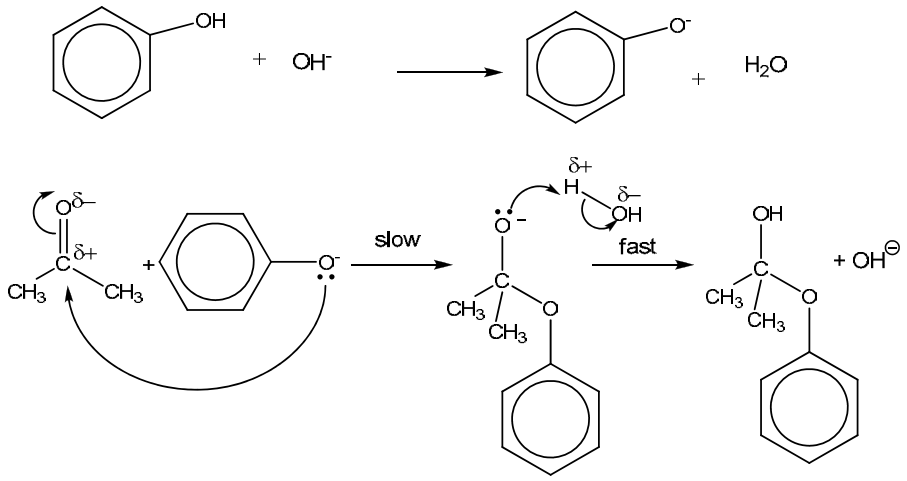
**Answers for SAJC 2013 Prelim Paper 3**

**1a** **3 chiral centres [1]**

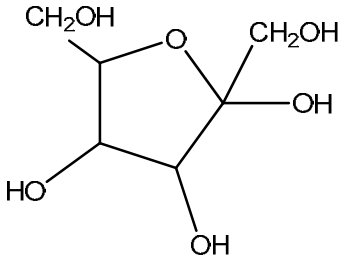
**(b)** **(i)** **Nucleophilic addition [1]**

**(ii)**




**[3]**

**(iii)**




**α-D-fructo-furanose** **[1]**

**(c)** **(i)** Balancing the equation,

$$2\text{D-fructose}\,(l) \rightleftharpoons \alpha\text{-D-fructofuranose}\,(l) + \alpha\text{-D-fructopyranose}\,(l)$$

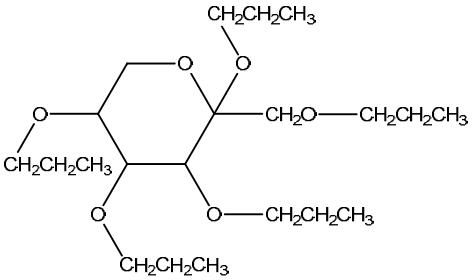
At equilibrium, D-fructose = 1- 0.7-0.22 = 0.08

Kc = (0.7)(0.22)/(0.08)$^2$ = 24.1 **[2]**

**(ii)** Change the temperature of the reaction. **[1]**

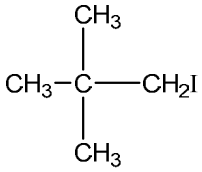
**(d)** **(i)** nucleophilic substitution **[1]**

**(ii)**




**[1]**

**(iii)**



(I) Slower as has a **larger alkyl group that increases the steric hindrance** experienced by nucleophile attacking the alkyl halide. **[2]**

(II) Slower as C-Cl bond is **stronger** and **harder to be broken**. **[2]**

**(e)** **(i)** Hydrolysis**[1]**

**(ii)** When temperature increases, the **kinetic energy of invertases increases** resulted in **denaturation/** protein **losing their native conformation**. **[1]**
The **van der Waals' interactions** in the tertiary structure and quaternary and the **hydrogen bonds** in the secondary, tertiary and quaternary structures are broken. **[1]**

**(iii)** At low [substrate], **active sites are not filled** hence **r = k[substrate**]. **[1]**
At high [substrate], all active sites are filled up hence reaction is zero order wrt [substrate] **[1]**

**2** **(a)** From the Data Booklet:

**(i)**

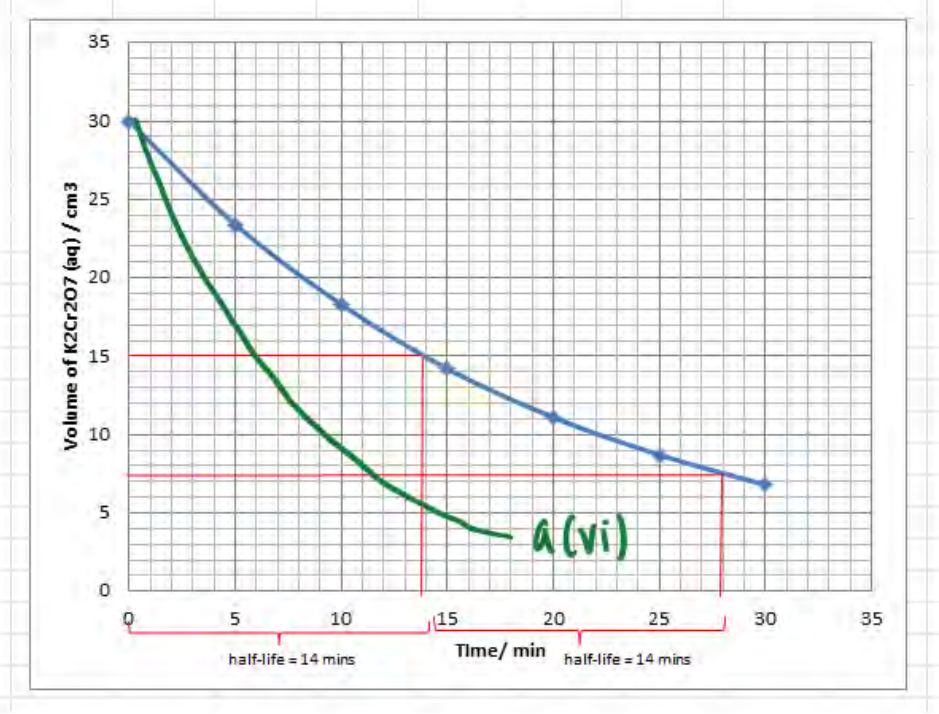
| Equation | $E^{\theta}$ |
|---|---|
| $O_2 + 2H^+ + 2e^- \rightleftharpoons H_2O_2$ | +0.68 |
| $Cr_2O_7^{2-} + 14H^+ + 6e \rightleftharpoons 2Cr^{3+} + 7H_2O$ | +1.33 |

$3H_2O_2 + Cr_2O_7^{2-} + 8H^+ \rightarrow 2Cr^{3+} + 7H_2O + 3O_2$
$E^{\theta}_{cell}$ = 1.33 – 0.68 = + 0.65 V. Therefore, reaction is feasible. **[3]**

**(ii)** Hence, 3 moles of $H_2O_2$ reacts with 1 mole of $Cr_2O_7^{2-}$.
No. of moles of $Cr_2O_7^{2-}$ = 0.1 x 30/1000 = 3 x$10^{-3}$ mol
No. of moles of $H_2O_2$ in 10.0 $cm^3$= 9 x$10^{-3}$ mol
$[H_2O_2]$ = 0.900 mol $dm^{-3}$ **[1]**

**(iii)** Some hydrogen peroxide has **decomposed** into oxygen and water. **[1]**

**(iv)**




Half-life = 13-15 min
Hence, the rate order is 1 with respect to the concentration of hydrogen peroxide.**[3]**

**(v)** $R=k[H_2O_2]^1$ **[1],** $k= \ln 2/t_{1/2} = \ln 2/ (14) = 0.0495\ min^{-1}$ **[2]**

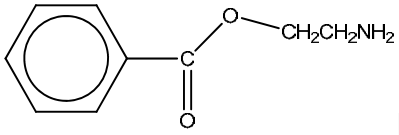
**(vi)** A more steeper curve drawn on the same graph, labeled with $NH_3$.**[1]**

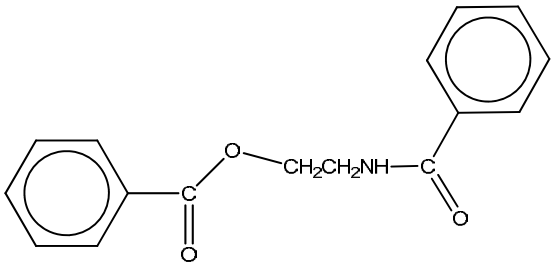
**(b)**

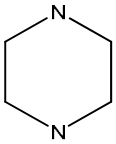
| Evidence | Conclusion |
|---|---|
| In the presence of sulfuric acid, 2 g of MEA reacts with 4.0 g of benzoic acid to form an acidic Compound **B,** $C_9H_{12}NO_2$ | • 2 g of MEA = 0.03279 mol<br>4 g of benzoic acid = 4/122 = 0.03279 mol<br>• 1 mole of MEA reacts with 1 mole of benzoic acid<br>• condensation/ nucleophilic substitution<br>• MEA contains an alcohol* group. |
| 2 g of MEA require 9.2 g of benzoyl chloride to react completely to form Compound **C,** $C_{16}H_{15}NO_3$ and copious white fumes. | • 9.2 g of benzoyl chloride = 9.2/140.5 = 0.06548 mol<br>• 1 mole of MEA reacts with two mole of benzoyl chloride<br>• condensation/ nucleophilic substitution,<br>• producing copious white fumes of HCl<br>• MEA contains 1 alcohol*<br>• MEA contains 1 amine* group |
| It is a simple aliphatic organic compound that can dissolve in water to form a weakly basic solution | • MEA likely to contain an amine* |
| MEA can also react with gaseous $PCl_5$ to form a cyclic Compound **D**, $C_4H_{10}N_2$ as one of the products under room temperature and pressure | • MEA contains an alcohol group*.<br>• The cyclic compound is due to intra-condensation/ nucleophilic substitution. |

| **Maximum [4]** | |
|---|---|

MEA: $NH_2CH_2CH_2OH$ **[1]**

Compound B:  **[1]**

Compound C:  **[1]**

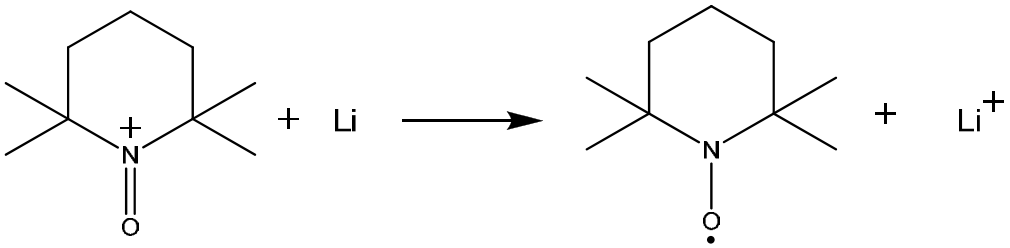
Compound D:  **[1]**

**3 (a) (i)** Anode: $Li \rightarrow Li^+ + e^-$ **[1]**
Cathode: $Li^+ + CoO_2 + e^- \rightarrow LiCoO_2$ **[1]**

**(ii)** In transition elements, the difference in energy levels between 3d and 4s orbitals is small. Hence after the 4s electrons are removed, it does not require a lot more energy to remove the 3d electrons hence exhibiting variable oxidation states.
**[2]**

**(b) (i)** From Data Booklet
$Li^+ + e \rightleftharpoons Li$ $\quad E^\theta = -3.04$ V

Overall equation**:**



$E^\theta cell = E^\theta_{cathode} - E^\theta_{anode}$
$3.6 = E^\theta_{cathode} - (-3.04)$
$E^\theta_{cathode} =$ **+ 0.56 V** **[3]**

(ii) With the increase in carbon side chain, the **electron cloud size increases**, results in an increase in induced dipole-induced dipole interactions in PTMA compared to TEMPO-NO radical**.**

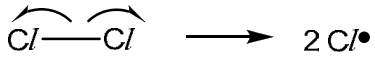
Hence, the pd-pd/Van der Waals/H-bonding interactions between polar solvents and PTMA will not be exothermic enough to overcome the stronger induced dipole-

induced dipole interactions in PTMA and pd-pd interactions between polar solvents to dissolve it. Hence, solubility is reduced.

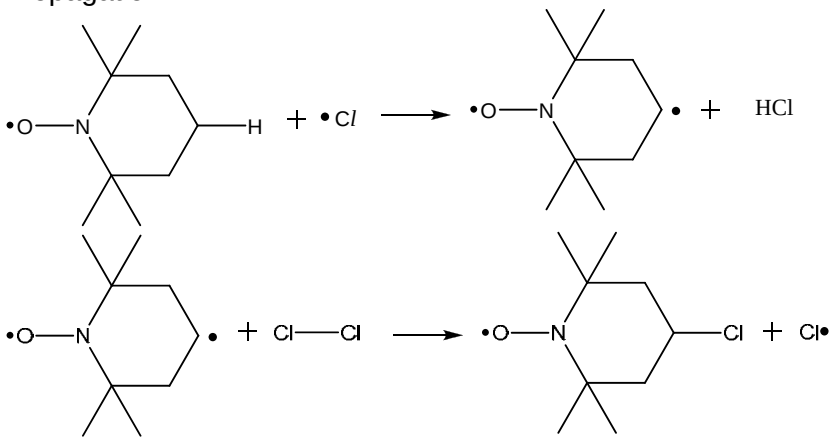
**[2]**

(iii) Li will react with water to form LiOH
$2Li + 2H_2O \rightarrow 2\ LiOH + H_2$ **[1]**

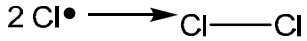
(iv) Free radical substitution
Initiation

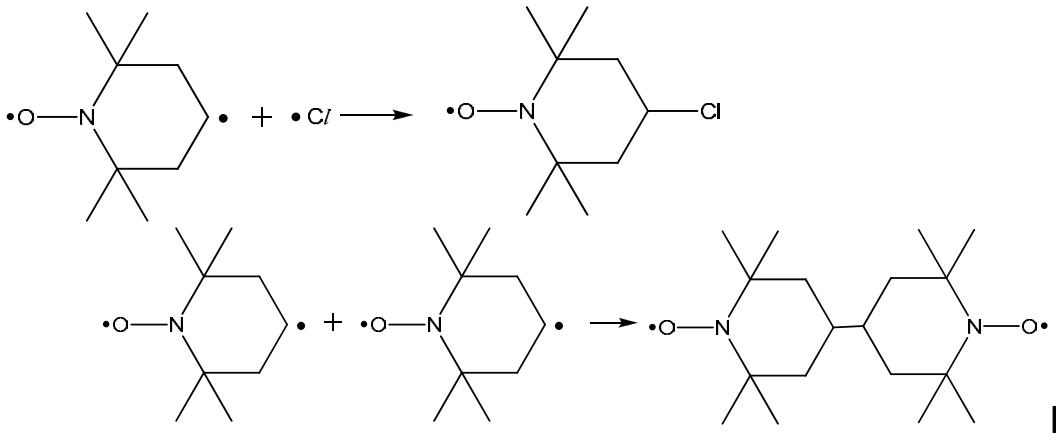


Propagation



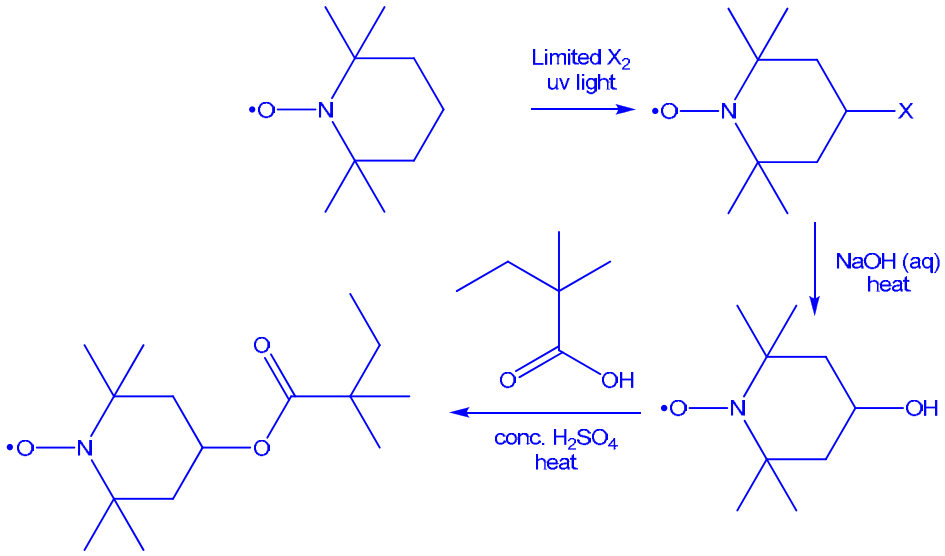
Termination **(Any 2)**





**[4]**

(v)




**[3]**

**[13]**

(c) Mass of Li to be restored = 100/87 x 1.25 = 1.4367 g
No. of mole of Li = 1.4367/ 6.9 = 0.20823 mol
No. of C = 0.20823 x 96500 = 20094 C
Time = 20094/ 3 = 6698 sec = 1.86 hr **[3]**

**[3]**
**[Total marks: 20]**

**4 (a) (i)** $K_p = \dfrac{(P_{NO2})^2}{P_{N2O4}}$

Moles of $N_2O_4$ = 21/ 92 = 0.2283

Initial pressure:

PV = nRT

$P = \dfrac{0.2283 \times 8.314 \times (45+273)}{30 \times 10^{-6}}$ , = 20120 kPa

| | $N_2O_4$ | $NO_2$ |
|---|---|---|
| Initial /kPa | 20120 | 0 |
| Equilibrium/ kPa | 20120 – x | 2x |

20120 + x = 33400, x = 13280 kPa

$Kp = \dfrac{(2x13280)^2}{20120 - 13280} = 1.03x10^5 kPa$ **[4]**

**(ii)** (I) At $30^0$C, since vessel Y has the lowest moles of $N_2O_4$, which shows that

equilibrium has shifted to the right.

When the system is subjected to larger volume and hence lower pressure, the system will shift to increase pressure to favour the side with more moles of gases.

The order of the vessel is Z < X < Y. **[3]**

(II) From the data, when temperature is the highest, there is least number of moles of $N_2O_4$ which implies that equilibrium shift right at high temperature.

When temperature is high, system favours the endothermic reaction to remove excess heat. This implies that the forward reaction is endothermic.

When temperature increases, increase in rate of forward reaction is greater than increase in rate of backward reaction, $K_p$ increases. **[3]**

**(b) (i)** Initial pH:

$[OH^-] = \sqrt{10^{-4.2} \times 0.25} = 3.9434 \times 10^{-3}$

pH = 14 + lg $3.9434 \times 10^{-3}$

pH = 11.6 **[1]**

Maximum buffer capacity:

pOH = $pK_b$

pH = 14 – 4.2 = 9.8 **[1]**

Equivalence point:

No. of moles of amphetamine = $\frac{20}{1000} \times 0.25 = 0.005$

Volume of nitric acid needed to reach equivalence point =

$0.005 \div 0.2 = 25\ cm^3$

[salt] = $0.005 \div \frac{25 + 20}{1000}$

$[H^+] = \sqrt{10^{-9.8} \times \frac{1}{9}} = 4.196 \times 10^{-6}$

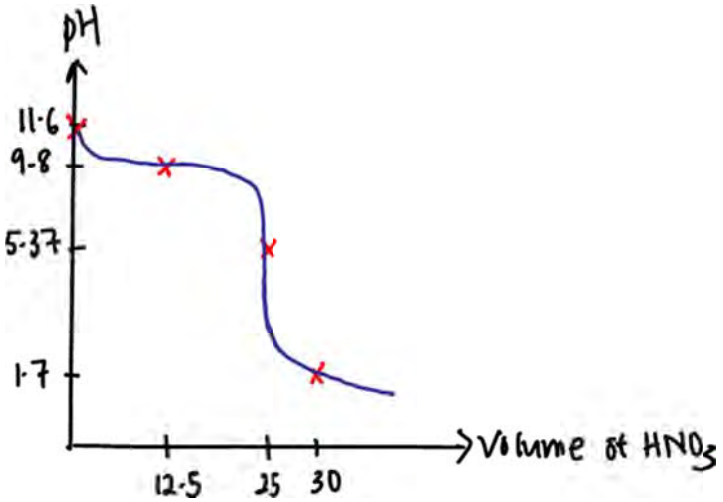
pH = 5.37**[1]**

After 30 $cm^3$ of nitric acid was added:

Excess acid = 30 – 25 = 5

$[H^+] = \left(0.2 \times \frac{5}{1000}\right) \div \frac{50}{1000} = 0.02$

pH= 1.70 **[1]**




**Graph and labelling [2]**

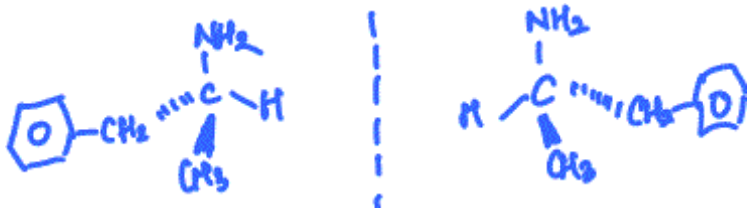
**(i)** $[C_6H_5CH_2CH(CH_3)NH_3^+]_2SO_4^{2-}$ **[1]**

**(ii)** % composition of amphetamine in amphetamine sulphate

$= \frac{2x\,(12x9+14+14)}{368} \times 100 = 73.91\%$

% composition of amphetamine in tablet = 73.91 / 4 = 18.5% **[2]**

**(iii)** Diagram **[1]**



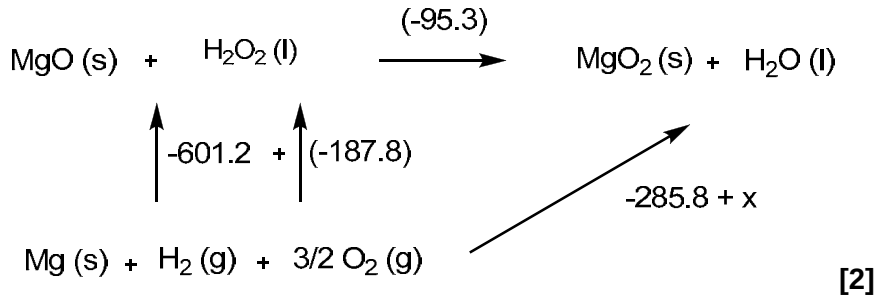
**[10]**

**[Total marks: 20]**

**5 (a) (i)**

**[1]**

**(ii)**




**[2]**

By Hess Law,

– 601.2 – 187.8 – 95.3 = –285.3 + x

x= – 599 kJ $mol^{-1}$ **[1]**

**(iii)** $MgO_2 \rightarrow MgO + ½ O_2$ **[1]**

**(iv)** $\Delta H = (-601.2) – (-599) = - 2.2$ kJ $mol^{-1}$ **[1]**

**(v)**

- From the Data Booklet, the ionic radii of Group II cations: **<u>$Mg^{2+}$ = 0.065nm, $Ca^{2+}$ = 0.099 nm and $Ba^{2+}$ = 0.135nm</u>**.
- Down the group, the size of the cation decreases while the charge remains constant. **<u>Charge density decreases in the order of $Mg^{2+} > Ca^{2+} > Ba^{2+}$.</u>**
- The **<u>degree of polarisation decreases in the order of $Mg^{2+} > Ca^{2+} > Ba^{2+}$.</u>** As a result of polarisation, the **<u>O-O is weakened</u>** decreasingly down the group.
- Thus, $MgO_2$ is the **<u>easiest</u>** to decompose followed by $CaO_2$ then $BaO_2$. Hence, its rate of decomposition is the fastest. **[3]**

**(b)** A = $Al_2O_3$, B = $P_4O_{10}$, C = $Na_2O$

<u>Reactions with water:</u>

$Na_2O$ (s) + $H_2O$ (*l*) $\rightarrow$ 2NaOH (aq)

$P_4O_{10}$ (s) + $6H_2O$ (*l*) $\rightarrow$ $4H_3PO_4$ (aq)

$Al_2O_3$ has high lattice energy and hence is not able to dissolve in water.

<u>A reacts with solutions of B and C respectively:</u>

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

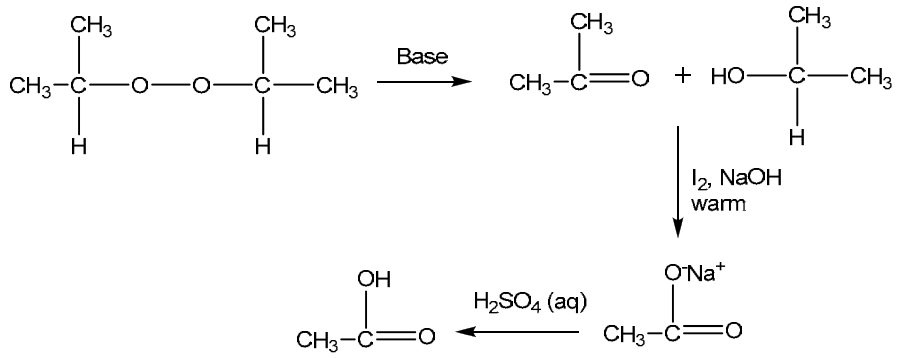
$Al_2O_3$ (s) + $2H_3PO_4$ (aq) $\rightarrow$ $2AlPO_4$ (aq) + $3H_2O$ (*l*)

<u>Reactions of solutions of B and C with salts</u>

$2 H_3PO_4$ (aq) + $3 Na_2CO_3$ (s) $\rightarrow$ $2 Na_3PO_4$(aq) + $3 CO_2$(g) + $3 H_2O$(l)

NaOH(aq) + $NH_4NO_3$(aq) $\rightarrow$ $NaNO_3$(aq) + $NH_3$(g) + $H_2O$ (l) **[6]**

**(c)** **(i)**




**[4]**

**(ii)** Oxygen is more electronegative than carbon. **[1]**

**[5]**

**[Total marks: 20**