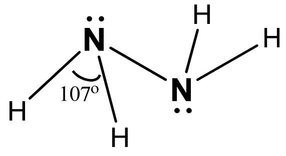
Preliminary 2 H1 Chemistry Paper 2 Mark Scheme

1. **(a)**



Trigonal pyramidal

(b) ………$3N_2H_4 \rightarrow 4NH_3 + N_2$

(c) ……… Formation of more stable molecules

(d) No of moles of hydrazine = 25/1000 x 1.40 = 0.035

No. of moles of electrons = 4 x 0.035 = 0.140

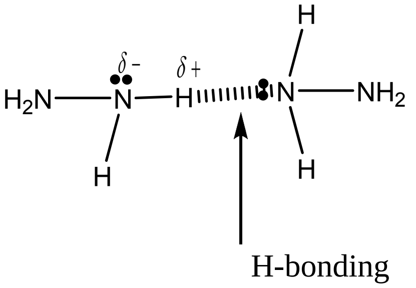
No. of moles of $KMnO_4$ = 35/1000 x 1 = 0.035

Mole ratio of $KMnO_4$: electrons = 1:4

Thus, final oxidation number = + 7 – 4 = + 3

Section A

(e) **(i)**



(ii) There are stronger hydrogen bonding exist between the hydrazine molecules compared to weak van der waalsforces of attraction between the molecules of ethane. Since more energy is required to break stronger H-bonding, the boiling point of hydrazine is higher.

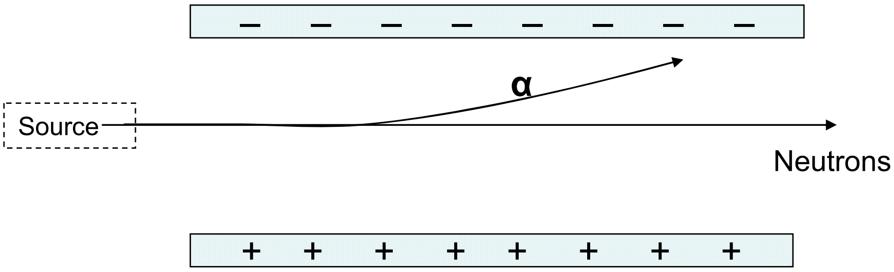
2 **(a)** **(i)** Number of protons : ……31……

Number of neutrons: ……37……

Marker's Comments:

- Easy questions but many students made mistakes.
- Many students use the Ar of Ga as 69.7 (average value of the different isotopes) given in Data Booklet.
- Some students even mistaken Ga for Ge.

(ii)



II. Deflection is proportional to $\frac{charge}{mass}$. Since deuterium ion is half the mass of alpha particle and half of it's charge, the deflection remains the same at 3^{o}.

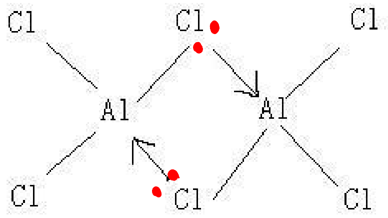
(b) **(i)**

Al_2O_3 (s) + 2NaOH(aq) + $3H_2O \rightarrow$ $2NaAl[OH]_4$ (aq)

$AlCl_3$ (s) + $6H_2O \rightarrow [Al(H_2O)_6]^{3+}$ (aq) + $3Cl^-$ (aq)

$[Al(H_2O)_6]^{3+}$ (aq) $\rightarrow$ $[Al(H_2O)_5(OH)]^{2+}$ (aq) + H^+ (aq)

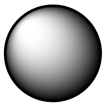
(ii)



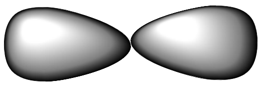
(c) **(i)** Isoelectronic refers to ions having the same number of electrons.

(ii) $1s^2 2s^2 2p^6$

(iii)



s-orbital: **Spherical**



p-orbital: **Dumb-bell**

(iv) Al: $1s^2 2s^2 2p^6 3s^2 3p^1$ Mg: $1s^2 2s^2 2p^6 3s^2$

Since less energy is required to remove the valence electron from the higher energy p-orbital of the Al atom compared to the s-orbital of Mg atom.

3 **(a)**

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

Units: $mol^{-2}dm^6$

(b) **(i)** The system will reduce the pressure by shifting equilibrium to the left.

(ii) The finely-divided iron acts as catalyst. The catalyst lowers the activation energy of the reaction.

Equilibrium is attained faster as it speeds up the rates of both the forward and reverse reactions equally.

Hence it has no effect on the position of the equilibrium.

(c) **(i)** step I

Reagent(s) and Conditions:

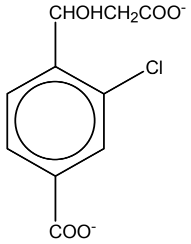
… Cl_2 (g),…… $FeCl_3$ or $AlCl_3$ catalyst …………

step II

Reagent(s) and Conditions:

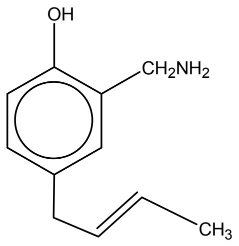
… Br_2 in CCl_4 ……… uv light………………

(ii)

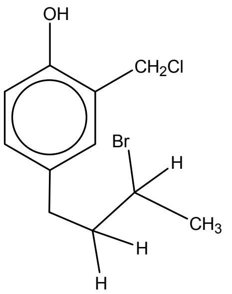


(iii) Free radical substitution This reaction is not specific

4 **(a)** **(i)** **NH_3, heat in sealed tube**

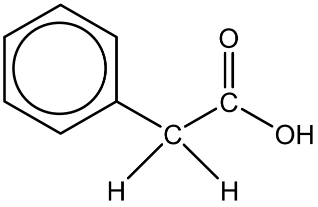


(ii) **HBr, room temperature**

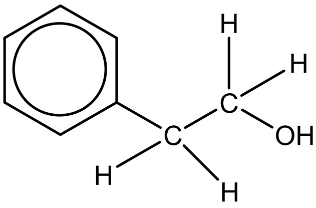


(b) **Reagent(s) and Conditions**: Add 2,4-dinitrophenylhydrazine
Observations:
With Compound X: there is no orange precipitate observed.
With Compound Z: there is orange precipitate observed.

(c) **(i)**



Intermediate A



Intermediate B

(ii) **step I**
Reagent(s) and Conditions:

…… I_2 (aq), NaOH(aq), reflux…………

step II
Reagent(s) and Conditions:

…… $LiAlH_4$, dry ether, followed by water…………

Section B

1 **(a)**

$$K_c = \frac{[I_3^-]}{[I_2][I^-]} \quad mol^{-1}\ dm^3$$

(b) **(i)**

	I^- (aq) +	I_2 (aq) $\rightleftharpoons$	I_3^- (aq)
Initial amt	**0.058**	**0.080**	**0**
Change	–0.0375	–0.0375	+0.0375
(i) Eqm amt	**0.0205**	0.0425	**+0.0375**
Eqm conc	0.0205/0.5	0.0425 / 0.5	0.0375/0.5

(ii) $$K_c = \frac{[I_3^-]}{[I_2][I^-]} = \frac{\left[\frac{0.0375}{0.5}\right]}{\left[\frac{0.0205}{0.5}\right]\left[\frac{0.0425}{0.5}\right]} = 21.5\ mol^{-1}\ dm^3$$

(c) **(i)** Amount of iodine in toluene layer = 0.084 x **500**/1000 = 0.042 mol
Amount of iodine in aqueous layer = 0.0425 – 0.042 = 5 x 10^{-4} mol

(ii) $$\text{Partition coefficient} = \frac{[I_2 \text{ in toluene}]}{[I_2 \text{ in water}]} = \frac{(0.084)}{\left(\frac{5x10^{-4}}{500/1000}\right)} = 84.0$$

(d) **(i)** Reagents/conditions: PBr_3, heat

(ii) Compound **K**: $(CH_3)_2CHCN$

Compound **L**: $(CH_3)_2CHCOOCH_2CH_3$

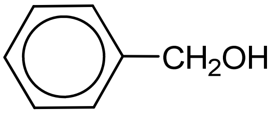
(e) **(i)** $$CH_3CH_2CH_2CH_2OH \xrightarrow{[O]} \underset{\textbf{S}}{C_4H_8O} \xrightarrow[\text{step II}]{HCN} \textbf{T}$$

Compound S: $CH_3CH_2CH_2CHO$

Compound T: $CH_3CH_2CH_2CHOH(CN)$

(ii) nucleophilic addition

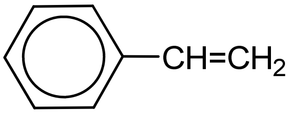
(f) **(i)**



(ii) The **<u>nucleophile for compound G is OH⁻.</u>**

Compound **H**: ✓**<u>nucleophile is $CH_3CH_2O^-$.</u>**

(iii) Type of reaction : elimination of HCl



(iv)
Test: add NaOH(aq) to each sample & heat
Then add excess HNO_3(aq), followed by $AgNO_3$(aq)
Obs:

Compound F: **white ppt of AgCl**
Bromobenzene: no ppt.

2 **(a)** **(i)** pH is defined as pH = -log [H^+]
Where [H^+] is the concentration of hydrogen ions in aqueous solution.

(ii) [H^+] of acetylsalicylic acid = (5.62/100) x 0.1 = 5.62 x 10^{-3} mol dm^{-3} [1]

(iii) $K_a = \frac{[H^+][C_8O_2H_7COO^-]}{[C_8O_2H_7COOH]}$ [1]

$= \frac{[5.62\times10^{-3}]^2}{[0.1]}$ = 3.16 x 10^{-4} mol dm^{-3} [1]

(iv) When small amounts of OH^- are added, $C_8O_2H_7COOH$ will react with the OH^- and pH changes are resisted.
$C_8O_2H_7COOH + OH^- \rightarrow C_8O_2H_7COO^- + H_2O$

When small amounts of H^+ are added, $C_8O_2H_7COO^-$ will react with the H^+ and pH changes are resisted.

$C_8O_2H_7COO^- + H^+ \rightarrow C_8O_2H_7COOH$

(v) Phenolphthalein
pH working range of indicator (8-10) coincides with the pH of end point.

(b) **(i)** Amt of salicylic acid = $\frac{10}{138}$ = 0.072463 mol

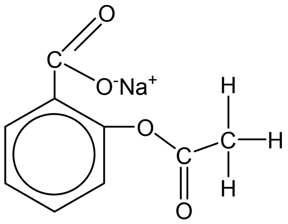
Amt of acetic anhydride = $\frac{20}{102}$ = 0.19608 mol

Limiting reagent = salicylic acid

Amt of Aspirin = 0.072463 mol
Mass of Aspirin formed = 0.072463 x 180 = 13.0 g

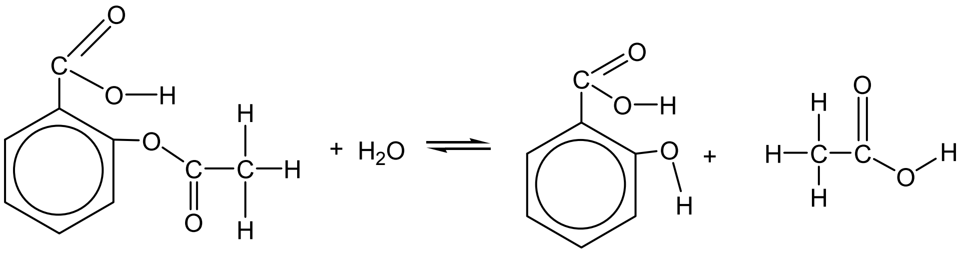
(ii) Aspirin decompose to form ethanoic acid which smells like vinegar.

(iii)



The type of reaction is acid-carbonate.

(iv)
Dilute HCl and heat.



(c) **(i)** $MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$

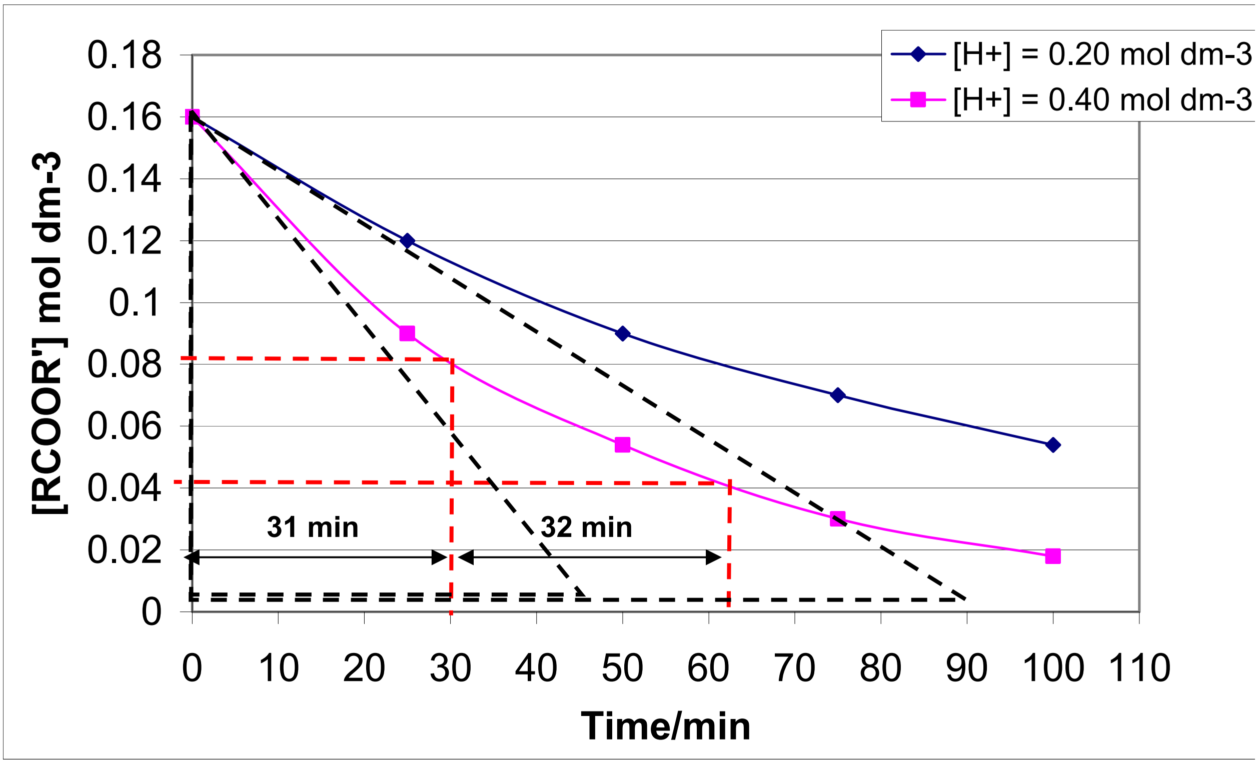
(ii) Amt of HCl = $1 \times \frac{0.2}{100}$ = 2×10^{-3} mol

Amt of $MgCO_3$ needed = 2×10^{-3} / 2 = 1×10^{-3} mol

Amt of $MgCO_3$ in one tablet = $(\frac{20}{100} \times 325 \times 10^{-3})$/ 84.3 = 7.7106×10^{-4} mol

Number of tablets = 1×10^{-3} / (7.7106×10^{-4}) = 1.29 = 2

3(a)



(b) **(i)** Since the half lives for the hydrolysis of ester are relatively constant, 31 min and 32 min respectively, the reaction is first order with respect to RCOOR'

(ii) Initial rate when [HCl] = 0.20 mol dm^{-3} = 1.758×10^{-3}
Initial rate when [HCl] = 0.40 mol dm^{-3} =3.556×10^{-3}

When concentration of HCl doubles, initial rate of reaction increase by approximately 2 times [1/2M], $\frac{3.556 \times 10^{-3}}{1.758 \times 10^{-3}}$.
Hence the reaction is first order with respect to HCl.

(iii) Rate = k[RCOOR'][HCl] [1M]

using $[H^+] = 0.20$ mol dm^{-3}

$$k = \frac{\text{rate}}{[RCOOR'][HCl]}$$

$= 5.49 \times 10^{-2}$ mol^{-1} dm^3 min^{-1}

(c) **(i)** $CH_3CH_2OH\ (l) + \frac{7}{2}O_2\ (g) \rightarrow 2CO_2\ (g) + 3H_2O\ (l)$

(ii) No of mole of ethanol = 0.034783
Heat evolved = 250 x 4.18 x (67-22) = 47025J

Enthalpy change of combustion of ethanol = $\frac{47025}{0.034783}$
= 13500 $kJmol^{-1}$

(iii) There is heat loss to the surrounding and incomplete combustion of ethanol.

(iv)

Bonds broken (endothermic)	**No. of moles**	**Bond energy / kJ mol^{-1}**
C–C	1	350X1
C–H	5	410X5
O-H	1	460X1
C-O	1	360X1
O=O	7/2	496X7/2

Bonds formed (exothermic)	**No. of moles**	**Bond energy / kJ mol^{-1}**
C=O	4	740X4
O-H	6	460X6

$\Delta H_1^\theta = \Sigma$ B.E. (bonds broken) - Σ B.E. (bonds formed)

= [(1x350) +(5x410) + (1x460)+(360X1)+(7/2X496)]- [(740X4)+(460X6)]

= 456 – 5720 = –764 kJ mol^{-1}

(d) **(i)** Melting points of Na_2O and Al_2O_3 are high because they form giant ionic structures with strong electrostatic force of attraction between the oppositely charged particles. Hence large amount of energy is required to overcome the strong forces and melting point is high.

The melting point of Al_2O_3 higher than Na_2O due to the higher charge density of Al^{3+} than Na^+. Hence the forces of attraction between Al^{3+} and O^{2-} is greater than Na^+ and O^{2-}.

Melting points of SiO_2 is high because they form giant covalent structures with strong covalent bonds between the Si and O atoms. Hence large amount of energy is required to overcome the strong covalent bonds and melting point is high.

Melting points of SO_2 is low because they form simple covalent structures with weak van der waals' force between the SO_3 molecules.Hence small amount of energy is required to overcome the weak van der waals' forces and melting point is low.

(ii) Na_2O (s) **reacts** vigorously with water to form an alkaline NaOH(aq) solution.

$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$ [1/2M] pH = 12-13
$Al_2O_3(s)$ does not dissolve in water. [1/2M] pH = 7
$SiO_2(s)$ does not dissolve in water. [1/2M] pH = 7
$SO_3(l)$ **react** with water to give acidic solutions. [1/2M]

$SO_3(l) + H_2O(l) \rightarrow H_2SO_4(aq)$ [1/2M] pH = 1-2

End of Paper