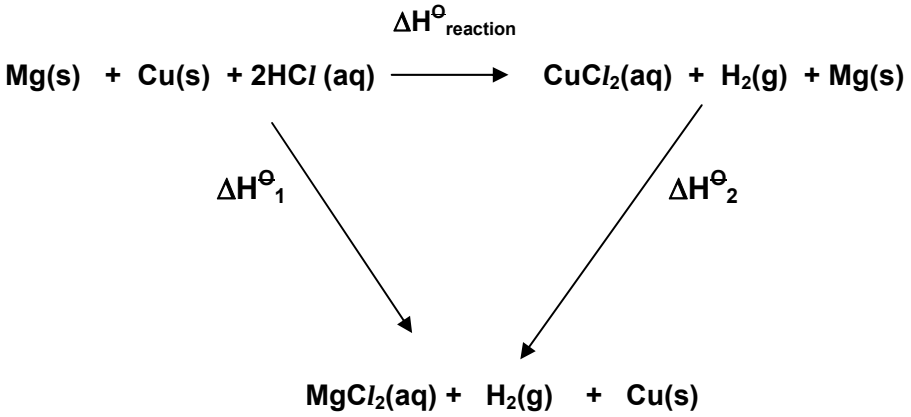
1 (a)



- **By Hess' law,**

  $\Delta H^{\ominus}_{reaction} = \Delta H^{\ominus}_{1} - \Delta H^{\ominus}_{2} = (x - y)$ kJ mol^{-1}

- **Correct energy cycle with balanced equations and state symbols**

[2]

(b) Example:

Assuming 100 cm^3 of acid is used and a temperature raise of 10 ^{o}C is to be achieved.

$m_{acid}C\Delta T = m_{Mg}/M_{r(Mg)} \times 460\ 000$

$100 \times 4.2 \times 10 = m_{Mg} \times 460\ 000/24.3$

$m_{Mg} = (24.3)[100 \times 4.2 \times 10)/460000]$

$= 0.22$ g

No. of moles of acid required to completely react off all Mg(s) = 2(0.22/24.3)

= 0.0181 mol

No. of moles of HCl in 100 cm^3 = 5 x 100/1000 = 0.5 mol

Hence, there is sufficient acid in 100 cm^3 to react with all Mg(s).

<u>Marking points [Justification]:</u>

- **Appropriate change in temperature (any value in the range 5 – 15 ^{o}C)**
- **Appropriate mass and volume of acid used to achieve the change in temperature.**
- **Appropriate mass and volume of acid in terms of appropriate quantity i.e. not too small or large amount (at least 0.1 g and 20 cm^3)**

Procedure:

- **Use a <u>100 cm^3 measuring cylinder</u> to measure out 100 cm^3 of HCl(aq)**

acid into a styrofoam cup. Record the initial temperature of the solution.

- **Using an electronic balance, weigh out accurately about 0.2 g of powdered Mg(s) into a dry empty weighing bottle.**
- **Use a -10 to 100°C thermometer to measure the temperature of the 100 cm^3 of HC*l*(aq) acid in the styrofoam cup.**
- **Pour the powered Mg(s) into the Styrofoam cup containing the HC*l*(aq), stir and measure the <u>highest temperature reached</u>. Record the final temperature reached.**
- **<u>Reweigh</u> the weighing bottle to determine the exact amount of Mg(s) that was poured into the styrofoam cup.**

<u>Marking points [Procedures]:</u>

- **Correct sequence of steps that will lead to useful data.**
- **Selection of apparatus is appropriate and types of apparatus used are clearly stated. (Note: this mark is only awarded if the suggested procedure is appropriate.)**

[5]

(c)

Mass of weighing bottle + Mg(s) / g	
Mass of weighing bottle + residual Mg(s) after transferring / g	
Mass of Mg(s) / g	

Initial temperature of HC*l*(aq) / °C	
Final temperature of HC*l*(aq) / °C	
Temperature change / °C	

<u>Marking points [Tables]:</u>

- **Correct <u>headers and units</u> for both tables to record data about mass and temperature.**

[1]

(d) Mass of Mg(s) = a g

ΔT = b ^oC

Volume of acid = c cm^3

Heat change = $mC\Delta T$

= c x 4.2 x b

= 4.2(cb) J

No. of moles of Mg(s) used = a/24.3 mol

Therefore $\Delta H^{\ominus}_1$ = - 4.2(cb) ÷ a/24.3

= - 102.06 (cb/a) J mol^{-1}

Marking points [Data Collection]:

- **Shows correct way to calculate heat change.**
- **Shows correct way to calculate $\Delta H^{\ominus}_1$.**

[2]

(e) The acid used is corrosive as it is rather concentrated 5 mol dm^{-3}, one should avoid any contact with the acid by wearing gloves.

Or

The reaction is vigorous and might splash out of the styroform cup, one should wear gloves and goggles.

[1]

(f) ΔG = ΔH - $T\Delta S$

A reaction can be considered feasible if ΔG is negative.

ΔS of the reaction should be positive as the reaction result in the formation of gas which is considered more disorderly. ΔH for this reaction is positive. It is possible for ΔG to be negative at high temperature where $|T\Delta S| > |\Delta H|$.

[1]

[Total: 12]

2 (a) (i) ●$8H^+ + 8I^- + H_2SO_4 \rightarrow 4I_2 + H_2S + 4H_2O$

(ii) ●**Violet vapour of iodine, trace white fumes of HI, and a pungent hydrogen sulfide (smells like rotten eggs) will be evolved**.

(iii) ●**It is to cool the beaker surface so that the iodine vapour can be deposited as a solid.**

(iv) ●When I_2 is in contact with I^-, the reddish-brown I_3^- ion would be formed.

(v) ●The yield would likely be lower as some of the iodine would react with the sodium hydroxide.

●$3I_2 + 6NaOH \rightarrow 5NaI + NaIO_3 + 3H_2O$

($I_2 + 2NaOH \rightarrow NaI + NaIO + H_2O$ is also acceptable)

[6]

(b) (i) ●H_2O_2 oxidises the I^-, to aqueous I_2, so a brown solution would be obtained.

●$H_2O_2 + 2I^- + 2H^+ \rightarrow I_2 + 2H_2O$

(ii) $E^{\theta}_{Cl_2/Cl^-} = +1.36V$

$E^{\theta}_{H_2O_2/H_2O} = +1.77V$

●1 mark for both values quoted

●Since $E^{\theta}_{H_2O_2/H_2O}$ is more positive than $E^{\theta}_{Cl_2/Cl^-}$, H_2O_2 can oxidise chloride to chlorine while it itself is reduced to H_2O. Hence, the oxidation of iodide may not be complete.

(iii) ●Both cyclohexane and iodine have simple molecular structures, are non-polar and have van der Waals' (vdW) forces of attraction between their molecules.

●When iodine dissolves in cyclohexane, the energy released from the vdW forces formed between iodine and cyclohexane is enough to overcome the vdW forces between iodine molecules and the vdW forces between cyclohexane.

●On shaking with cyclohexane, I_2 will dissolve in the colourless cyclohexane to form a violet organic layer. Brown colour of aqueous layer fades.

(iv) ●Cyclohexane is flammable, and can cause a fire to break out / iodine may sublime and escape.

(v) ●Dilute aqueous NH_3 should be added. AgC*l* is soluble in NH_3(aq) but AgI is not. If there was significant amount of silver chloride in the precipitate obtained, much of the precipitate dissolved upon adding aqueous NH_3.

(vi) ●Sunlight likely catalysed the decomposition of silver chloride / redox reaction between the Ag^+ and C*l*$^-$ ions to form silver metal and chlorine

gas.

●Silver metal atoms are likely to be formed in nanoclusters in the range of 70 nm, producing the purplish colouration.

[11]

(c) **●$2CuI_2(s) \rightarrow 2CuI(s) + I_2(aq)$**

[1]

[Total: 18]

3 **(a)** **(i)** Anode: **$Ag(s) \rightarrow Ag^+(aq) + e^-$**

Cathode: **$Ag^+(aq) + e^- \rightarrow Ag(s)$** } ●

(ii) **Explanation: ●As current passes through this electrolytic cell, the silver electrode will get oxidized to form Ag^+ ions which enter the solution. Ag^+ ions in the electrolyte will get reduced to silver metal and plates onto the spoon at the cathode.**

Observation: Overtime as current passes through the electrolytic cell, the ●silver electrode become thinner and the object is plated with a layer of silver coating.

[3]

(b) **●For every Ag^+ ion reduced and plated onto the object, one Ag^+ ion will be released into the electrolyte as the silver electrode is oxidized to release Ag^+ ion.**

[1]

(c) **(i)** **●Effervescence of oxygen gas at the positive electrode.**

(ii) ● **$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$**

$Ag^+ + e^- \rightarrow Ag$ (x4)

●Overall: $2H_2O + 4Ag^+ \rightarrow O_2 + 4H^+ + 4Ag$

(iii) **No. of mol of Ag = 10/107 = 0.0935mol**

●No. of mol of e- transferred = 0.0935mol

Total Quantity of charge = 0.0935 x 96500 = 9018.7C

Q = It

9018.7 = 5(t)

●t= 1803.7s = 0.5hrs

(iv) **$C(s) + O_2(g) \rightarrow CO_2(g)$**

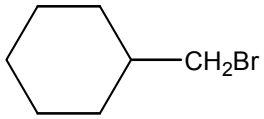
The graphite electrode will react with O_2 gas/ be ●<u>oxidized by O_2 gas to form CO_2</u> and thus needs to be replaced after some time.

[6]

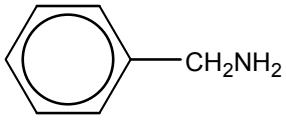
[Total: 10]

4 **(a)**

● C is



● D is



[2]

(b) **(i)** **Rate = k $[C]^x [NH_3]^y$ =** $\frac{\text{amount of } C_6H_{11}CH_2NH_2}{t}$

Hence, $[C]^x[NH_3]^y \propto \frac{1}{t}$ **or** $\frac{[C]_1^x[NH_3]_1^y}{[C]_2^x[NH_3]_2^y} = \frac{t_2}{t_1}$

Comparing Experiment 1 and 2

● $\frac{(0.40)^x(4.00)^y}{(0.30)^x(4.00)^y} = \frac{24}{18}$ ➔ **x = 1**

Order of reaction with respect to [C] is 1

Comparing Experiment 1 and 3

● $\frac{(0.40)(4.00)^y}{(0.50)(4.40)^y} = \frac{13}{18}$ ➔ **y ≈ 1**

Order of reaction with respect to $[NH_3]$ is 1

(ii) **● Rate = k [C] $[NH_3]$**

(iii) **● Bimolecular nucleophilic substitution (S_N2)**

[4]

(c) (i) **Maximum concentration of [D] = 0.5 moldm^{-3}**

●Since the same graph is obtained when [NH_3] is doubled, it means that [NH_3] has no effect on the rate of reaction

Order of reaction with respect to [NH_3] is 0

●From the graph, the half life of the reaction is constant at 30 min

Order of reaction with respect to [bromomethylbenzene] is 1

For an S_N1 reaction, the rate of reaction is first order with respect to the alkylhalide only. Hence the data is consistent with the given mechanism.

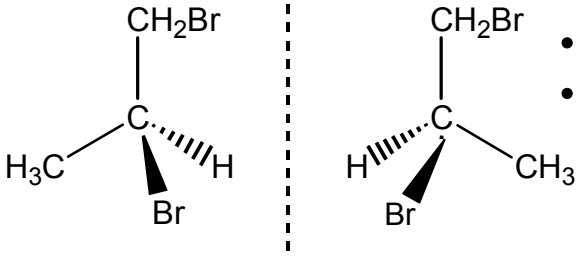
(ii) $t_{\frac{1}{2}} = \frac{\ln 2}{k} \rightarrow k = \frac{\ln 2}{t_{\frac{1}{2}}}$

● $k = \frac{\ln 2}{t_{\frac{1}{2}}} = \frac{\ln 2}{30} = 0.0231\ min^{-1}$

(iii) **●The delocalized electrons in the benzene ring can extend outside the benzene ring to the positively charged carbon atom of the carbocation. Resonance can thus occur dispersing the positive charge on the carbocation and stabilizing it.**

[4]

(d) (i)



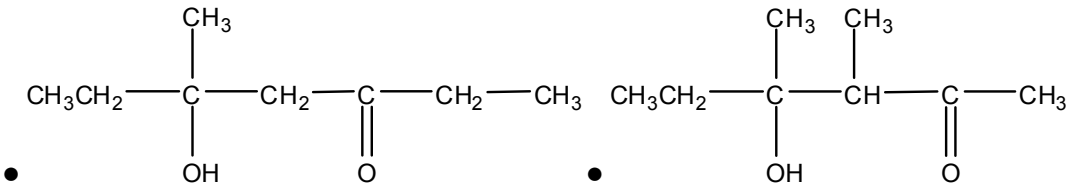
- **1 mark for correct product**
- **1 mark for optical isomers**

(ii) **●3-bromopropene undergoes electrophilic addition with HBr. In the first step, a carbocation and Br^- ion is formed. The carbocation ($CH_2BrCHCH_3^+$) has a trigonal planar shape with respect to the positively charged carbon atom. In the second step, the Br^- ion can attack the positively charged carbon atom from both sides of the plane with equal probability.**

●A racemic mixture that does not rotate the plane of polarized light is formed.

[4]

(e)



[2]

[Total: 16]

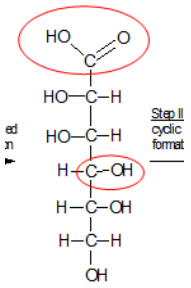
5 (a) Primary alcohol, secondary alcohol, ester

[2]

(b) (i) ●**Step II: Condensation (Nucleophilic Substitution)**

●**Step III: Elimination / Oxidation**

(ii)

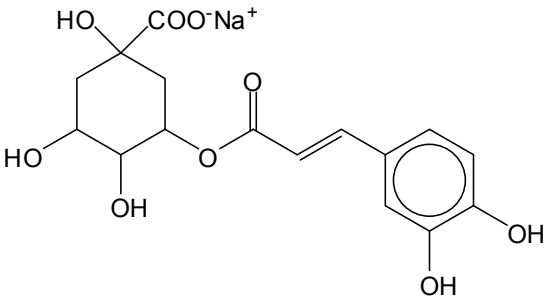


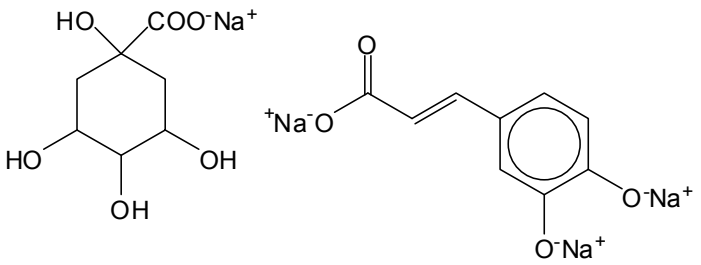
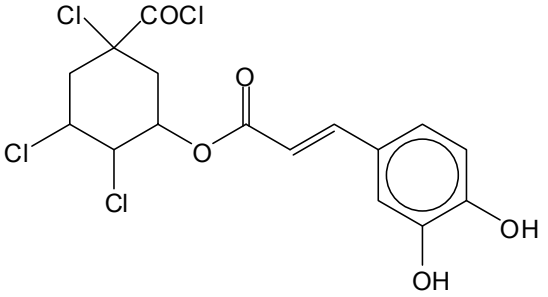
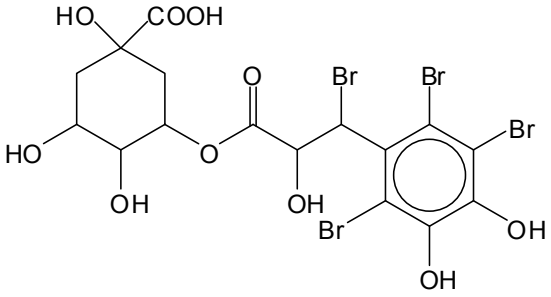
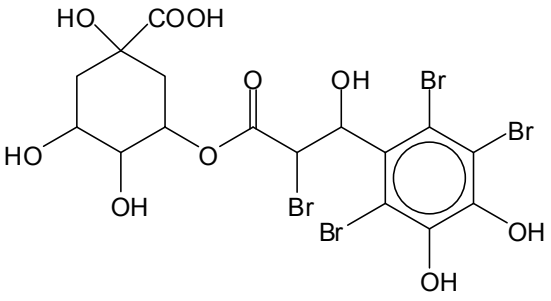
Intermediate J

●

[3]

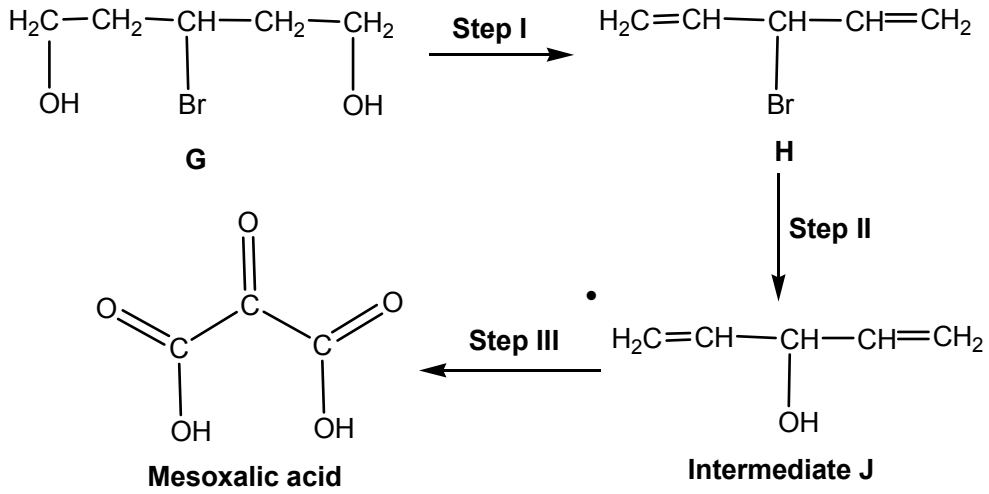
(c)

Reagent	**Structural formula of organic compounds**
Solid Na_2CO_3	

aq NaOH, heat	
PCl_5	
aq Br_2	 OR 

[5]

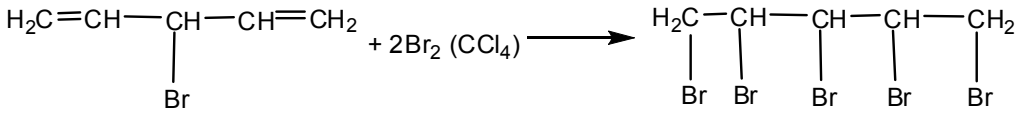
(d) (i)



Step	Reagents and conditions
I	• **excess concentrated H_2SO_4, 180 °C or Al_2O_3, 400 °C**
II	• **NaOH(aq), heat/reflux**
III	• **$KMnO_4$(aq), dilute H_2SO_4, heat/reflux**

(ii) **•Add Br_2 dissolved in CCl_4 under room conditions each to compound G and H separately.**

With compound H, decolourisation of Br_2 and no decolourisation for G



•

(other acceptable answers include:

Br_2(aq), PCl_5, Na metal)

[6]

[Total:16]