

G.C.E.(A/L) Examination

2011 August

Chemistry I / Two hours

Instructions :

- * This paper consists of 08 pages (Periodic Table is provided)
- * 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 $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

1. The 3d block element that shows the highest electrical conduction is,

(1) Mn	(2) Co	(3) Ni
(4) Cu	(5) Ti	
2. The increasing order of atomic radii of the elements C, P, S, As and Se is,

(1) C < P < S < As < Se	(2) C < P < Se < As	(3) C < S < P < As < Se
(4) C < S < Se < P < As	(5) C < S < P < Se < As	
3. The correct structure of propynal is,

(1) $\text{CH} \equiv \text{CCHO}$	(2) $\text{CH}_2 = \text{CHCHO}$	(3) $\text{CH}_3\text{CH}_2\text{CHO}$
(4) $\text{CH} - \text{CCH}_2\text{OH}$	(5) $\text{CH}_2 = \text{CHCH}_2\text{OH}$	
4. A colourless solid X liberates a brown gas on heating with dil. HCl, and a colourless alkaline gas on heating with NaOH. The solid X is,

(1) NH_4NO_2	(2) NH_4NO_3	(3) NH_4Cl
(4) NaBr	(5) NaNO_3	
5. The energy of one mole of photons with wave-length 305 nm is, (Planck constant = $6.62 \times 10^{-34} \text{ Js}$, speed of light = $3.00 \times 10^8 \text{ ms}^{-1}$)

(1) 256 kJ	(2) 302 kJ	(3) 392 kJ
(4) 452 kJ	(5) 512 kJ	
6. The number of subshells (sub energy levels), orbitals and the maximum number of electrons that could be present in the main energy level described by the principal quantum number, $n = 3$ are respectively,

(1) 9, 3 and 8	(2) 3, 9 and 18	(3) 3, 6 and 32
(4) 2, 9 and 18	(5) 3, 4 and 18	
7. Which of the following statements is incorrect with regard to the arrangement of electrons among main energy levels and orbitals?
 - (1) When orbitals of equal energy are available, they first fill singly (one electron in each orbital), with electron spins parallel.
 - (2) No two electrons in an atom can have the same four quantum numbers.
 - (3) Electrons occupy orbitals in such a way as to minimize the energy of the atom.

- (4) The maximum number of electrons in a main energy level described by the principal quantum number, n , is equal to $2n^2$
- (5) The energy of an atom is minimized by filling completely the principal energy levels in succession.

8. The mass of a sample containing only SrCO_3 and BaCO_3 is 0.800 g. When the sample is dissolved in excess dilute acid, the volume of CO_2 gas liberated at standard temperature and pressure is 0.112 dm^3 . The mass percentage of SrCO_3 in the sample is, ($\text{C} = 12$, $\text{O} = 16$, $\text{Sr} = 88$, $\text{Ba} = 137$)

(1) 30	(2) 56	(3) 70
(4) 80	(5) 84	
9. Which one of the following statements is not true with regard to 3d block elements of the periodic table?
 - (1) The highest oxidation state of each of the elements Sc, Ti, V, Cr and Mn is equal to the number of the group the element belongs to.
 - (2) The highest oxidation state of each of the elements Fe, Co, Ni, Cu and Zn is less than the number of the group the element belongs to.
 - (3) All cations of the elements have vacant 4s orbitals and all valence electrons occupy 3d orbitals.
 - (4) Ions such as MnO_4^- , $\text{Cr}_2\text{O}_7^{2-}$ and CrO_4^{2-} in which elements are in their highest oxidation states tend to be good reducing agents, whereas ions such as Ni^{2+} and Zn^{2+} are good oxidizing agents.
 - (5) Zn has the lowest melting point of the 3d block elements.
10. The enthalpy change of which of the following chemical reactions corresponds to the standard enthalpy of formation of CaO(s) ?

(1) $\text{Ca}^{2+}(\text{g}) + \text{O}^{2-}(\text{g}) \rightarrow \text{CaO(s)}$	(2) $\text{Ca(g)} + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{CaO(s)}$	(3) $\text{Ca(s)} + \text{O(g)} \rightarrow \text{CaO(s)}$
(4) $2\text{Ca(s)} + \text{O}_2(\text{g}) \rightarrow 2\text{CaO(s)}$	(5) $\text{Ca(s)} + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{CaO(s)}$	
11. The increasing order of the rate at which the following compounds undergo nitration is,

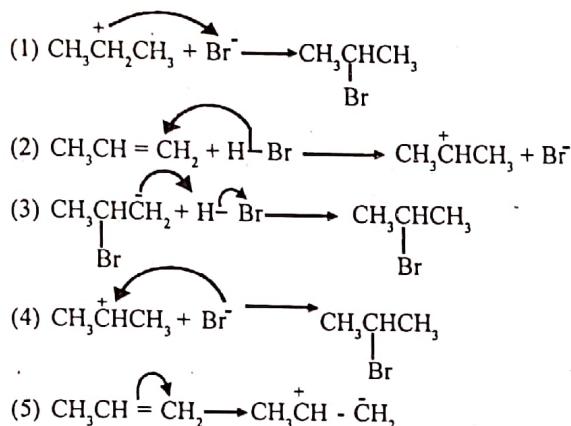
A	B	C	D

 - (1) A < C < D < B
 - (2) A < D < C < B
 - (3) A < D < B < C
 - (4) D < A < C < B
 - (5) D < C < A < B
12. The increasing order of the pH of the aqueous solutions (a) to (d) are,

(a) 0.1 mol $\text{dm}^{-3} \text{ NH}_4\text{Cl}$	(2) a < b < d < c
(b) 0.5 mol $\text{dm}^{-3} \text{ NH}_4\text{Cl}$	(3) a < b < c < d
(c) 0.1 mol $\text{dm}^{-3} \text{ CH}_3\text{COONa}$	(4) b < a < d < c
(d) 0.5 mol $\text{dm}^{-3} \text{ CH}_3\text{COONa}$	(5) d < c < b < a

 - (1) b < a < c < d
 - (2) a < b < d < c
 - (3) a < b < c < d
 - (4) b < a < d < c
 - (5) d < c < b < a

13. Which of the following represents a correct step of the mechanism of the reaction between propene and HBr?



14. Equal volumes of HNO_3 of pH = 2.0 and of HCl of pH = 1.0 were mixed. The pH of the mixture is,

(1) 1.0 (2) 1.3 (3) 1.5 (4) 2.0 (5) 3.0



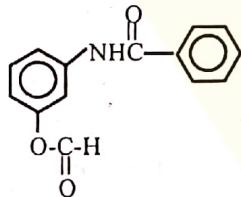
The increasing order of the boiling points of the above compounds is,

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

16. The percentage ionization of an aqueous solution of 0.10 mol dm^{-3} HCOOH at 25°C is,

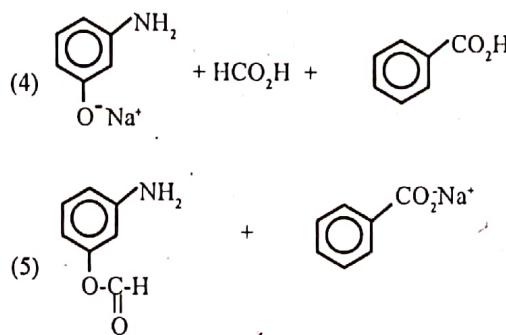
(K_a of HCOOH at $25^\circ\text{C} = 1.7 \times 10^{-4} \text{ mol dm}^{-3}$)
(1) 0.4 (2) 2 (3) 4 (4) 10 (5) 40

17. The compound given below was heated with excess aq. NaOH



The products formed from this reaction are,

- (1) $\text{CO}_2\text{Na}^+ + \text{HCO}_2\text{Na}^+ + \text{NH}_2$
- (2) $\text{NH}_2 + \text{HCO}_2\text{Na}^+ + \text{CO}_2\text{Na}^+$
- (3) $\text{NH}_2 + \text{HCO}_2\text{Na}^+ + \text{CO}_2\text{Na}^+$



18. The IUPAC name of $[\text{Co}(\text{OH})(\text{NH}_3)_4(\text{H}_2\text{O})]^{2+}$ is.

- (1) tetraamminehydrooxo aquacobalt (III) ion
(2) hydrooxo aqua tetraammine cobalt (III) ion
(3) tetraammine aqua hydroxocobalt (II) ion
(4) tetraammine aqua hydroxocobalt (III) ion
(5) hydroxotetraammine aquacobalt (III) ion

19. The element X forms the stable $\text{X}^{3+}(\text{aq})$ ion with five unpaired electrons in aqueous solution. An atom of element X has four unpaired electrons in its ground state. The element X is,

- (1) Fe (2) Cr (3) Sc (4) Co (5) Al

20. The reagent/ reagents which cannot be used to distinguish between KBr and KI is/are,

- (1) aqueous $\text{Pb}(\text{NO}_3)_2$ (2) conc. H_2SO_4
(3) I_2/CCl_4 (4) Br_2/CCl_4
(5) aqueous AgNO_3 and conc. NH_3

21. The products obtained when sulphur reacts with conc. HNO_3 are,

- (1) H_2SO_4 , NO and H_2O (2) SO_2 , NO_2 and H_2O
(3) H_2S , NO_2 and H_2O (4) SO_2 , NO and H_2O
(5) SO_2 , SO_3 , NO_2 and H_2O

22. At a certain temperature, the value of the equilibrium constant K_e for the following reaction is



When 0.90 mol of $\text{H}_2(\text{g})$ and 0.90 mol of $\text{CO}_2(\text{g})$ are introduced to a 5.0 dm^3 vessel, the concentration $\text{CO}(\text{g})$ at equilibrium at the same temperature is,

- (1) 0.12 mol dm^{-3} (2) 0.24 mol dm^{-3}
(3) 0.36 mol dm^{-3} (4) 0.60 mol dm^{-3}
(5) 1.2 mol dm^{-3}

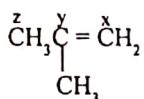
23. Compound A decolorizes alkaline KMnO_4 solution. Consider the following statements regarding

- (a) It may contain a double bond
(b) It may contain a triple bond
(c) It may be an aldehyde
(d) It may be a ketone

The correct statement/s regarding the compound A is/are

- (1) (a) only (2) (a) and (b) only
(3) (a) and (c) only (4) (a), (b) and (c) only
(5) (a), (b) and (d) only

32. The correct statement/s regarding the structure of the following compound is/are,



- (a) Carbon atoms labelled x, y and z lie on one straight line.
- (b) The angle between C-H bonds on the carbon atom labelled as x is 160° .
- (c) All four carbon atoms lie on one plane.
- (d) The distance between carbon atoms labelled x and y is less than the distance between carbon atoms labelled y and z.

33. The correct statement/s with regard to extraction/ production of elements / compounds is/are,

- (a) CaCl_2 is used to lower the temperature required to bring NaCl to the molten state, during the extraction of Na metal.
- (b) Purification of bauxite is the first step in the extraction of Al metal.
- (c) Ammonia and carbon monoxide are used as raw materials in the production of urea.
- (d) SO_2 and H_2 gases are used in the production of sulphur from H_2S present in natural gas.

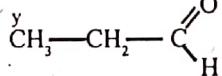
34. Which of the following statements is/are true regarding natural rubber?

- (a) SO_2 and CO_2 gases are evolved when tyres made of natural rubber are burnt in air.
- (b) Natural rubber is a polymer of propene.
- (c) Natural rubber has double bonds with trans configuration.
- (d) Vulcanization of natural rubber introduces cross linking between carbon chains.

35. By which of the following processes is/are H_2 released at the cathode?

- (a) Electrolysis of an aqueous CuSO_4 solution using copper electrodes.
- (b) Electrolysis of an aqueous CuSO_4 solution using platinum electrodes.
- (c) Electrolysis of water using carbon electrodes.
- (d) Electrolysis of an aqueous NaCl solution using carbon electrodes.

36. The correct statement/s regarding the following compound is/are.



- (a) It undergoes an electrophilic addition reaction with HCN.
- (b) The hydrogen atoms attached to carbon atom labelled y exhibit acidic character.
- (c) It reacts with NaBH_4 to form an alcohol.
- (d) It undergoes oxidation when reacted with $[\text{Ag}(\text{NH}_3)_2]^+ \text{OH}^-$ to form a carboxylic acid.

37. Which of the following statements is/are true regarding polyvinylchloride (PVC)?

- (a) It is a synthetic polymer that can be softened by heating.
- (b) It does not contain double bonds.
- (c) It is formed by addition polymerization of $\text{CHCl}=\text{CHCl}$.
- (d) it possesses weak intermolecular attractive forces between polymer chains

38. Which of the following is/are **not** an assumption/ assumptions of the molecular kinetic theory of gases?

- (a) Gaseous molecules are very small and hence their masses can be neglected in calculations.
- (a) Gaseous molecules are very small and hence their volumes can be neglected in calculations.
- (c) Collisions among gaseous molecules are perfectly elastic.
- (d) At a given temperature the kinetic energies of all gaseous molecules are the same.

39. Which of the following statements is/are true regarding Rutherford's gold foil experiment?

- (a) All the positive charges reside in a small region referred to as the nucleus.
- (b) The atom has a large empty space in which electrons move around the nucleus.
- (c) Thompson's model of the atom was proved acceptable.
- (d) Electrons travel in fixed orbitals.

40. Which of the following steps raise/ raises the pH of an aqueous solution at constant temperature by 2 units?

- (a) Decreasing the existing concentration of H^+ in solution 200 times.
- (b) Decreasing the existing concentration of H^+ in solution by 2.0 mol dm^{-3} .
- (c) Decreasing the existing concentration of H^+ in solution 100 times.
- (d) Decreasing the existing concentration of H^+ in solution by 0.01 mol dm^{-3} .

- In questions No. 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.

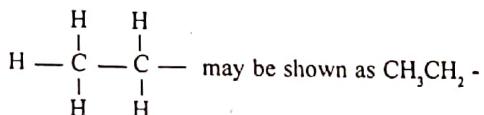
Response	First Statement	Second Statement
(1)	True	True, and correctly explains the first statement.
(2)	True	True, but does not explain the first statement correctly.
(3)	True	False
(4)	False	True
(5)	False	False

First Statement	Second Statement
41. The pH of a dibasic acid in which the first ionization constant is K_1 , is higher than the pH of a monobasic acid of the same concentration and the same ionization constant (K_1).	The acid strength of a substance depends only on the number of ionizable hydrogen atoms present in its molecule.
42. LiI has more covalent character than LiF .	When the cation is small and /or has a high charge, it has a high polarization power.
43. Diazonium salts of aromatic amines react with water to form phenols.	Diazonium salts can act as nucleophilic reagents.
44. As long as the temperature is maintained constant, the equilibrium constant of a chemical equilibrium system does not change by the addition of a catalyst.	A catalyst decreases the activation energy of both the forward reaction and the backward reaction by the same fraction.
45. Phenol readily reacts with bromine water giving a white precipitate.	Bromine adds to compounds containing double bonds.
46. CO_2 does not contribute to acid rain.	Carbonic acid is formed when CO_2 dissolves in water.
47. In a chemical reaction, all molecules with energy greater than the activation energy form products.	In all chemical reactions, the reactants must go through a state having energy greater than the energy of reactants.
48. The concentration of Fe(III) in an aqueous solution can be determined using salicylic acid.	The intensity of the colour of the complex formed by Fe(III) with salicylic acid, depends on the concentration of the complex.
49. The boiling point of CO_2 is higher than the boiling point of formaldehyde.	Intermolecular attractive forces between CO_2 molecules are stronger than intermolecular attractive forces between formaldehyde molecules.
50. The amount of dissolved oxygen is not a measure of water pollution.	Concentration of oxygen in polluted water depends only on the temperature of the water/ air system.

G.C.E. (A/L) Examination
2011 August
Chemistry II / Three hours

- Instructions :
- Periodic Table is provided.
 - Use of calculators is not allowed.
 - In answering questions 04 and 10, you may represent alkyl groups in a condensed manner.

Example :



PART A - Structured Essay (Pages 02-08)

Answer all the questions.

Write your answer in the space provided below 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 09-14)

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.

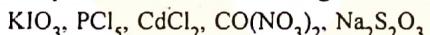
* Universal gas constant, $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$

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

PART A - STRUCTURED ESSAY

Answer all four questions. Each question carries 10 marks.

1. (a) You are provided with the following list of compounds.

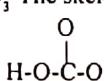


Which one of the above compounds.

- (i) is used as a primary standard in volumetric analysis?
- (ii) gives a pale yellow precipitate when dil. H_2SO_4 is added to its aqueous solution?
- (iii) undergoes hydrolysis to give an acid with a tetrahedral structure?
- (iv) gives a dark yellow precipitate when dissolved in dil. HCl and H_2S is passed through the solution?
- (v) gives a blue coloured solution on addition of conc. HCl to its aqueous solution?

(2.0 marks)

- (b) The following parts (i) - (vi) are based on the bicarbonate ion, HCO_3^- . The skeleton of HCO_3^- is given below.



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

- (ii) Draw resonance structures for this ion and comment on their relative stabilities.

- (iii) Deduce the shapes around the following atoms using the VSEPR theory.

I. C

II. O attached to H

- (iv) Indicate the electron pair geometry (arrangement of electron pairs) around the following atoms.

I. C

II. O attached to H

- (v) Indicate the hybridization of the following atoms.

I. C

II. O attached to H

- (vi) Identify the atomic orbitals/hybrid orbitals involved in the formation of the following σ bonds present in the Lewis structure drawn in (i) above.

I. between C and O attached to H

II. between O and H

(6.0 marks)

- (c) The following table gives the approximate values of melting points and electrical conduction (in relative terms excellent, good, poor, very poor or nil) of five substances, Mg, CO_2 , SiO_2 , NaCl and MgO . Complete the table by writing the formula of the appropriate substance in the column provided under the heading "Substance."

Substance	Melting point/K	Electrical conduction in the solid state	Electrical conduction in the molten/liquid state
(1)	3200	poor	good
(2)	1100	poor	good
(3)	920	excellent	excellent
(4)	200	very poor/nil	very poor/nil
(5)	1900	very poor/nil	very poor/nil

(2.0 marks)

M is a non-transition element. Some chemical properties of this element are given below.

- It burns in air with a bright white flame to give a mixture of two compounds, A and B.
- It does not react with cold water but reacts slowly with hot water and steam with the evolution of a colourless, flammable gas, C.
- It reacts with conc. HNO_3 to form NO_2 .

- (i) Identify the element M and state one important use of it.

- (ii) Write the ground state electronic configuration of M.

- (iii) Write the chemical formulae of A, B and C.

A

B

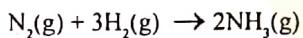
C

- (iv) One of the compounds A or B, reacts with water with the evolution of a gas. Identify this gas.
- (v) Give the balanced chemical equation for the reaction between conc. HNO_3 and M.
- (vi) Give the balanced chemical equation for the reaction of M with hot water.
- (vii) Using an acid-base indicator explain how you would demonstrate in the laboratory, the occurrence of the reaction of M with hot water.
- (viii) Giving reasons indicate whether the electron affinity of M would be positive or negative.
- (ix) State whether the solubilities of oxides and hydroxides of the elements in the group of the Periodic Table to which M belongs decrease or increase or increase down the group. (Reasoning not required)

element	strongly acidic	weakly acidic	amphoteric	weakly basic	strongly basic
P					
M					
Q					

(10 marks)

3. (a) Consider the chemical reaction,



and the thermochemical data given below (at 25°C)

Chemical species	$\text{N}_2(\text{g})$	$\text{H}_2(\text{g})$	$\text{NH}_3(\text{g})$
Standard enthalpy of formation /kJ mol ⁻¹	0.00	0.00	-46.1
Standard entropy/ J K ⁻¹ mol ⁻¹	191.5	130.7	192.3

(i) Calculate ΔH° for the above reaction at 25°C

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(ii) Calculate ΔS° for the above reaction at 25°C.

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- (iii) I. Write an expression to relate ΔG of a chemical reaction to its ΔH and ΔS
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- II. Calculate ΔG° for the above reaction at 25°C.
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(5.0 marks)

- (b) (i) Non-volatile solute A dissolves in solvent B forming the ideal solution C. At a given temperature, the vapour pressure of the pure solvent and that of solution C are p^0 and p respectively. The mole fraction of the solvent in solution C is x_B .
- I. Write the Raoult's law in the form of an equation for solution C, in terms of the symbols given above.
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- II. The mole fraction of the solute in solution C is x_A . Write an equation for the Raoult's law in terms of p , p^0 and x_A . Hence, derive a mathematical expression for x_A .
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- (ii) Calculate the mole fraction of the solute in each of the following solutions P, Q and R.
- P : 2.0 mol dm⁻³ aqueous solution of glucose which has a density of 1.26 g cm⁻³.
- Q : Solution containing 180 g of glucose in 162 g of water.
- R : Solution containing 171 g of sucrose in 171 cm³ of water
- Consider that the density of water is 1.0 g cm⁻³.
- Relative molar masses of water, glucose and sucrose are 18, 180 and 342 respectively.
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(iii) Arrange the solutions P, Q and R in the order of their increasing vapour pressures, according to Raoult's law

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(iv) Write the Raoult's law as an equation for a mixture consisting of glucose, sucrose and water where the masses of these are known.

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(5.0 marks)

4. (a) (i) State the characteristic type of reaction that benzene undergoes.

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(ii) Give the structure of the product and the mechanism, for the reaction between benzene and $(\text{CH}_3)_2\text{CHCl}$ in the presence of anhydrous AlCl_3 .

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PART B - ESSAY

Answer all four questions. Each question carries 15 marks.

5. (a) At a temperature of 300 K and at a pressure of 1.0×10^5 Pa, a sample of oxygen gas weighing 3.2 g exists in a rigid vessel of volume V. Another rigid vessel of volume V which has been fully evacuated is connected to this vessel, allowing the gas to spread in both vessels. The temperature of the combined vessels is then raised to 400 K. At the same temperature, gas X is then introduced into the combined vessels, until the pressure is raised to 2.0×10^5 Pa. If the mass of the gas X required for this purpose is 8.8 g, calculate the relative molar mass of X. Assume that both these gases behave ideally and that they do not react with each other. (O = 16)

(3.0 marks)

- (b) Solute S distributes in solvent A and solvent B in a molar ratio of 1 : 9. (S is more soluble in solvent B)

Solute S distributes in solvent A and solvent C in a molar ratio of 1 : 4. (S is more soluble in solvent C)

Solute S does not react with A, B or C. Further, A, B and C are immiscible with each other.

(i) Calculate the partition coefficient of S between A and B.

(ii) Calculate the partition coefficient of S between A and C.

(iii) A 25.00 cm^3 sample of 0.10 mol dm^{-3} S in solvent A was thoroughly mixed with 25.00 cm^3 of solvent B and the layers were allowed to separate. Calculate the concentration of S remaining in phase A.

(iv) After equilibrium was reached, a 10.00 cm^3 sample of phase/ from step (iii) above was thoroughly mixed with 20.00 cm^3 of solvent C, and the layers were allowed to separate. Calculate the concentration of S remaining in phase A.

Note : In these calculations, assume that the temperature is constant and that S does not undergo polymerization.

(6.0 marks)

- (c) A sample of P gas was heated up to 481 K in a rigid container of volume 1.0 dm^3 in order to reach the following equilibrium.



At equilibrium, it was found that the total pressure of the system was 1.2×10^5 Pa and that the partial pressure of R(g) was 2.0×10^4 Pa.

(i) Calculate the partial pressures of P(g) and Q(g).

(ii) Calculate the concentrations of P(g), Q(g) and R(g) at equilibrium.

(iii) Calculate the equilibrium constant, K_e for the above equilibrium.

$$(RT = 4.0 \times 10^3 \text{ J mol}^{-1} \text{ at } 481 \text{ K})$$

(6.0 marks)

6. (a) In aqueous medium, the ionization constant, K_a of the monobasic acid HA is $1.0 \times 10^{-5} \text{ mol dm}^{-3}$ at 25°C

(i) Calculate the pH of a $0.100 \text{ mol dm}^{-3}$ aqueous solution of HA at 25°C .

(ii) Derive a relationship for $[\text{HA(aq)}]$ in terms of $[\text{H}_3\text{O}^{\cdot}(\text{aq})]$ and K_a . $[\text{A}^{\cdot}(\text{aq})]$

$[\text{H}_3\text{O}^{\cdot}(\text{aq})]$, $[\text{HA(aq)}]$ and $[\text{A}^{\cdot}(\text{aq})]$ represent the concentrations of $\text{H}_3\text{O}^{\cdot}$, HA and A^{\cdot} respectively, at equilibrium in aqueous medium.

(iii) The pH of the HA solution with the initial concentration of $0.100 \text{ mol dm}^{-3}$ is maintained at 4.0, by the addition of an appropriate quantity of a suitable base. Calculate $[\text{HA(aq)}]$ and $[\text{A}^{\cdot}(\text{aq})]$ in this case, using the relationship obtained in (ii) above.

(iv) Using the relationship derived in Part (ii) above, calculate the pH value at which $[\text{HA(aq)}] = [\text{A}^{\cdot}(\text{aq})]$ in solution.

(v) Calculate the pH of the solution prepared by mixing 55.00 cm^3 of HA solution of initial concentration $0.0500 \text{ mol dm}^{-3}$ with 50.00 cm^3 of NaOH of initial concentration $0.0500 \text{ mol dm}^{-3}$.

State the assumptions, if any used in this calculation.

(7.5 marks)

(b) (i) Calculate the concentration of H^+ ions in solution when a sample of 4.00 g of pure CaCO_3 is allowed to react with 500.0 cm^3 of 0.30 mol dm^{-3} HCl solution. (Relative molar mass of CaCO_3 = 100)

(ii) 250.0 cm^3 of 0.06 mol dm^{-3} NaOH solution is added to 250.0 cm^3 of the solution obtained in step (i) above, maintaining the temperature at 25°C . Show that no precipitation occurs.

Solubility product of Ca(OH)_2 at 25°C is $6.5 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}$.

(iii) Calculate the minimum mass of solid $\text{Ca(NO}_3)_2$ that should be added to the solution obtained in step (ii) above in order to observe a precipitation in it, while maintaining the temperature at 25°C .

(N = 14, O = 16, Ca = 40)

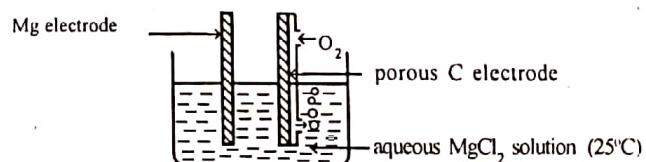
Note : Assume that there are no volume changes during mixing of solutions.

(7.5 marks)

7. (a) (i) Sketch a magnesium electrode at its standard state. Label all parts.

(ii) Explain briefly why the absolute potential of an electrode cannot be measured.

(iii) Consider the electrochemical cell given below, prepared using a pure magnesium electrode and a porous carbon electrode. Both electrodes are immersed in a MgCl_2 electrolyte solution of a known concentration as shown in the diagram.



The equilibrium reactions at the Mg electrode and the C electrode, and their standard electrode potentials are shown below.



I. Identify the cathode of the cell.

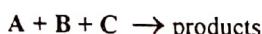
II. At standard state, calculate the electromotive force (e.m.f.) of the above cell.

III. Write balanced equations for the anode reaction, the cathode reaction and the overall cell reaction, that occur when the electrodes are externally connected using a conducting wire.

- IV. What would you expect to observe if a solution of NaCl of the same concentration was used in place of the solution of MgCl₂ as the electrolyte in the cell? Explain briefly your answer.
- V. When the above cell connected to a circuit, the current produced decreases gradually with time. State two methods that could be used to raise the current to a satisfactory level again. Briefly explain the basis of the methods stated by you.

(6.5 marks)

- (b) (i) Define the terms, initial rate and average rate for a given chemical reaction.
- (ii) The reactants A, B and C react with each other in an aqueous medium to yield products, as shown below.

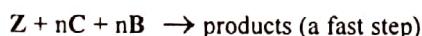
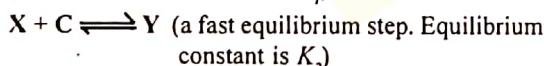
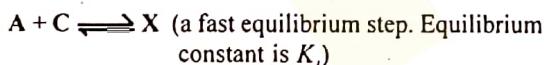


The table below gives the results of four experiments performed at 30°C to investigate the kinetics of this reaction.

Experiment	Initial concentration of A/mol dm ⁻³	Initial concentration of B/mol dm ⁻³	Initial concentration of C/mol dm ⁻³	Initial rate of formation of products / mol dm ⁻³ s ⁻¹
1	0.10	0.10	0.10	8.0×10^{-4}
2	0.20	0.10	0.10	1.6×10^{-3}
3	0.20	0.20	0.10	3.2×10^{-3}
4	0.10	0.10	0.20	3.2×10^{-3}

- I. Write a mathematical expression to relate the rate of the above reaction to concentrations of A, B and C.
- II. Calculate the order with respect to each reactant A, B and C.
- III. Write an expression for the rate of the reaction using the orders obtained with respect to A, B and C.
- IV. How does the rate of the above reaction change from its initial value if the concentration of C is tripled keeping the concentrations of each species A and B unchanged?

- (iii) It has been assumed that the above reaction takes place in the following elementary steps.



Indicate which of these steps will determine the rate of the reaction.

Write a rate expression for the reaction taking place in that step.

Hence, derive a rate expression for the reaction in step (b) (ii) above, in terms of [A], [B] and [C].

Note : The order with respect to each reactant of any elementary reaction is the same as the stoichiometric coefficient of that reactant.

(8.5 marks)

PART C - ESSAY

Answer all two questions only. Each question carries 15 marks.

8. (a) A and B are two water soluble crystalline compounds. When aqueous solutions of A and B are mixed together, an insoluble compound C and a water soluble compound D are formed. Given below are some tests carried out to identify A and B.

Test	Observation
1. Compound A was heated.	A reddish - brown gas evolved.
2. Aluminium (Al) powder and NaOH were added to an aqueous solution of A, the mixture was warmed and the gas evolved was tested with moist litmus.	Red litmus turned blue.
3. H ₂ S was passed into an aqueous solution of A.	A black precipitate was formed.
4. Dilute HCl was added to an aqueous solution of A.	A white precipitate was formed.
5. The mixture obtained in test (4) above was boiled.	Precipitate dissolved to give a clear solution.
6. The hot solution formed in (5) above was allowed to cool.	White needles precipitated.
7. BaCl ₂ was added to an aqueous solution of B.	A white precipitate insoluble in dil. HCl and dil. HNO ₃ was formed.
8. Filtrate from (7) above was divided into two portions and tested as follows. I. NH ₄ OH was added II. A small amount of conc. HNO ₃ was added followed by KSCN.	A dirty green precipitate was formed. The solution turned blood red in colour.

- (i) Identify compounds A and B explaining the above observations.
- (ii) Write balanced chemical equations for the reactions taking place in (1), (2), (3) and (4).
- (iii) Identify compound C
- (iv) To identify the cation and the anion present in compound A, give one chemical test for each, other than those given in the question.
- (b) Solution P contains SO₄²⁻, Cu²⁺ and H⁺. The following procedures (1-3) were used to determine their concentrations.
- Procedure :
- (1) Excess BaCl₂ solution was added to 25.00 cm³ of the solution P, to precipitate SO₄²⁻ as BaSO₄. The precipitate was filtered, washed and dried till a constant mass was observed. The mass of the precipitate was 2.335 g. Determine the concentration of SO₄²⁻ in solution P in mol dm⁻³. (O = 16, S = 32, Ba = 137)
 - (2) H₂S was bubbled through 25.00 cm³ of solution P to precipitate Cu²⁺ as CuS. The precipitate was filtered, washed with water, and the filtrate was kept to be used in procedure (3). The precipitate was transferred into a

tetraion flask containing 30.00 cm^3 of 0.28 mol dm^{-3} acidic KMnO_4 to produce Cu^{2+} , Mn^{2+} , and SO_2 . The solution was boiled to remove SO_2 , and the excess KMnO_4 was titrated with 0.10 mol dm^{-3} Fe^{2+} solution. The burette reading at the end point was 10.50 cm^3 . Determine the concentration of Cu^{2+} in solution P in mol dm^{-3} .

- (3) The filtrate from procedure (2) above was placed in a titration flask, boiled to remove H_2S and cooled to room temperature. To this, both 5% KIO_3 and 5% KI were added in excess. The volume of 0.40 mol dm^{-3} $Na_2S_2O_3$ solution required to titrate the liberated iodine was 25.00 cm^3 .

Determine the concentration of H^+ in solution P in mol dm⁻³.

(7.5 marks)

9. (a) Oxidized and reduced forms of nitrogen gas are important chemical species that are involved in environmental pollution.

(i) Give the chemical formulae of **three** nitrogen species with positive oxidation states that contribute to atmospheric pollution.

(ii) Give the chemical formulae of **three** nitrogen species that contribute to ground water pollution.

(iii) Indicate the basic processes by which nitrogen gas is converted to more chemically active forms as given in (i) and (ii) above.

(iv) Explain briefly how the Haber process indirectly contributes to environmental pollution.

(b) Photochemical smog is a major atmospheric pollution problem associated with industrialization and transportation along with specific climatic conditions.

- (i) Explain how photochemical smog develops.
 - (ii) Indicate how you would become aware of the presence of photochemical smog.
 - (iii) List **four** major toxic products found in photochemical smog. Give chemical reactions to show the formation of one toxic product that does **not** contain carbon.
 - (iv) Give **three** adverse effects due to photochemical smog.
 - (v) Suggest a method by which the formation of photodchemical smog can be reduced.

(c) (i) Indicate briefly the steps involved in the production of C from copper pyrites.

Note : Balanced chemical equations for the relevant reactions should be given.

- (ii) Give one chemical test to identify Cu^{2+} ions in an aqueous solution. (3.5 marks)

(3.5 marks)

- (d) The manufacture of common salt (NaCl) is an important industry in Sri Lanka.

(i) Indicate the factors you would consider to be important in selecting locations to set up salterns.

(ii) Give a brief outline of the steps involved in the production of common salt.

(iii) The mother liquor obtained during production of common salt is a rich source of chemical compounds.

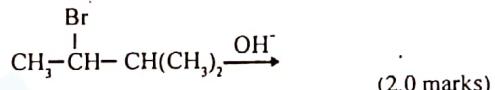
List a metal and non metal that are recovered from the mother liquor on a large scale.

(4.0 marks)

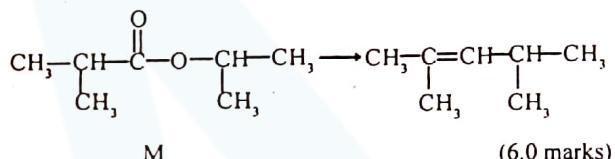
10. (a) (i) Explain why alkyl halides tend to undergo nucleophilic substitution reactions.
(ii) Explain why chlorobenzene does **not** undergo nucleophilic substitution reactions readily.

(4.0 marks)

- (b) Draw the structures of the **three** main products that can be expected from the reaction given below.

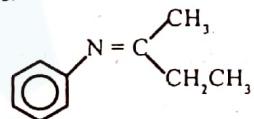


(c) Show how you would carry out the following synthesis using **M** as the **only** organic starting compound.



(d) (i) Show how you would synthesize 2-butanone using acetylene (C_2H_2) as the **only** organic starting compound.

(ii) Show how you would synthesize the following compound using 2-butanone as one of the starting compounds.



(3.0 marks)

	1	H		2	He													
1	3	4																
2	L i	B e																
3	11	12																
4	N a	M g																
5	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
6	K	C a	S c	T i	V	C r	M n	F e	C o	N i	C u	Z n	G a	G e	A s	S e	B r	K r
7	R b	S r	Y	Z r	N b	M o	T c	R u	R h	P d	A g	C d	I n	S n	S b	T e	I	X e
8	55	56	L a	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
9	C s	B a	L u	H f	T a	W	R e	O s	I r	P t	A u	H g	T l	P b	B i	P o	A t	R n
10	87	88	A c	104	105	106	107	108	109	110	111	112	113				
11	F r	R a	L r	R f	D b	S g	B h	H s	M t	U un	U uu	U ub	U ut					

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La	C e	P r	N d	P m	S m	E u	G d	T b	D y	H o	E r	T m	Y b	L u
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
A c	T h	P a	U	N p	P u	A m	C m	B k	C f	E s	F m	M d	N o	L r

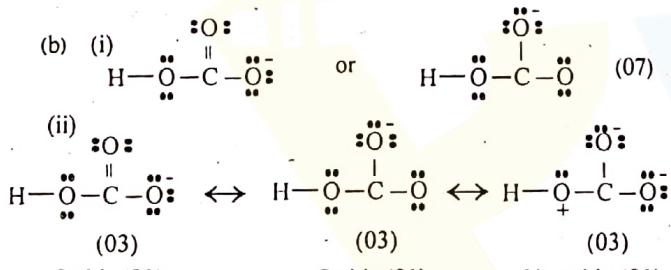
G.C.E. (A/L) Examination Chemistry – 2011 (New)

M.C.Q. Answers

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

PART A - STRUCTURED ESSAY

1. (a) (i) KIO_3
(ii) $\text{Na}_2\text{S}_2\text{O}_3$
(iii) PCl_5
(iv) CdCl_2
(v) $\text{CO}(\text{NO}_2)_2$ (04 x 5 = 20)



Reason -
Oxygen carries a positive charge (03)

- (i.) I C

 - Total number of electron pairs around C = 4 (01)
 - VSEPR pairs or sigma electron pairs = 3 (01)
 - Lone pairs = 0 (01)
 - Shape = trigonal planar (04)

II. O attached to H

- Total number of electron pairs around O = 4 (01)
 VSEPR pairs = 4 or two sigma electron pairs
 and two lone pairs of electrons (01)
 Lone pairs = 2 (01)
 Shape = angular / V shape (04)

- (iv) I. C - trigonal planar (03)
 II. O attached to H - tetrahedral (03)

(v) I C-SP² (03)
 II O attached to H - SP³ (03)

(vi) I between C and O attached to H -

O -SP³ (hybrid orbital) (03) + C - SP² (hybrid orbital) (03)

II between O and H -

O -SP³ (hybrid orbital) (03) + H - is (atomic orbital)
(03)

(c)	Substance	Melting point/K	Electrical conduction in the solid state	Electrical conduction in the molten/liquid state
(1) MgO	3200	poor	good	
(2) NaCl	1100	poor	good	
(3) Mg	920	excellent	excellent	
(4) CO ₂	200	very poor/nil	very poor/nil	
(5) SiO ₂	1900	very poor/nil	very poor/nil	

$$(04 \times 5) = 20$$

(100)

- ## 2. (i) Mg (Magnesium)

Uses.

- * Manufacture of alccys used in aircraft manufacture
 - * Fireworks (Mg powder)
 - * Flashlight powders for photography
 - * Manufacture of batteries
 - * To prevent corrosion
 - * Synthesis of Grignard reagent

(any one use) (05)

- (ii) $1S^2\ 2S^2\ 2P^6\ 3S^2$ (05)

(iii) A - MgO or Mg_3N_2 (05)
 B - Mg_3N_2 or MgO (05)
 C - H_2 (05)

(iv) NH_3 or Ammonia (05)

(v) $Mg + 4HNO_3 \rightarrow Mg(NO_3)_2 + 2NO_2 + 2H_2O$ (10)

(vi) $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$ (10)

(vii) 1. Place a strip of Mg in a boiling tube containing hot water. (03)
 2. Add a few drops of an acid - base indicator e.g. phenolphthalein (03)
 3. $OH^- / Mg(OH)_2$ are formed (03)
 4. This will cause the phenolphthalein to turn pink. (03)

- (viii) positive (06)
 The added electron occupies a 3p sub-shell that is higher in energy. (03)
 Hence, electron affinity is positive (03)
 OR
 Magnesium has S^2 configuration for the valency shell which is stable (02)
 Addition of an electron disturbs the stability (02)
 Hence, difficult to add. Therefore, electron affinity is positive. (02)

(ix) Oxides - increases (05)
 Hydroxides - increases (05)

(x)

element	strongly acidic	weakly acidic	amphoteric	weakly basic	strongly basic
P					✓
M				✓	
Q			✓		

$$(02 \times 3) = 06 \\ (100)$$

3. (a) (i) $\Delta H_{rxn}^{\circ} = \sum \Delta H_{(products)}^{\circ} - \sum \Delta H_{(reactants)}^{\circ}$ (05)
 $= 2 \times (-46.1 \text{ kJ mol}^{-1}) - (1 \times 0.00 \text{ kJ mol}^{-1} + 3 \times 0.00 \text{ kJ mol}^{-1})$ (03+02)
 $\Delta H_{rxn}^{\circ} = -92.2 \text{ kJ mol}^{-1}$ (03+02)

(ii) $\Delta S_{rxn}^{\circ} = \sum S_{(products)}^{\circ} - \sum S_{(reactants)}^{\circ}$ (05)
 $= 2 \times (192.3 \text{ J K}^{-1} \text{ mol}^{-1}) - (1 \times 191.5 \text{ J K}^{-1} \text{ mol}^{-1} + 3 \times 130.7 \text{ J K}^{-1} \text{ mol}^{-1})$ (03+02)
 $= -199 \text{ J K}^{-1} \text{ mol}^{-1}$ (03+02)

(iii) I. $\Delta G = \Delta H - T\Delta S$ (10)
II. $\Delta G^{\circ} = -92.2 \text{ kJ mol}^{-1} - 298 \text{ K} (-0.199 \text{ kJ mol}^{-1} \text{ K}^{-1})$ (03+02)
 $= -32.9 \text{ kJ mol}^{-1}$ (03+02)

(b) (i) I. $P = X_B P^{\circ}$ OR $\frac{P^{\circ} - P}{P^{\circ}} = 1 - X_A$ (04)

II. $P = (1 - X_A) P^{\circ}$ OR $1 - X_B = X_A$ (04)
 $P = P^{\circ} - X_A P^{\circ}$ OR $X_A = \frac{P^{\circ} - P}{P^{\circ}}$ (04)

(ii) P Consider 1000 cm³ of solution
Total mass = 1000 cm³ x 1.26 g cm⁻³ = 1260 g (02)
Mass of glucose = 2 mol x 180 g mol⁻¹ = 360 g (02)
Mass of water = 1260 g - 360 g = 900 g (02)
Amount of water = $\frac{900 \text{ g}}{18 \text{ g mol}^{-1}} = 50 \text{ mol}$ (02)

Moles fraction of glucose = $\frac{2 \text{ mol}}{2 \text{ mol} + 50 \text{ mol}}$
 $= \frac{1}{26} = 0.039$ (02)

R. Amount of sucrose = $\frac{171 \text{ g}}{342 \text{ g mol}^{-1}} = 0.5 \text{ mol}$ (02)

Amount of water = $\frac{171 \text{ g}}{18 \text{ g mol}^{-1}} = 9.5 \text{ mol}$ (02)

Mole fraction of sucrose = $\frac{0.5 \text{ mol}}{0.5 \text{ mol} + 9.5 \text{ mol}}$
 $= \underline{\underline{0.05}}$ (02)

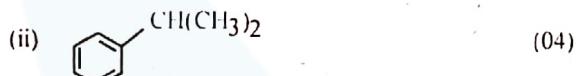
Q : Amount of glucose = $\frac{180 \text{ g}}{180 \text{ g mol}^{-1}} = 1 \text{ mol}$ (02)
Amount of water = $\frac{162 \text{ g}}{18 \text{ g mol}^{-1}} = 9 \text{ mol}$ (02)
Mole fraction of glucose = $\frac{1 \text{ mol}}{1 \text{ mol} + 9 \text{ mol}}$
 $= \frac{1}{10} = \underline{\underline{0.1}}$ (02)

(iii) Q < R < P (08)

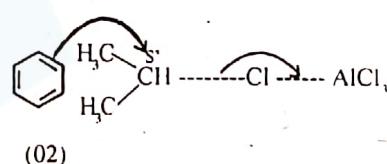
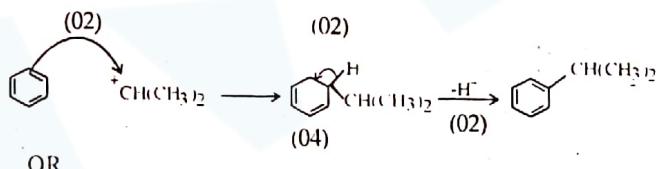
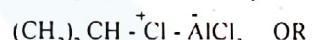
(iv) P = P⁰ (1 - mole fraction of glucose - mole fraction of sucrose) (08)

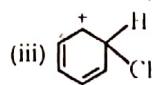
Part marks : Mole fraction of solutes in solution = sum of mole fraction of glucose and sucrose (04)

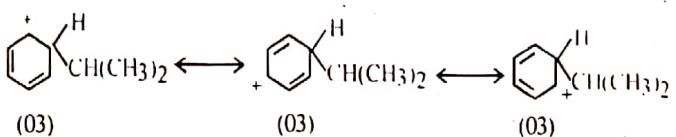
4. (a) (i) Electrophilic Substitution (04)



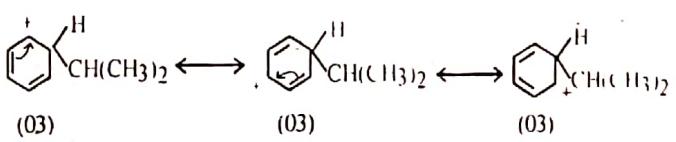
mechanism



(iii)  is stabilized by resonance as shown below (03)



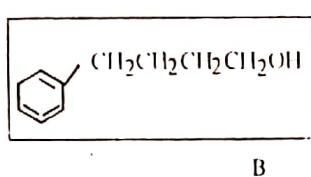
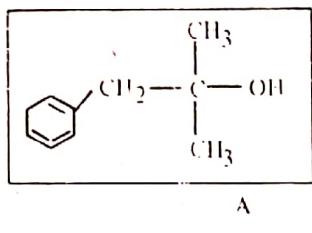
OR



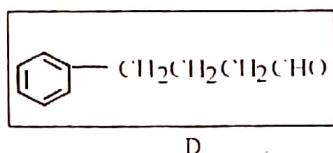
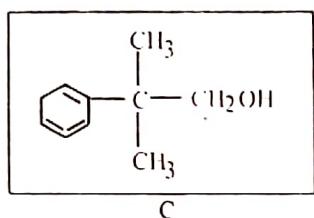
(iv) 

(06)

(b) (i)

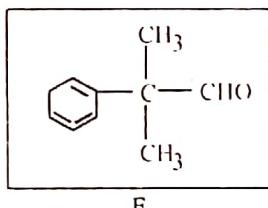


A



D

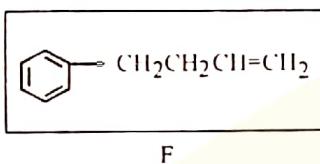
C



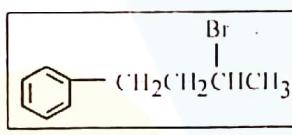
E

(05 x 5)

(ii)



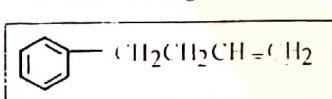
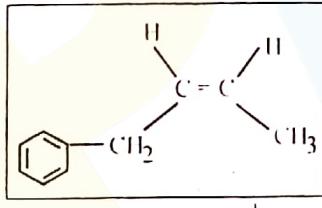
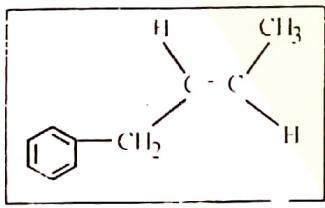
F



G

(05 x 2)

(iii)



(05 x 3)

If $\text{C}_n\text{H}_5\text{CH}_2\text{CH}=\text{CHCH}_3$ given and cis/trans not shown in the structure by drawing only 05 marks.

(iv) yes (05)

(v) G has a carbon atom joined to four different groups or chiral centre or asymmetric carbon atom (05)

100

PART B - ESSAY

5 (a) Amount of $\text{O}_2 = \frac{3.2\text{g}}{32\text{g mol}^{-1}} = 0.10\text{ mol}$ (02+01)

$\text{PV} = nRT$ (03)

Before addition of X

$(1.0 \times 10^5 \text{ Pa})V = 0.10\text{ mol} \times R \times 300\text{ K}$... (01) (02+01)

After addition of X

Let M = molar mass of X

Amount of X = $\frac{8.8\text{g}}{M}$ (02+01)

Total number of moles of gases = $[0.10\text{ mol} + \frac{8.8\text{g}}{M}]$ (02+01)

$(2.0 \times 10^5 \text{ Pa})2V = \left[0.10\text{ mol} + \frac{8.8\text{g}}{M} \right] \times R \times 400\text{ K}$... (2) (02+01)

$\frac{(2)(2.0 \times 10^5 \text{ Pa})2V}{(1)(1.0 \times 10^5 \text{ Pa})V} = \frac{\left[0.10\text{ mol} + \frac{8.8\text{g}}{M} \right] \times R \times 400\text{ K}}{0.10\text{ mol} \times R \times 300\text{ K}}$ (02+01)

$1.2\text{ mol} = 0.4\text{ mol} + \frac{8.8\text{g} \times 4}{M}$ (03)

$M = \frac{8.8\text{g} \times 4}{(1.2 - 0.4)\text{ mol}}$ (03)

$M = 44\text{ g mol}^{-1}$

OR

Rel. mol mass of X = 14 (02+01)

Alternative answer for 5 (a)

Before addition of X,

Volume is doubled, pressure is halved

$P_1 = 5.0 \times 10^4 \text{ Pa}$ (02+01)

To calculate pressure at 400 K

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ (03)

$\frac{5 \times 10^4 \text{ Pa}}{300 \text{ K}} = \frac{P_2}{400 \text{ K}}$ (02+01)

$P_2 = \frac{4}{3} \times 5.0 \times 10^4 \text{ Pa}$ (02+01)

After addition of X

$P \propto n$

initially, $n = \frac{3.2\text{g}}{32\text{g mol}^{-1}} = 0.10\text{ mol}$ (02+01)

$\frac{4}{3} \times 5.0 \times 10^4 \text{ Pa} \propto 0.10\text{ mol}$ (03)

$2.0 \times 10^5 \text{ Pa} \propto n$ (03)

$\frac{4/3 \times 5 \times 10^4 \text{ Pa}}{2.0 \times 10^5 \text{ Pa}} = \frac{0.10\text{ mol}}{n}$ (02+01)

$n = 0.30\text{ mol}$

$$\text{Moles of X added} = 0.30 \text{ mol} - 0.10 \text{ mol} = 0.20 \text{ mol} \quad (03)$$

$$\text{Molar mass of X} = \frac{8.8 \text{ g}}{0.20 \text{ mol}} = 44 \text{ g mol}^{-1}$$

OR

$$\text{Rel. mol. mass} = 44 \quad (02+01)$$

5 (a) - 30 marks

5. (b) Partition coefficient between

$$\text{A and B} = \frac{[S]_A}{[S]_B} = \frac{1}{9} \quad (04)$$

OR

$$\frac{[S]_B}{[S]_A} = 9 \text{ is also accepted.}$$

(ii) Partition coefficient between

$$\text{A and C} = \frac{[S]_A}{[S]_C} = \frac{1}{4} \quad (04)$$

OR

$$\frac{[S]_C}{[S]_A} = 4 \text{ is also accepted.}$$

(iii) Let C = Concentration of S in phase A after partition equilibrium in mol dm⁻³.

$$\text{Concentration of S in phase B} = (0.10 - C) \text{ mol dm}^{-3} \quad (04)$$

Since the volumes of the two phases are equal.

$$\frac{C}{0.10 - C} = \frac{1}{9} \quad (04)$$

$$0.10 - C = 9C \quad (04)$$

$$C = 0.01$$

$$\text{Concentration of S remained in A} = 0.01 \text{ mol dm}^{-3} \quad (3+1)$$

Alternative answer for 5b (iii)

After partition equilibrium, let

$$n_1 = \text{Mol of S in phase A}$$

$$n_2 = \text{Mol of S in phase B}$$

Since the volume of the two phases are equal.

$$\frac{n_1}{n_2} = \frac{1}{9} \quad (04)$$

$$\frac{n_1}{n_1 + n_2} = \frac{1}{10} \quad (04)$$

$$\text{Concentration of S remained in A} = \frac{1}{10} \times 0.10 \text{ mol dm}^{-3} \quad (3+1)$$

$$= 0.010 \text{ mol dm}^{-3} \quad (03+01)$$

$$5 (b)(iii) = (16)$$

(iv) Partition begins having 0.010 mol dm⁻³ of S in phase A

Let X = Number of mol of S remained in phase A

After equilibrium is reached

Concentration of S in phase C

$$\begin{aligned} &= \frac{0.010 \text{ mol dm}^{-3} \times \frac{10.00 \text{ dm}^3}{1000}}{\frac{20.00 \text{ dm}^3}{1000}} \quad (03+01) \\ &= \frac{0.10 - 1000x \text{ mol}}{20.00 \text{ dm}^{-3}} \quad (03+01) \end{aligned}$$

$$\text{Concentration of S in phase A} = \frac{x \text{ mol}}{\frac{10.00 \text{ dm}^3}{1000}} \quad (3+1)$$

$$= \frac{1000x}{10.00} \text{ mol dm}^{-3} \quad (3+1)$$

$$\begin{aligned} &\frac{\left(\frac{1000x}{10.00} \text{ mol dm}^{-3} \right)}{\frac{0.10 - 1000x \text{ mol}}{20.00 \text{ dm}^{-3}}} = \frac{1}{4} \quad (04) \\ &\left(\frac{0.10 - 1000x}{20.00} \right) = \frac{4000x}{10.00} \quad (04) \end{aligned}$$

$$\begin{aligned} 0.10 - 1000x &= 8000x \\ 9000x &= 0.10 \\ x &= 1.1 \times 10^{-5} \quad (04) \end{aligned}$$

Concentration of S remained in phase A

$$= \frac{1.1 \times 10^{-5}}{\frac{10.00 \text{ dm}^3}{1000}} \quad (3+1)$$

$$= 1.1 \times 10^{-3} \text{ mol dm}^{-3} \quad (3+1)$$

$$5 (b)(iv) = (36)$$

Alternative answer for 5b (iv)

After equilibrium is reached, let

$$n_1' = \text{Mol of S in phase A}$$

$$n_2' = \text{Mol of S in phase C}$$

$$\text{Concentration of S in phase A} = \frac{n_1' \text{ mol}}{\frac{10.00 \text{ dm}^3}{1000}} \quad (03+01)$$

$$= \frac{1000 n_1' \text{ mol}}{10.00} \text{ mol dm}^{-3} \quad (03+01)$$

$$\begin{aligned} \text{Concentration of S in phase C} &= \frac{n_2' \text{ mol}}{\frac{20.00 \text{ dm}^3}{1000}} \quad (03+01) \\ &= \frac{1000 n_2' \text{ mol}}{20.00} \text{ mol dm}^{-3} \quad (03+01) \end{aligned}$$

$$\frac{\frac{1000 n_1' \text{ mol dm}^{-3}}{10.00}}{\frac{1000 n_2' \text{ mol dm}^{-3}}{20.00}} = \frac{1}{4} \quad (04)$$

$$\frac{2 n_1'}{n_2'} = \frac{1}{4} \quad \text{OR} \quad \frac{n_1'}{n_2'} = \frac{1}{8} \quad (04)$$

$$\frac{n_1'}{n_1' + n_2'} = \frac{1}{9} \quad (04)$$

$$\begin{aligned} \text{Concentration of S remained in A} &= \frac{1}{9} \times 0.010 \text{ mol dm}^{-3} \quad (3+1) \\ &= 0.0011 \text{ mol dm}^{-3} \quad (03+01) \end{aligned}$$



Partial pressure of R = $2.0 \times 10^4 \text{ Pa}$ (given)

Partial pressure of Q = $4.0 \times 10^4 \text{ Pa}$ (03+01)

Partial pressure of P =

= total pressure - P. pressure of Q - P. pressure of R

$$= 1.2 \times 10^5 \text{ Pa} - 2.0 \times 10^4 \text{ Pa} - 4.0 \times 10^4 \text{ Pa} \quad (03+01)$$

$$= 6.0 \times 10^4 \text{ Pa} \quad (03+01)$$

$$5(c)(i) = \textcircled{12} \quad (04)$$

$$(ii) PV = nRT \quad (04)$$

$$(1.2 \times 10^5 \text{ Pa}) \times (1.0 \times 10^{-3} \text{ m}^3) = n \times 4.0 \times 10^3 \text{ J mol}^{-1} (3+1)$$

$$n = 0.030 \text{ mol} \quad (3+1)$$

mol of each component = Total no. of mol x fractional pressure

$$n_P = 0.030 \text{ mol} \times \frac{6.0 \times 10^4}{1.2 \times 10^5} = 0.015 \text{ mol} \quad (04)$$

$$n_Q = 0.030 \text{ mol} \times \frac{4.0 \times 10^4}{1.2 \times 10^5} = 0.010 \text{ mol} \quad (04)$$

$$n_R = 0.030 \text{ mol} - 0.015 \text{ mol} - 0.010 \text{ mol} = 0.005 \text{ mol} \quad (04)$$

At equilibrium.

$$\text{Concentration of P} = 0.015 \text{ mol dm}^{-3} \quad (03+01)$$

$$\text{Concentration of Q} = 0.010 \text{ mol dm}^{-3} \quad (03+01)$$

$$\text{Concentration of R} = 0.005 \text{ mol dm}^{-3} \quad (03+01)$$

$$5(c)(ii) = \textcircled{36} \quad (06)$$

Alternative answer for 5c(ii)

$$P = CRT \quad \text{OR} \quad C = P/RT \quad (06)$$

$$C_P = \frac{6.0 \times 10^4 \text{ pa}}{4.0 \times 10^3 \text{ J mol}^{-1}} \quad (05+01)$$

$$= 15.0 \text{ mol m}^{-3} = 0.015 \text{ mol dm}^{-3} \quad (03+01)$$

$$C_Q = \frac{4.0 \times 10^4 \text{ pa}}{4.0 \times 10^3 \text{ J mol}^{-1}} \quad (05+01)$$

$$= 10.0 \text{ mol m}^{-3} = 0.010 \text{ mol dm}^{-3} \quad (03+01)$$

$$C_R = \frac{2.0 \times 10^4 \text{ pa}}{4.0 \times 10^3 \text{ J mol}^{-1}} \quad (05+01)$$

$$= 5.0 \text{ mol m}^{-3} = 0.005 \text{ mol dm}^{-3} \quad (03+01)$$

$$5(c)(ii) = \textcircled{36} \quad (06)$$

$$(iii) K_p = \frac{[Q]^2 [R]}{[P]^2} \quad (04)$$

$$= \frac{(0.010 \text{ mol dm}^{-3})^2 (0.005 \text{ mol dm}^{-3})}{(0.015 \text{ mol dm}^{-3})^2} \quad (03+01)$$

$$= 2.2 \times 10^{-3} \text{ mol dm}^{-3} \quad (03+01)$$

Alternative answer for 5c(iii)

$$K_p = \frac{P_Q^2 P_R}{P_P^2} \quad (04)$$

$$= \frac{(4.0 \times 10^4 \text{ pa})^2 (2.0 \times 10^4 \text{ pa})}{(6.0 \times 10^4 \text{ pa})^2} \quad (02+01)$$

$$= \frac{8}{9} \times 10^4 \text{ pa} \quad (02+01)$$

$$K_p = \frac{K_p}{RT} \quad (03)$$

$$= \frac{(8/9) \times 10^4 \text{ pa}}{4.0 \times 10^3 \text{ J mol}^{-1}} \quad (02+01)$$

$$= 2.2 \text{ mol m}^{-3} \text{ or } 2.2 \times 10^{-3} \text{ mol dm}^{-3} \quad (02+01)$$

$$5(c)(iii) = \textcircled{12} \quad (04)$$

$$6(a)(i) HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq) \quad (03)$$

Initially, 0.100 mol dm⁻³

At eqm. 0.100 - x x mol dm⁻³ (02+01)

$$K_a = \frac{[H_3O^+(aq)][A^-(aq)]}{[HA(aq)]} \quad (03)$$

$$= \frac{x^2}{0.100 - x} \text{ mol dm}^{-3} \quad (03)$$

Assumption x is negligible compared to 0.100
OR

$$0.100 - x \approx 0.100 \quad (03)$$

$$\frac{x^2}{0.100} = 1.0 \times 10^{-3} \quad (03)$$

$$x^2 = 1.0 \times 10^{-6} \quad (03)$$

$$x = 1.0 \times 10^{-3} \quad (03)$$

$$[H_3O^+] = 1.0 \times 10^{-3} \text{ mol dm}^{-3} \quad (03)$$

$$pH = -\log(1.0 \times 10^{-3}) = 3.00 \quad (03)$$

$$6(a)(i) = \textcircled{24} \quad (04)$$

$$(ii) ka = \frac{[H_3O^+(aq)][A^-(aq)]}{[HA(aq)]} \quad (06)$$

$$\frac{[H_3O^+(aq)]}{[A^-(aq)]} = \frac{[H_3O^+(aq)]}{ka} \quad (06)$$

$$(iii) pH = 4.0 ; [H_3O^+] = 1 \times 10^{-4} \text{ mol dm}^{-3} \quad (02+01)$$

$$[HA] + [A^-] = 0.100 \text{ mol dm}^{-3} \quad (01) \quad (02+01)$$

$$\frac{[HA]}{[A^-]} = \frac{1.0 \times 10^{-4} \text{ mol dm}^{-3}}{1.0 \times 10^{-5} \text{ mol dm}^{-3}} = 10$$

$$[HA] = 10[A^-] \quad (02) \quad (03)$$

From ① and ②.

$$10[A^-] + [A^-] = 0.100 \text{ mol dm}^{-3}$$

$$[A^-] = 1/11 \times 0.100 \text{ mol dm}^{-3} \quad (03)$$

$$[A^-] = 9.09 \times 10^{-3} \text{ mol dm}^{-3} \quad (02+01)$$

$$[HA] = 9.09 \times 10^{-2} \text{ mol dm}^{-3} \quad (02+01)$$

$$6(a)(iii) = 18 \quad (18)$$

(iv)

$$\frac{[HA(aq)]}{[A^-(aq)]} = \frac{[H_3O^+(aq)]}{K_a}$$

$$\text{when } [HA] = [A^-]$$

$$\frac{[H_3O^+]}{K_a} = 1 \quad (03)$$

$$[H_3O^+] = K_a = 1.0 \times 10^{-5} \text{ mol dm}^{-3} \quad (02+01)$$

$$\text{pH} = -\log(1.0 \times 10^{-5}) = 5.00 \quad (03)$$

$$6(a)(iv) = 09 \quad (09)$$

$$(v) \text{ pH} = pK_a + \log \frac{[A^-]}{[HA]} \quad (03)$$

After reaction between HA and NaOH.

$$\text{Concentration of HA} = \frac{5.00 \text{ cm}^3 \times 0.0500 \text{ mol dm}^{-3}}{105.00 \text{ cm}^3} \quad (02+01)$$

$$\text{Concentration of A}^- = \frac{50.00 \text{ cm}^3 \times 0.0500 \text{ mol dm}^{-3}}{105.00 \text{ cm}^3} \quad (02+01)$$

$$\text{pH} = -\log(1.0 \times 10^{-5}) + \log \frac{[50.00 \text{ cm}^3 \times 0.0500 \text{ mol dm}^{-3} / 105.00 \text{ cm}^3]}{[5.00 \text{ cm}^3 \times 0.0500 \text{ mol dm}^{-3} / 105.00 \text{ cm}^3]} \quad (02+01)$$

$$\text{pH} = 5.00 + \log 10.0 \\ = 6.00 \quad (03)$$

Alternative answer for 6a(v)

After reaction between HA and NaOH

$$\text{Concentration of HA} = \frac{5.00 \text{ cm}^3 \times 0.0500 \text{ mol dm}^{-3}}{105.00 \text{ cm}^3} \quad (02+01)$$

$$= 2.38 \times 10^{-3} \text{ mol dm}^{-3}$$

$$\text{Concentration of A}^- = \frac{50.00 \text{ cm}^3 \times 0.0500 \text{ mol dm}^{-3}}{105.00 \text{ cm}^3} \quad (02+01)$$

$$= 2.38 \times 10^{-2} \text{ mol dm}^{-3}$$

$$K_a = \frac{[H_3O^+(aq)][A^-(aq)]}{[HA(aq)]} \quad \text{OR} \quad H_3O^+(aq) = \frac{K_a [HA(aq)]}{[A^-(aq)]} \quad (03)$$

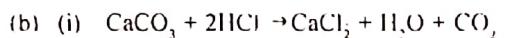
$$[H_3O^+(aq)] = \frac{[1.0 \times 10^{-5} \text{ mol dm}^{-3}][2.38 \times 10^{-3} \text{ mol dm}^{-3}]}{[2.38 \times 10^{-2} \text{ mol dm}^{-3}]}$$

$$= 1.0 \times 10^{-4} \text{ mol dm}^{-3}$$

$$\text{pH} = -\log 1.0 \times 10^{-4} \\ = 6.00 \quad (03)$$

Assumption Concentrations of HA and A⁻ after reaction \approx their equilibrium concentrations (03)

$$6(a)(v) = 18 \quad (18)$$



$$\text{Amount of CaCO}_3 = 4.00 \text{ g} / 100 \text{ g mol}^{-1} = 0.040 \text{ mol} \quad (04+01)$$

$$\text{Amount of HCl} = 0.30 \text{ mol dm}^{-3} \times 0.10 \text{ dm}^{-3} = 0.15 \text{ mol} \quad (04+01)$$

$$\begin{aligned} \text{Excess amount of HCl} &= 0.15 \text{ mol} - 2 \times 0.040 \text{ mol} \\ &= 0.07 \text{ mol} \end{aligned} \quad (04+01)$$

$$\begin{aligned} \text{Concentration of H}^+ &= 0.07 \text{ mol} / 0.500 \text{ dm}^3 \\ &= 0.14 \text{ mol dm}^{-3} \end{aligned} \quad (04+01)$$

$$6(b)(i) = 25 \quad (25)$$

(ii) 250 cm³ of 0.14 mol dm⁻³ H⁺ + 250 cm³ of 0.16 mol dm⁻³ NaOH

$$[Ca^{2+}(aq)] = \frac{0.020 \text{ mol}}{0.500 \text{ dm}^3} = 0.04 \text{ mol dm}^{-3} \quad (04+01)$$

$$[OH^-(aq)] = \frac{0.16 \text{ mol dm}^{-3} \times 0.250 \text{ dm}^3 - 0.14 \text{ mol dm}^{-3} \times 0.250 \text{ dm}^3}{0.500 \text{ dm}^3} \\ = 0.01 \text{ mol dm}^{-3} \quad (04+01)$$

$$[Ca^{2+}(aq)][OH^-(aq)]^2 = (0.04 \text{ mol dm}^{-3})^2 \quad (05)$$

$$= 4 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9} \quad (04+01)$$

$$< k_{sp} = (6.5 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}) \text{ No precipitation occurs.} \quad (05)$$

$$\text{OR} \quad [OH^-(aq)] \text{ required to precipitate} = \left(k_{sp} / [Ca^{2+}(aq)]^{1/2} \right) \quad (02)$$

$$= \left[\frac{6.5 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}}{0.04 \text{ mol dm}^{-3}} \right]^{1/2} \quad (02+01)$$

$$= 1.3 \times 10^{-2} \text{ mol dm}^{-3} \quad (04+01)$$

Concentration of [OH⁻(aq)] in solution $< 1.3 \times 10^{-2} \text{ mol dm}^{-3}$
No precipitation occurs. (05)

$$6(b)(ii) = 25 \quad (25)$$

$$(iii) [OH^-(aq)] = 0.01 \text{ mol dm}^{-3}$$

Concentration of Ca²⁺ required to precipitate Ca(OH)₂

$$= \frac{K_{sp}}{[OH^-(aq)]^2}$$

$$= \frac{6.5 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}}{(0.01 \text{ mol dm}^{-3})^2} \quad (04+01)$$

$$= 6.5 \times 10^{-2} \text{ mol dm}^{-3}$$

Concentration of Ca²⁺ added for precipitation [as Ca(NO₃)₂] $= 6.5 \times 10^{-2} \text{ mol dm}^{-3} - 0.04 \text{ mol dm}^{-3} \quad (04+01)$
 $= 0.025 \text{ mol dm}^{-3}$

$$\text{Molar mass of Ca(NO}_3)_2 = 164 \text{ g mol}^{-1} \quad (05)$$

$$\text{Mass of Ca(NO}_3)_2 \text{ to be added} \quad (05)$$

$$= 0.025 \text{ mol dm}^{-3} \times 0.500 \text{ dm}^3 \times 164 \text{ g mol}^{-1} \quad (05)$$

$$= 2.05 \text{ g} \quad (04+01)$$

$$6(b)(iii) = 25 \quad (25)$$

Alternative answer for 6b(iii)

$$\text{Molar mass of Ca(NO}_3)_2 = 164 \text{ g mol}^{-1} \quad (05)$$

Let X mass of Ca(NO₃)₂ to be added for precipitation

$$\text{Concentration of Ca}^{2+} \text{ in solution} = 0.04 \text{ mol dm}^{-3} + \frac{X / (164 \text{ g mol}^{-1})}{0.500 \text{ dm}^3} \quad (04+01)$$

$[\text{OH}^-]$ does not change

$$\left[\frac{0.040 \text{ mol dm}^{-3} + X (164 \text{ g mol}^{-1})}{0.500 \text{ dm}^{-3}} \right] = 0.065 \text{ mol dm}^{-3} \quad (05)$$

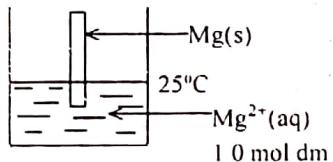
$$X = 0.025 \text{ mol dm}^{-3} \times 0.500 \text{ dm}^{-3} \times 164 \text{ g mol}^{-1}$$

$$= 2.05 \text{ g}$$

Minimum mass of $\text{Ca}(\text{NO}_3)_2$ to be added for precipitation
= 2.05 g (04+01)

$$6 \text{ (b) (iii)} = (25)$$

7. (a) (i)



4 answers x 03 marks (12)

- (ii) • Potential develops on an electrode as a result of accumulation of charges on the electrode and the adjacent layer of solution. (02)
- One terminal of the potential measuring device must be connected to the electrode and the other terminal is partially immersed in the solution. (02)
- The charge accumulated on the second terminal immersed in solution too develops an electrical potential on the surface. (02)
- Potential measured of the first electrode is the potential with respect to that of the second electrode. (Therefore, the potential measured is not the absolute potential of the electrode concerned). (02)

OR

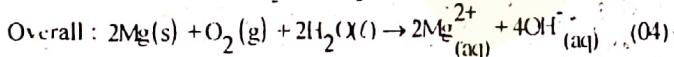
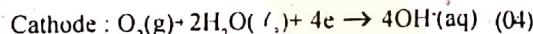
What can be measured is the potential of an electrode with respect to the potential of another electrode. (04)

(iii) (I) C electrode (04)

$$(II) E_{\text{cell}}^{\circ} = E_{\text{cathode}}^{\circ} - E_{\text{Anode}}^{\circ}$$

$$= 0.40 \text{ V} - (-2.37 \text{ V}) \quad (03+01)$$

$$= 2.77 \text{ V} \quad (01)$$



(iv) Change in potential of the Mg electrode OR

Change in e.m.f. (04)

Comment : Electrolyte is changed or Mg^{2+} is not present. (04)

(v) 16 marks for any two following answers

1. Replace the Mg electrode with a new electrode (04)
Comment : Mg is used up in the cell reaction (04)

2. Add water (04)
Comment : H_2O is used up in the cell reaction OR
To maintain the initial water level (04)

3. Replace/clean the porous C electrode (04)
Comment : To remove $\text{Mg}(\text{OH})_2$ precipitate deposited on the porous C electrode (04)
OR Add $\text{Mg}^{2+}(\text{aq})$ solution.

(b) (i) Initial rate : (Average) rate for a small change in time from the starting point of a reaction (05)

Average rate : The average value of individual rates determined over a certain period of time during the course of a reaction. (05)

7 (b) (i) = (10)

(ii) I. rate $\propto [A]^a [B]^b [C]^c$ (04)

$$\text{II. } 8.0 \times 10^{-4} \text{ mol dm}^{-3}\text{s}^{-1} \propto [0.10 \text{ mol dm}^{-3}]^a [0.10 \text{ mol dm}^{-3}]^b [0.1 \text{ mol dm}^{-3}]^c \quad (3+1)$$

$$1.6 \times 10^{-3} \text{ mol dm}^{-3}\text{s}^{-1} \propto [0.20 \text{ mol dm}^{-3}]^a [0.10 \text{ mol dm}^{-3}]^b [0.10 \text{ mol dm}^{-3}]^c \quad (3+1)$$

$$3.2 \times 10^{-3} \text{ mol dm}^{-3}\text{s}^{-1} \propto [0.20 \text{ mol dm}^{-3}]^a [0.20 \text{ mol dm}^{-3}]^b [0.10 \text{ mol dm}^{-3}]^c \quad (3)$$

$$3.2 \times 10^{-3} \text{ mol dm}^{-3}\text{s}^{-1} \propto [0.10 \text{ mol dm}^{-3}]^a [0.10 \text{ mol dm}^{-3}]^b [0.20 \text{ mol dm}^{-3}]^c \quad (3+1)$$

$$(2)/(1) \quad 2 = 2^a, \quad a = 1 \text{ or order with respect to A = 1} \quad (04)$$

$$(3)/(2) \quad 2 = 2^b, \quad b = 1 \text{ or order with respect to B = 1} \quad (04)$$

$$(4)/(1) \quad 4 = 2^c, \quad c = 2 \text{ or order with respect to C = 2} \quad (04)$$

iii. rate $\propto [A][B][C]^2$ (04)

iv. Increased by a factor of $3^2 = 9$ (03 + 04)

7 (b) (ii) = (43)

(iii) Slow step OR $\text{Y} + \text{B} \rightarrow \text{Z}$ (04)

Rate $\propto [\text{Y}][\text{B}]$ (08)

$$k_1 = \frac{[\text{X}]}{[\text{A}][\text{C}]} \quad (04)$$

$$k_2 = \frac{[\text{Y}]}{[\text{X}][\text{C}]} \quad (04)$$

$$k_1 k_2 = \frac{[\text{X}]}{[\text{A}][\text{C}]} \cdot \frac{[\text{Y}]}{[\text{X}][\text{C}]} = \frac{[\text{Y}]}{[\text{A}][\text{C}]^2} \quad (04)$$

$$[\text{Y}] = k_1 k_2 [\text{A}][\text{C}]^2 \quad (04)$$

$$\text{Rate} = k_1 k_2 [\text{A}][\text{B}][\text{C}]^2$$

OR

$$\propto [\text{A}][\text{B}][\text{C}]^2 \quad (04)$$

7 (b) (iii) = (32)

PART C - ESSAY

8. (a) (i)

Observation

Inference

1 brown gas \rightarrow presence of nitrates (03)

2 red litmus turns blue \rightarrow presence of NO_3^- / NO_2^- / NH_4^+ (01x3)

3 black precipitate \rightarrow PbS / CuS / HgS / Bi_2S_3 / Ag_2S / CoS / NiS any three (01x3)

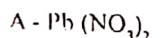
4 white precipitate \rightarrow PbCl_2 or AgCl (02 + 01)

5 white precipitate dissolved \rightarrow PbCl_2 , (03)

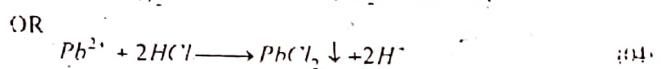
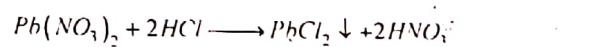
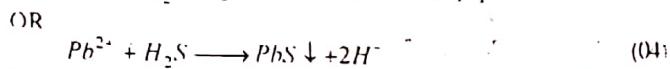
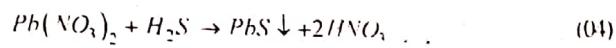
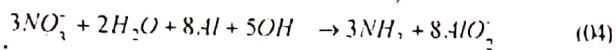
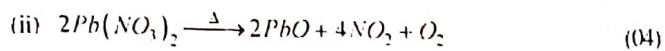
6 white needles \rightarrow PbCl_3 ,

7 white precipitate insoluble → presence of SO_4^{2-} (03)
in dil. HCl & dil. HNO_3

8 i) dirty green precipitate
ii) blood red colour } presence of Fe^{2+} (03)



(10 + 10)



1) Add K_2CrO_4 to a solution of A yellow precipitate (soluble in NaOH)

2) Add dil. H_2SO_4 to a solution of A white precipitate which dissolves in conc. NH_4OAc

3) Add dil. NaOH to a solution of A white precipitate which dissolves in excess NaOH

4) Add KI to a solution of A yellow precipitate which dissolves on boiling and precipitates as golden spangles on cooling.

(any one) 03 + 02

For NO_3^-

1) Add conc. H_2SO_4 to solid A and heat. Reddish-brown / brown fumes

2) To a solution of A - Add a freshly prepared solution of FeSO_4 followed by conc. H_2SO_4 slowly down the sides of the test-tube or Brown ring test

3) Add conc. H_2SO_4 to solid A followed by Cu turnings and warm reddish - brown / brown gas with a blue solution

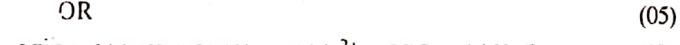
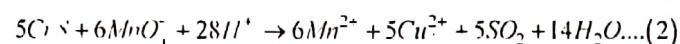
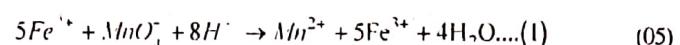
(any one) 03 + 02

8 (a) = 75

8 (b) (i) Weight of BaSO_4 = 2.335g
Molar mass of BaSO_4 = 233 g mol⁻¹ (02)
Moles of BaSO_4 = $2.335 / 233 = 0.010$ (03)
Therefore, moles of SO_4^{2-} = 0.010 (02)
 $= 0.010 \times 1000 / 251, \text{ mol dm}^{-3}$ (03)
 $= 0.40 \text{ mol dm}^{-3}$ (03 + 02)

(15 marks)

(iii)



$$\text{Moles of Fe}^{2+} = \frac{0.1}{1000} \times 10.5 \quad (02)$$

$$= 1.05 \times 10^{-3} \quad (01)$$

$$\text{From eq. ① moles of MnO}_4^- \text{ remaining} = \frac{1}{5} (1.05 \times 10^{-3}) \quad (02)$$

$$= 2.1 \times 10^{-4} \quad (01)$$

$$\text{Moles of KMnO}_4 \text{ added} = \frac{30.00}{1000} \times 0.28 \quad (02)$$

$$= 8.4 \times 10^{-3} \quad (01)$$

$$\text{Moles of MnO}_4^- \text{ reacted with CuS} = (8.4 \times 10^{-3}) - (2.1 \times 10^{-4}) \quad (02)$$

$$= 8.2 \times 10^{-3} \quad (02)$$

$$\text{From eq. ②, moles of CuS} = \frac{5}{6} \times 8.2 \times 10^{-3} \quad (05)$$

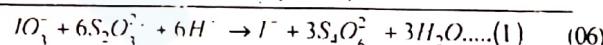
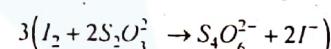
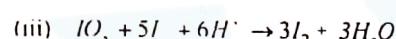
$$= 6.8 \times 10^{-3} \text{ or } 7 \times 10^{-3} \quad (03)$$

Therefore, moles of Cu^{2+} in $25.00 \text{ cm}^3 = 6.8 \times 10^{-3}$ or 7×10^{-3} (03)

$$[\text{Cr}^{2+}] = (6.8 \times 10^{-3}) / 25 \times 1000 \text{ or } (7 \times 10^{-3}) / 25 \times 1000 \text{ mol dm}^{-3} \quad (03)$$

$$[\text{Cu}^{2+}] = 0.27 \text{ mol dm}^{-3} \text{ Or } 0.28 \text{ mol dm}^{-3} \quad (03 + 02)$$

(15 marks)



$$\text{Moles of S}_2\text{O}_3^{2-} = 0.4 / 1000 \times 25 \quad (03)$$

From eq.(1), moles of I^- in $25.00 \text{ cm}^3 = 0.4 / 1000 \times 25$ (03)

$$[\text{H}^+] = 0.4 / 1000 \times 25 \times 1000 / 25 \text{ mol dm}^{-3} \quad (03)$$

$$[\text{H}^+] = 0.4 \text{ mol dm}^{-3} \quad (03 + 02)$$

(20 marks)

9 (a) (i) NO, NO_2 , HNO_3 , N_2O (03 x 3)

(ii) NO_2 , NO_3^- , NH_4^+ , (NH_3) (03 x 3)

(iii) Biological fixation, Industrial fixation, Atmospheric fixation, combustion of fossil fuels

any three (03 x 3)

(iv) Most of the NH_3 produced by Haber process is used to manufacture fertilizers which are potential water pollutants. (03)

9 (a) = 30

(b) (i) volatile hydrocarbons and nitrogen oxides (NO_x) produced by vehicles and industries react in the atmosphere in the presence of sunlight (UV) to form photochemical oxidants (secondary pollutants). Which also combine with primary emissions to form photochemical smog.

Or

volatile hydrocarbons and nitrogen oxides (NO_x) produced by vehicles and industries react in the atmosphere in the presence of sunlight (UV) to form photochemical oxidants (e.g. ozone, atomic oxygen). These contribute to the formation of photochemical smog.

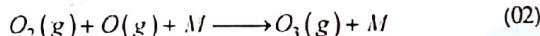
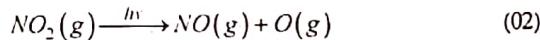
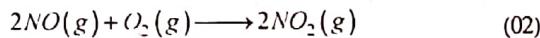
(01 x 8)

- (ii) • reduced visibility (around noon due to formation of aerosols)
- brownish or yellowish or yellow - brown haze formed (during the middle of the day)
- breathing difficulties.

(any two) (03 + 03)

- (iii) O₃, short chain aldehydes (HCHO, CH₃CHO, CH₂=CH CHO), peroxyacetyl nitrate (PAN), peroxy benzonitrile (PBN) and alkyl nitrates (e.g. CH₃ONO₂)

(any four) (03 x 4)



(M is a third body (N₂) which absorbs energy)

(iv) Adverse effects

(1) Affects human health

- Affects respiratory system and causes coughing, wheezing, asthma etc.
- Can cause eye and nose irritation.

(2) Damage to materials - O₃ causes rubber to deteriorate through fission of double bonds and also reduces quality of fabrics and bleaches dyes.

(3) Toxic to plants - shortage of food world wide

(4) Affects the atmosphere - aerosols reduce visibility.

(any three) (03 x 3)

- (v) (1) Fix catalytic converters in vehicles (to convert CO and unburnt hydrocarbons to CO₂ & H₂O and NO_x to N₂(g) & O₂(g))

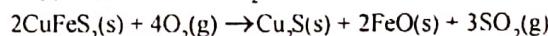
(2) Reduce industrial emissions.

(3) Use of alternative fuels (in hybrid cars, electric cars)

any one (04)

9 (b) = (45)

- (c) (i) (1) Copper pyrites (CuFeS₂) is roasted in air (02)



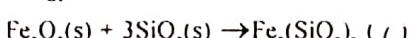
or (04)



- (2) The products are then heated with silica to form a molten slag which floats on molten Cu₂S (02)



or



The slag is then separated. (01)

- (3) The impure Cu₂S(s) is heated in air so that part of it reacts to form Cu₂O (02)



- (4) The remaining Cu₂S is now mixed with CuO and heated in the absence of air (02)

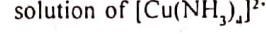


(Blister Cu - 2 - 3 % impure) (02)

- (5) Impure blister Cu is purified by electrolysis using CuSO₄ solution (04)

- (ii) Add NH₄OH (02) - gives a blue precipitate, Cu(OH)₂ (01)

Dissolves in excess NH₄OH (01) to give a dark blue



OR

Add potassium ferrocyanide, K₄[Fe(CN)₆], to the neutral or acidic solution. (03). A reddish - brown precipitate is formed. (02)

OR

Make solution basic with NaOH (or fehlings - B), and add glucose or an aldehyde and heat the solution (03)

A brick red precipitate is formed (02) 9 (c) = (35)

- (d) (i) 1) Large flat land with water impervious clay soil close to the ocean or lagoon.

- 2) Strong sunlight should prevail during most of the year.

- 3) Area that has dry, fast moving winds.

- 4) Area with low rainfall. (01 x 10)

- (ii) (1) Sea water is pumped into the first tank (large). (01) water evaporated by sunlight (01), solution becomes concentrated (01) CaCO₃ precipitates (03) and settles down.

- (2) Remaining solution is transferred to another tank (medium) (01), water evaporates by sunlight (01), solution becomes concentrated (01) CaSO₄ precipitates (03) and settles down.

- (3) Remaining solution is pumped to another tank (small) (01), water evaporates by sunlight (01), NaCl precipitates (03).

This contains Mg²⁺, Ca²⁺ and SO₄²⁻ as impurities (01)

- (4) NaCl collected is stored outside the tank for about six months (02). Ca²⁺ and Mg²⁺ salts absorb moisture from air and form a solution (02) whereas, NaCl remains as a solid (02)

OR

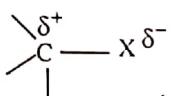
NaCl obtained is washed with the mother liquor to obtain purified NaCl (washed salt) (06)

- (iii) Metal - Mg (03)

- Non metal - Br₂ (03)

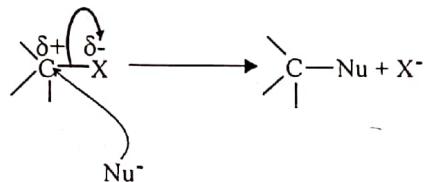
9 (d) = (40)

10. (a) (i) The C-X bond is polarized (03) because of the higher electronegativity of X (04) to create a partial positive charge on C (03)



A nucleophile carrying a pair of electrons available (02) to form a bond (to carbon) will be attracted (reacts readily) to the carbon atom (02)

The C-X bond will break (02) with the bonding electrons leaving with X and carbon forms a new bond with the nucleophile (02).

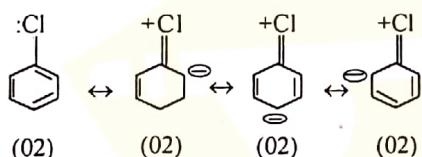


Thus nucleophile substitutes X (02)

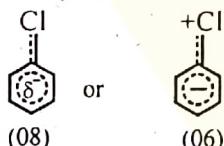
10 (a) (i) = (20)

- (a) (ii) The C-Cl bond has a double bond character (04) and is more difficult to break (04) due to delocalization of a pair of electrons on the chlorine atom (04) with the benzene ring.

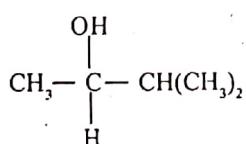
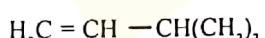
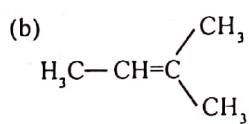
This can be explained by resonance.



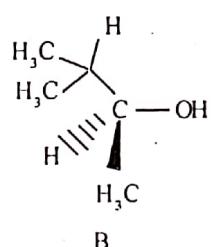
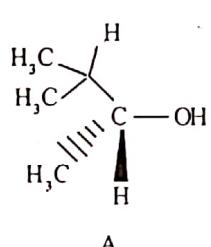
OR



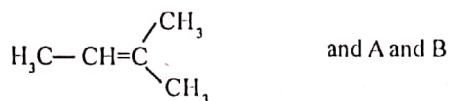
10 (a) (ii) = (20)



- * Alcohol could be represented as two optical isomers i.e. two structures as shown below.



Then the required answer is

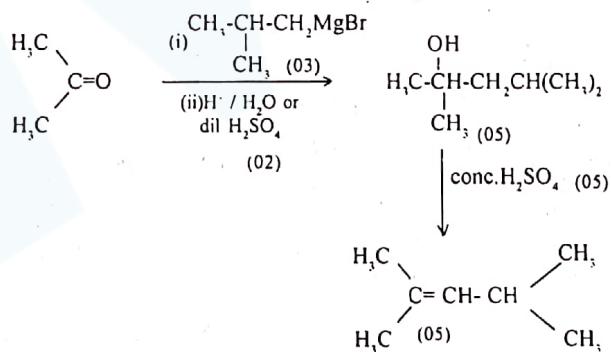
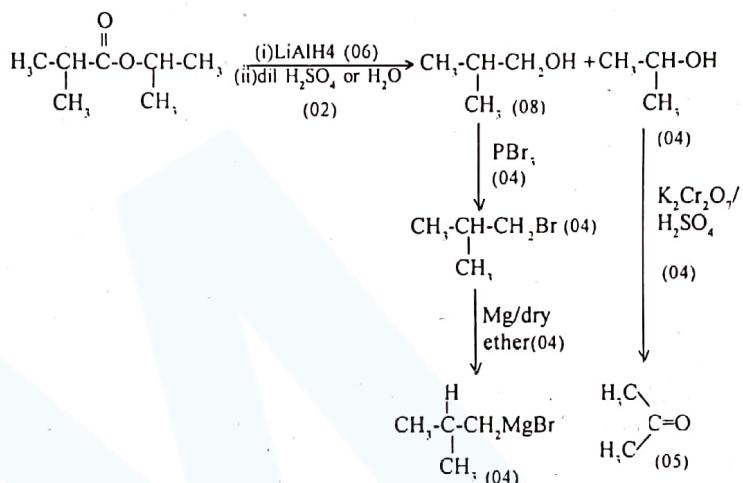


Allocation of marks for 10 (b)

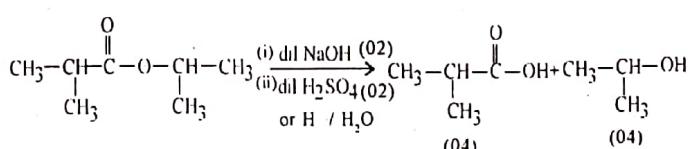
One correct structure	07 marks
Two correct structure	14 marks
Three correct structure	20 marks

10 (b) = (20)

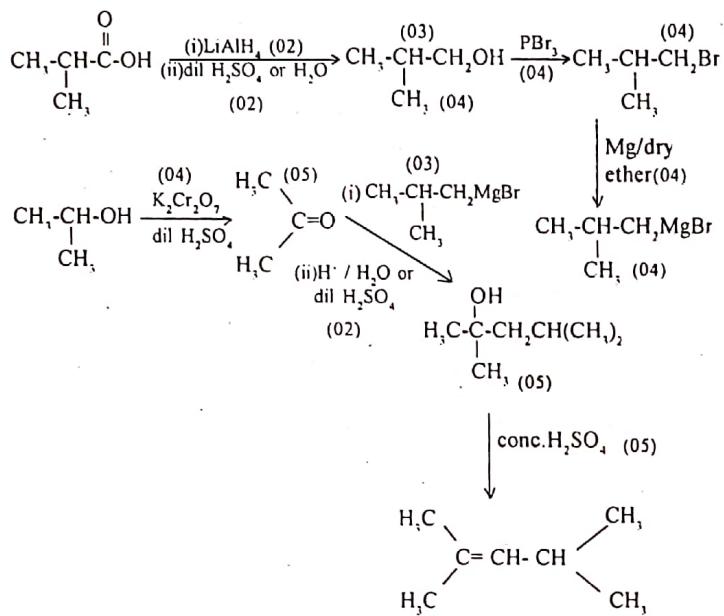
10. (c) Method 1 : 60 marks



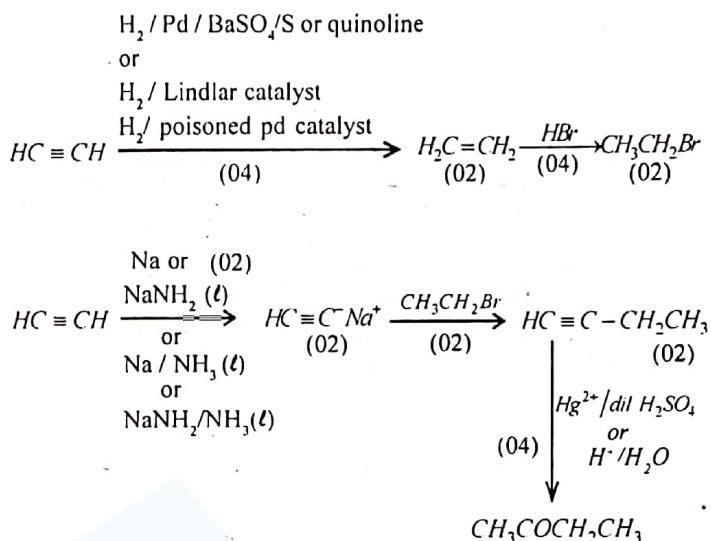
- Method 2 : Total 60 marks



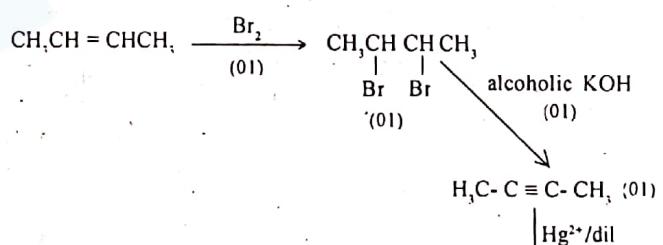
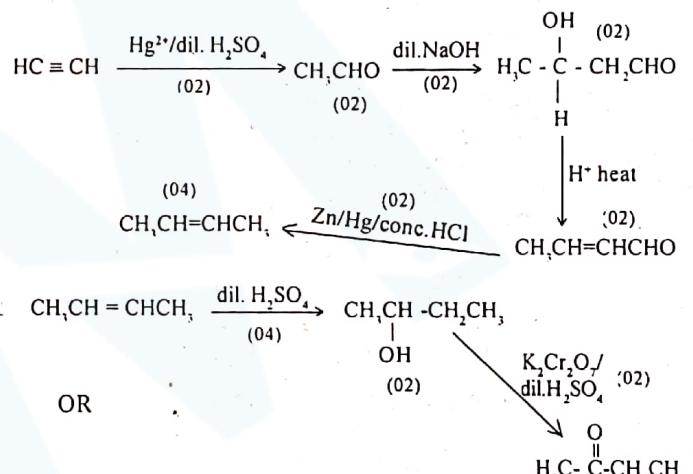
If acid hydrolysis → 04 marks



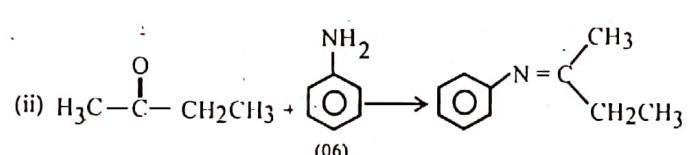
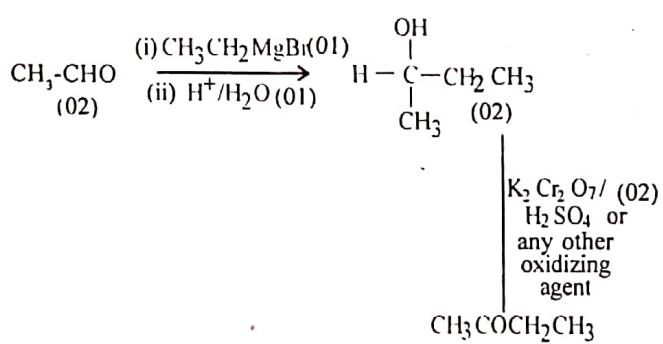
Method 3 : Total marks 24



Method 4 : Total marks 24



10 (d) (i) = (24) Marks



10 (d) (ii) = (06)