G.C.E. (A/L) Examination
Chemistry - 2007

M.C.Q. Answers

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

PART A - STRUCTURED ESSAY

Answer all four questions. Each question carries **10 marks**

(01) (a) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6 3d^{10}\ 4s^2 4p^3$ (5)

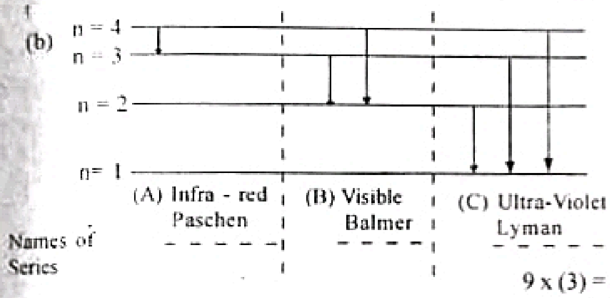
(ii) + 3 +5 (5) + (5)

(iii) As_2O_3 and As_2O_5 (5) + (5)

or As_4O_6 and As_4O_{10}

(a) = 25 marks

(b)



9 x (3) = 27

(c) (i) Y = S (sulphur) Z = O (Oxygen) (10) + (10)

(ii) YZ_2 = Angular/ V- shaped YZ_3 = Trigonal planar

(5 +5)

(d) C< D <A<B (18)

(d) = ⑱marks

(02) (a) (i) FeO. Fe_2O_3 (4)+(4)

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

OR $MnO_4^- \equiv 5Fe^{2+}$ (2)

Amount of MnO_4^- reacted $= \dfrac{20.0 \times 0.1}{1000}$

$= 2.0 \times 10^{-3}$ mol (4)

The Amount of FeO (Fe^{2+}) $= 5 \times 2.0 \times 10^{-3}$ mol

$= 1.0 \times 10^{-2}$ mol (4)

$=$ 0.01 mol

mass of Fe_3O_4 Oc (232) $= 0.01 \times 232$ g = 2.32g (4)

∴ mass of Fe_2O_3 = 5. 52g - 2.32g = 3. 20g (4)

Amount of Fe_2O_3 (160) $= \dfrac{3.20}{160}$ = 0.02 mol (4)

Molar ratio = $Fe_2O_3 : Fe_3O_4$ = 0.02 : 0.01

= 2 : 1 (4)

(iii) Iron from Fe_2O_3 = 0.02 mol x 112g mol^{-1}

= 2. 24 g (4)

Iron from Fe_3O_4 = 0.01 mol x 168 g mol^{-1}

= 1. 68 g (4)

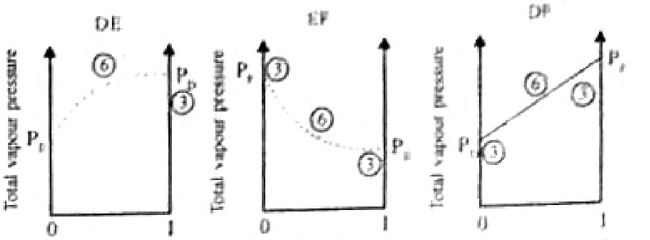
Total from 5.52g of mixture of $Fe_2O_3 + Fe_3O_4$

= 3. 92 g

Iron from 1.0 kg of mixture $= \dfrac{3.92g}{5.52g} \times 1000g$ (4)

$= \underline{710g}$ (4)

(a) = ㊿ marks



(3) x 6 = (18)

(6) x 3 = (18)

(36)

(ii) (I), (II), (III) - Award 14 marks for all candidates.

(b) = 50 marks

(03) (a) (i)

C	H	N	Cl
$\dfrac{55.6}{12.0}$	$\dfrac{6.2}{1.0}$	$\dfrac{10.8}{14.0}$	$\dfrac{27.4}{35.5}$ (4x01)
4.6	6.2	0.77	0.77 (4x01)
4.6 / 0.77	6.2/ 0.77	0.77/ 0.77	0.77/ 0.77
6	8	1	1 (4x01)

C_6H_8NCl (4)

(ii) No. of mol of NaOH mol $= \dfrac{0.4 \times 25}{1000} = 0.01$ (4)

0.01 mol of NaOH = 0.01 mol of A (4)

0.01 mol of A = 1.30 g

∴ 1 mol of A $= \dfrac{1.30}{0.01}$ g = 130g (4)

∴ Relative molar mass = 130 (4)

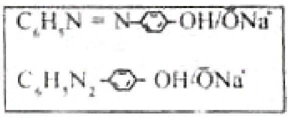
(iii) M (C_6H_8NCl) = 129.5 (4)

∴ molecular formula of A = C_6H_8NCl (4)

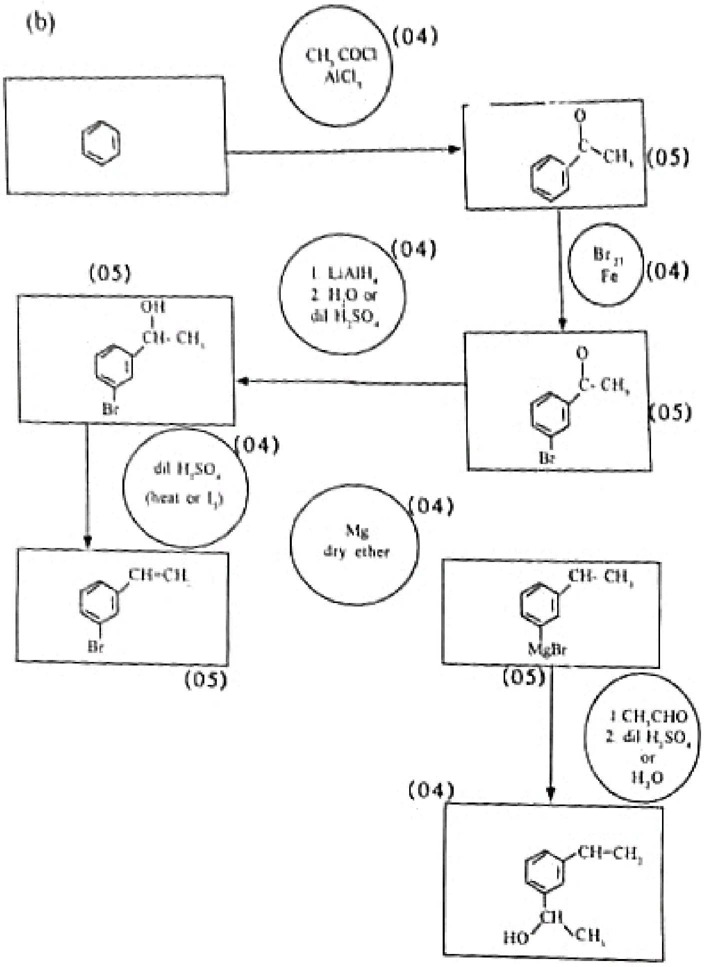
(iv)

A
$C_6H_5NH_3^+\ Cl^-$
$(C_6H_5NH_2.HCl)$
$(C_6H_5NH_3Cl)$
(05)

B
$C_6H_5N{=}N^+Cl^-$
$(C_6H_5N_2^+Cl^-)$
$(C_6H_5N_2Cl)$
$C_6H_5\text{-}N \equiv \dot{N}Cl^-$
(05)

C

$C_6H_5N = N\text{-}C_6H_4\text{-}OH/\bar{O}Na^+$
$C_6H_5N_2\text{-}C_6H_4\text{-}OH/\bar{O}Na^+$
(05)

(b)



4 (a).

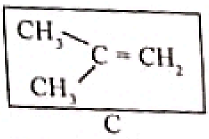
(b) = 49 marks

$CH_3CH{=}CH\text{-}CH_3$

A

$CH_3CH_2CH{=}CH_2$

B



$(CH_3)_2C = CH_2$

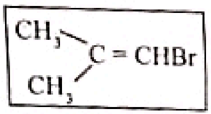
C

$CH_3C{\equiv}CCH_3$

D

$CH_3CH_2C{\equiv}CH$

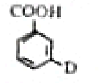
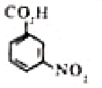
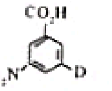
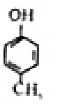
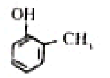
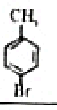
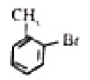
E



$(CH_3)_2C = CHBr$

(b) (i)

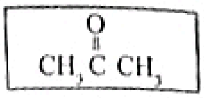
6 x 06 (a) = 36 marks

	P Reactant	Q Reagents	R Active species	S Major product/s	
I	 (D-deuterium)	Conc. HNO_3 Conc. H_2SO_4	NO_2^+ OR NO_2^+ HSO_4^-	 	(3) (3) (3)
II		CH_3Cl $AlCl_3$	CH_3^+ OR CH_3^+ $AlCl_4^-$	 	(3) (3) (3)
III		Br_2 , $FeBr_3$	Br^+ OR Br^+ $FeBr_4^-$	 	(3) (3) (3)
IV	CH_3COCH_2 CH_2COOH	$NaBH_4$	BF_4^- OR H^-	$CH_3\text{-}\underset{OH}{CH}CH_2CH_2CO_2^-(Na^+)$ OR $CH_3\underset{OH}{CH}\text{-}CH_2CH_2COOH$ OR $CH_3COCH_2CH_2CO^-(Na^+)$	(3) (3)
V	CH_4 excess	Cl_2 sunlight	$Cl^\bullet$	CH_3Cl	(3) (3)

(b)(i) = 39 marks

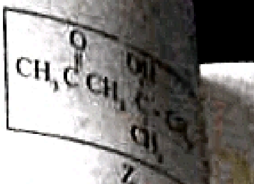
$CH_3C{\equiv}CH$

X



$CH_3\overset{O}{\overset{\|}{C}}CH_3$

Y



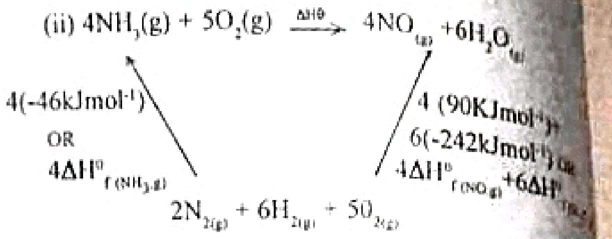
Z

4- Hydroxy -4- methylpentan - 2 - one

OR

(4 - Hydroxy -4- methyl - 2 - pentanone)

(5) (a) (i) $4NH_{3(g)} + 5O_{2(g)} \rightarrow 4NO_{(g)} + 6H_2O_{(g)}$



3 equations x 03 marks = 09 (in the cycle or in the

3 values (1 + 1) marks = 06 relationship)

15 marks

ΔH° = -4mol (-46 KJmol^{-1}) + 4mol (90 KJmol^{-1}) +6mol (-242 KJmol^{-1})

= (+184+360 - 1452) KJ

= -908KJ

Alternative approch I

(1) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ ΔH° = 2 (-46KJmo

(2) $N_2(g) + O_2(g) \rightarrow 2NO(g)$ ΔH° = 2 (90KJmol

(3) $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ ΔH° = 2 (-242KJm

3 equations x 03 marks (9)

3 values x (1 + 1) marks (6)

2 x (2) -2 x (1) + 3 x (3)

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

ΔH^0 = 2 x 2 mol (90KJmol^{-1}) -2 x 2mol (-46kJmol^{-1})+ 3x2 mol (-242KJmol^{-1})

= -908 KJ

Alternative approch II

$\Delta H^0 = 4\ \Delta H^0_f\ (NO, g) + 6\Delta H^0_f\ (NH_3, g) - 5\ \Delta H^0_f\ (O_2, g)$

4 terms x 3 marks

= 4 mol (90KJmol^{-1}) + 6mol (-242KJmol^{-1}) -4 mol(-46KJmo

First 3 terms x (2 + 1) marks =

= - 908 KJ

Total for part (ii) = 25 mark

(iii) $N_2\ (g) + O_2\ (g) \rightarrow 2NO\ (g)$ ΔH^0 = 2(90KJmol^{-1})

This reaction (Reaction I) is endothermic, and the Reaction (II) is exothermic

Reaction (II) is more likely to produce NO (g)

Total for part (iii) = 10 mark

Total for 5 (a) = 40 marks

(b) (i) $A(g) \rightleftharpoons B(g) + C(g)$

	A(g)	B(g)	C(g)	
Initially	2.0	1.0	1.0 mol	(3)
At equilibrium	1.6	1.2	1.6 mol	(3)
Amount reacted/ formed	0.4	0.2	0.6 mol	(3)

Note Direct deduction of amounts reacted or formed is also acceptable and (09) marks should be awarded.

The whole number ratio or

Stoichiometry	2	1	3	(3)

Balanced equation

$2A(g) \rightleftharpoons B(g) + 3C(g)$ (3)

Total for part (i) = 15 marks

(ii) $K_c = \dfrac{[B(g)][C(g)]^3}{[A(g)]^2}$ (3)

Total for part (ii) = 3 marks

(iii) $K_p = K_c(RT)^n$ OR $K_p = K_c(RT)^2$

OR $K_p = \dfrac{[B(g)][C(g)]^3}{[A(g)]^2}$ (3)

$$= \frac{(1.2\,\text{mol}/4.157\,\text{dm}^3)(1.6\,\text{mol}/4.157\,\text{dm}^3)^3(8.314\,\text{J mol}^{-1}\text{K}^{-1} \times 500\,\text{K})^2}{(1.6\,\text{mol}/4.157\,\text{dm}^2)^2}$$

5 terms x (02 + 01) marks (15)

$= 1.92 \times 10^6\ \text{J}^2\,\text{dm}^{-6}$ (2+1)

$= 1.92 \times 10^6 \times 10^6\ \text{J}^2\text{m}^{-6}$

$= 1.92 \times 10^{12}\ \text{Pa}^2$ or $\text{N}^2\,\text{m}^{-4}$ (2+1)

Alternative approach

$PV = nRT$ or $P = nRT/V$ (3)

$P = \dfrac{(4.4\,\text{mol})(8.314\,\text{mol}^{-1}\,\text{K}^{-1})(500\text{k})}{4.157 \times 10^{-3}\,\text{m}^{-3}}$

4 terms x (1 + 1) marks (8)

$P = 4.4 \times 10^6\ \text{Pa}$ (1+1)

$K_p = \dfrac{P_B \times P_C^{\,3}}{P^2_A}$ (3)

$$K_p = \frac{\left[\frac{1.2\,\text{mol}}{4.4\,\text{mol}} \times 4.4 \times 10^6\,\text{Pa}\right]\left[\frac{1.6\,\text{mol}}{4.4\,\text{mol}} \times 4.4 \times 10^6\,\text{Pa}\right]^3}{\left[\frac{1.6\,\text{mol}}{4.4\,\text{mol}} \times 4.4 \times 10^6\,\text{Pa}\right]^2}$$

3 terms x (1 + 1) marks (8)

$K_p = 1.92 \times 10^{12}\ \text{Pa}^2$ (1+1)

Total for part (iii) = 24 marks

(iv) K_p at 700K $= 5.1 \times 10^{13}\ \text{Pa}^2$

K_p has increased with increasing temperature (4)

Reaction is not exothermic (OR endothermic) (4)

Total for part (iv) = 8 marks

Total for part 5 (b) = 50 marks

(c) (i) $X(g) + Y(g) \rightleftharpoons 2Z(g)$

	X(g)	Y(g)	2Z(g)	
Initially	2	2	-- mol	(2)
At equilibrium	2 - x	2-x	2x mol	(2)

where x = amount of X (g) reacted = amount of Y (g) reacted

Total no. of mol at equilibrium = (2 -x) + (2 -x) + 2x =4 (2)

Partial pressures at eqilibrium

$p_x(g) = \dfrac{2-x}{4}\,p$ atm (p = total pressure of the system) (1 + 1)

$p_y(g) = \dfrac{2-x}{4}\,p$ atm (1 + 1)

$p_z(g) = \dfrac{2x}{4}\,p$ atm (1 + 1)

$K_p = \dfrac{p_z^2(g)}{p_x(g)\,p_y(g)}$ (2)

$$K_p = \frac{\left(\frac{2x}{4}\,p\ \text{atm}\right)^2}{\left[\frac{2-x}{4}\,p\ \text{atm}\right]\left[\frac{2-x}{4}\,p\ \text{atm}\right]} \quad (2)$$

$= \left(\dfrac{2x}{2-x}\right)^2$ (2)

$\therefore \left(\dfrac{2x}{2-x}\right)^2 = 4$ (2)

$\dfrac{2x}{2-x} = 2$

$2x = 4 - 2x$

$x = 1$ (4)

$\therefore$ mol of x at equilibrium = 2 - x = 1 (2)

mol of y at equilibrium = 2 - x = 1 (2)

mol of Z at equilibrium = 2x = 2 (2)

Total for part (I) = 30 marks

II. $PV = nRT$ OR $P = \dfrac{nRT}{V}$ (2)

$P = \dfrac{4\text{mol} \times 8.314\ \text{JK}^{-1}\,\text{mol}^{-1} \times 500\text{K}}{16.628 \times 10^{-3}\ \text{m}^3}$ (2)

No marks if the value or the unit of any quantity is wrong

$= 1 \times 10^6\ \text{Nm}^{-2}$ (1 + 1)

Total for part (II) = 06 marks

II. $X(g) + Y(g) \rightleftharpoons 2Z(g)$

	X (g)	Y(g)	2Z(g)		
Initially	2	2	—	mol	
Equilibrium	1	1	2	mol	
added	—	—	1	mol	
New Initial	1	1	3	mol	(2)
New Equilibrium	1 + x /2	1+x /2	3 - x	mol	(2)

$K_p = \dfrac{p_z^2(g)}{P_x(g)\,p_y(g)}$

$$= \frac{\left[\frac{3-x}{5}\,P\ \text{atm}\right]^2}{\left[\frac{1+\frac{x}{2}}{5}\,P\ \text{atm}\right]\left[\frac{1+\frac{x}{2}}{5}\,P\ \text{atm}\right]} \quad (2)$$

$= \left[\dfrac{3-x}{1+\frac{x}{2}}\right]^2$

$\therefore \left[\dfrac{3-x}{1+\frac{x}{2}}\right]^2 = 4$ (2)

$x = \dfrac{1}{2}$ (4)

Alternative approch

$$X(g) + Y(g) \rightleftharpoons 2Z(g)$$

Approach I	$1+x$	$1+x$	$3-2X$ mol
	$x = 1/4$		
OR			
Approach II	$1-x/2$	$1-x/2$	$3+x$ mol
	$x = -1/2$		
OR			
Approach III	$1-x$	$1-x$	$3+2x$ mol
	$x = -1/4$		

Maximum marks (10)

$\therefore$ mol of x at equilibrium = 5/4 (2)

mol of y at equilibrium = 5/4 (2)

mol of Z at equilibrium = 5/2 (2)

Total for part (ii) = 18 marks

(iii) No. of mol of both Y and Z is increased by one

But the equilibrium constant expression has a square term for Z (2)

Increase in the no. of mol of Z has a stronger effect on equilibrium constant expression (2)

According to the he Chatlier Principle, the equilibrium will shift to the left (2)

Total for part (iii) = 06 marks

Total for 5(C) = 60 marks

6. (a) (i) I. Drop the first end point as it is too large (or much different) compared to the other two measurements. (5)

Average of the remaining (or other two) measurements $= \dfrac{12.5 + 11.95}{2}$ cm^3

$= 12.00$ cm^3 (3 + 2)

Stoichiomertry of the reaction between H^+ and OH^- is 1 : 1

OR

$H^+ + OH^- \rightarrow H_2O$ OR

$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + H_2O$ (3)

Average concentration of OH^- in the filterate

$= \dfrac{(12.00 cm^3)(0.050 mol dm^{-3})}{25.00 cm^3}$ (2+1)

$= 2.4 \times 10^{-2}$ mol dm^{-3} (1 + 1)

$$Ca(OH)_{2(s)} \rightleftharpoons Ca^{2+}(aq) + 2OH^-(aq)$$

Solubility product = $\left[Ca^{2+}\right]_{aq} \left[OH^-\right]^2_{aq}$ (3)

$= \left[\dfrac{(OH^- aq)}{2}\right]\left[OH^-(aq)\right]^2$ (3)

$= \dfrac{1}{2}\left[OH^-\right]^3_{aq}$

$= \dfrac{1}{2}(2.4 \times 10^{-2} mol dm^{-3})^3$ (2+1)

$= 6.9 \times 10^{-6}$ mol^{3}dm^{-9} (1+1)

Alternative approch

Average concentration of $Ca(OH)_2$ in the filterate

$= \dfrac{(12.00 cm^3)(0.050 mol dm^{-3})}{2.(25.00 cm^3)}$

$= 1.2 \times 10^{-2}$ mol dm^{-3}

$$Ca(OH)_{2(s)} \rightleftharpoons Ca^{2+}(aq) + 2OH^-(aq)$$

Solubility product = $[Ca^{2+}]aq\ [OH^-]^2 aq$

$= (1.2 \times 10^{-2} mol dm^{-3})(2.4 \times 10^{-2} mol dm^{-3})^2$

$= 6.9 \times 10^{-6}$ mol^3 dm^{-9}

Total for (I) = 2

(ii) pink (OR red) to colorless

(iii) methyl orange OR methyl red or any other acceptable acid-base indicator

(iv) Any one of the following

- to reject outlying readings
- to obtain a reproducible result
- to obtain a reliable result
- to minimize erros
- to get consistent values

(v) Shake vigorously the initial suspension for a longer time

Repeat experiment

If the same readings (or readings within the experimental error) are obtained, the solution had been saturated with $Ca(OH)_2$

(vi) No

Solubility product of $CaCO_3$ is very small [or much smaller than that of $Ca(OH)_2$]

CO_3^{2-} concentration in a saturated solution of $CaCO_3$ is very low. very low Concentrations can detected using a titration

Total for a (i) = 50

06. a. (ii). Consider 25.00cm^3 portion of the clear filtered

Concentration of OH^- due to NaOH.

$OH^- = 2.50g \left[\dfrac{10}{100}\right]\left[\dfrac{1}{40 g mol^{-1}}\right]\left[\dfrac{1}{0.250 dm^3}\right]$

$= 2.5 \times 10^{-2}$ mol dm^{-3}

Let S = concentration of Mg^{2+} ions in the filtrate

Solubility product, $K_{sp} = \left[Mg^{2+}\right]aq \left[OH^-\right]^2$

$1.2 \times 10^{-11} mol^3 dm^{-9} = S(2.5 \times 10^{-2} mol dm^{-3})^2$

$\therefore \quad S = \dfrac{1.2 \times 10^{-11} mol^3 dm^{-9}}{(2.5 \times 10^{-2} mol dm^{-3})^2}$

$= 1.9 \times 10^{-8}$ mol dm^{-3} (2+2)

Total for I = 20

(II) Expected end point $= \left[\dfrac{(2.5 \times 10^{-2} mol dm^{-3})\left(\dfrac{25.00}{1000} dm^3\right)}{0.050 mol dm^{-3}}\right]$

$= \dfrac{12.50}{1000}$dm^{-3} or 12.50cm^3 (2+2)

Total for II =

Assumption - Amount of OH^- in solution due to dissolution of $Mg(OH)_2$ is negligible compared that devived dissolving NaOH (4)

Justification :

Approach I

$Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq)$ (2)

From I, $[Mg^{2+}] = 1.9 \times 10^{-4}$ mol dm^{-3} (2)

Concentration of OH^- (OR amount of OH^- in 1 dm^3 of solution) due to dissolution of $Mg(OH)_2$

$= 2 \times 1.9 \times 10^{-4}$ mol dm^{-3}

$= 3.8 \times 10^{-4}$ mol dm^{-3} (2)

This is much less than 2.5×10^{-2} mol dm^{-3} (2)

Concentration (OR amount) of OH^- due to dissolution of $Mg(OH)_2$ is negligible

Approach II

$Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq)$ (2)

k_{sp} of $Mg(OH)_2 = 1.2 \times 10^{-11}$ mol^3 dm^{-9}

Solubility of $Mg(OH)_2$ in the absence of any common ion

$= (1.2 \times 10^{-11}/4)^{1/3}$ mol dm^{-3} < 1.5×10^{-4} mol dm^{-3} (2)

In the presence of a common ion (OH^-), solubility of $Mg(OH)_2$ will be less (2)

Concentration of OH^- in solution due to dissolution of $Mg(OH)_2$ << $[OH^-]$ coming from NaOH.

The latter is 2.5×10^{-2} mol dm^{-3} (2)

Amount of OH^- in solution due to dissolution of $Mg(OH)_2$ can be neglected when compared to 2.5×10^{-2} mol dm^{-3}

Total for a (ii) = 40 marks

(b) $HX + NaOH \rightleftharpoons NaX + H_2O$ (4)

End point has passed to observe a pH of 11.0 (4)

Let C be the concentration of the acid in mol dm^{-3}.

Amount of HX mixed $= C \times \frac{25.00}{1000}$ mol (2+2)

Amount of NaOH mixed $= 0.10 \left[\frac{50}{1000}\right]$ mol (2+2)

Concentration of OH^- in the mixture

$$= \frac{0.10\left[\frac{50}{1000}\right] \text{mol} - C\left[\frac{25}{1000}\right] \text{mol}}{\frac{75.00}{1000}\ \text{dm}^3} \quad (4)$$

$$= \frac{5.00 - 25.00\,C}{75.00}\ \text{mol dm}^{-3} \quad (2+2)$$

$POH = 14.00 - pH = 3.00$ (4)

$$-\log_{10} \frac{5.00 - 25.00\,C}{75.00} = 3.00$$

$$\frac{5.00 - 25.00\,C}{75.00} = 10^{-3} \quad (4)$$

$C = 0.197$ mol dm^{-3} (2+2)

End point has not been reached to observe a pH of 4.0. All NaOH added is reacted with HX(aq) in 1:1 stoichiometric ratio to produce $Na^+(aq)$, $X^-(aq)$ and H_2O (l)

Concentration of X^- in the mixture $= \frac{0.10 \times 20.00}{45.00}$ mol dm^{-3} (4)

Concentration of HX in the mixture

$$= \frac{0.197 \times 25.00 - 0.10 \times 20.00}{45.00}\ \text{mol dm}^{-3} \quad (4)$$

Concentration of H^+ in the mixture $= 1 \times 10^{-4}$ mol dm^{-3} (4)

$Hx(aq) \rightleftharpoons H^+(aq) + x^-(aq)$

$$\text{Dissociation Constant} = \frac{[H^+(aq)][x^-(aq)]}{[Hx(aq)]} \quad (2)$$

$$= \frac{1.0 \times 10^{-4}\ \text{mol dm}^{-3}\left[\frac{0.10 \times 20.00}{45.00}\right] \text{mol dm}^{-3}}{\frac{0.197 \times 25.00 - 0.10 \times 20.00}{45.00}\ \text{mol dm}^{-3}} \quad (2+2)$$

$= 6.84 \times 10^{-5}$ mol dm^{-3} (2+2)

Assumption - Hydrolysis of the anion $X^-(aq)$ derived from the weak acid HX is negligible. Temperature is 25°C. (4)

Total for (b) = 60 marks

07. (a) (i) $2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 8H_2O + 10CO_2$ (10)

Total for i) = 10 marks

(ii) $\text{Rate} \propto [MnO_4^-]^{\alpha}[C_2O_4^{2-}]^{\beta}[H^+]^{\gamma}$ (4)

where α, β and γ are orders with respect to MnO_4^-, $C_2O_4^{2-}$, H^+ respectively.

Container	$[MnO_4^-]$/ moldm^{-3}	$[C_2O_4^{2-}]$ / moldm^{-3}	$[H^+]$/ moldm^{-3}
1.	**0.005**	**0.005**	**0.10**
2.	**0.015**	**0.005**	0.10
3.	0.005	**0.010**	0.010
4.	0.005	0.005	**0.050**

Calculation of 07 different concentrations (underlined) x 4 marks (28)

Rate $\propto$ volume of CO_2 evolved (4)

$9.5\ \alpha\ (0.005)^{\alpha} (0.005)^{\beta} (0.10)^{\gamma}$ .... (1)

$29.0\ \alpha\ (0.015)^{\alpha} (0.005)^{\beta} (0.10)^{\gamma}$ .... (2)

$19.5\ \alpha\ (0.005)^{\alpha} (0.010)^{\beta} (0.10)^{\gamma}$ .... (3)

$10\ \alpha\ (0.005)^{\alpha} (0.005)^{\beta} (0.05)^{\gamma}$ .... (4)

04 relationships x 04 marks = (16)

(2)/(1) $29.0 / 9.5 = (0.015/0.005)^{\alpha}$ OR $3 = 3^{\alpha}$ (02)

$\alpha = 1$ (02)

(3)/(1) $19.5 / 9.5 = (0.010/0.005)^{\beta}$ OR $2 = 2^{\beta}$ (02)

$\beta = 1$ (02)

(4)/(1) $9.5 / 10.0 = (0.10/0.05)^{\gamma}$ OR $1 = 2^{\gamma}$ (02)

$\gamma = 0$ (02)

OR valid qualitative arguments to show that $\alpha = 1$, $\beta = 1$ and $\gamma = 0$ (12)

Rate $\propto [MnO_4^-][C_2O_4^{2-}]$ (4)

Total for (ii) = 68 marks

(iii) $[MnO_4^-] = 0.010\ moldm^{-3}$
OR
$[MnO_4^-]$ is doubled OR order with respect to MnO_4^- is one (2)
Rate is increased by a factor of two (2)

Total for (iii) = 4 marks

(iv) (I) pH = 2.0 Rate does not change (2)

Reason : Rate does not depend on pH OR
Rate expression has no H^+= term OR
The reaction is zeroth order w.r.t. $[H^+]$ (2)

(ii) pH = 10.0 Rate cannot be predicted (2)
MnO_2 is formed in basic medium and therefore the reaction does not proceed as written. (2)

Total for (iii) = 8 marks
Total for 7 (a) = 90 marks

(b) (I) I. $1.25V = E^\theta_{H^+/H_2} - E^\theta_{P^{2+}/P}$ OR

$E^\theta cell = E^\theta_{cathode} - E^\theta_{anode}$ (3)
$E^\theta_{P^{2+}/P} = -1.25\ V$ (3)
$0.95 = E^\theta_{P^{2+}/P} - E^\theta_{Q^{2+}/Q}$ (3)
$0.95 = -1.25V - E^\theta_{Q^{2+}/Q}$ (3)
$E^\theta_{Q^{2+}/Q} = -1.25V - 0.95V = -2.20V$ (3)

(II) $P^{2+}(aq) + Q\ (s) \longrightarrow Q^{2+}(aq) + P\ (s)$ (9)

III. Concentration of $P^{2+}(aq)$ is increased ⇒
Reaction goes forward. (3)
e.m.f is increased (3)

Total for (i) = 30 marks

(ii) Use two inert electrodes as the cathode and the anode (4)
E.g.. Carbon, platinum, stainless steel, graphite, etc (2)
Electrolyze the solution to produce H_2(g)and Cl_2 (g) (4)
$Mg(OH)_2$ will precipitate and deposit at the bottom (4)
Separate and collect the deposit (4)

Electrode reactions -

$2H_2O\ (1) + 2e \rightarrow 2OH^-_{(aq)} + H_{2(g)}$ OR

$2H^+_{(aq)} + 2e \rightarrow H_2(g)$ (6)

$2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e$ (6)

OR

- Evaporate $MgCl_2$ solution to dryness, fuse $MgCl_2$ and electrolyze. (4)
- Use inert electrodes e.g. Graphite, platinum or stainless steel (2)
- Heat Mg in oxygen or air to produce MgO (2)
- React MgO with water to get $Mg(OH)_2$ Filter and collect $Mg(OH)_2$ (2)

Electrode reactions

$Mg^{2+}\ (l) + 2e \rightarrow Mg\ (l)$

$2Cl^-\ (l) \rightarrow Cl_{2(g)} + 2e$

Total for (ii) = 30
Total for 7 (b) = 6

(08) (a) (i) (I) $Na_2S_2O_3$ Solution
Dil H_2SO_4 Solution
Na_2CO_3 Solution

The two solutions that do not show any reaction
mixed are $Na_2S_2O_3$ and Na_2CO_3

The **other** solution is dil H_2SO_4

The solution that gives a pale yellow ppt. with dil H_2SO_4 is $Na_2S_2O_3$ OR The solution that gives efferscence (CO_2) with dil H_2SO_4 is Na_2CO_3

The remaining solution is Na_2CO_3 / $Na_2S_2O_3$

II $NaNO_3$ Solution
NH_4NO_3 Solution
NH_4Cl Solution

Heat each solution with NaOH. The solution that **does not** evolve NH_3 is $NaNO_3$ [illegible].

Heat the **other** two solutions (with NaOH) until evolution of NH_3 ceases.
Then add Al powder and heat further

The solution that evolves NH_3 again is NH_4NO_3

The other solution is NH_4Cl

(ii) (I) Presence of a transition metal ion

(II) Absence of group I (or Ag^+, Pb^{2+}, Hg_2^{2+})

(III) Presence of Cu^{2+}, Hg^{2+}, Bi^{3+}, Pb^{2+}

(IV) Presence of Cu^{2+}

(V) Presence of Zn^{2+} or Al^{3+} (2+

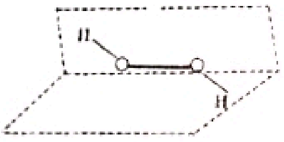
The cations present are Cu^{2+} (04) and Zn^{2+} (02) or Al^{3+} (02) continue addition of NH_4OH in test V. (04)
If the white ppt. persistst the cation present is Al^{3+} (04)
If the ppt. dissolves, it is Zn^{2+} (04) [Charcoal block test with cobalt nitrate is also acceptable. Test (04) Observations 04 + 04]

Total for 8 (a) = 80

b. (i) Y is H_2O_2 (or Hydrogen peroxide)

(ii) $H - \overset{\bullet\bullet}{\underset{\bullet\bullet}{O}} - \overset{\bullet\bullet}{\underset{\bullet\bullet}{O}} - H$ OR $H \bullet \times \overset{\times\times}{\underset{\times\times}{O}} \times \bullet \overset{\bullet\bullet}{\underset{\bullet\bullet}{O}} \bullet \times H$

(iii)



(5)

(iv)(A) $2KMnO_4 + 5H_2O_2 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5O_2$ (5)

OR

$2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 2Mn^{++} + 8H_2O + 5O_2$

(B) $2KMnO_4 + 3H_2O_2 \rightarrow 2MnO_2 + 3O_2 + 2H_2O + 2KOH$

OR

$2MnO_4^- + 3H_2O_2 \rightarrow 2MnO_2 + 3O_2 + 2H_2O + 2OH^-$ (5)

(C) $H_2O_2 + 2NaBr + H_2SO_4 \rightarrow Na_2SO_4 + Br_2 + 2H_2O$

OR

$H_2O_2 + 2Br^- + 2H^+ \rightarrow Br_2 + 2H_2O$

OR

$H_2O_2 + 2NaBr + 2H^+ \rightarrow 2Na^+ + Br_2 + 2H_2O$ (5)

(D) $2H_2O_2 \rightarrow 2H_2O + O_2$ (5)

(E) $4H_2O_2 + PbS \rightarrow PbSO_4 + 4H_2O$

OR

$4H_2O_2 + S^{2-} \rightarrow SO_4^{2-} + 4H_2O$ (5)

(v) Disproporationation (5)

(vi) Antiseptic / bleaching agent (5)

(v) Hydrogen bonding (5)

Total for 8 (b) = 70 marks

(9) (a) (i) $NH_2CONH_2 + 2NaOH \rightarrow Na_2CO_3 + 2NH_3$ (5)

$(NH_4)_2SO_4 + 2NaOH \rightarrow 2NH_3 + Na_2SO_4 + 2H_2O$ (5)

When the solution containing the mixture of urea and $(NH_4)_2SO_4$ boiled with excess NaOH, what remains is a mixture of Na_2CO_3 equivalent to the amount of urea and the unreacted (excess) NaOH. (10)

With phenolphthalein, the end point is obtained when the following reactions are complete :

NaOH (remaining) + HCl $\rightarrow$ NaCl + H_2O

$Na_2CO_3 + HCl \rightarrow NaHCO_3 + NaCl$ (5)

With, methyl orange, the end point is obtained when the following reactions are complete :

NaOH (remaining) + HCl $\rightarrow$ NaCl + H_2O

$Na_2CO_3 + 2HCl \rightarrow CO_2 + 2NaCl + H_2O$ (5)

Therefore the difference in readings is equivalent to the amount of $NaHCO_3$. This is equivalent to the amount of Na_2CO_3 formed and hence to the amount of urea. (5)

The difference in burette readings $= 50.0 - 30.0\ cm^3$
$= 20.0\ cm^3$

The no. of moles of HCl in $20.0\ cm^3$

$= \frac{1.0}{1000} \times (20.0) = 0.02$ mol

$= 0.02$ mol (5)

The amount of urea in $50.0\ cm^3$ of fertilizer solution

$= 0.02$ mol (5)

The concentration of urea in the fertilizer solution

$= \frac{0.02}{50.0} [\times 1000]\ mol\ dm^{-3}$ (5)

$= 0.40\ mol\ dm^{-3}$ (5)

The volume of $1.0\ moldm^{-3}$ HCl required to react with $35.0 cm^3$ of $2.0\ mol\ dm^{-3}$ NaOH solution $= 70.0\ cm^3$ (5)

The volume of HCl equivalent to the amount of NaOH that has reacted with $(NH_4)_2SO_4$ $= 70\ cm^3 - 50\ cm^3$
$= 20\ cm^3$ (5)

The volume of NaOH that reacted with $(NH_4)_2SO_4$
$= 10.00\ cm^3$ (5)

Amount of NaOH reacted with $(NH_4)_2SO_4$

$= \frac{2.0}{1000} \times 10.00$

$= 0.02$ mol (5)

Amount of $(NH_4)_2SO_4$ in $50.0\ cm^3$ of fertilizer soln

$= \frac{0.02}{2}$

$= 0.01$ mol (5)

Concentration of $(NH_4)_2SO_4$ in fertilizer soln

$= \frac{0.01}{50.0} \times 1000\ mol\ dm^{-3}$ (5)

$= 0.20\ mol\ dm^{-3}$ (5)

Total for 9 (a) = 90 marks

9(b) Purple coloured ion : $[Cr(H_2O)_6]^{3+}$ (10)

Green coloured ion : $[Cr(H_2O)_4Cl_2]^+$ (10)

(ii)	Na–O–H	K–O–H	Cl–O–H	Br–O–H
	0.9 3.5 2.1	0.8 3.5 2.1	3.0 3.5 2.1	2.8 3.5 2.1
Difference	2.6 1.4	2.7 1.4	0.5 1.4	0.7 1.4

Large difference in E.N. between Na and O (2.6) in NaOH and between K and O (2.7) in KOH (5)

They ionize as $Na^+\ OH^-$ and $K^+\ OH^-$ (5)

Therefore NaOH and KOH are basic (5)

KOH is more basic than NaOH (5)

In HOBr and HOCl the E.N. difference between the halogen and oxygen is quite small (0.7 and 0.5) (5)

The X - O bond is covalent (5)

Ionization occurs forming H^+ and ClO^- in HOCl and H^+ and BrO^- in HOBr (5)

They are therefore acidic

HOCl is more acidec than HOBr (5)

Total for 9 (b) = 60 marks

(10) (a) (i) High bond energy of N_2 (g) OR N_2 is a very stable molecule (10)

(ii) The reaction $3H_2 + N_2 = 2NH_3$ is exothermic (5)
Therefore equilibrium yield of NH_3 decreases with increasing temperature (5)

The yield is high at low temperatures (88% at 200°C) but the time taken to reach equilibrium is long as the reaction rate is low (5)

Temp. of 550°C is used as a compromise where the yield is reasonable and the reaction rate is not too small (5)

(iii) Finely divided iron (Fe) or oxides of iron (5)

(iv) This is gas phase reaction and takes place on the **surface** of Fe particles (5)
Catalyst is used in a finely divided state to **increase the surface area.** (10)

(v) $2NH_3 + 3CuO \rightarrow N_2 + 3H_2O + 3Cu$ (10)
Ammonia is passed over **heated** CuO (5)

OR
[$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$ (10)
Burning ammonia in O2 (5)]

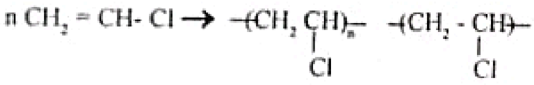
(vi) Production of fertilizer (Ammonium sulphate, ammonium nitrate)
Production of Na_2CO_3 (solvay process)
As a disinfectant / cleaning agent / refrigerant
cany two uses (5 +5)

Total for 10 (a) = 75 marks

(b) (i) Addition polymerization :
Reaction Repeat Unit


$n CH_2 = CH - CH_3 \rightarrow -\!\!(CH_2 - \underset{CH_3}{CH})_n\!- \quad (5) \qquad -\!\!(CH_2 - \underset{CH_3}{CH})\!- \quad (5)$

OR

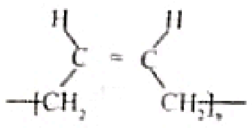

$n CH_2 = CH - Cl \rightarrow -\!\!(CH_2 \underset{Cl}{CH})_n\!- \qquad -\!\!(CH_2 - \underset{Cl}{CH})\!-$

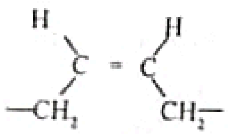
Condensation polymerization :

$nClCO_2(CH_2)_4COCl + nH_2N(CH_2)_6NH_2 \rightarrow$ (5)
$-\!\![CO(CH_2)_4COHN(CH_2)_6NH]_n\!- + 2nHCl$

Repeat unit :
$-\!\![CO(CH_2)_4COHN(CH_2)_6NH]$ (5)

(ii) Polymer Repeat unit


(5)


(5)

(iii) Low water solubility of apatite and dolomite
Therefore not suitable for short - term crops
Conversion to a more soluble form :
- Formula of apatite $Ca_5(PO_4)_3X$ or $3Ca_3(PO_4)$
(X = Cl, F, OH)

Any two methods ; Descriptions (10) + (10)
Equations (5) + (5)

Acidulation with H_2SO_4

$2Ca_5(PO_4)_3X + 7H_2SO_4 \rightarrow 3Ca(H_2PO_4)_2 + 7CaSO_4$

Acidulation with HCl

$2Ca_5(PO_4)_3X + 14HCl \rightarrow 3Ca(H_2PO_4)_2 + 7CaCl_2$

Treating with H_3PO_4

$2Ca_5(PO_4)_3X + 10H_3PO_4 \rightarrow 8Ca(H_2PO_4)_2 + 2CaX$

Heating with sodium carbonate and silica sand at

$Ca_5(PO_4)_3X + 2Na_2CO_3 \rightarrow 3CaNaPO_4 + 2CaCO_3$

Heating with serpentine (Mg_2SiO_4)

$2Ca_5(PO_4)_3X + 3Mg_2SiO_4 \rightarrow 3Ca_2SiO_4 + 2Mg_3(PO_4)$
$+ 2HX + Ca_3(PO_4)_2$

- using apatite mixed with peat
- Peat is acidic

∴ **Reacts slowly with apatite forming more soluble products**

Total for 10 (b) = 75 marks