P < Ne  
 (3) P < N < K < Na < Ne < Ar      (4) K < Na < N < P < Ne < Ar  
 (5) K < Na < P < N < Ar < Ne
3. What is the IUPAC name of the following compound?  

$$\begin{array}{c} \text{O} & \text{Br} \\ || & | \\ \text{CH}_3\text{CH}_2\text{O} & -\text{C}-\text{CH}=\text{C}-\text{CH}_2\text{CHO} \end{array}$$
  
 (1) 3-bromo-5-ethoxy-5-oxo-3-pentenal  
 (2) ethyl-3-bromo-5-oxopent-2-enoate  
 (3) ethyl 3-bromo-2-en-5- oxopentanoate  
 (4) ethyl 3-bromo-5-oxo-2-pentenoate  
 (5) 3-bromo-1-ethoxy-5-oxo-2-pentenal
4. When the compound X having C, H, O only was treated with excess acetylchloride a compound having a relative molecular mass 126 units higher than that of X was obtained. The number of hydroxyl groups in X is  
 (1) 1      (2) 2      (3) 3      (4) 4      (5) 5
5. The number of atomic orbitals possible for which the quantum numbers  $n = 3$  and  $m_l = -1$  is  
 (1) 1      (2) 2      (3) 3      (4) 4      (5) 5
6. The electron pair geometry and the molecular shape of  $\text{XeO}_2\text{F}_2$  respectively, are  
 (1) trigonal bipyramidal and see-saw.  
 (2) trigonal bipyramidal and tetrahedral.  
 (3) tetrahedral and see-saw.  
 (4) see-saw and trigonal bipyramidal.  
 (5) square planar and tetrahedral.
7. A mixture of  $\text{Fe}_2\text{O}_3$  and  $\text{FeO}$  is found to contain 72.0% Fe by mass. The mass of  $\text{Fe}_2\text{O}_3$  in 1.0 g of this mixture is ( $\text{O} = 16$ ,  $\text{Fe} = 56$ )  
 (1) 0.37 g      (2) 0.52 g      (3) 0.67 g  
 (4) 0.74 g      (5) 0.83 g

8. Samples of  $\text{F}_2(\text{g})$  and  $\text{Xe}(\text{g})$  are mixed in a container of fixed volume. The partial pressures of  $\text{F}_2(\text{g})$  and  $\text{Xe}(\text{g})$  before they react are  $8.0 \times 10^{-3} \text{ kPa}$  and  $1.7 \times 10^{-5} \text{ kPa}$  respectively. When all of the  $\text{Xe}(\text{g})$  has reacted, forming a solid compound, the partial pressure of the remaining  $\text{F}_2(\text{g})$  was  $4.6 \times 10^{-5} \text{ kPa}$ . The system was maintained at a constant temperature during the above process. What is the formula of the solid compound formed?

- (1)  $\text{XeF}_2$       (2)  $\text{XeF}_3$       (3)  $\text{XeF}_4$   
 (4)  $\text{XeF}_6$       (5)  $\text{XeF}_8$

9. When an inorganic solid X was treated with dil.  $\text{HCl}$ , a colourless solution and a gas that turned a filter paper moistened with lead acetate solution black were produced. When the colourless solution was subjected to the flame test, an apple green coloured flame was observed.

Solid X is

- (1)  $\text{BaS}$       (2)  $\text{CuSO}_3$       (3)  $\text{BaSO}_3$   
 (4)  $\text{NiS}$       (5)  $\text{CuCO}_3$

10. Which of the following statements is **false** with regard to hypochlorous acid ( $\text{HOCl}$ ) ?

- (1)  $\text{HOCl}$  is a weak acid.  
 (2) The oxidation state of chlorine in  $\text{HOCl}$  is -1.  
 (3)  $\text{I}_2$  is produced when  $\text{KI}$  is added to an aqueous solution of  $\text{HOCl}$ .  
 (4) In basic solution  $\text{HOCl}$  disproportionates on heating.  
 (5)  $\text{HOCl}$  reacts with alkali to form salts called hydrochlorites.

11. A volume of  $50.00 \text{ cm}^3$  of  $0.01 \text{ mol dm}^{-3}$   $\text{NaOH}$  solution was added to  $50.00 \text{ cm}^3$  of  $0.11 \text{ mol dm}^{-3}$  solution of the weak acid HA. The pH of the final mixture was found to be 6.2. If  $K_a$  is the dissociation constant of the acid, which of the following answers indicates its  $\text{pK}_a$  value?

- (1) 5.2      (2) 6.0      (3) 6.2      (4) 7.0      (5) 7.2

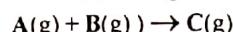
12. The IUPAC name of  $[\text{Co}(\text{CN})_3(\text{NH}_3)_4]^+$  is

- (1) tetraammoniadicyanocobalt(III) ion  
 (2) tetraamminedicyanocobalt(III) ion  
 (3) dicyanotetraaminecobalt(III) ion  
 (4) tetraamminedicyanidecobalt(III) ion  
 (5) tetraaminedicyanocobalt(III) ion

13. A  $50.00 \text{ cm}^3$  sample of a solution containing  $\text{Fe}^{2+}$  is titrated with  $0.02 \text{ M } \text{K}_2\text{Cr}_2\text{O}_7$  in acidic medium. The volume of  $\text{K}_2\text{Cr}_2\text{O}_7$  required to react all the  $\text{Fe}^{2+}$  is  $25.00 \text{ cm}^3$ . If this titration is carried out using  $0.02 \text{ M } \text{KMnO}_4$  instead of  $0.02 \text{ M } \text{K}_2\text{Cr}_2\text{O}_7$ , the volume of  $\text{KMnO}_4$  required is

- (1)  $22.00 \text{ cm}^3$       (2)  $23.00 \text{ cm}^3$       (3)  $25.00 \text{ cm}^3$   
 (4)  $27.00 \text{ cm}^3$       (5)  $30.00 \text{ cm}^3$

14. Consider the following elementary reaction.



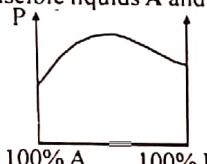
The rate constant of the reaction at temperature T is  $k$ .  $n$  mol of A and  $n$  mol of B were mixed and allowed to react in a rigid container of volume  $V$ . If the universal gas constant is R, and the rate of reaction at time  $t$  is  $Q$ , the pressure ( $P$ ) of the vessel at time  $t$  is given by

- (1)  $P = Q^2 \frac{RT}{V}$       (2)  $P = \left[ \frac{n}{V} + \left( \frac{Q}{k} \right)^{\frac{1}{2}} \right] RT$   
 (3)  $P = \frac{Q}{k} \frac{RT}{V}$       (4)  $P = \left( \frac{n}{V} + \frac{Q}{k} \right) RT$   
 (5)  $P = \frac{2nRT}{V}$

15. Volatile liquids A and B form an ideal solution when mixed. It was observed that the pressure of the vapour phase, which is in equilibrium with the liquid phase was doubled when the composition in the liquid phase was changed from  $X_A = 0.2$ ,  $X_B = 0.8$  to  $X_A = 0.6$  and  $X_B = 0.4$ . The system was maintained at a constant temperature during the above process. The saturated vapour pressures of A and B at this temperature are  $P_A^0$  and  $P_B^0$  respectively. Which of the following relationships is correct?

- (1)  $\frac{P_A^0}{P_B^0} = 6$       (2)  $P_A^0 + P_B^0 = \frac{1}{2}$       (3)  $\frac{P_A^0}{P_B^0} = \frac{4}{3}$   
 (4)  $\frac{P_A^0}{P_B^0} = \frac{3}{4}$       (5)  $\frac{P_A^0}{P_B^0} = \frac{1}{6}$

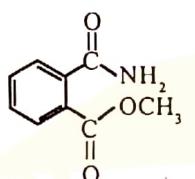
16. The variation of vapour pressure (P) with composition of a mixture of two miscible liquids A and B is shown in the figure.



Which of the following answers is true about the intermolecular attractive forces?

- (1) A-A < A-B < B-B      (2) A-A > A-B > B-B  
 (3) A-A < A-B > B-B      (4) A-A > A-B < B-B  
 (5) A-A = A-B = B-B

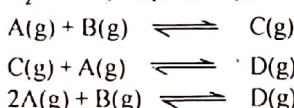
17.



What is the major product obtained when the compound above is treated with  $\text{LiAlH}_4$  and the reaction mixture is neutralized?

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

18. Consider the following equilibria with equilibrium constants  $K_1$ ,  $K_2$  and  $K_3$ , respectively.



Which of the following equations shows the relationship among the three equilibrium constants?

- (1)  $K_1 = K_1 + K_2$       (2)  $K_3 = \sqrt{K_1 K_2}$       (3)  $K_3 = \frac{1}{K_1 K_2}$   
 (4)  $K_1 = K_1 K_2$       (5)  $K_1 = K_1 - K_2$

19. Which of the following arrangements shows the correct increasing order of pH of the following 1 M aqueous solutions?



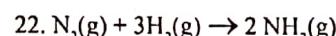
- (1) KOH <  $\text{CaCl}_2$  <  $\text{CH}_3\text{COO}^-\text{Na}^+$  <  $\text{CH}_3\text{COOH}$  < HCl  
 (2) HCl <  $\text{CaCl}_2$  <  $\text{CH}_3\text{COOH}$  < KOH <  $\text{CH}_3\text{COO}^-\text{Na}^+$   
 (3)  $\text{CH}_3\text{COOH}$  < HCl <  $\text{CaCl}_2$  < KOH <  $\text{CH}_3\text{COO}^-\text{Na}^+$   
 (4) HCl <  $\text{CH}_3\text{COOH}$  <  $\text{CH}_3\text{COO}^-\text{Na}^+$  <  $\text{CaCl}_2$  < KOH  
 (5) HCl <  $\text{CH}_3\text{COOH}$  <  $\text{CaCl}_2$  <  $\text{CH}_3\text{COO}^-\text{Na}^+$  < KOH

20. What is the total number of resonance structures that can be drawn for the  $\text{HN}_3$  molecule?

- (Skeleton of the molecule, H—N=N—N)  
 (1) 2      (2) 3      (3) 4      (4) 5      (5) 6

21. Which of the following statements with regard to 3d-block transition elements is false?

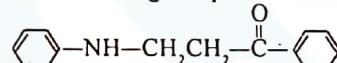
- (1) Variable oxidation states result because of the comparable energies of 3d and 4s atomic orbitals.  
 (2) The electronegativity gradually decreases across the period from left to right.  
 (3) They have stronger metallic characteristics than those belonging to the s-block of the same period.  
 (4) Many ionic and covalent compounds of transition metals are coloured.  
 (5) Their densities are higher than the s-block elements of the same period.



The reaction above is thermodynamically spontaneous at 298 K, but not so at high temperature. Which of the following is true about the reaction at 298 K?

- (1)  $\Delta G$ ,  $\Delta H$  and  $\Delta S$  all are positive.  
 (2)  $\Delta G$ ,  $\Delta H$  and  $\Delta S$  all are negative.  
 (3)  $\Delta G$  and  $\Delta H$  are negative and  $\Delta S$  is positive.  
 (4)  $\Delta G$  and  $\Delta S$  are negative and  $\Delta H$  is positive.  
 (5)  $\Delta G$  and  $\Delta H$  are positive and  $\Delta S$  is negative.

23. Predict the major product that will be obtained from the bromination of the following compound with  $\text{Br}_2/\text{FeBr}_3$ .

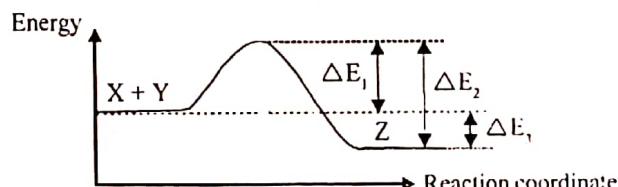


- (1)   
 (2)   
 (3)   
 (4)   
 (5)

24. Which of the following reactions is not likely to take place during chlorination of methane in the presence of light?

- (1)  $\text{Cl} - \text{Cl} \rightarrow 2\text{Cl}^\cdot$   
 (2)  $\text{CH}_4 + \text{Cl}^\cdot \rightarrow \text{CH}_3\text{Cl} + \text{H}^\cdot$   
 (3)  $\text{CH}_4 + \text{Cl}^\cdot \rightarrow \text{CH}_3^\cdot + \text{HCl}$   
 (4)  $\text{CH}_3^\cdot + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}^\cdot$   
 (5)  $\text{CH}_3^\cdot + \text{Cl}^\cdot \rightarrow \text{CH}_3\text{Cl}$

25. The energy diagram for the reaction  $\text{X} + \text{Y} \rightarrow \text{Z}$  is shown below.



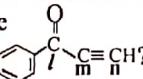
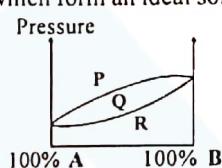
The rate of this reaction is dependent on

- (1)  $\Delta E_1$  only.      (2)  $\Delta E_2$  only.      (3)  $\Delta E_1$  only  
 (4)  $\Delta E_1 + \Delta E_2$       (5)  $\Delta E_2 + \Delta E_1$

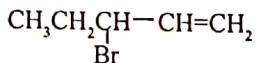
26. Which of the following statements is **false** with regard to *s*-block elements?
- Group I elements are strong oxidizing agents.
  - Group I elements have the lowest first ionisation energy values in a period.
  - Group II elements are smaller than the corresponding Group I elements.
  - In general, Groups I and II elements form ionic compounds.
  - Group II elements are harder and have higher melting points than those of Group I.
27. Which of the following statements regarding ammonia ( $\text{NH}_3$ ) is **false**?
- The oxidation state of N in  $\text{NH}_3$  is -3.
  - $\text{NH}_3$  gives a pink colour with Nessler's reagent.
  - $\text{NH}_3$  is used as one of the raw materials in the manufacture of nitric acid.
  - $\text{NH}_3$  is used to remove the acidic constituents in crude oil.
  - $\text{NH}_3$  is produced on heating  $\text{NaNO}_3$  with Al powder and aqueous NaOH.
28. Which of the following statements with regard to molecular oxygen ( $\text{O}_2$ ) and ozone ( $\text{O}_3$ ) is **false**?
- Molecular oxygen and ozone are allotropes.
  - In the lower atmosphere photochemical reactions generate ozone from molecular oxygen.
  - The O—O bond length of ozone is greater than the O—O bond length of molecular oxygen.
  - Both molecular oxygen and ozone are greenhouse gases.
  - Since molecular oxygen and ozone absorb UV radiation in the upper atmosphere, human life on earth is protected.
29. A  $25.00 \text{ cm}^3$  volume of aqueous  $\text{CuSO}_4$  solution is electrolysed using two platinum electrodes. The current during the electrolysis was kept at  $10^{-2} \text{ A}$  and it took 9.65 seconds to deposit all the  $\text{Cu}^{2+}$  as Cu on the cathode. What is the concentration of  $\text{Cu}^{2+}$  in the solution? ( $1 \text{ F} = 96500 \text{ C mol}^{-1}$ )
- $1 \times 10^{-5} \text{ M}$
  - $2 \times 10^{-5} \text{ M}$
  - $4 \times 10^{-5} \text{ M}$
  - $5 \times 10^{-5} \text{ M}$
  - $1 \times 10^{-4} \text{ M}$
30. A solid sample contains only  $\text{CaCO}_3$  and  $\text{MgCO}_3$ . To completely react the  $\text{CaCO}_3$  and  $\text{MgCO}_3$  present in the sample,  $42.00 \text{ cm}^3$  of  $0.088 \text{ M HCl}$  were required. The anhydrous chloride salts from the reaction, obtained by evaporation of the filtrate weighed 0.19 g. The mass of  $\text{CaCO}_3$  present in the solid sample is ( $\text{C} = 12, \text{O} = 16, \text{Mg} = 24, \text{Ca} = 40, \text{Cl} = 35.5$ )
- 0.05 g
  - 0.07 g
  - 0.09 g
  - 0.11 g
  - 0.12 g
- For each of the questions 31 to 40, one or more responses out of the four responses (a), (b), (c) and (d) given 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 correct.

#### Summary of above Instructions

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

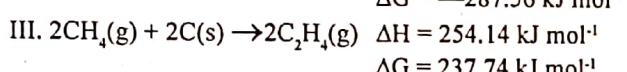
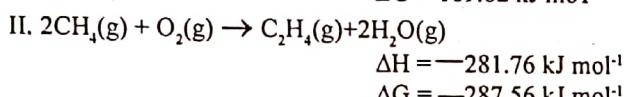
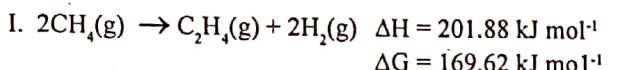
31. Values of  $E^\circ$  for the  $\text{Ce}^{4+}/\text{Ce}^{3+}$  and  $\text{Fe}^{2+}/\text{Fe}$  are +1.72 V and -0.44 V respectively. According to these data which of the following statements is/are **true**?
- $\text{Ce}^{4+}$  is a weaker oxidizing agent than  $\text{Fe}^{2+}$ .
  - $\text{Ce}^{4+}$  will reduce  $\text{Fe}^{2+}$ .
  - $\text{Ce}^{4+}$  is a better oxidizing agent than  $\text{Fe}^{2+}$ .
  - $\text{Ce}^{4+}$  will oxidize Fe.
32. Which of the following statements is/arc **true** regarding the molecule 
- All carbon atoms are  $sp^2$  hybridized.
  - Carbon atoms labelled as *l*, *m* and *n* and the oxygen atom lie in the same plane.
  - All C—H bonds are equal in length.
  - Carbon atoms labelled as *l*, *m* and *n* lie in a straight line.
33. Shown below is the constant temperature phase diagram of A and B, which form an ideal solution.
- 
- Which of the following statements is/are **true**?
- The boiling point of compound A is higher than the boiling point of compound B.
  - The vapour phase and liquid phase exist in equilibrium in the region Q.
  - Only the vapour phase exists in the region P.
  - Only the liquid phase exists in the region R.
34. Which of the following statements is/are **true** regarding polymers?
- Natural rubber has double bonds with cis configuration.
  - Polyvinyl Chloride (PVC) is formed by addition polymerization of  $\text{CHCl}=\text{CHCl}$ .
  - Polystyrene and nylon are both prepared by condensation polymerization.
  - Both urea-formaldehyde and phenol-formaldehyde polymers contain  $\text{C=O}$  groups in their structures.
35. The gases A and B react to form the product P. The material X in fine particle form, has been suggested for use as a catalyst for this reaction. The material X provides an alternative mechanism consisting of three steps. The activation energies for the three steps and for the reaction without X are given below
- | Activation energy / $\text{kJ mol}^{-1}$ |    |
|--|----|
| Without X                                | 50 |
| With X step I                            | 10 |
| With X step II                           | 5  |
| With X step III                          | 50 |
- Which of the following statements is/are **true**?
- Use of X will not change the reaction rate significantly.
  - Activation energy in step III can be lowered by using more X.
  - Use of X increases the rate of the reaction because X is a material with a large surface area.
  - Increasing of temperature will increase the reaction rate, regardless of whether X is used or not.
36. Which of the following statements is/are **true** regarding phenol?
- Phenol reacts readily with formaldehyde in acidic or basic medium.
  - Phenol is less acidic than ethanol.
  - Phenol reacts with aq.  $\text{NaHCO}_3$  and gives  $\text{CO}_2$ .
  - Phenol undergoes a substitution reaction with  $\text{Br}_2$ .

37. Which of the following statements is/are true regarding the compound represented by the structure given below?



- (a) It can exist in two stereoisomeric forms.
- (b) Catalytic hydrogenation of it gives a compound which does not show stereoisomerism.
- (c) Treatment of it with alcoholic KOH gives a compound which does not show stereoisomerism.
- (d) Treatment of it with aqueous KOH gives a compound which does not show stereoisomerism.

38.  $\Delta H$  and  $\Delta G$  data at temperature T are provided for the following reactions.



Which of the following statements is/are true at temperature T?

- (a) All three reactions I, II and III could be used to produce  $\text{C}_2\text{H}_4$  from  $\text{CH}_4$ .
- (b) Reaction I has a negative entropy change.
- (c) Reaction II is the only feasible reaction for producing  $\text{C}_2\text{H}_4$  from  $\text{CH}_4$ .
- (d) Reaction III has a positive entropy change.

39. During cation analysis, Group I metal ions are precipitated as chlorides. Which of the following statements is/are true regarding the Group I analysis?

- (a)  $\text{Ag}^+$ ,  $\text{Hg}_2^{2+}$ ,  $\text{Hg}_2^{2+}$  and  $\text{Pb}^{2+}$  form insoluble chlorides with the addition of dil. HCl.
- (b) Only  $\text{AgCl}$  and  $\text{PbCl}_2$  dissolve in aqueous  $\text{NH}_3$  and will not reprecipitate with the addition of dil. HCl.
- (c) Only  $\text{Ag}^+$ ,  $\text{Hg}_2^{2+}$  and  $\text{Pb}^{2+}$  form insoluble chlorides with the addition of dil. HCl.
- (d)  $\text{Pb}^{2+}$  does not precipitate in hot conc. HCl.

40. Which of the following statements is/are false with regard to  $\text{H}_2\text{O}_2$ ?

- (a) In the  $\text{H}_2\text{O}_2$  molecule, the two hydroxyl groups lie in the same plane.
- (b)  $\text{H}_2\text{O}_2$  can act both as an oxidizing agent and a reducing agent in both acidic and basic media.
- (c) Pure  $\text{H}_2\text{O}_2$  is a colourless, strongly hydrogen bonded liquid.
- (d) The oxygen atoms in  $\text{H}_2\text{O}_2$  are  $sp$  hybridized.

- In questions Nos. 41 to 50, 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 and mark appropriately on your answer sheet.

	First Statement	Second Statement
41	All emissions end up at $n = 1$ for the Balmer series in the hydrogen spectrum.	The Bohr model is used to explain the origin of the hydrogen spectrum.
42	2-Butanone (MW 72) has a higher boiling point than that of pentane (MW 72).	There are no hydrogen bonds between pentane molecules.
43	2-Methyl-1-propanol gives a turbidity with conc. HCl / $\text{ZnCl}_2$ much faster than does 2-methyl-2-propanol.	Tertiary carbocations are more stable than primary carbocations.
44	$\text{CaCO}_3(\text{s})$ does not decompose to $\text{CO}_2(\text{g})$ and $\text{CaO}(\text{s})$ at room temperature, but it could be decomposed by increasing the temperature.	Gibbs energy change of a reaction can always be made negative by increasing the temperature.
45	Intermolecular forces between $\text{SO}_2$ molecules are stronger than those between $\text{CO}_2$ molecules.	Intermolecular forces between polar molecules are stronger than those between non-polar molecules of similar mass.
46	$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3-\text{C}-\text{CH}_2\text{CH}_3 \text{ and} \\ \text{OH} \\ \text{CH}_2=\overset{\text{O}}{\underset{\text{C}}{\text{C}}}-\text{CH}_2\text{CH}_3 \text{ are two} \\ \text{resonance structures of the} \\ \text{same compound.} \end{array}$	The number of double bonds in resonance structures of a given compound should be the same.
47	At constant temperature, doubling the concentration of all the reactants in the elementary reaction $2\text{A} + \text{B} \rightarrow 3\text{D} + \text{E}$ increases the rate by a factor of 8.	In an elementary reaction, the order with respect to a reactant is equal to its stoichiometric coefficient.
48	In the extraction of iron, the reduction of haematite by CO takes place in three stages.	The temperature of the blast furnace used in the extraction of iron decreases from top to bottom.
49	Increasing the temperature will always increase the reaction rate.	The activation energy of a reaction decreases when the temperature is increased.
50	Ammonia and carbon monoxide are used as raw materials in the manufacture of urea.	Ammonium carbonate formed by the reaction of ammonia and carbon monoxide, decomposes to give urea.

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

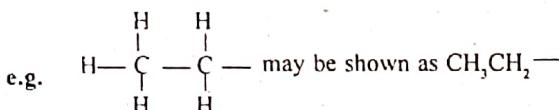
# GCE (A/L) Examination

## New Syllabus

### 2013 August - Chemistry II

Three hours

- A Periodic Table is provided on page 15.
- Use of calculators is not allowed.**
- Universal gas constant,  $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$  and Avogadro constant  $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$
- In answering this paper you may represent alkyl groups in a condensed manner.



#### PART A - Structured Essay (Pages 2-8)

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

#### PART B and PART C - Essay (pages 9-14)

Answer four questions selecting two questions from each part. Use the paper supplied for this purpose.

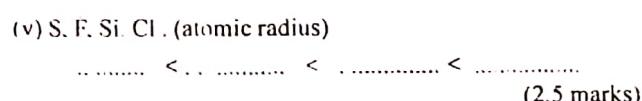
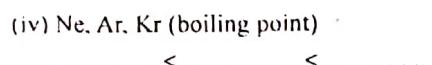
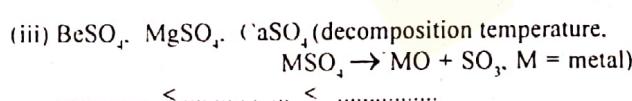
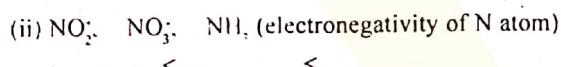
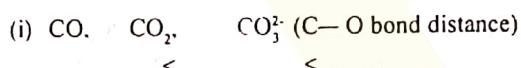
At the end of the time allotted for this paper, tie the answers to three parts A, B and C together so that Part A is on top and hand them over to the Supervisor.

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

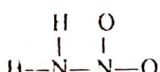
#### PART A - STRUCTURED ESSAY

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

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



- (b) Nitramide ( $\text{H}_2\text{N}-\text{NO}_2$ ) is a weak acid. It decomposes to  $\text{N}_2\text{O}$  and  $\text{H}_2\text{O}$  in the presence of a base. Answer the parts (i) to (v) which are based on nitramide. Its skeleton is given below:



- (i) Draw the most acceptable Lewis structure for this molecule

- (ii) Draw the resonance structures for this molecule. Giving reasons, comment on their stabilities.

- (iii) State the following:

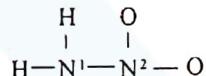
- electron pair geometry (arrangement of electron pairs) around the atoms
- shape around the atoms
- hybridization of the atoms

given in the table below.

	The N attached to two H atoms	The N attached to two O atoms
I electron pair geometry		
II shape		
III hybridization		

- (iv) Is this molecule polar or non-polar? .....

- (v) Identify the atomic/ hybrid orbitals involved in the formation of the following bonds in the Lewis structure drawn in part (i) above. N atoms are labelled 1 and 2 as given below:



- I.  $\text{N}^1$  and  $\text{N}^2$

- II.  $\text{N}^1$  and H

(6.5 marks)

- (c) Xe,  $\text{CH}_3\text{Cl}$ , HF

Of the substances given above, which one /ones will have the forces given below?

- dipole - dipole forces .....
- hydrogen bonding forces .....
- London dispersion forces .....

(1.0 mark)

2. (a) Element A belongs to the s-block. Its first ionization energy is the highest in the group. A reacts with water liberating a gas B. The resulting solution from this reaction gives a red colouration to a Bunsen burner flame and the metal oxide on evaporation. A reacts with  $\text{N}_2(\text{g})$  to give compound C. The reaction of A with  $\text{H}_2(\text{g})$  gives a salt-like basic compound D. On treatment with  $\text{H}_2\text{O}$ , C gives a gas E which turns red litmus blue.

- (i) Identify A, B, C, D and E giving their chemical formulae.

A = ..... B = ..... C = ..... D = ..... E = .....

- (ii) Give balanced chemical equations for the reactions described above.

.....  
.....  
.....  
.....  
.....  
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(3.0 marks)

(b) The following questions are based on the transition metals, V and Cr and their compounds.

- (i) Give the ground state electronic configuration of V  
.....
- (ii) State the positive oxidation states of V. ....
- (iii) Give the chemical formulae of the oxides formed by V in the positive oxidation states given in (ii) above. Indicate whether each of these oxides is acidic, amphoteric or basic.  
.....  
.....  
.....

- (iv) Write the chemical formulae of two oxocations formed by V. State their colours in aqueous acidic medium.  
.....

- (v) What is the simplest ion that chromium forms in aqueous solution? State its colour. Predict what you would expect to observe when solid  $\text{Na}_2\text{CO}_3$  is added to an aqueous solution of this ion.  
.....

- (vi) Give one use of the metal V.  
.....

- (vii) What would you observe when a green coloured aqueous solution of  $\text{CrCl}_3$  is subjected to the following?

- I. Addition of a few drops of dilute NaOH.  
.....
- II. Addition of excess dilute NaOH followed by  $\text{H}_2\text{O}_2$ , and then heated.  
.....

- (viii) When a concentrated solution of  $\text{K}_2\text{Cr}_2\text{O}_7$  is treated with conc.  $\text{H}_2\text{SO}_4$ , the bright red acidic oxide X of chromium is precipitated. On heating X, the green amphoteric oxide Y is obtained. Y could also be obtained on heating  $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ . Give the chemical formulae of X and Y.

$$\text{X} = \dots \quad \text{Y} = \dots$$

- (ix) What would you observe when dil. NaOH is added to a solution of  $\text{K}_2\text{Cr}_2\text{O}_7$ ?  
.....

Give one advantage and one disadvantage of using  $\text{K}_2\text{Cr}_2\text{O}_7$  in titrations.

Advantage: .....

Disadvantage: .....

(7.0 marks)

- 3 Chlorine gas is used as an oxidizing agent to oxidize the metal ion,  $\text{M}^{2+}(\text{aq})$  to  $\text{M}^{3+}(\text{aq})$ . The following data are given

Reaction	Standard enthalpy change $\Delta H^\circ$ at 25 °C (kJ mol <sup>-1</sup> )
$\text{M}(\text{s}) \rightarrow \text{M}^+(\text{aq}) + \text{e}^-$	- 32.5
$\text{M}(\text{s}) \rightarrow \text{M}^{2+}(\text{aq}) + 2\text{e}^-$	- 48.5
$\text{M}(\text{s}) \rightarrow \text{M}^{3+}(\text{aq}) + 3\text{e}^-$	- 82.5
$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^-(\text{aq})$	- 334.0

$$E^\circ_{\text{M}^{3+}/\text{M}^{2+}} = + 0.77 \text{ V}$$

$$E^\circ_{\text{Cl}_2/\text{Cl}^-} = + 1.36 \text{ V}$$

The above oxidation is carried out electrochemically.

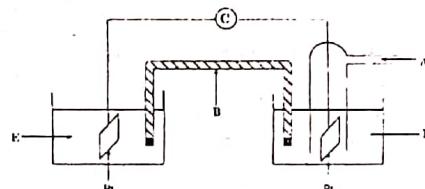
- (i) Write half reactions for oxidation and reduction processes and derive the cell reaction.

Oxidation reaction : .....

Reduction reaction : .....

Cell reaction : .....

- (ii) The following diagram shows the experimental setup needed to measure  $E^\circ_{\text{cell}}$  of the above reaction. Identify A - E, giving physical state, concentration/ pressure where applicable.



A : ..... B : ..... C : .....

D : ..... E : .....

- (iii) Calculate  $E^\circ_{\text{cell}}$  for the above cell.

- (iv) Calculate the standard enthalpy change ( $\Delta H^\circ$ ) at 25 °C, for the cell reaction given in part (i).

- (v) The relationship between standard Gibbs's energy change,  $\Delta G^\circ$  for the cell reaction and  $E^\circ_{\text{cell}}$  is given by

$$\Delta G^\circ = -k E^\circ_{\text{cell}}$$

where,  $k = 1.93 \times 10^5 \text{ J mol}^{-1}\text{V}^{-1}$

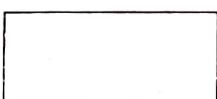
Calculate the standard Gibbs energy change ( $\Delta G^\circ$ ) at 25 °C, for the above cell reaction.

- (vi) Calculate the standard entropy change ( $\Delta S^\circ$ ) at 25 °C, for the above cell reaction.

(10.0 marks)

- 4 (a) (i) Compound A exhibits optical isomerism and has the molecular formula  $\text{C}_7\text{H}_{16}$ .

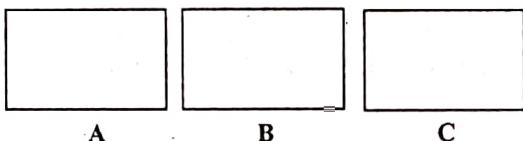
- I. Draw two possible structures for A which are not enantiomers of each other, in the boxes given below



- II. State the isomeric relationship between the two structures you have drawn

(ii) B and C are optically inactive compounds with the molecular formula  $C_6H_{14}$ . Both B and C exhibit geometric isomerism. B and C are not geometric isomers of each other. Catalytic hydrogenation of either B or C yields the same compound A.

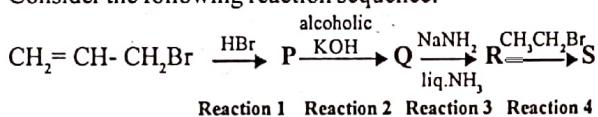
- I. Draw the structures of A, B and C in the boxes given below (It is not necessary to draw the stereoisomeric forms).



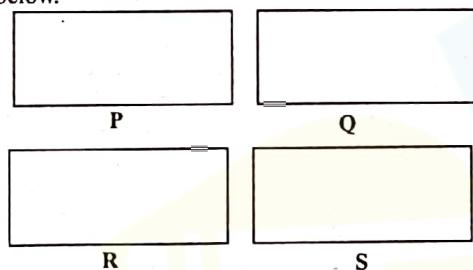
- II. Write the IUPAC names of B and C.

B : .....  
C : ..... (5.5 marks)

- (b) Consider the following reaction sequence:



- (i) Draw the structures of P, Q, R and S in the boxes given below.

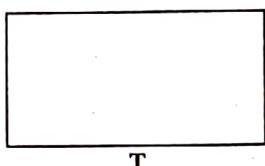


- (ii) Classify each of the reactions in the above sequence as nucleophilic addition ( $A_N$ ), electrophilic addition ( $A_E$ ), nucleophilic substitution ( $S_N$ ), electrophilic substitution ( $S_E$ ), elimination (E) or acid-base (AB), by writing  $A_N$ ,  $A_E$ ,  $S_N$ ,  $S_E$ , E, AB in the appropriate cages.

Reaction	1	2	3	4
Reaction type				

- (iii) Write the mechanism for Reaction 1.

- (iv) Draw the structure of the product T obtained when Reaction 1 is carried out in the presence of peroxide.



- (v) It has been found that T is also formed in Reaction 1, as a minor product. By considering the mechanism of the reaction, explain why the major product in Reaction 1 is P and not T.

(4.5 marks)

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

## PART B - ESSAY

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

5. (a) A and B are volatile and completely miscible liquids which form an ideal solution when mixed. A mixture containing 1.0 mol of liquid A and 1.0 mol of liquid B was placed in a closed container. When the system reached equilibrium, the pressure and volume of the gaseous phase, and the mole ratio of A/B in this phase were found to be  $1.0 \times 10^3 \text{ Pa}$ ,  $0.8314 \text{ m}^3$  and 2/3 respectively. The system was maintained at 200 K.

Calculate the following.

- (i) the total number of moles in the gas phase.  
(ii) the mole fractions of A and B in the liquid phase.  
(iii) the saturated vapour pressures of A and B.

(5.0 marks)

- (b) In a saturated solution of  $\text{Mn}(\text{OH})_2$  at 25 °C, the concentration of  $\text{Mn}^{2+}$  is  $1.0 \times 10^{-5} \text{ mol dm}^{-3}$ . The solubility product of  $\text{Mg}(\text{OH})_2$  at 25 °C is  $1.0 \times 10^{-10} \text{ mol}^3 \text{ dm}^{-9}$ .  $K_b$  of  $\text{NH}_4\text{OH}$  at 25 °C is  $1.6 \times 10^{-5} \text{ mol dm}^{-3}$ .

- (i) Calculate the solubility product of  $\text{Mn}(\text{OH})_2$  at 25°C.  
(ii) Calculate the concentration of hydroxide ions in a 0.01 mol dm<sup>-3</sup>  $\text{NH}_4\text{OH}$  solution at 25°C.  
(iii) Determine the concentration of  $\text{NH}_4\text{OH}$  necessary to start precipitation of  $\text{Mn}(\text{OH})_2$  from a 0.001 mol dm<sup>-3</sup> solution of  $\text{MnSO}_4$ .  
(iv) If 5.35 g of  $\text{NH}_4\text{Cl}$  is dissolved in 1.00 dm<sup>-3</sup> of 1.00 mol dm<sup>-3</sup>  $\text{NH}_4\text{OH}$  solution, calculate the concentration of hydroxide ions in the solution. (H = 1.0, N = 14.0, Cl = 35.5)  
(v) Calculate the number of moles of solid  $\text{NH}_4\text{Cl}$  required to prevent the precipitation of  $\text{Mg}(\text{OH})_2$  in a solution to be made by mixing 0.50 dm<sup>-3</sup> of a 0.02 mol dm<sup>-3</sup> solution of  $\text{Mg}(\text{NO}_3)_2$  and 0.50 dm<sup>-3</sup> of a 0.20 mol dm<sup>-3</sup> solution of  $\text{NH}_4\text{OH}$ .  
(vi) Explain the use of  $\text{NH}_4\text{Cl}$  in group analysis.

(10.0 marks)

6. (a) Consider the reaction,



where m, n and c are stoichiometric coefficients of M, N and C respectively.

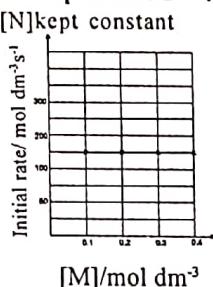
- (i) Considering the above reaction to be an elementary reaction, write an expression for the rate of reaction. (The rate constant of the reaction = k.)  
(ii) Two experiments were conducted to find the order of the reaction.

**Experiment 1:** Initial rate was measured varying the concentration of M while keeping the concentration of N constant.

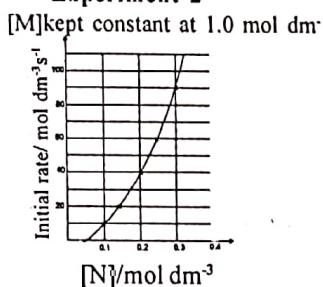
**Experiment 2:** Initial rate was measured varying the concentration of N while keeping the concentration of M constant at 1.0 mol dm<sup>-3</sup>.

Both experiments were conducted at the same temperature. The results of the experiments are shown in the graphs below.

**Experiment 1**



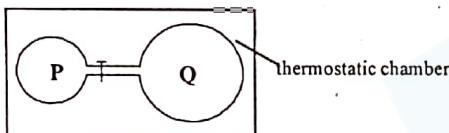
**Experiment 2**



- Find the order of the reaction with respect to M.
- Find the order of the reaction with respect to N.
- What is the overall order of the reaction?
- Find the rate constant, k of the reaction.

(6.0 marks)

- (b) Two rigid bulbs P (volume = V) and Q (volume = 2V) connected by a tap are placed in a thermostatic chamber as shown below.



Initially the tap is closed. P contains 1.0 mol of gas AB and Q is empty. When the temperature of the system was increased to 400 K, AB(g) dissociated into A(g) and B(g) according to the equilibrium reaction given below.

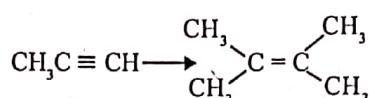


The equilibrium constant for the above equilibrium is  $K_c$ . When the system has reached equilibrium (first equilibrium) the amount of A(g) was found to be x mol. The tap was opened and the system was allowed to reach equilibrium again (second equilibrium). The amount of A(g) formed was found to be y mol.

- Show that  $K_c V (1-x) = x^2$  and  $3K_c V(1-y) = y^2$ .
- If  $y = 0.5$  mol, calculate the value of x.
- Explain your answer in (ii) above using the Le Chatelier's principle.
- The temperature of the system was increased to 600 K. When the system reached equilibrium (third equilibrium) the pressure of the system was 1.7 times that at the second equilibrium. The amount of A(g) at the third equilibrium was z mol. Calculate the value of z.
- Show that the decomposition of AB(g) is endothermic.
- State any assumption/s made in your calculations.

(9.0 marks)

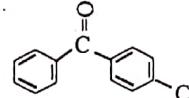
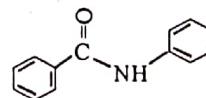
7. (a) Using only the chemicals given in the list, show how you would carry out the following conversion.



List of chemicals
$\text{NaBH}_4$ , $\text{HgSO}_4$ ,
dil. $\text{H}_2\text{SO}_4$ ,
conc. $\text{H}_2\text{SO}_4$ , $\text{PCl}_5$ ,
$\text{Mg}$ , ether

(4.0 marks)

- (b) Show how you would synthesize compound B using compound A as the only organic starting material.

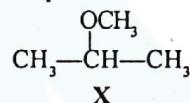


A

B

(6.0 marks)

- (c) It is possible to synthesize the following compound X using two different pathways. Each pathway can be written as a nucleophilic substitution reaction.



- (i) Write the reactants for each pathway.

- (ii) One of the above pathways will result in the formation of another compound Y in addition to X. Identify the reactants involved in this pathway and write the structure of Y.

- (iii) State what type of reaction is involved in the formation of Y.

- (iv) Assume that the reactants identified in (ii) above, form X, by a two step reaction. Show how X is formed by writing these two steps. Use curved arrows to indicate movement of electrons.

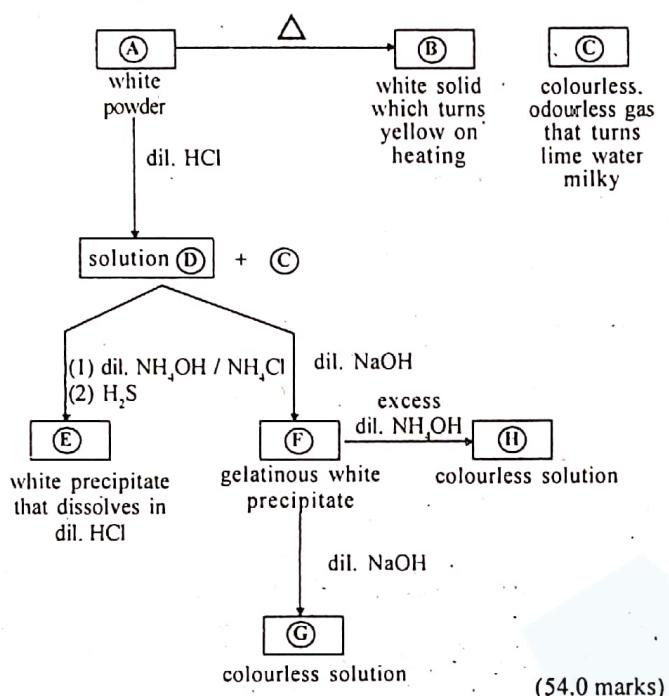
(5.0 marks)

### PART C - ESSAY

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

8. (a) Reactions of compounds of an element in the 3d block of the Periodic Table are given below.

Identify the species A, B, C, D, E, F, G and H.



(b) Tests (1) and (2) were carried out with an aqueous solution Z produced by passing the colourless gas P into water. The tests and observations are given below.

Test	Observation
(1) Added an acidified solution of $K_2Cr_2O_7$ to the solution.	A clear green solution was obtained.
(2) Added $H_2O_2$ to the solution and warmed. Then added a solution of $BaCl_2$ .	A white precipitate insoluble in dil. HCl was formed.

- (i) Identify gas P. (Reasons are not required.)
  - (ii) Give balanced chemical equations for the reactions that occur in tests (1) and (2).
  - (iii) When gas Q was passed through solution Z, a pale yellow (could be seen as white) turbidity resulted.
    - I. Identify gas Q. (Reasons are not required.)
    - II. Give the balanced chemical equation for this reaction.
- (5.0 marks)

(c) A sample given for analysis was found to contain  $NaOH$ ,  $Na_2CO_3$  and an inert water soluble substance. The following procedure was used to determine the percentage of  $Na_2CO_3$  in the sample.

Note: The inert substance does not participate in the reactions in the procedure given below.

Procedure:

A weight of 42.40 g of the sample was transferred quantitatively to a 500 cm<sup>3</sup> volumetric flask and made upto the mark with distilled water. The flask was shaken thoroughly (solution X).

(1) A 25.00 cm<sup>3</sup> portion of solution X was titrated with dil. HCl solution using methyl orange as the indicator, until the colour changed from orange to red. The burette reading at the end point was 32.00 cm<sup>3</sup>.

(2) A 25.00 cm<sup>3</sup> portion of solution X was warmed to 70 °C and 1%  $BaCl_2$  solution was added in slight excess. The  $BaCO_3$  precipitate formed was filtered, and the filtrate was titrated with dil. HCl solution using phenolphthalein as the indicator until the colour changed from pink to colourless. The burette reading at the end point was 24.00 cm<sup>3</sup>.

(3) To a 25.00 cm<sup>3</sup> volume of the dil. HCl solution, 5%  $KIO_3$  and 5%  $KI$  solutions were added in excess. The liberated  $I_2$  was titrated with a 0.50 mol dm<sup>-3</sup>  $Na_2S_2O_3$  solution using starch as the indicator. The burette reading at the end point was 12.50 cm<sup>3</sup>.

- (i) Determine the concentration of the HCl solution.
  - (ii) Calculate the percentage of sodium carbonate in the sample.
  - (iii) State any assumption/s made in calculating the above.
- (C = 12, O = 16, Na = 23) (5.0 marks)

9. (a) (i) I. With the aid of balanced chemical equations list the steps involved, along with the reaction conditions, in the manufacture of  $H_2SO_4$  using the Contact Process.  
 II. Briefly describe the physicochemical principles related to this process.  
 III. Give two uses of  $H_2SO_4$ .

- (ii) Using balanced chemical equations, indicate how the following conversions could be carried out industrially:  
 I. limestone  $\rightarrow C_2H_2$   
 II.  $N_2 \rightarrow NaNO_2$

**Note:** Where applicable give the reaction conditions and indicate how the reagents/reactants are obtained industrially.

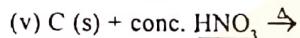
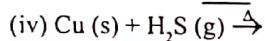
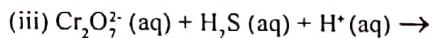
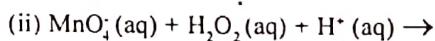
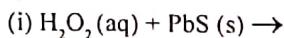
- (iii) The following questions are based on the manufacture of  $Na_2CO_3$  using the Solvay Process.
    - I. State the starting materials used in this process.
    - II. Indicate how the materials stated in I are obtained.
    - III. Give the final by-product of this process.
    - IV. Give two reasons as to why low temperatures are used in this process.
    - V. Give two uses of  $Na_2CO_3$ .
    - VI. Propose a method to convert the final by-product stated in III to gypsum, using sea water as a natural resource.
- (7.5 marks)

- (b) As an alternative to chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) were introduced to reduce the ozone layer depletion. However, both these groups of compounds not only deplete the ozone layer but also contribute to other environmental problems

- (i) Draw the chemical structures of all the CFCs and HCFCs with a single C atom. Label each of them as a CFC or HCFC.
- (ii) "Under normal atmospheric conditions, HCFCs are more reactive than CFCs." Comment on this statement.
- (iii) Name another environmental problem that is associated with CFCs and HCFCs. Comment on their relative contribution towards this environmental problem.
- (iv) Identify **three** properties of CFCs that make them suitable for use as refrigerants.
- (v) Explain how CFCs contribute to the depletion of the ozone layer.
- (vi) Briefly describing the consequence of the depletion of the ozone layer, identify **three** problems associated with it.

(7.5 marks)

10. (a) Predict the products and give balanced chemical equations for the following reactions. State the action of the species underlined. in the reaction.



(2.5 marks)

- (b) A solution T has been prepared by dissolving 0.300 g of FeC<sub>2</sub>O<sub>4</sub> in dilute H<sub>2</sub>SO<sub>4</sub>. The solution was heated to 65°C. Calculate the volume of 0.025 mol dm<sup>-3</sup> KMnO<sub>4</sub> solution required to react completely with FeC<sub>2</sub>O<sub>4</sub> under these conditions.

(C=12, O= 16, Fe=56)

**Note :** Consider FeC<sub>2</sub>O<sub>4</sub> to exist as Fe<sup>2+</sup> and C<sub>2</sub>O<sub>4</sub><sup>2-</sup> in solution T.

(5.0 marks)

- (c) Liquefied-petroleum gas (LP gas) is commonly used as a fuel for cooking purposes in Sri Lanka. It is a mixture of liquefied propane and butane, under high pressure. The following data are provided.

Substance	Standard enthalpy of formation $\Delta H_f^\circ$ at 25°C (kJ mol <sup>-1</sup> )
H <sub>2</sub> O (l)	- 286
CO <sub>2</sub> (g)	- 394
C <sub>3</sub> H <sub>8</sub> (g)	- 104
C <sub>4</sub> H <sub>10</sub> (g)	- 126

- (i) Calculate the standard enthalpies of combustion of propane and butane gases at 25°C.
- (ii) Calculate the amount of heat needed to increase the temperature of 400 g of water from 25°C to 85°C. (Heat capacity of water is 4.2 J g<sup>-1</sup>°C<sup>-1</sup>).
- (iii) Assuming complete combustion would take place, calculate the mass of CO<sub>2</sub> emitted in each case when the above process (ii) is carried out using:
- I. propane as the fuel.
  - II. butane as the fuel.
- (iv) Based on your calculations in (iii) above, identify which fuel is more environmentally friendly and explain why it is so.

(7.5 marks)

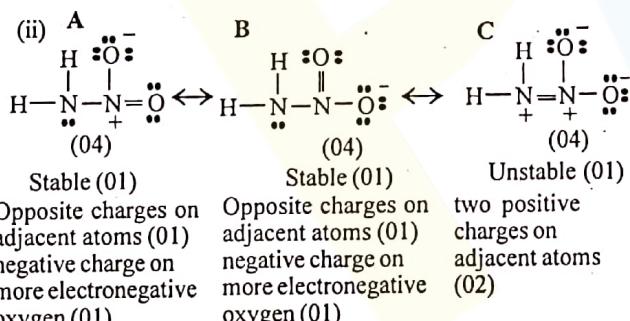
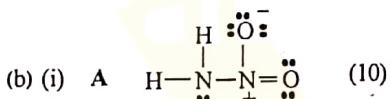
**G.C.E. (A/L) Examination  
Chemistry - 2013**

**M.C.Q. Answers**

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

**PART A - STRUCTURED ESSAY**

1. (a) (i)  $\text{CO} < \text{CO}_2 < \text{CO}_3^{2-}$   
(ii)  $\text{NH}_3 < \text{NO}_3^- < \text{NO}_2^+$   
(iii)  $\text{BeSO}_4 < \text{MgSO}_4 < \text{CaSO}_4$   
(iv)  $\text{Ne} < \text{Ar} < \text{Kr}$   
(v)  $\text{F} < \text{Cl} < \text{S} < \text{Si}$  (05 x 5) 1 (a) (25)



(iii)

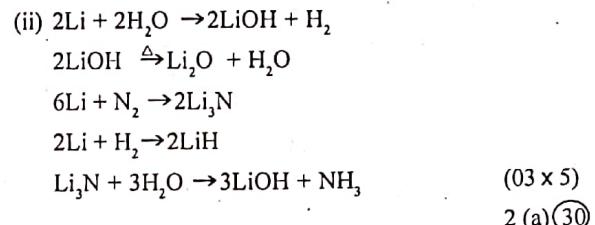
	The N attached to two H atoms	The N attached to two O atoms
I electron pair geometry	tetrahedral	trigonal planar (03+03)
II Shape	Pyramidal	trigonal planar (03+03)
III hybridization	$\text{SP}^3$	$\text{SP}^2$ (03+03)

- (iv) polar (04)  
(v) I  $\text{N}^1$  and  $\text{N}^2$   $\text{SP}^3 + \text{SP}^2$  (03+03)  
II  $\text{N}^1$  and H  $\text{SP}^3 + \text{1S}$  (03+03)

1 (b) (65)

- (c) (i)  $\text{CH}_3\text{Cl}$ , HF (02+02)  
(ii) HF (02)  
(iii)  $\text{Xe}$ ,  $\text{CH}_3\text{Cl}$ , HF (02+01+01) 1 (c) (10)

2. (a) (i) A = Li; B =  $\text{H}_2$ ; C =  $\text{Li}_3\text{N}$ ; D =  $\text{LiH}$ ; E =  $\text{NH}_3$  (03 x 5)



2 (a) (30)

- (b) (i)  $1\text{S}^2 2\text{S}^2 2\text{P}^6 3\text{S}^2 3\text{P}^6 3\text{d}^3 4\text{S}^2$  or  
 $1\text{S}^2 2\text{S}^2 2\text{P}^6 3\text{S}^2 3\text{P}^6 4\text{s}^2 3\text{d}^3$  (05)

- (ii) +2, +3, +4, +5 (02 x 4)

- (iii) VO - basic       $\text{VO}_2$  - amphoteric  
 $\text{V}_2\text{O}_3$  - basic       $\text{V}_2\text{O}_5$  - acidic (amphoteric) (02 x 8)

- (iv)  $\text{VO}_2^+$  - yellow  
 $\text{VO}^{2+}$  - blue (01 x 4)

- (v)  $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$  - Violet/blue violet or  $\text{Cr}^{3+}_{(\text{aq})}$  or  $\text{Cr}^{3+}$  - Green (04 + 04)

Evolution of  $\text{CO}_2$  or evolution of bubbles or green precipitate (04)

- (vi) as an alloying ingredient in steel or in alloys or as a catalyst ( $\text{V}_2\text{O}_5$ ) (04)

- (vii) I. green precipitate (03)  
II. yellow solution (03)

- (viii) X =  $\text{CrO}_3$ , Y =  $\text{Cr}_2\text{O}_3$  (03+03)

- (ix) Solution turns yellow or orange solution turns yellow (03)

- (x) Advantage : it's primary standard or titration can be done in the presence of chloride ions (03)

Disadvantage : difficult to observe colour change at end point or not a self - indicator (03)

2 (b) (70)

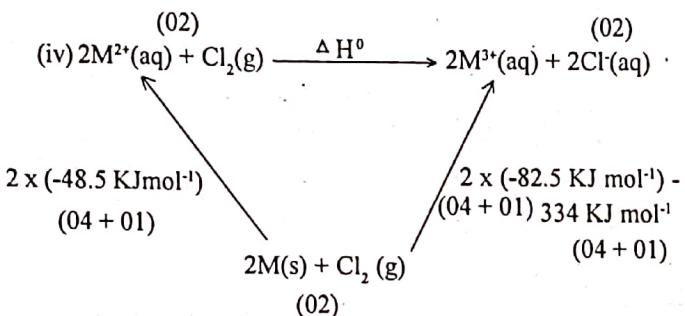
3. (i) Oxidation reaction :  $\text{M}^{2+}(\text{aq}) \rightarrow \text{M}^{3+}(\text{aq}) + \text{e}$  (05)

Reduction reaction :  $\text{Cl}_2(\text{g}) + 2\text{e} \rightarrow 2\text{Cl}^-(\text{aq})$  (05)

Cell reaction :  $2\text{M}^{2+}(\text{aq}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{M}^{3+}(\text{aq}) + 2\text{Cl}^-(\text{aq})$  (05)

- (ii) A :  $\text{Cl}_2$  (g, 1 atm)      B : Satt bridge  
C : Voltmeter (potentiometer)  
D :  $\text{Cl}^-$  (aq, 1.0  $\text{mol dm}^{-3}$ )  
E : Mixture of  $\text{M}^{2+}$  (aq, 1.0  $\text{mol dm}^{-3}$ ) and  $\text{M}^{3+}$  (aq, 1.0  $\text{mol dm}^{-3}$ ) (05 x 5)

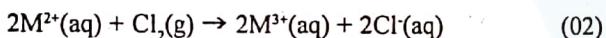
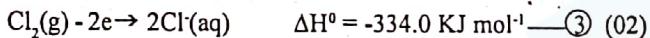
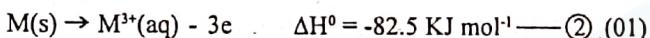
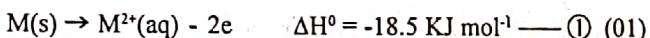
$$\begin{aligned}
 \text{(iii)} \quad E_{\text{cell}}^{\circ} &= E_{\text{Cl}_2/\text{Cl}^-}^{\circ} - E_{\text{M}^{3+}/\text{M}^{2+}}^{\circ} \quad \text{or} \\
 E_{\text{cell}}^{\circ} &= E_{\text{cathode}}^{\circ} - E_{\text{anode}}^{\circ} \quad \text{or} \\
 E_{\text{cell}}^{\circ} &= E_{\text{RHS}}^{\circ} - E_{\text{LHS}}^{\circ} \quad (05) \\
 &= 0.59 \text{ V} \quad (04 + 01)
 \end{aligned}$$



$$\Delta H^{\circ} = 2 \times (-82.5 \text{ KJ mol}^{-1}) - 2 \times (-48.5 \text{ KJ mol}^{-1}) + (-334.0 \text{ KJ mol}^{-1})$$

$$\Delta H = -402 \text{ KJ mol}^{-1} \quad (03 + 01)$$

Alternate Answer.



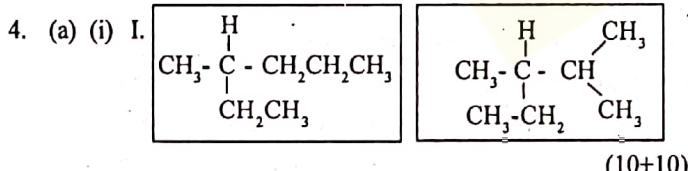
$$\Delta H^{\circ} = 2 \times \textcircled{2} - 2 \times \textcircled{1} + \textcircled{3}$$

$$\Delta H^{\circ} = 2 \times (-82.5 \text{ KJ mol}^{-1}) - 2 \times (-48.5 \text{ KJ mol}^{-1}) + (-334.0 \text{ KJ mol}^{-1}) \quad (04 + 01) \quad (04 + 01) \quad (04 + 01)$$

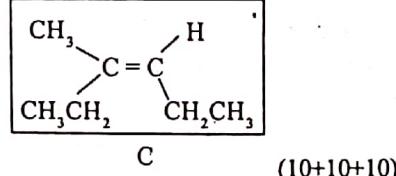
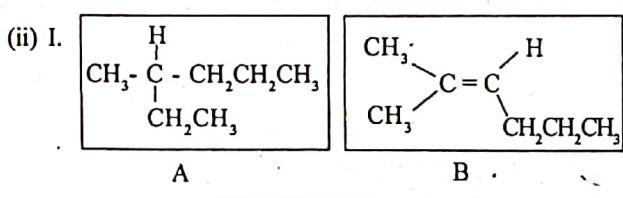
$$\Delta H = -402 \text{ KJ mol}^{-1} \quad (03 + 01)$$

$$\begin{aligned}
 \text{(v)} \quad \Delta G^{\circ} &= -KE_{\text{cell}}^{\circ} \\
 &= -1.93 \times 10^5 (\text{J mol}^{-1}\text{V}^{-1}) \times 0.59 \quad (04 + 01) \\
 &= -113.87 \text{ KJ mol}^{-1} \quad (04 + 01)
 \end{aligned}$$

$$\begin{aligned}
 \text{(vi)} \quad \Delta G^{\circ} &= \Delta H^{\circ} - T\Delta S^{\circ} \quad (05) \\
 \Delta S^{\circ} &= 288 \text{ KJ mol}^{-1} / (-298K) \quad (04 + 01) \\
 \Delta S^{\circ} &= -0.97 \text{ KJ mol}^{-1} \text{ K}^{-1} \quad (04 + 01)
 \end{aligned}$$

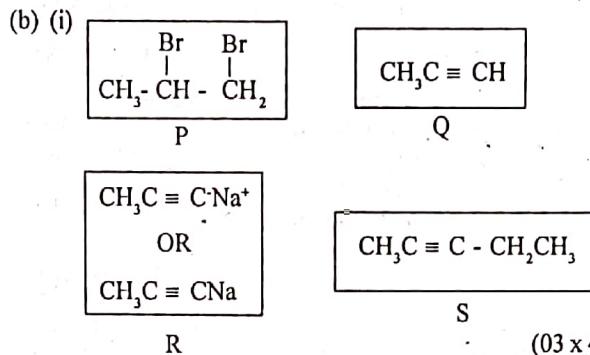


(II) Structural isomers or constitutional isomers or chain isomers (03)



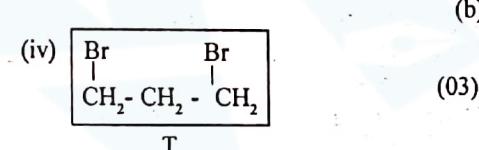
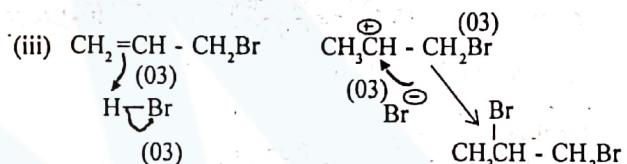
II. B : 3 - methyl - 2- hexene (01)  
 C : 3- methyl - 3- hexene (01)  
 (B and C can be interchanged, the correct IUPAC names should be written)

4 (a) 55



Reaction	1	2	3	4
Reaction type	A <sub>E</sub>	E	AB	S <sub>N</sub>

(03 x 4)



(v) Intermediate carbo cation for P	Intermediate carbo cation for T
$\text{CH}_3\overset{+}{\text{C}}\text{-CH}_2\text{Br}$	$\text{CH}_2\overset{+}{\text{C}}\text{-CH}_2\text{Br}$
Secondary carbo cation, more stable	Primary carbo cation, less stable

4 (b) 45 marks

5. (a) (i) PV = nRT  
 n =  $\frac{PV}{RT}$   
 n =  $\frac{1.0 \times 10^3 \text{ Pa} \times 0.8314 \text{ m}^3}{8.314 \text{ Jmol}^{-1}\text{K}^{-1} \times 200 \text{ K}}$  (04 + 01)  
 n = 0.5 mol

5(a) (i) 10 marks

(ii) Number of moles of A in gas phase = n<sub>A</sub>

Number of moles of B in gas phase = n<sub>B</sub>

mole fraction of A in gas phase = X<sub>A</sub>

mole fraction of B in gas phase = X<sub>B</sub>

mole fraction of A in liquid phase = X<sub>A</sub><sup>l</sup>

mole fraction of B in liquid phase = X<sub>B</sub><sup>l</sup>

$$\frac{X_A}{X_B} = \frac{n_A}{n_B} = \frac{2}{3} \quad (03)$$

$$n = n_A + n_B = 0.5 \quad (03)$$

$$n_A = 0.2 \text{ mol} \quad (01 + 01)$$

$$n_B = 0.3 \text{ mol} \quad (01 + 01)$$

$$\text{Amount of A left in the liquid phase} = (1.0 - 0.2) \text{ mol} \\ = 0.8 \text{ mol} \quad (01+01)$$

$$\text{Amount of B left in the liquid phase} = (1.0 - 0.3) \text{ mol} \\ = 0.7 \text{ mol} \quad (01+01)$$

$$X_A^1 = \frac{0.8 \text{ mol}}{(0.8 + 0.7) \text{ mol}} = \frac{8}{15} = 0.533 \quad (03)$$

$$X_B^1 = \frac{0.7 \text{ mol}}{(0.8 + 0.7) \text{ mol}} = \frac{7}{15} = 0.467 \quad (03)$$

5 (a) (ii) 20

$$1.6 \times 10^{-5} \text{ mol dm}^{-3} = \frac{[\text{OH}^-(\text{aq})]^2 (\text{mol dm}^{-3})^2}{0.01 \text{ mol dm}^{-3}} \quad (02 + 01)$$

$$[\text{OH}^-(\text{aq})] = 4.0 \times 10^{-4} \text{ mol dm}^{-3} \quad (02 + 01)$$

5 (b) (ii) 10

$$(iii) K_{sp} = [\text{Mn}^{2+}(\text{aq})] [\text{OH}^-(\text{aq})]^2 \\ 4 \times 10^{-15} (\text{mol}^3 \text{dm}^{-9}) = 10^{-3} (\text{mol dm}^{-3}) \times [\text{OH}^-(\text{aq})]^2$$

$$[\text{OH}^-(\text{aq})]^2 = \frac{4 \times 10^{-15} (\text{mol}^3 \text{dm}^{-9})}{10^{-3} (\text{mol dm}^{-3})} \\ = 4 \times 10^{-12} (\text{mol dm}^{-3})^2 \quad (04 + 01)$$

$$[\text{OH}^-(\text{aq})] = 2 \times 10^{-6} (\text{mol dm}^{-3}) \quad (04 + 01)$$

$$(iii) \text{ Partial pressure of A} = P_A$$

$$\text{Partial pressure of B} = P_B$$

$$\text{Saturated vapour pressure of A} = P_A^0$$

$$\text{Saturated vapour pressure of B} = P_B^0$$

Applying Dalton's law,

$$P_A = P \times X_A = 1.0 \times 10^3 \text{ Pa} \frac{0.2 \text{ mol}}{0.5 \text{ mol}} \quad (02)$$

$$P_A = 4.0 \times 10^2 \text{ Pa} \quad (01)$$

Similarly

$$P_B = P \times X_B = 1.0 \times 10^3 \text{ Pa} \frac{0.3 \text{ mol}}{0.5 \text{ mol}} \quad (02)$$

$$P_B = 6.0 \times 10^2 \text{ Pa} \quad (01)$$

Applying Raoult's law,

$$P_A^0 = P_A = \frac{4.0 \times 10^2 \text{ Pa}}{X_A^1} = \frac{4.0 \times 10^2 \text{ Pa}}{8/15 \text{ mol}} \quad (03 + 01)$$

$$= 7.5 \times 10^2 \text{ Pa} \quad (02 + 01)$$

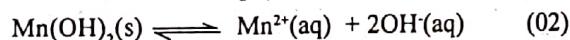
$$P_B^0 = P_B = \frac{6.0 \times 10^2 \text{ Pa}}{X_B^1} = \frac{6.0 \times 10^2 \text{ Pa}}{7/15 \text{ mol}} \quad (03 + 01)$$

$$= 1.286 \times 10^3 \text{ Pa} \quad (02 + 01)$$

5 (a) (iii) 20

5 (a) 50

$$(b) \text{ Solubility of Mn(OH)}_2 \text{ at } 25^\circ\text{C} = 1.0 \times 10^{-5} \text{ mol dm}^{-3}$$



$$K_{sp} = [\text{Mn}^{2+}(\text{aq})] [\text{OH}^-(\text{aq})]^2 \quad (02)$$

$$K_{sp} = 1 \times 10^{-5} \text{ mol dm}^{-3} \times (2 \times 10^{-5} \text{ mol dm}^{-3})^2 \quad (02 + 01)$$

$$K_{sp} = 4 \times 10^{-15} \text{ mol}^3 \text{dm}^{-9} \quad (02 + 01)$$

5 (b) (i) 10

$$(ii) \text{NH}_4\text{OH}(\text{aq}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq}) \quad (01)$$

$$K_b = \frac{[\text{NH}_4^+(\text{aq})] [\text{OH}^-(\text{aq})]}{[\text{NH}_4\text{OH}(\text{aq})]} \quad (01)$$

Since  $\text{NH}_4\text{OH}$  is a weak base, amount dissociated is very small.

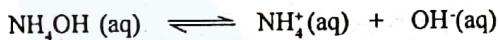
$$[\text{NH}_4^+(\text{aq})] = [\text{OH}^-(\text{aq})] \text{ and } [\text{NH}_4\text{OH}(\text{aq})] \\ = 0.01 \text{ mol dm}^{-3} \quad (02)$$

The  $[\text{OH}^-(\text{aq})]$  necessary to just precipitate  $\text{Mn(OH)}_2$

$$= 2 \times 10^{-6} \text{ mol dm}^{-3}$$

assume that the concentration of  $\text{NH}_4\text{OH}$  necessary to provide

$$[\text{OH}^-(\text{aq})] = 2 \times 10^{-6} \text{ mol dm}^{-3} \text{ is } x.$$



$$x - 2 \times 10^{-6} \text{ mol dm}^{-3} \quad 2 \times 10^{-6} \text{ mol dm}^{-3} \quad 2 \times 10^{-6} \text{ mol dm}^{-3}$$

$$1.6 \times 10^{-5} \text{ mol dm}^{-3} = \frac{[2 \times 10^{-6}]^2 (\text{mol dm}^{-3})^2}{x - 2 \times 10^{-6} \text{ mol dm}^{-3}} \quad (04 + 01)$$

$$x = 2.25 \times 10^{-6} \text{ mol dm}^{-3} \quad (04 + 01)$$

OR

$$1.6 \times 10^{-5} \text{ mol dm}^{-3} = \frac{[2 \times 10^{-6}]^2 (\text{mol dm}^{-3})^2}{x} \quad (04 + 01)$$

$$x = 2.5 \times 10^{-7} \text{ mol dm}^{-3} \quad (04 + 01)$$

5 (b) (iii) 20

$$(iv) \text{ Mol. Wt. of NH}_4\text{Cl} = 53.5 \text{ g mol}^{-1}$$

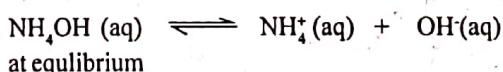
$$\text{Therefore the amount of NH}_4\text{Cl} = \frac{5.35 \text{ g}}{53.5 \text{ g mol}^{-1}}$$

$$= 0.1 \text{ mol} \quad (01 + 01)$$

Since  $\text{NH}_4\text{Cl}$  is completely dissociated in aqueous medium

$$[\text{NH}_4^+(\text{aq})] = 0.1 \text{ mol dm}^{-3} \quad (01 + 01)$$

Let's take the concentration of  $\text{NH}_4\text{OH}$  as  $C \text{ mol dm}^{-3}$  the degree of dissociation as  $\alpha$



$$C(1-\alpha) \text{ mol dm}^{-3} \quad C \alpha \text{ mol dm}^{-3} \quad C \alpha \text{ mol dm}^{-3}$$

$$[\text{NH}_4^+(\text{aq})] = (0.1 + \alpha) \text{ mol dm}^{-3} = 0.1 \text{ mol dm}^{-3} \quad (03 + 01)$$

$$[\text{NH}_4\text{OH}(\text{aq})] = (1.0 - \alpha) \text{ mol dm}^{-3} = 1.0 \text{ mol dm}^{-3} \quad (03 + 01)$$

$$1.6 \times 10^{-5} \text{ mol dm}^{-3} = \frac{0.1 \text{ mol dm}^{-3} [\text{OH}^-(\text{aq})] \text{ mol dm}^{-3}}{1.0 \text{ mol dm}^{-3}} \quad (03 + 01)$$

$$[\text{OH}^-(\text{aq})] = 1.6 \times 10^{-4} \text{ mol dm}^{-3} \quad (03 + 01)$$

5 (b) (iv) 20

(v) The  $[\text{Mg}(\text{NO}_3)_2(\text{aq})]$  in the final solution

$$\frac{0.02 \text{ mol dm}^{-3} \times 0.50 \text{ dm}^3}{1.0 \text{ dm}^3} = 0.01 \text{ mol dm}^{-3} \quad (04 + 01)$$

To avoid the precipitation of  $\text{Mg(OH)}_2(\text{s})$  in the final mixture, the following criteria should be satisfied.

$Mg(NO_3)_2$  is completely dissociated to  $Mg^{2+}$  and  $NO_3^-$  ions.  
Therefore  $[Mg^{2+}(aq)]$  in the final solution =  $0.01\text{ mol dm}^{-3}$  in order for  $Mg(OH)_2$  not to precipitate  
 $K_{sp} \geq [Mg^{2+}(aq)][OH^-(aq)]^2$

$$1 \times 10^{-10} (\text{mol}^3 \text{dm}^{-9}) \geq 10^{-2} (\text{mol dm}^{-3}) \times [OH^-(aq)]^2$$

$$[OH^-(aq)]^2 \geq \frac{1 \times 10^{-10} (\text{mol}^3 \text{dm}^{-9})}{10^{-2} (\text{mol dm}^{-3})}$$

$$= 1 \times 10^{-8} (\text{mol dm}^{-3})^2 \quad (04 + 01)$$

$$[OH^-(aq)] \leq 1 \times 10^{-4} \text{ mol dm}^{-3} \quad (04 + 01)$$

The  $[NH_4Cl(aq)]$  in the final solution

$$\frac{0.20 \text{ mol dm}^{-3} \times 0.5 \text{ dm}^3}{1.0 \text{ dm}^3} = 0.10 \text{ mol dm}^{-3} \quad (04 + 01)$$

Let the required concentration of  $NH_4Cl$  to keep  $[OH^-(aq)]$  at  $1 \times 10^{-4} \text{ mol dm}^{-3}$  be  $x$

Since amount dissociated is very small,

$$[NH_4^+(aq)] = NH_4Cl(aq) = x$$

$$1.6 \times 10^{-5} \text{ mol dm}^{-3} = \frac{x (\text{mol dm}^{-3}) 1 \times 10^{-4} (\text{mol dm}^{-3})}{0.1 \text{ mol dm}^{-3}} \quad (04 + 01)$$

$$x = 1.6 \times 10^{-2} \text{ mol dm}^{-3} \quad (04 + 01)$$

$$\begin{aligned} \text{The amount of } NH_4Cl \text{ necessary to prevent } Mg(OH)_2 \\ \text{precipitation} &= 1.6 \times 10^{-2} \text{ mol dm}^{-3} \times 1.0 \text{ dm}^3 \\ &= 1.6 \times 10^{-2} \text{ mol} \quad (04 + 01) \end{aligned}$$

5 (b) (v) (35)

(vi) In group separation to avoid the precipitation of  $Mg(OH)_2$  in group III or other cations that may precipitate as hydroxides),  $NH_4Cl$  is added before adding  $NH_4OH$ . (05)

5 (b) (vi) 05 marks

5 (b) (100)

$$6. (a) (i) \text{ Rate} = K [M]^m [N]^n \quad (10)$$

6 (a) (i) (10)

(ii) I According to the first graph, the rate of the reaction is independent of  $[M]$ . Therefore, the order of the reaction with respect to  $M$  must be zero ( $m = 0$ )

(10)

$$\text{Therefore, Rate} = K[N]^n \quad (05)$$

II From second graph, when  $N = 0.1 \text{ mol dm}^{-3}$ ,

$$\text{Rate} = 10 \text{ mol dm}^{-3} \text{s}^{-1}, \text{ when } N = 0.2 \text{ mol dm}^{-3}$$

$$\text{Rate} = 40 \text{ mol dm}^{-3} \text{s}^{-1}$$

When the concentration is doubled, rate increased four times, therefore the order with respect to  $N$  is 2

OR (20)

using data for any two points,

$$10 \text{ mol dm}^{-3} \text{s}^{-1} = K(0.1 \text{ mol dm}^{-3})^n - ① \quad (04 + 01)$$

$$40 \text{ mol dm}^{-3} \text{s}^{-1} = K(0.2 \text{ mol dm}^{-3})^n - ② \quad (04 + 01)$$

$$\frac{②}{①} \frac{40 \text{ mol dm}^{-3} \text{s}^{-1}}{10 \text{ mol dm}^{-3} \text{s}^{-1}} = \left[ \frac{0.2 \text{ mol dm}^{-3}}{0.1 \text{ mol dm}^{-3}} \right]^n \quad (04 + 01)$$

$$4 = 2^n$$

$$n = 2 \quad (05)$$

$$\text{III Overall order} = n + m = 2 + 0 = 2 \quad (05)$$

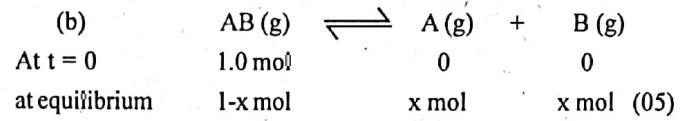
(IV) From equation (1),

$$K = \frac{10 \text{ mol dm}^{-3} \text{s}^{-1}}{(0.1 \text{ mol dm}^{-3})^2} \quad (04 + 01)$$

$$= 1000 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$$

6 (a) (ii) (50)

6 (a) (60)

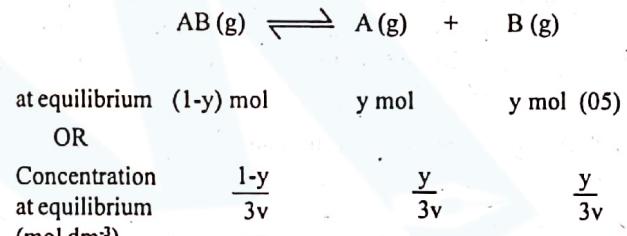


$$K_c = \frac{(x/v)(x/v)}{(1-x/v)} = \frac{x^2}{(1-x)v} \quad (05)$$

$$K_c v (1-x) = x^2$$

After opening the tap the volume is increased to  $3v$ .

The amount dissociated is  $y$  mol



$$K_c = \frac{(y/3v)(y/3v)}{(1-y/3v)} = \frac{y^2}{(1-y)3v} \quad (05)$$

$$3K_c v (1-y) = y^2$$

6 (b) (i) (20)

(ii) Equilibrium constant  $K_c$  in both occasions is the same because there is no change in temperature. (05)

$$K_c = \frac{x^2}{(1-x)v} = \frac{y^2}{(1-y)3v} \quad (05)$$

if  $y = 0.5 \text{ mol}$

$$\frac{x^2}{(1-x)v} = \frac{(0.5 \text{ mol})^2}{(1.0 \text{ mol} - 0.5 \text{ mol}) 3v} \quad (05)$$

$$\frac{x^2}{(1-x)} = \frac{(0.5 \text{ mol})^2}{3(0.5 \text{ mol})} = \frac{0.5 \text{ mol}}{3} \quad (05)$$

$$3x^2 - 0.5 \text{ mol} (1-x) = 0$$

$$(3x - 1 \text{ mol})(2x + 1 \text{ mol}) = 0$$

$$x = \frac{1}{3} \text{ mol OR } x = -\frac{1}{2} \text{ mol (cannot be accepted)}$$

$$x = 0.33 \text{ mol} \quad (05)$$

6 (b) (ii) (20)

(iii) When volume is  $V$ , the amount dissociated =  $0.33 \text{ mol}$ , when the volume is increased to  $3V$  the amount dissociated =  $0.5 \text{ mol}$ . Increasing of volume decreases the pressure of the system, more  $AB(g)$  is dissociated to counter this change. (10)

6 (b) (iii) (20)

(iv) Applying PV = nRT to second equilibrium,

$$y = 0.5$$

$$n = 1 + y = 1.5 \text{ mol} \quad (04+01)$$

Volume = 3V and T = 400 K

$$P_2 = 1.5 \frac{R \times 400 \text{ K}}{3V} \quad (05)$$

When the temperature is increased to 600 K

Pressure =  $P_3 = 1.7 P_2$

Apply PV = nRT for third equilibrium

$$n = (1 + Z) \text{ mol} \quad (04+01)$$

V = 3v and T = 600 K

$$P_3 = 1.7 \left[ 1.5 \frac{R \times 400 \text{ K}}{3v} \right] = \frac{(1+Z) R \times 600 \text{ K}}{3v} \quad (05)$$

$$1 + Z = \frac{1.5 \times 400 \text{ K} \times 1.7}{600 \text{ K}} = 1.7$$

$$Z = 0.7 \text{ mol} \quad (04+01)$$

6 (b) (iv) (25)

(v) Increasing of temperature from 400 K to 600 K (at constant volume) has increased the amount dissociated. Therefore, supply of heat has driven the forward reaction. Therefore, the forward reaction must be endothermic. (10)

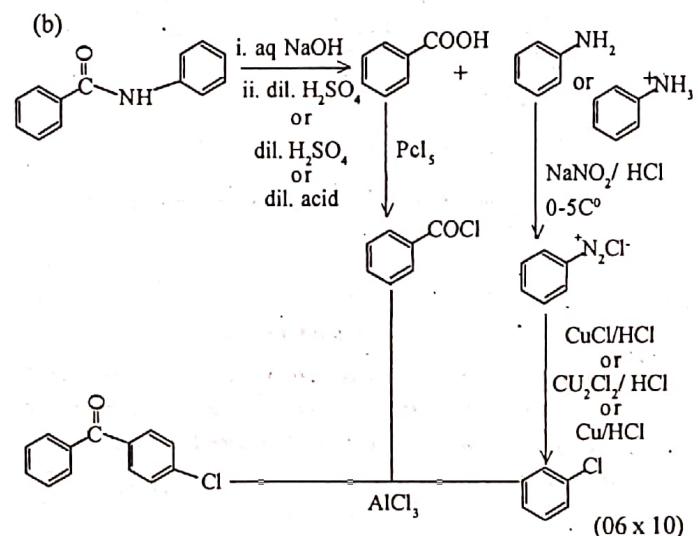
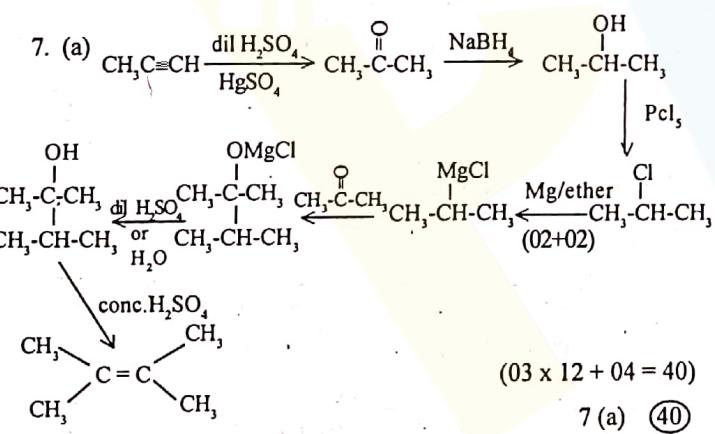
$$6 (b) (v) \quad (10)$$

(vi) All the gasses behave as ideal gasses

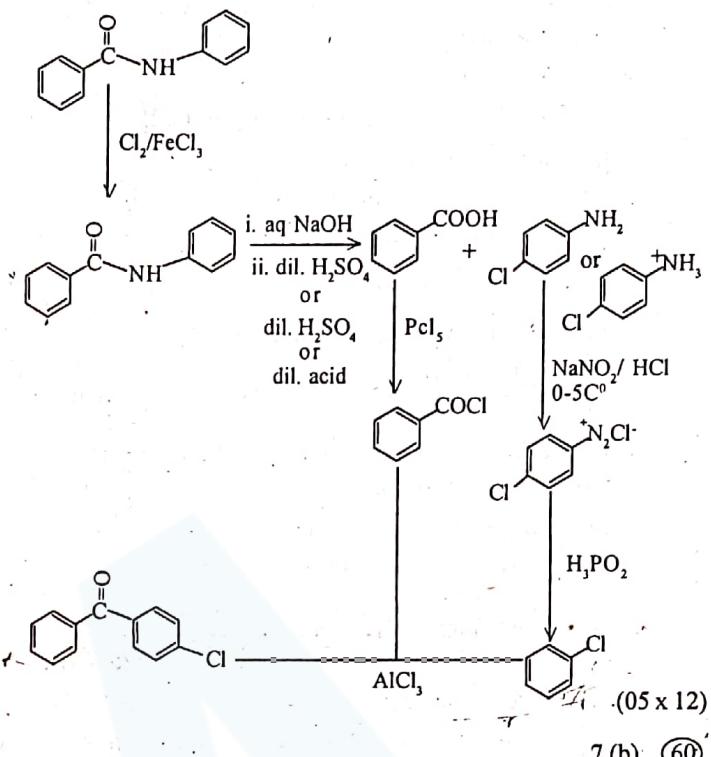
$$(05)$$

$$6 (b) (vi) \quad (05)$$

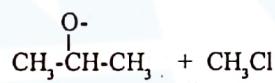
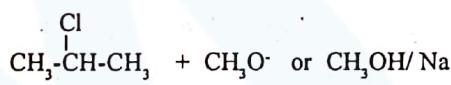
$$6 (b) \quad (90)$$



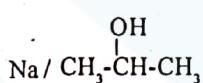
### Alternate Scheme



(c) (i)

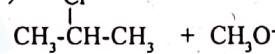


or



7 (c) (i) (24)

(ii)



$$y = \text{CH}_3\text{CH} = \text{CH}_2 \quad (04)$$

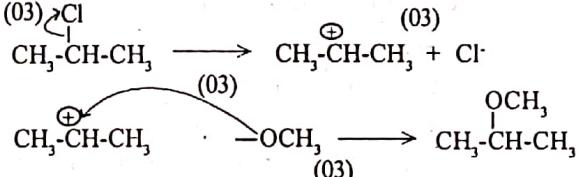
7 (c) (ii) (08)

(iii) Elimination

(06)

7 (c) (iii) (06)

(iv)

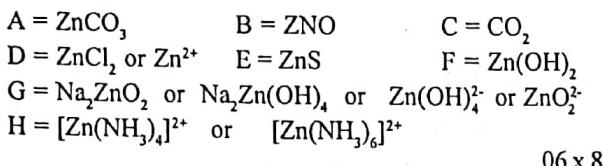


7 (c) (iv) (12)

7 (c) (50)

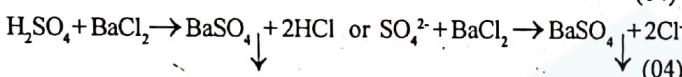
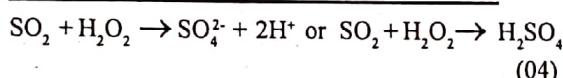
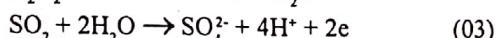
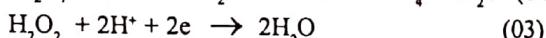
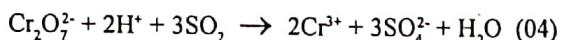
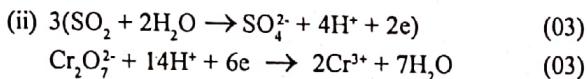
**Part C - Essay**

8. (a)

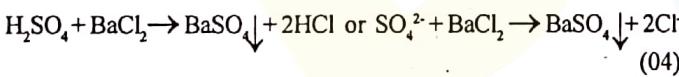
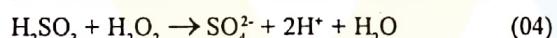
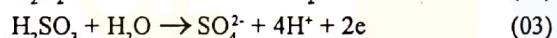
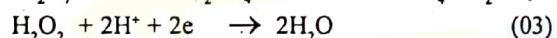
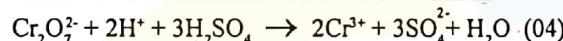
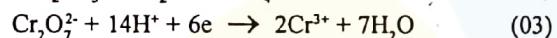
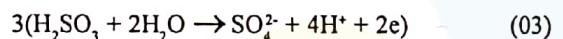


06 x 8

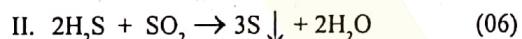
if all answers are correct 02  
8 (a) (50)



Alternate answer

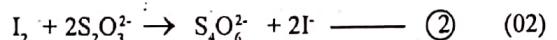
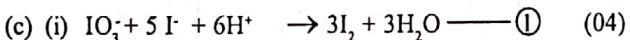


8 (b) (ii) (24)



8 (b) (iii) (16)

8 (b) (50)



$$\text{moles of S}_2\text{O}_3^{2-} = \frac{0.50}{1000} \times 12.50 \quad (02)$$

$$\text{moles of I}_2 = \frac{0.50}{1000} \times 12.5 \times \frac{1}{2} \quad (02)$$

$$\text{moles of H}^+ = \frac{0.50}{1000} \times 12.5 \times \frac{1}{2} \times 2 \quad (02)$$

$$[\text{H}^+] = \frac{0.50}{1000} \times 12.5 \times \frac{1}{2} \times 2 \times \frac{1000}{25.0} \quad (02)$$

$$= 0.25 \text{ mol dm}^{-3} \quad (02)$$

(The relationship  $\text{H}^+ \equiv \text{S}_2\text{O}_3^{2-}$  can also be used in the above calculation)

8 (c) (i) 16



moles of HCl required to react with NaOH &  $\text{Na}_2\text{CO}_3 =$

$$\frac{0.25}{1000} \times 32.0 \quad (03)$$

$$\text{moles of HCl required to react with NaOH} = \frac{0.25}{1000} \times 24.0 \quad (03)$$

Therefore, moles of HCl required to react with  $\text{Na}_2\text{CO}_3$

$$\frac{0.25}{1000} \times 32.0 - \frac{0.25}{1000} \times 24.0 \quad (03)$$

$$= 0.008 - 0.006 = 0.002 \quad (03)$$

$$\text{Therefore, moles of } \text{Na}_2\text{CO}_3 \text{ in } 25.0 \text{ cm}^3 = \frac{0.002}{2} \quad (03)$$

$$\text{moles of } \text{Na}_2\text{CO}_3 \text{ in } 500.0 \text{ cm}^3 = \frac{0.002}{2} \times 20 \quad (03)$$

$$= 0.02 \quad (03)$$

$$\text{molecular mass of } \text{Na}_2\text{CO}_3 = 106 \text{ gmol}^{-1}$$

$$\text{mass of } \text{Na}_2\text{CO}_3 = 0.02 \times 106 = 2.12 \text{ g} \quad (03)$$

$$\% \text{Na}_2\text{CO}_3 \text{ in sample} = \frac{2.12}{42.4} \times 100 \quad (03)$$

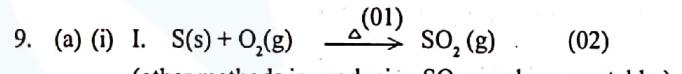
$$= 5.0 \% \quad (03)$$

8 (c) (ii) (29)

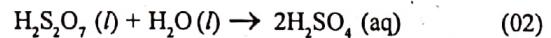
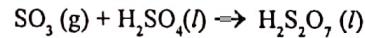
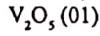
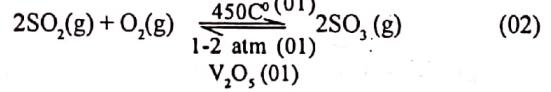
(iii) All the carbonate in the solution is precipitated as  $\text{BaCO}_3$  on the addition of excess  $\text{BaCl}_2$  (05)

8 (c) (iii) (05)

8 (c) (50)



(other methods in producing  $\text{SO}_2$  are also acceptable.)



9 (a) (i) (I) (12)

II. The reaction between  $\text{SO}_2$  and  $\text{O}_2$  is reversible (01) and exothermic (01) and the number of molecules decreases in the forward reaction. (01)

According to the Le chatelier principle (01) the forward reaction will be favoured by low temperature (01) and high pressure (01).

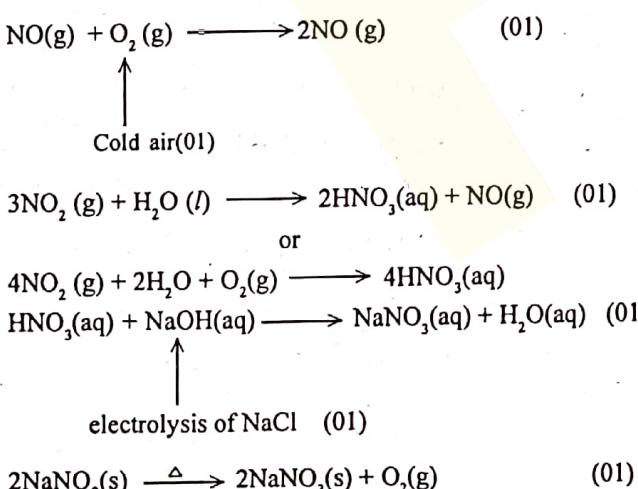
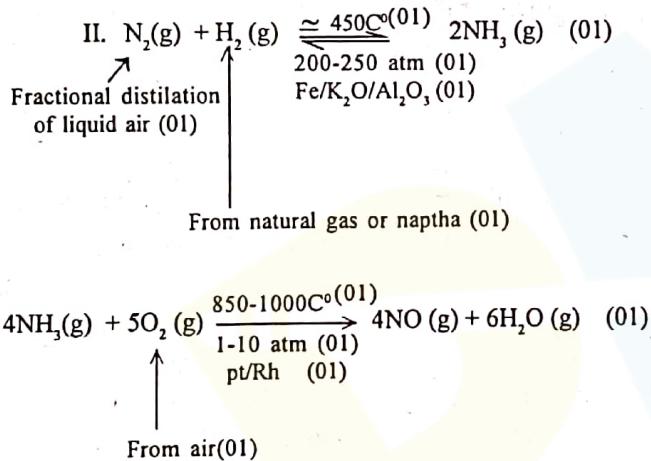
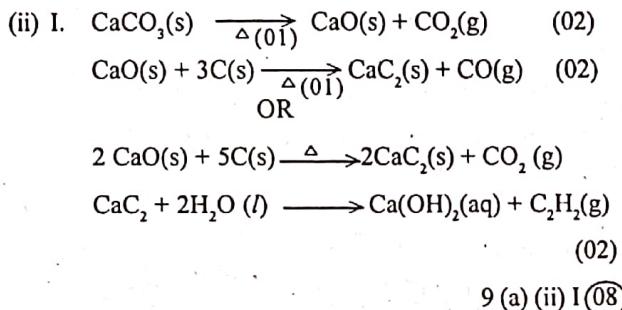
The small advantage gained in this reaction by using high pressure is more than offset by the greater cost of equipment that would be needed (01). Hence, 1-2 atm pressure is used.

At low temperatures, the rate of reaction is low. (01) Hence, a temperature of  $450^\circ\text{C}$  is used to get an acceptable rate. A catalyst,  $(\text{V}_2\text{O}_5)$ , is used (01) to speed up the rate of the reaction (01) and achieve the equilibrium condition faster (01).

9 (a) (i) (II) (11)

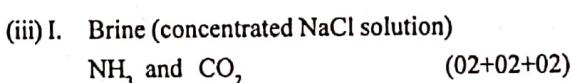
III. Manufacture of fertilizer  
 Manufacture of chemicals  
 Manufacture of plastics  
 Manufacture of synthetic fibres  
 Drying agent (gases)  
 Oxidizing agent  
 Production of explosives  
 In automobile batteries / battery acid

any two (01 x 2)  
 9 (a) (i) (III) (25)  
 9 (a) (i) (25)



Note : Physical states are not required

9 (a) (ii) (II) (17)  
 9 (a) (ii) (25)



II. Brine - from sea water (02)  
 $\text{NH}_3$  - from the Haber process (02)  
 $\text{CO}_2$  - from lime stone (02)

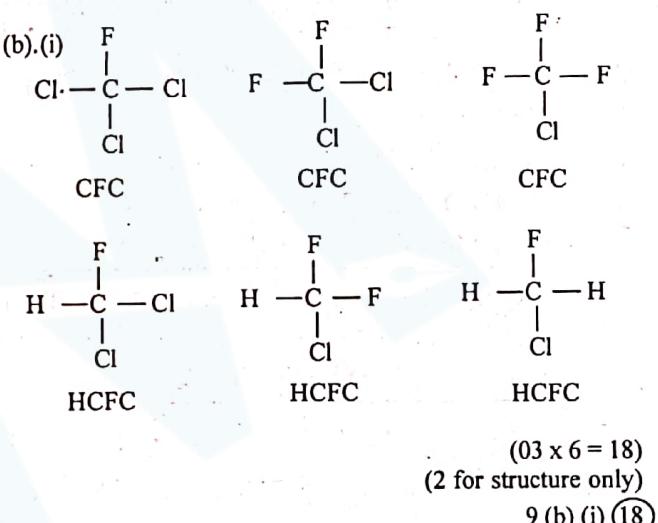
III.  $\text{CaCl}_2$  (02)

(iv) to precipitate  $\text{NaHCO}_3$  (02)  
 to dissolve gases in brine (02)

(v) manufacture of glass, detergents, soap, sodium silicate and paper to soften hard water, as washing soda in detergents any two (02 + 02)

(vi)  $\text{CaCl}_2$  is added to remaining mother liquor after precipitating  $\text{NaCl}$  from sea water (01)  
 Good source of  $\text{SO}_4^{2-}$  (01)  
 $\text{CaCl}_2 + \text{SO}_4^{2-} \longrightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O}$  (gypsum) (01)

9 (a) (iii) (25)  
 9 (a) (75)



(ii) Statement is correct (03)  
 Compared to C-F and C - Cl bonds are weaker (03) and subjected to react with environmental chemicals. (03)

9 (b) (ii) (09)

(iii) Global warming (03) Both the CFC's and HCFC's are greenhouse gases (03) that contribute to the elevation of atmospheric temperatures (03). Since HCFC's are more reactive their atmospheric lifetime is shorter (03) and hence the contribution to the global warming is less than that of CFC's (03).

9 (b) (iii) (15)

(iv) Chemical inert  
 Physiological inert  
 Nonflammable  
 Easily compressible and expandable  
 Less viscosity  
 Low boiling points  
 High specific heat

any three 03 x 3 = 09  
 9 (b) (iv) (09)

(v) At the higher elevations, CFCs are exposed to UV radiation. UV radiation cleaves C-Cl (or C-F) bonds (03) and generates chlorine (or fluorine) radicals (03). These radicals catalyze the destruction of ozone molecules (03) and deplete the levels of ozone in upper atmosphere (03)

9 (b) (v) (12)

(vi) Depletion of ozone layer allows the penetration of high energy UV to the ground (03)

Penetrated UV can contribute to following problems.

Elevate the atmospheric temperature  
produce ozone at the ground level.

Cataract

Skin Carcinoma

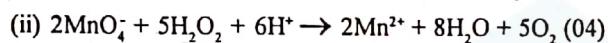
Effect on vegetation (any three, 03 marks each)

9 (b) (vi) (12)

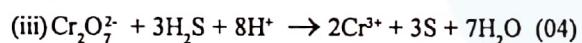
9 (b) (75)



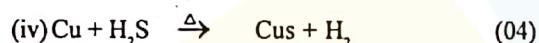
Oxidizing agent or undergoes reduction. (01)



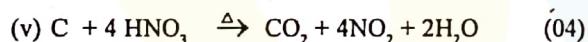
Reducing agent or undergoes oxidation (01)



Reducing agent or undergoes oxidation (01)



Oxidizing agent or undergoes reduction or acts as an acid. (01)

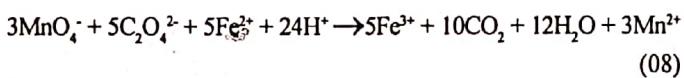
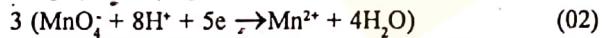
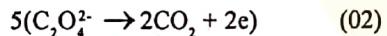
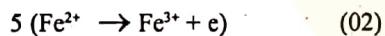


Oxidizing agent or undergoes reduction. (01)

10 (a) (25)

### (b) Method 1

Half reactions taking place :



Molar mass of  $\text{FeC}_2\text{O}_4$  = 144g

$$\text{Moles of } \text{FeC}_2\text{O}_4 = \frac{0.300 \text{ g}}{144 \text{ g}} \quad (03)$$

$$\text{Moles of } \text{Fe}^{2+} = \text{moles of } \text{C}_2\text{O}_4^{2-} = \frac{0.300 \text{ g}}{144 \text{ g}} = 2.08 \times 10^{-3} \quad (03)$$

Let the volume of  $\text{KMnO}_4$  be  $V \text{ cm}^3$

$$\text{moles of } \text{MnO}_4^- = \frac{0.025 \text{ g}}{1000} \times V \quad (03)$$

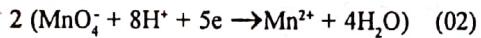
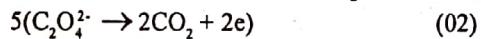
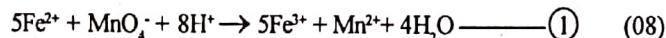
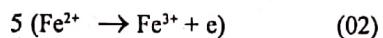
Therefore, moles of  $\text{Fe}^{2+}$  = moles of  $\text{C}_2\text{O}_4^{2-}$

$$= \frac{0.025}{1000} \times V \times \frac{5}{3} \quad (03 + 03 + 09)$$

$$\frac{0.025}{1000} \times V \times \frac{5}{3} = 2.08 \times 10^{-3} \quad (07)$$

$$V = 50.0 \text{ cm}^3 \quad (04+01)$$

### Method 2



$$\text{Moles of } \text{Fe}^{2+} = \text{moles of } \text{C}_2\text{O}_4^{2-} = \frac{0.300}{144 \text{ g}} = 2.08 \times 10^{-3} \quad (03 + 03)$$

Let the volume of  $\text{MnO}_4^-$  for reaction ① be  $V_1 \text{ cm}^3$

$$\text{moles of } \text{MnO}_4^- = \frac{0.025}{1000} \times V_1 \quad (03)$$

$$\text{Therefore, moles of } \text{Fe}^{2+} = \frac{0.025}{1000} \times V_1 \times 5 \quad (03)$$

$$\frac{0.025}{1000} \times V_1 \times 5 = 2.08 \times 10^{-3} \quad (03)$$

$$V_1 = 16.67 \text{ cm}^3 \approx 16.7 \text{ cm}^3 \quad (03)$$

Let the volume of  $\text{MnO}_4^-$  for reaction ② be  $V_2 \text{ cm}^3$

$$\text{moles of } \text{MnO}_4^- = \frac{0.025}{1000} \times V_2 \quad (03)$$

$$\text{moles of } \text{C}_2\text{O}_4^{2-} = \frac{0.025}{1000} \times V_2 \times \frac{5}{2} \quad (03)$$

$$\frac{0.025}{1000} \times V_2 \times \frac{5}{2} = 2.08 \times 10^{-3} \quad (03)$$

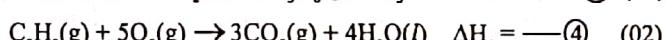
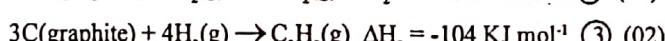
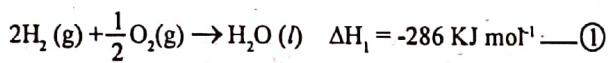
$$V_2 = 33.28 \text{ cm}^3 \approx 33.3 \text{ cm}^3 \quad (03)$$

$$\text{Total volume} = 16.7 \text{ cm}^3 + 33.3 \text{ cm}^3 \quad (01)$$

$$= 50.0 \text{ cm}^3 \quad (04+01)$$

$$10(b) \quad (50)$$

### (c) (i) Burning of propane

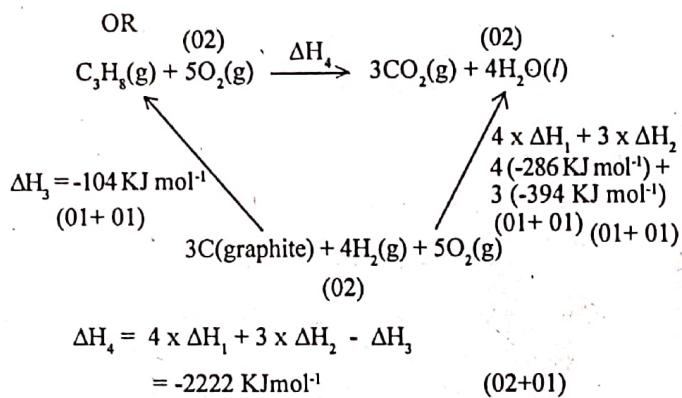


$$\Delta H_4 = 4 \times \Delta H_1 + 3 \times \Delta H_2 - \Delta H_3$$

$$\Delta H_4 = 4(-286 \text{ KJ mol}^{-1}) + 3(-394 \text{ KJ mol}^{-1}) - (-104 \text{ KJ mol}^{-1})$$

$$(01+01) \quad (01+01) \quad (01+01) \quad (02+01)$$

$$= -2222 \text{ KJ mol}^{-1} \quad (02+01)$$



Mass of  $CO_2$  emitted  
 $= 1.36 \times 10^{-1} \text{ mol} \times 44 \text{ g mol}^{-1}$   
 $= 5.98 \text{ g} \quad (04+01)$

Amount of butane needed to produce the amount of heat in (ii)  
 $= 1/2220 \text{ KJ mol}^{-1} \times 100.8 \text{ KJ}$   
 $= 3.50 \times 10^{-2} \text{ mol} \quad (04+01)$

Amount of  $CO_2$  emitted  
 $= 3.50 \times 10^{-2} \text{ mol} \times 4$   
 $= 1.40 \times 10^{-1} \text{ mol} \quad (04+01)$

Mass of  $CO_2$  emitted  
 $= 1.40 \times 10^{-1} \text{ mol} \times 44 \text{ g mol}^{-1}$   
 $= 6.16 \text{ g} \quad (04+01)$

10 (c) (iii) = 30

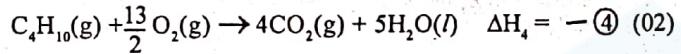
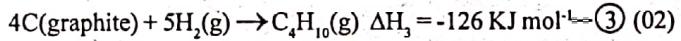
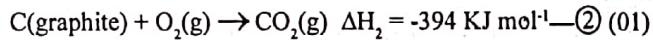
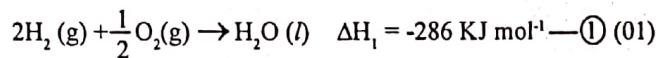
(iv) propane is a more environmental friendly fuel because it emits less  $CO_2$  compared to butane when the same amount of heat is produced.

(05)

10 (c) (iv) = 05

10 (c) 75

### Burning of butane



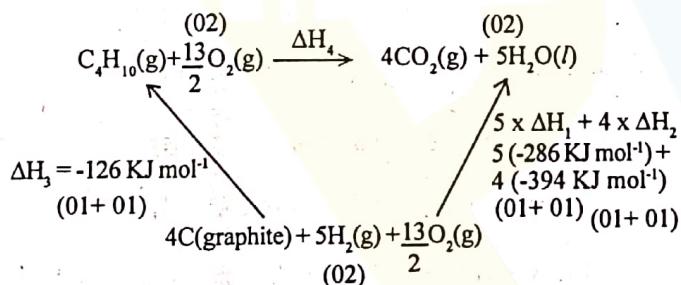
$$\Delta H_4 = 5 \times \Delta H_1 + 4 \times \Delta H_2 - \Delta H_3$$

$$\Delta H_4 = 5(-286 \text{ KJ mol}^{-1}) + 4(-394 \text{ KJ mol}^{-1}) - (-126 \text{ KJ mol}^{-1})$$

$$(01+01) \quad (01+01) \quad (01+01)$$

$$= -2880 \text{ KJ mol}^{-1} \quad (02+01)$$

OR



$$\Delta H_4 = 5 \times \Delta H_1 + 4 \times \Delta H_2 - \Delta H_3$$

$$= -2880 \text{ KJ mol}^{-1} \quad (02+01)$$

10 (c) (i) = 30

(ii) Heat needed to increase the temperature of 400 g of water from 25°C to 85°C

$$q = 400 \text{ g} \times 4.2 \text{ J g}^{-1} \text{ °C}^{-1} \times (85 - 25)^\circ\text{C} \quad (04+01)$$

$$= 100.8 \text{ KJ} \quad (04+01)$$

10 (c) (ii) 10

(iii) I Amount of propane needed to produce the amount of heat in (ii)

$$= 1/2222 \text{ KJ mol}^{-1} \times 100.8 \text{ KJ}$$

$$= 4.54 \times 10^{-2} \text{ mol} \quad (04+01)$$

Amount of  $CO_2$  emitted

$$= 4.54 \times 10^{-2} \text{ mol} \times 3$$

$$= 1.36 \times 10^{-1} \text{ mol} \quad (04+01)$$