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

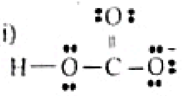
(ii) $Na_2S_2O_3$

(iii) PCl_5

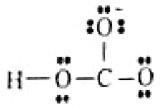
(iv) $CdCl_2$

(v) $CO(NO_3)_2$ (04 x 5 = 20)

(b) (i)

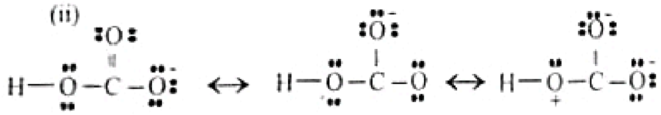


or



(07)

(ii)



(03) (03) (03)

Stable (01) Stable (01) Unstable (01)

Reason -

Oxygen carries a positive charge (03)

(iii) 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-SP^2 (03)

II O attached to H - SP^3 (03)

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

O -SP^3 (hybrid orbital) (03) + C - SP

II between O and H -

O -SP^3 (hybrid orbital) (03) + H - 1s (atomic

(c)

	Substance	Melting point /K	Electrical conduction in the solid state	Electrical conduction in the molten/liquid
(1)	MgO	3200	poor	good
(2)	NaCl	1100	poor	good
(3)	Mg	920	excellent	excellent
(4)	CO_2	200	very poor/nil	very poor
(5)	SiO_2	1900	very poor/nil	very poor

(04 x 5)

2. (i) Mg (Magnesium)

Uses.

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

(any one use)

(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 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)

(b)

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

(02 x 3) = 06

(100)

3.(a)(i) $\Delta H^0_{rxn} = \Sigma\Delta H^0_{f(products)} - \Sigma\Delta H^0_{f(reactants)}$ (05)

$= 2\times(-46.1\ kJmol^{-1}) - (1\times 0.00\ kJmol^{-1} + 3\times 0.00 kJmol^{-1})$ (03+02)

$\Delta H^0_{rxn} = -92.2\ KJmol^{-1}$ (03+02)

(ii) $\Delta S^0_{rxn} = \Sigma S^0_{(products)} - \Sigma S^0_{(reactants)}$ (05)

$= 2\times(192.3\ JK^{-1}mol^{-1}) - (1\times 191.5\ JK^{-1}mol^{-1} + 3\times 130.7\ JK^{-1}mol^{-1})$ (03+02)

$= -199\ JK^{-1}\ mol^{-1}$ (03+02)

(iii) I $\Delta G = \Delta H - T\Delta S$ (10)

II $\Delta G^0 = -92.2\ KJ\ mol^{-1} - 298\ K\ (-0.199\ KJ\ mol^{-1}K^{-1})$ (03+02)

$= -32.9\ KJ\ mol^{-1}$ (03+02)

(b) (i) I $P = X_B P^0$ OR $\frac{P^0 - P}{P^0} = 1 - X_A$ (04)

II $P = (1 - X_A)P^0$ $1 - X_B = X_A$ (04)

$P = P^0 - X_A P^0$ OR

$X_A = \frac{P^0 - P}{P^0}$ $X_A = \frac{P^0 - P}{P^0}$ (04)

(ii) P Consider $1000\ cm^3$ of solution

Total mass = $1000\ cm^3 \times 1.26 g\ cm^{-3} = 1260\ g$ (02)

Mass of glucose = $2\ mol \times 180\ g\ mol^{-1} = 360\ g$ (02)

Mass of water = $1260\ g - 360\ g = 900\ g$ (02)

Amount of water $= \frac{900\ g}{18\ g\ mol^{-1}} = 50\ mol$ (02)

Moles fraction of glucose $= \frac{2\ mol}{2\ mol + 50\ mol}$

$= \frac{1}{26} = 0.039$ (02)

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

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

Mole fraction of sucrose $= \frac{0.5 mol}{0.5\ mol + 9.5\ mol}$

$= 0.05$ (02)

Q Amount of glucose $= \frac{180\ g}{180\ g\ mol^{-1}} = 1\ mol$ (02)

Amount of water $= \frac{162\ g}{18\ g\ mol^{-1}} = 9\ mol$ (02)

Mole fraction of glucose $= \frac{1\ mol}{1\ mol + 9\ mol}$

$\frac{1}{10} = 0.1$ (02)

(iii) Q < R < P (08)

(iv) $P = P^0$(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)

(ii)  (04)

mechanism

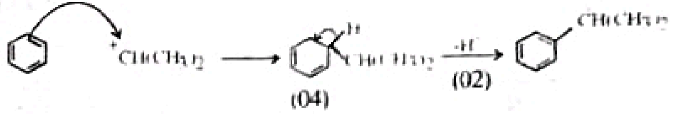
$(CH_3)_2CHCl + AlCl_3 \rightarrow (CH_3)_2\overset{\delta^+}{C}H \cdots Cl \cdots \overset{\delta^-}{A}lCl_3$ OR

$(CH_3)_2\ CH - \overset{+}{C}l - \overset{-}{A}lCl_3$ OR

$(CH_3)_2\ \overset{+}{C}H\ \overset{-}{A}lCl_4$ OR

$(CH_3)_2\ \overset{+}{C}H\ AlCl_4^-$ (04)

(02) (02)

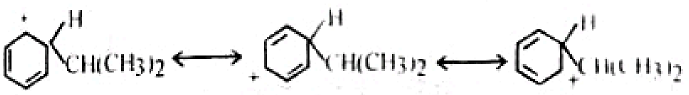


(04) (02)

OR

(02)

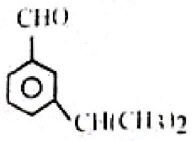
(iii)  is stabilized by resonance as shown below (03)



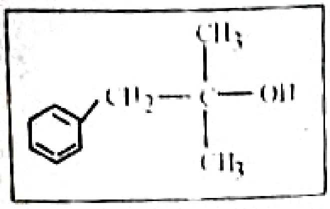
(03) (03) (03)

OR

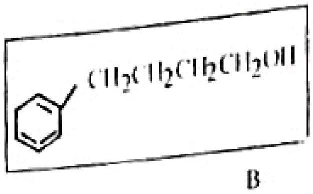
(03) (03) (03)

(iv)  (06)

(b) (i)



A



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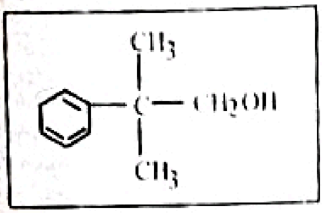

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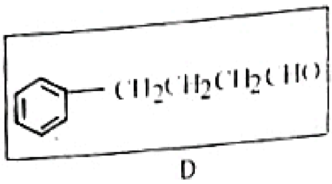

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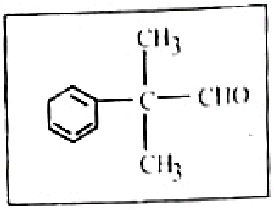
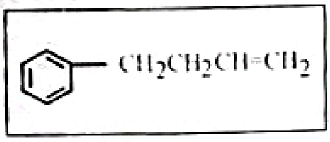


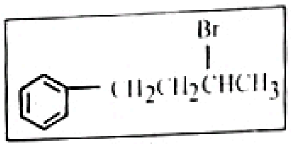
E

(05 x 5)

(ii)



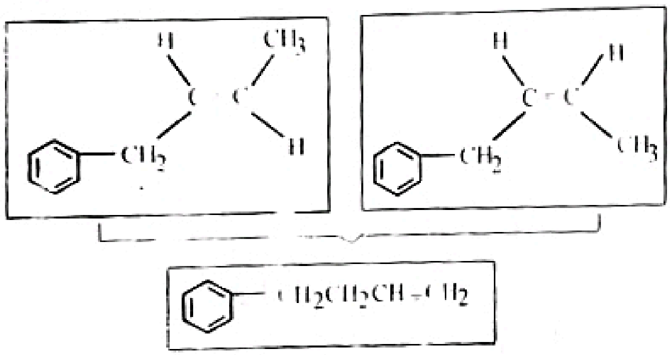
F



G

(05 x 2)

(iii)



(05 x 3)

If $C_6H_5CH_2CH = CHCH_3$ 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 O_2 $\frac{3.2g}{32g\ mol^{-1}} = 0.10\ mol$

$PV = nRT$

<u>Before addition of X</u>

$(1.0 \times 10^5 Pa)\ V = 0.10\ mol \times R \times 300\ k$ ...... (01)

<u>After addition of X</u>

Let M = molar mass of X

Amount of X = $\frac{8.8g}{M}$

Total number of moles of gases = $\left[0.10\ mol + \frac{8.8g}{M}\right]$

$$\left(2.0 \times 10^5\ pa\right)2v = \left[0.10mol + \frac{8.8g}{M}\right] \times R \times 400k \quad (2)$$

$$\frac{(2)}{(1)}\ \frac{\left(2.0 \times 10^5\ pa\right)2v}{\left(1.0 \times 10^5\ pa\right)v} = \frac{\left[0.10mol + \frac{8.8g}{M}\right] \times R \times 400k}{0.10mol \times R \times 300k}$$

$$1.2mol = 0.4mol + \frac{8.8g \times 4}{M}$$

$$M = \frac{8.8g \times 4}{(1.2 - 0.40)mol}$$

$$M = 44gmol^{-1}$$

OR

Rel. mol mass of X = 44

Alternative answer for 5 (a)

<u>Before addition of X.</u>

Volume is doubled pressure is halved

$P_1 = 5.0 \times 10^4\ Pa$

To calculate pressure at 400 K

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{5 \times 10^4\ Pa}{300\ K} = \frac{P_2}{400\ K}$$

$$P_2 = \frac{4}{3} \times 5.0 \times 10^4\ Pa$$

<u>After addition of X</u>

$$P \propto n$$

initially, $n = \frac{3.2\ g}{32\ g\ mol^{-1}} = 0.10\ mol$

$$\frac{4}{3} \times 5.0 \times 10^4\ Pa \propto 0.10\ mol$$

$$2.0 \times 10^5\ Pa \propto n$$

$$\frac{4/3 \times 5 \times 10^4\ Pa}{2.0 \times 10^5\ Pa} = \frac{0.10\ mol}{n}$$

$$n = 0.30\ mol$$

Moles of X added = 0.30 mol - 0.10 mol = 0.20 mol (03)

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

OR

Rel. mol. mass = 44 (02+01)

5 (a) - 30 marks

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5 (b) Partition coefficient between

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

OR $\dfrac{[S]_B}{[S]_A} = 9$ is also accepted.

(ii) Partition coefficient between

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

OR $\dfrac{[S]_C}{[S]_A} = 4$ is also accepted.

(iii) Let C = Concentration of S in phase A after partition equilibrium in mol dm^{-3}

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

(04)

Since the volumes of the two phases are equal.

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

$$0.10 - C = 9C$$

$$C = 0.01 \qquad (04)$$

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

Alternative answer for 5b (iii)

After partition equilibrium, let

n_1 = Mol of S in phase A

n_2 = Mol of S in phase B

Since the volume of the two phases are equal.

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

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

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

$= 0.010\text{ mol dm}^{-3}$ (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

$$= \frac{0.010\,mol\,dm^{-3} \times \frac{10.00}{1000}\,dm^{3} - x\,mol}{\frac{20.00}{1000}\,dm^{3}} \qquad (03+01)$$

$$= \frac{0.10 - 1000x\ mol}{20.00}\,mol\,dm^{-3} \qquad (03+01)$$

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

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

$$\frac{\left(\frac{1000x}{10.00}\,mol\,dm^{-3}\right)}{\frac{0.10 - 1000x}{20.00}\,moldm^{-3}} = \frac{1}{4} \qquad (04)$$

$$\left(\frac{0.10 - 1000x}{20.00}\right) = \frac{4000x}{10.00} \qquad (04)$$

$$0.10 - 1000x = 8000x$$

$$9000x = 0.10 \qquad (04)$$

$$x = 1.1 \times 10^{-5} \qquad (04)$$

Concentration of S remained in phase A

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

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

5 (b)(iv) = ㊱

Alternative answer for 5b (iv)

After equilibrium is reached, let

n'_1 = Mol of S in phase A

n'_2 = Mol of S in phase C

Concentration of S in phase A $= \dfrac{n'_1\text{ mol}}{\frac{10.00}{1000}\text{ dm}^3}$ (03+01)

$= \dfrac{1000\,n'_1}{10.00}\text{ mol dm}^{-3}$ (03+01)

Concentration of S in phase C $= \dfrac{n'_2\text{ mol}}{\frac{20.00}{1000}\text{ dm}^3}$ (03+01)

$= \dfrac{1000\,n'_2}{20.00}\text{ mol dm}^{-3}$ (03+01)

$$\frac{\frac{1000\,n'_1}{10.00}\text{ mol dm}^{-3}}{\frac{1000\,n'_2}{20.00}\text{ mol dm}^{-3}} = \frac{1}{4} \qquad (04)$$

$$\frac{2\,n'_1}{n'_2} = \frac{1}{4} \quad \text{OR} \quad \frac{n'_1}{n'_2} = \frac{1}{8} \qquad (04)$$

$$\frac{n'_1}{n'_1 + n'_2} = \frac{1}{9} \qquad (04)$$

Concentration of S remained in A $= \dfrac{1}{9} \times 0.010\text{ mol dm}^{-3}$ (3+1)

$= 0.0011\text{ mol dm}^{-3}$ (03+01)

(C) (i) $2P(g) \rightleftharpoons 2Q(g) + R(g)$

Partial pressure of R = 2.0×10^4 Pa (given)

Partial pressure of Q = 4.0×10^4 Pa ((03+01))

Partial pressure of P =

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

= 1.2×10^5 Pa - 2.0×10^4 Pa - 4.0×10^4 Pa (03+01)

= 6.0×10^4 Pa (03+01)

5 (c)(i) = ⑫

(ii) PV = nRT (04)

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

n = 0.030 mol (3+1)

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

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

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

n_R = 0.030mol - 0.015mol - 0.010mol = 0.005 mol (04)

At equilibrium.

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

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

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

5 (c)(ii) = ㊱

Alternative answer for 5c(ii)

P = CRT OR C = P/ RT (06)

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

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

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

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

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

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

5 (c)(ii) ㊱

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

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

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

Alternative answer for 5c(iii)

$$K_P = \frac{P_Q^2 P_R}{P_P^2}$$

$$= \frac{(4.0 \times 10^4 pa)^2 (2.0 \times 10^4 pa)}{(6.0 \times 10^4 pa)^2}$$

$$= \frac{8}{9} \times 10^4 pa$$

$$K_c = \frac{Kp}{RT}$$

$$= \frac{(8/9) \times 10^4 pa}{4.0 \times 10^3 Jmol^{-1}}$$

= 2.2 mol m^{-3} or 2.2 x 10^{-3} mol dm^{-3}

5 (c)(iii)

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

Initially. 0.100 — — mol dm

At eqm. 0.100 - x x x mol dm

(02+

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

$$= \frac{x^2}{0.100 - x} mol\ dm^{-3}$$

Assumption x is negligible compared to 0.100

OR

$0.100 - x \approx 0.100$

$$\frac{x^2}{0.100} = 1.0 \times 10^{-5}$$

$x^2 = 1.0 \times 10^{-6}$

$x = 1.0 \times 10^{-3}$

$[H_3O^+] = 1.0 \times 10^{-3} mol\ dm^{-3}$

$pH = -\log(1.0 \times 10^{-3}) = 3.0$

6 (a)(i) =

(ii)

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

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

(iii) pH = 4.0 ; $[H_3O^+]$ = 1x 10^{-4} mol dm^{-3} (02+

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

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

$[HA] = 10[A^-]$ —— (02)

From (1) and (2)

$0.1[A^-] + [A^-] = 0.100\ mol\ dm^{-3}$

$[A^-] = \frac{1}{1.1} \times 0.100\ mol\ dm^{-3}$

$[A^-] = 9.09 \times 10^{-2} mol\ dm^{-3}$ (03)

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

(02+01)

6 (a)(iii) = ⑱

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

when $[HA] = [A^-]$

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

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

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

6 (a)(iv) = (09)

(v) $$PH = PK_a + \log\frac{[A^-]}{[HA]}$$ (03)

After reaction between HA and NaOH.

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

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

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

(02+01)

PH = 5.00 + log 10.0

= 6.00 (03)

Alternative answer for 6a(v)

After reaction between HA and NaOH

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

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

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

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

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

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

$= 1.0 \times 10^{-6}\ mol\ dm^{-3}$

$PH = -\log 1.0 \times 10^{-6}$

= 6.00 (03)

Assumption Concentrations of HA and A- after reaction ≈ their equilibrium concentrations (03)

6 (a)(v) = ⑱

(b) (i) $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

Amount of $CaCO_3$ = 4.00g / 100g mol⁻¹ = 0.040 mol (04+01)

Amount of HCl = 0.30 mol dm⁻³ x 0.500dm³ = 0.15mol (04+01)

Excess amount of HCl = 0.15mol - 2 x 0.040 mol

= 0.07 mol (04+01)

Concentration of H^+ = 0.07 mol / 0.500 dm³

= 0.14 mol dm⁻³ (04+01)

6 (b)(i) = ㉕

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

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

$$\left[OH^-(aq)\right] = \frac{0.16 mol\ dm^{-3} \times 0.250 dm^3 - 0.14 mol\ dm^{-3} \times 0.250 dm^3}{0.500 dm^3}$$

$= 0.01 mol\ dm^{-3}$ (04+01)

$\left[Ca^{2+}(aq)\right]\left[OH^-(aq)\right]^2 = (0.040 mol dm^{-3})^3$ (05)

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

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

OR

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

$$= \left[\frac{6.5 \times 10^{-6} mol^3 dm^{-9}}{0.040 mol\ dm^{-3}}\right]^{\frac{1}{2}}$$ (02+01)

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

Concentration of [OH⁻ (aq)] in solution < 1.3 x 10⁻² moldm⁻³

No precipitation occurs (05)

6 (b) (ii) = ㉕

(iii) [OH⁻(aq)] = 0.01 mol dm⁻³

Concentration of Ca²⁺ required to precipitate $Ca(OH)_2$

$$= \frac{Ksp}{\left[OH^-(aq)\right]^2}$$

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

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

Concentration of Ca²⁺ added for precipitation [as $Ca(NO_3)_2$]

= 6.5 x 10⁻² mol dm⁻³ - 0.04 mol dm⁻³ (04+01)

= 0.025 mol dm⁻³

Molar mass of $Ca(NO_3)_2$ = 164 g mol⁻¹ (05)

Mass of $Ca(NO_3)_2$ to be added

= 0.025 mol dm⁻³ x 0.500 dm³ x 164g mol⁻¹ (05)

= 2.05g (04+01)

6 (b) (iii) = ㉕

Alternative answer for 6b (iii)

Molar mass of $Ca(NO_3)_2$ = 164 g mol⁻¹ (05)

Let X mass of $Ca(NO_3)_2$ to be added for precipitation

Concentration of Ca²⁺ in solution = 0.04 mol dm⁻³ + $\frac{X / (164\ gmol^{-1})}{0.500\ dm^3}$

(04+01)

$[OH^-]$ does not change

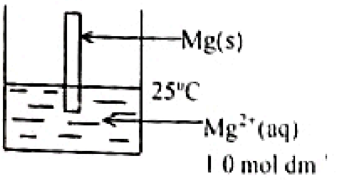
$$\left[0.040\ \text{mol dm}^{-3} + \frac{X\ (164\ \text{g mol}^{-1})}{0.500\ \text{dm}^{-3}}\right] = 0.065\ \text{mol dm}^{-3}$$ (05)

$x = 0.025\ \text{mol dm}^{-3} \times 0.500\ \text{dm}^3 \times 164\ \text{g mol}^{-1}$
$= 2.05\ \text{g}$

Minimum mass of $Ca(NO_3)_2$ to be added for precipitation
$= 2.05$ g (04+01)

6 (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 termial 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) $E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{Anode}$
$= 0.40\ V - (-2.37\ V)$ (03+01)
$= 2.77\ V$ (01)

(III) Anode $Mg(s) \rightarrow Mg^{2+}(aq) + 2e$ (04)

Cathode : $O_2(g) + 2H_2O(l) + 4e \rightarrow 4OH^-(aq)$ (04)

Overall : $2Mg(s) + O_2(g) + 2H_2O(l) \rightarrow 2Mg^{2+}_{(aq)} + 4OH^-_{(aq)}$ (04)

(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 $Mg(OH)_2$ precipitate deposited on the porous C electrode (04)
   OR Add Mg^{2+}(aq) solution

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

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

7 (b) (i) =

(ii) I. rate α $[A]^a [B]^b [C]^c$

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

$1.6 \times 10^{-3}\ \text{mol dm}^{-3}\text{s}^{-1}$ α $[0.20\text{mol dm}^{-3}]^a[0.10\text{mol dm}^{-3}]^b$ $[0.10\text{mol dm}^{-3}]^c$ —— (2)

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

$3.2 \times 10^{-3}\ \text{mol dm}^{-3}\text{s}^{-1}$ α $[0.10\ \text{mol dm}^{-3}]^a[0.10\text{mol dm}^{-3}]^b$ $[0.20\text{mol dm}^{-3}]^c$ —— (4)

(2)/(1) $2 = 2^a$, $a = 1$ or order with respect to A = 1
(3)/(2) $2 = 2^b$, $b = 1$ or order with respect to B = 1
(4)/(1) $4 = 2^c$, $c = 2$ or order with respect to C = 2

iii rate α $[A]\,[B]\,[C]^2$ (04)

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

7 (b) (ii) = [illegible]

(iii) Slow step OR $Y + B \rightarrow Z$
Rate α $[Y]\,[B]$ (04)

$$k_1 = \frac{[X]}{[A][C]}$$

$$k_2 = \frac{[Y]}{[X][C]}$$

$$k_1 k_2 = \frac{[X]}{[A][C]}\ \frac{[Y]}{[X][C]} = \frac{[Y]}{[A][C]^2}$$

$$[Y] = k_1 k_2 [A][C]^2$$

Rate = $k_1 k_2\ [A]\,[B]\,[C]^2$

OR

α $[A]\,[B]\,[C]^2$ (04)

7 (b) (iii) = (32)

PART C - ESSAY

8. (a) (i)

	Observation		Inference	
1	brown gas	→	presence of nitrates	(03)
2	red litmus turns blue	→	presence of NO_3^- / NO_2^-/ NH_4^+	(01x3)
3	black precipitate	→	PbS / CuS / HgS / Bi_2S_3 / Ag_2S CoS / NiS any three	(01x3)
4	white precipitate	→	$PbCl_2$ or AgCl	(02+01)
5	white precipitate dissolved	→	$PbCl_2$	(03)
6	white needles	→	$PbCl_2$	

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

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

A - $Pb(NO_3)_2$ B - $FeSO_4$ (10+10)

(ii) $2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + 4NO_2 + O_2$ (04)

$3NO_3^- + 2H_2O + 8Al + 5OH^- \rightarrow 3NH_3 + 8AlO_2^-$ (04)

$Pb(NO_3)_2 + H_2S \rightarrow PbS\downarrow + 2HNO_3$ (04)

OR $Pb^{2+} + H_2S \longrightarrow PbS\downarrow + 2H^+$ (04)

$Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2\downarrow + 2HNO_3$

OR $Pb^{2+} + 2HCl \longrightarrow PbCl_2\downarrow + 2H^+$ (04)

(iii) C - $PbSO_4$ (05)

(iv) For Pb^{2+}

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	brown ring
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)
$[SO_4^{2-}]$ = 0.010 x 1000/25 mol dm^{-3} (03)
= 0.40 mol dm^{-3} (03 +02)

(15 marks)

(ii)

$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$....(1) (05)

$5CuS + 6MnO_4^- + 28H^+ \rightarrow 6Mn^{2+} + 5Cu^{2+} + 5SO_2 + 14H_2O$....(2) (05)

OR

$5S^{2-} + 6MnO_4^- + 28H^+ \rightarrow 6Mn^{2+} + 5SO_2 + 14H_2O$ (03)

Moles of Fe^{2+} $= 0.1/_{1000} \times 10.5$ (02)
$= 1.05 \times 10^{-3}$ (01)

From eq. ① moles of MnO_4^- remaining $= 1/_5 (1.05 \times 10^{-3})$ (02)
$= 2.1 \times 10^{-4}$ (01)

Moles of $KMnO_4$ added $= 30.00/_{1000} \times 0.28$ (02)
$= 8.4 \times 10^{-3}$ (01)

Moles of MnO_4^- reacted with CuS $= (8.4 \times 10^{-3}) - (2.1 \times 10^{-4})$
$= 8.2 \times 10^{-3}$ (02)

From eq. ②, moles of CuS $= \frac{5}{6} \times 8.2 \times 10^{-3}$ (05)
$= 6.8 \times 10^{-3}$ or 7×10^{-3} (03)

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

$(Cu^{2+}) = (6.8 \times 10^{-3})/25 \times 1000$ or $(7 \times 10^{-3})/25 \times 1000$ $mol\ dm^{-3}$ (03)

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

(15 marks)

(iii) $IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$

$3(I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-)$

$IO_3^- + 6S_2O_3^{2-} + 6H^+ \rightarrow I^- + 3S_4O_6^{2-} + 3H_2O$.....(1) (06)

Moles of $S_2O_3^{2-}$ = 0.4 / 1000 x 25 (03)
From eq.(1), moles of H^+ in 25.00 cm^3 = 0.4 / 1000 x 25 (03)
$[H^+]$ = 0.4 / 1000 x 25 x 1000/25 mol dm^{-3} (03)
$[H^+]$ = 0.4 mol dm^{-3} (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 fules

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

Or

<u>volatile hydrocarbons</u> and <u>nitrogen oxides</u> (NO_x) produced by <u>vehicles</u> and <u>industries</u> react in the <u>atmosphere</u> in the <u>presence of sunlight (UV)</u> to form <u>photochemical oxidants</u> (e.g. ozone, atomic oxygen). <u>These contribute</u> 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) O_3, short chain aldehydes (HCHO, CH_3CHO, $CH_2=CH$ CHO), peroxyacetyl nitrate (PAN), peroxo benzonitrate (PBN) and alkylnitrates (e.g. CH_3ONO_2)
(any four) (03 x 4)

$$2NO(g)+O_2(g)\longrightarrow 2NO_2(g) \qquad (02)$$

$$NO_2(g)\xrightarrow{h\nu} NO(g)+O(g) \qquad (02)$$

$$O_2(g)+O(g)+M\longrightarrow O_3(g)+M \qquad (02)$$

(M is a third body (N_2) which absorbs energy)

(iv) <u>Adverse effects</u>

(1) Affects human health
- Affects respiratory system and causes coughing, wheezing, asthma etc
- Can cause eye and nose irritation

(2) Damage to materials - O_3 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 CO_2 & H_2O and NO to $N_2(g)$ & O_2 (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 ($CuFeS_2$) is roasted in air (02)

$$2CuFeS_2(s) + 4O_2(g) \rightarrow Cu_2S(s) + 2FeO(s) + 3SO_2(g)$$

or (04)

$$4CuFeS_2(s) + 9O_2(g) \rightarrow 2Cu_2S(s) + 2Fe_2O_3(s) + 6SO_2(g)$$

(2) The products are then heated with silica to form a molten slag which floats on molten Cu_2S (02)

$$FeO(s) + SiO_2(s) \rightarrow FeSiO_3(l)$$

or (03)

$$Fe_2O_3(s) + 3SiO_2(s) \rightarrow Fe_2(SiO_3)_3(l)$$

The slag is then separated (01)

(3) The impure $Cu_2S(s)$ is heated in air so
reacts to form Cu_2O

$$Cu_2S(s) + 3O_2(g) \rightarrow 2Cu_2O(s) + 2SO_2(g)$$

(4) The remaining Cu_2S is now mixed with Cu2O and
in the absence of air

$$Cu_2S(s) + Cu_2O(s) \rightarrow 6Cu + SO_2(g)$$

(Blister Cu - 2 - 3 % impure)

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

(ii) Add NH_4OH (02) - gives a blue precipitate, $Cu(OH)_2$
Dissolves in excess NH_4OH (01) to give a dark blue
solution of $[Cu(NH_3)_4]^{2+}$

OR

Add potassium ferrocyanide, $K_4[Fe(CN)_6]$, to the neutral
or acidic solution (03). A reddish - brown precipitate is
formed

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) <u>Large flat land</u> with <u>water impervious clay soil close</u>
<u>the ocean or lagoon.</u>

2) <u>Strong sunlight</u> should prevail during <u>most of the year</u>

3) Area that has <u>dry</u>, fast moving <u>winds.</u>

4) Area with <u>low rainfall</u>

(01 x 10)

(ii) (1) Sea water is pumped into the first tank (large), (01) water evaporated by sunlight (01), solution becomes concentrated (01) $CaCO_3$ precipitates (03) and settles down.

(2) Remaining solution is transferred to another tank (medium) 01, water evaporates by sunlight (01), solution becomes concentrated (01) $CaSO_4$ 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 Mg^{2+}, Ca^{2+} and SO_4^{2-} as impurities (01)

(4) NaCl collected is stored outside the tank for about six months (02), Ca^{2+} and Mg^{2+} salts absorb moisture from air and form, a solution (02) whereas. NaCl remains as a solid (02)

OR

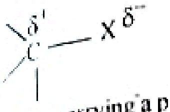
NaCl obtained is washed with the mother liquor to obtain purified NaCl (washed salt) (06)

(iii) Metal - Mg (03)

Non metal - Br_2 (03)

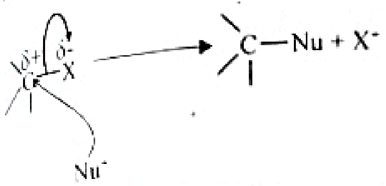
9 (d) =㊵

(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).

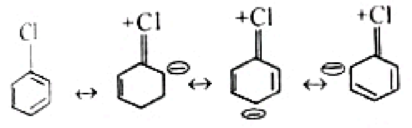


Thus nucleophile substitutes X (02)

10 (a) (i) = ⑳

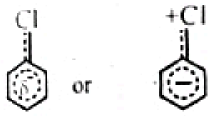
(a) (ii) The C-Cl bond has a double bond character (04) and is more difficult to break (04) due to delocalization of a pair of electrons on the chlorine atom (04) with the benzene ring.

This can be explained by resonance.



(02) (02) (02) (02)

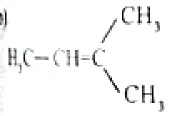
OR



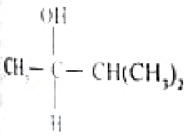
(08) (06)

10 (a) (ii) = ⑳

(b)

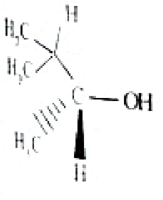


$H_2C = CH - CH(CH_3)_2$

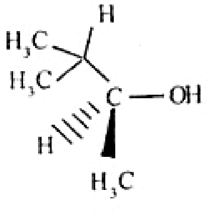


$$CH_3 - \overset{OH}{\underset{H}{C}} - CH(CH_3)_2$$

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

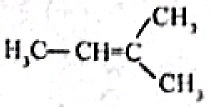


A



B

Then the required answer is



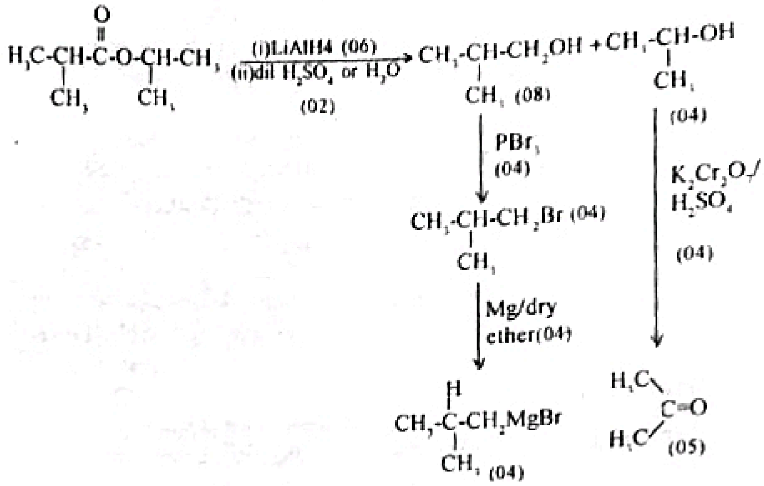
and A and B

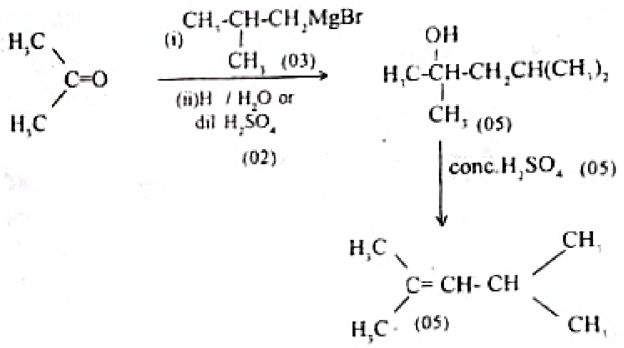
Allocation of marks for 10 (b)

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

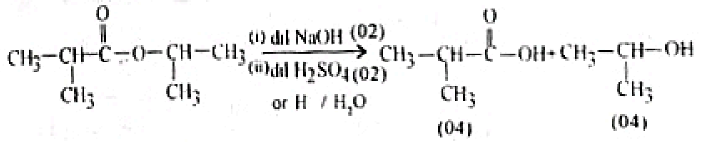
10 (b) = ⑳

10. (c) Method 1 : 60 marks



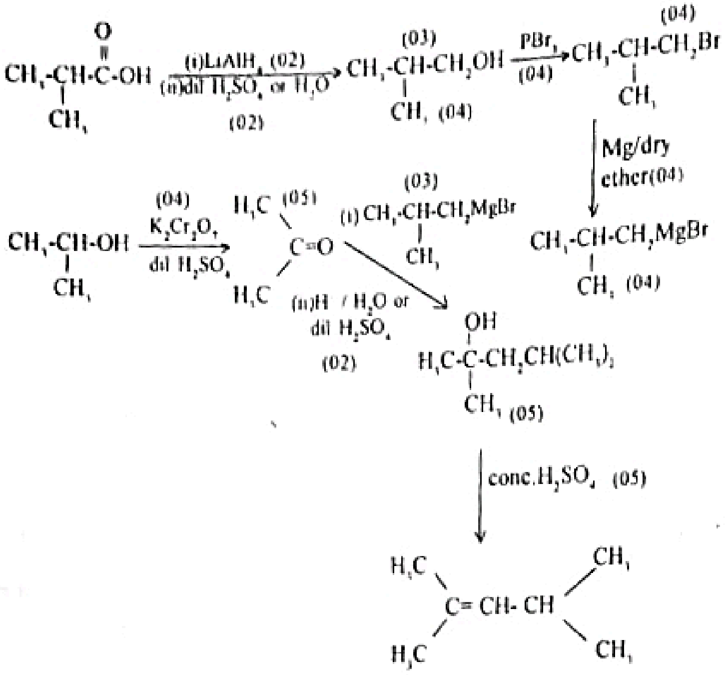


Method 2 : Total 60 marks



$$CH_3-\underset{CH_3}{CH}-\overset{O}{\overset{\|}{C}}-O-\underset{CH_3}{CH}-CH_3 \xrightarrow[\text{(ii) dil } H_2SO_4 \text{ (02) or } H^+ / H_2O]{\text{(i) dil NaOH (02)}} \underset{(04)}{CH_3-\underset{CH_3}{CH}-\overset{O}{\overset{\|}{C}}-OH} + \underset{(04)}{CH_3-\underset{CH_3}{CH}-OH}$$

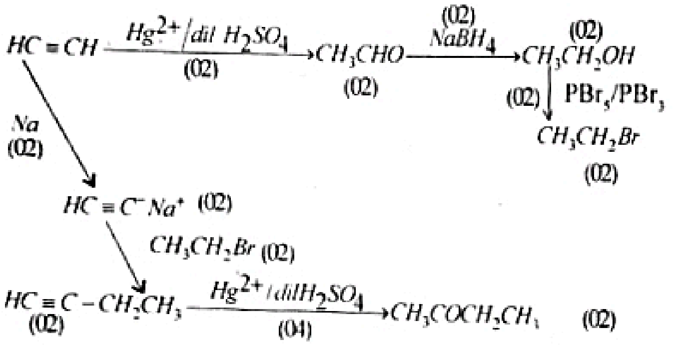
If acid hydrolysis → 04 marks



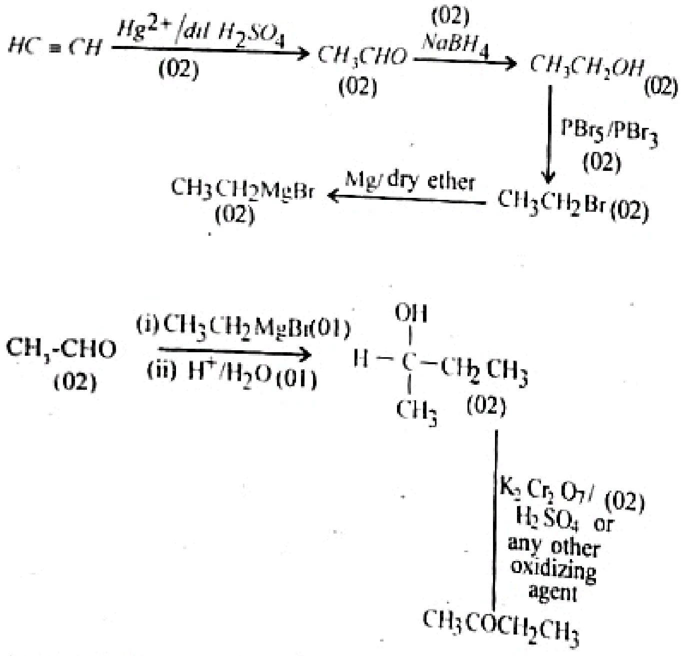
10 (C) = ⑥⓪

(10) (d) (i)

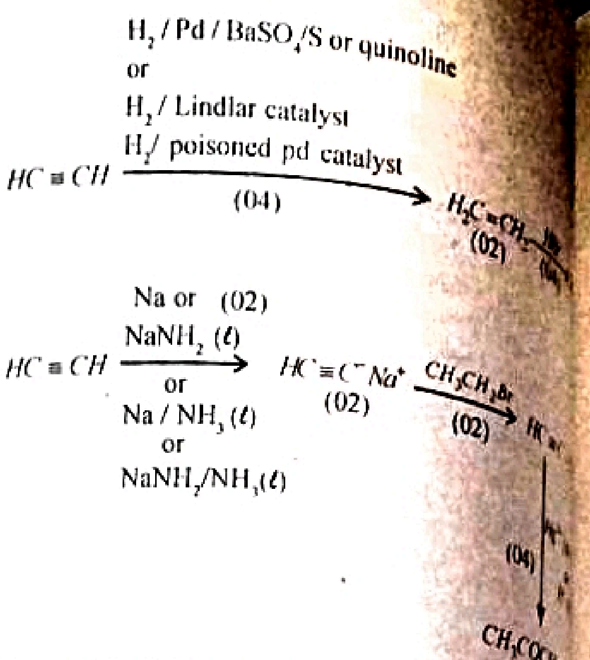
Method 1 : Total 24 marks



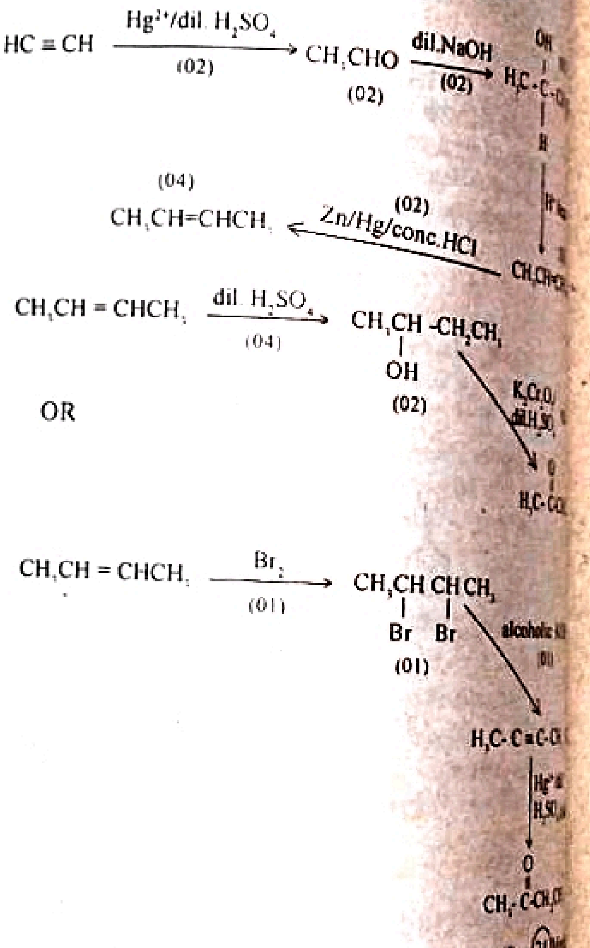
Method 2 : Total marks 24



Method 3 : Total marks 24

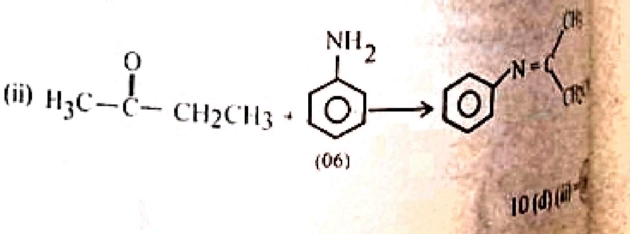


Method 4 : Total marks 24



10 (d) (i) = ㉔

(ii)



10 (d) (ii)