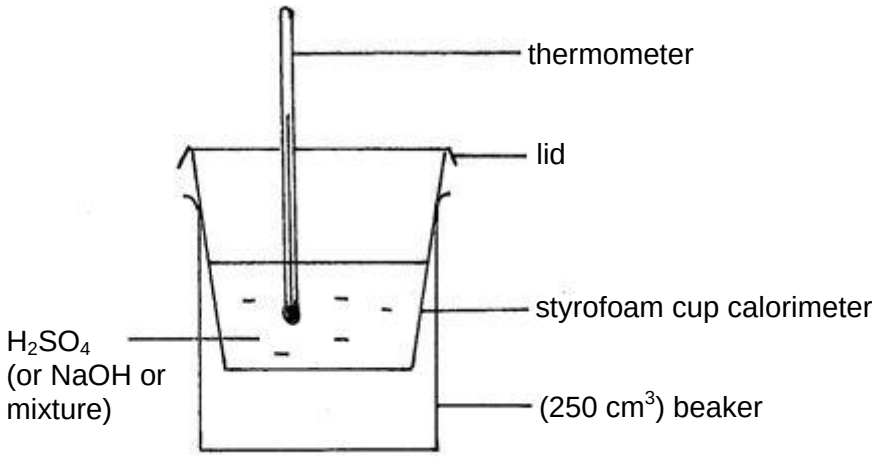
2013 C2 Chemistry Prelim Paper 2 – Answers

1 (a) Diagram: [1]

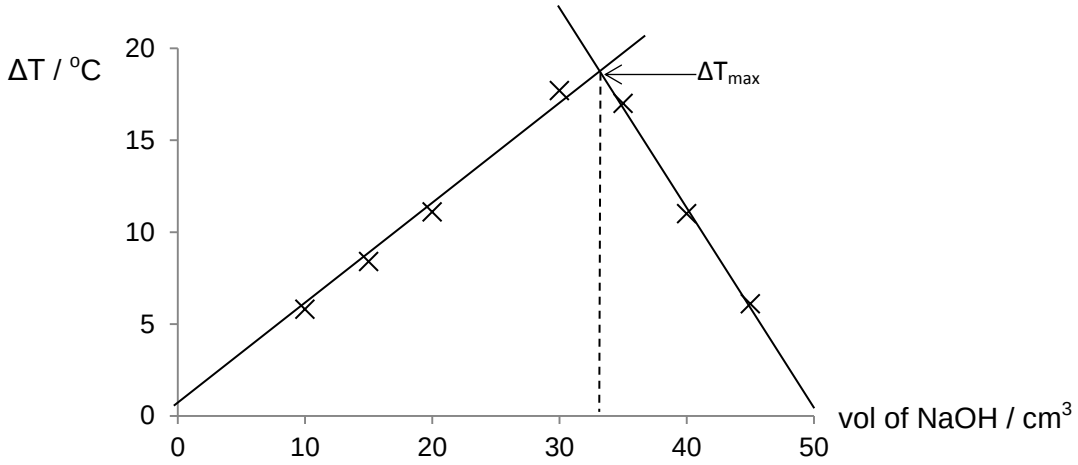


Example of procedure: **[5]**

1. Use a burette to transfer (volume) cm^3 of (H_2SO_4) into a styrofoam cup. (Place the cup in a 250 cm^3 beaker to prevent it tipping over.) Record the initial temperature of H_2SO_4 solution using a thermometer of precision (± 0.1 ^oC).
2. From a second burette, measure (volume) cm^3 of (NaOH) into another styrofoam cup. Record the initial temperature of NaOH solution.
3. Add H_2SO_4 solution to NaOH solution (or vice versa). Use the thermometer to stir the mixture gently.
4. Record the highest temperature reached.
5. Repeat steps 1 to 4 using the volumes in the table below.
6. The temperature change, $\mathbf{\Delta T} = T_{final} - T_{initial}$, where $T_{initial}$ is the weighted average by volume.

Experiment	Volume of H_2SO_4 / cm^3	Volume of NaOH / cm^3	Initial temperature of H_2SO_4 / ^oC	Initial temperature of NaOH / ^oC	Highest temperature / ^oC
1	5.00	45.00			
(given data)	10.00	40.00			11.0
2	15.00	35.00			
(given data)	20.00	30.00			18.4
3	30.00	20.00			
4	35.00	15.00			
5	40.00	10.00			

Sketch : [1]



Calculations: [3]

(i) Let volume of NaOH at ΔT_{max} (from the graph**)** = a cm^3

Then $\eta_{OH^-} = \frac{a}{1000}$ x 2.00 mol

and $\eta_{H_2SO_4}$ = ½ x $\frac{a}{1000}$ x 2.00 = $\frac{a}{1000}$ mol

Therefore, $[H_2SO_4] = \frac{n}{v} = \frac{\frac{a}{1000}}{\frac{(50 - a)}{1000}} = \frac{a}{(50 - a)}$ mol dm^{-3}

(ii) Heat change for the reaction Q = m x c x ΔT_{max} J
where m = 50 g,
c = specific heat capacity of the final solution in J g^{-1} K^{-1},
ΔT_{max} is read from graph (in K or °C)

$\Delta H_{neut} = - \frac{Q}{n}$ J mol^{-1}

where n = no of mol of H_2O formed = 2 x $\frac{a}{1000}$

Therefore, $\Delta H_{neut} = - \frac{\frac{m\ c\ \Delta T_{max}}{1000}}{2 \times \frac{a}{1000}} = - \frac{m\ c\ \Delta T_{max}}{2a}$ kJ mol^{-1}

(b) The results will be the <u>same for the concentration of sulfuric acid</u> (because the neutralization reaction occurs <u>according to stoichiometry</u> / the same no of moles of OH^- and H^+ is present.

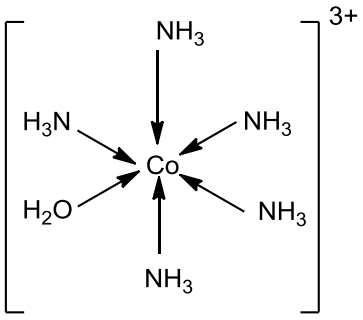
However, <u>the molar enthalpy change of neutralization will be different</u> because the precipitation of barium sulfate <u>occurs with an enthalpy change</u> / is exothermic.

[2]

2 (a) (i) no. of moles of $AgNO_3$ = 1.12 x 10^{-2}
no. of moles of Cl^- = 1.12 x 10^{-2}
no. of moles of **A** = 1.00/268.4 = 3.73 x 10^{-3}
no. of moles of free Cl^- ions per mole of **A** = (1.12 x 10^{-2})/(3.73 x 10^{-3}) = <u>3</u>

[2]

(ii)



[1]

(iii) Complex ion in **B**: $[Co(NH_3)_5Cl]^{2+}$ **[1]**

(iv) The different ligands in **A** and **B** cause the splitting of the d–orbitals to be different /energy gap between the splitted d–orbitals is different/ both absorb wavelength of different frequency, thus showing different complement colours. **[1]**

(b) **(i)** Pink Co(II) (aq) is oxidised to green Co(III) (aq) by aqueous hydrogen peroxide, while hydrogen peroxide is reduced to water.

After a while, the green Co(III) (aq) is reduced back to pink Co(II) (aq) by hydrogen peroxide while hydrogen peroxide is oxidised to oxygen gas.

[2]

(ii) Role: Co(II) (aq) is acting as a homogeneous catalyst.

Evidence:
- There is an intermediate Co(III) formed
- The rate of reaction speeds up
- Co(II) (aq) is regenerated

[3]

(iii) $2\ H_2O_2 \rightarrow O_2 + 2H_2O$ **[1]**

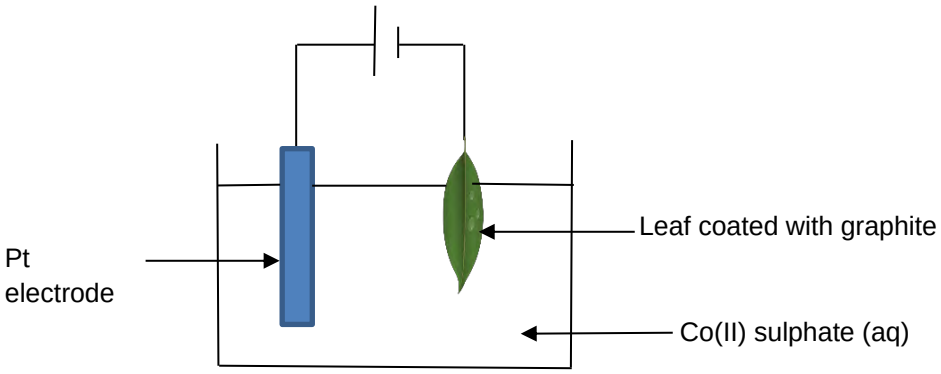
(iv) $Co^{3+} + e \rightleftharpoons Co^{2+}$ +1.82V
$O_2 + 4H^+ + 4e \rightleftharpoons 2H_2O$ +1.23V
E^o cell = +1.82 – (+1.23) = + 0.59 V

Co^{3+} reduced easily in the presence of water to Co^{2+}.

Tartaric acid stabilises Co^{3+}/ act as a complexing agent / act as a ligand.

[3]

(c) **(i)**



[1]

(ii) Cathode: $\underline{Co^{2+}(aq) + 2e \rightarrow Co(s)}$
Anode: $\underline{2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e}$

[2]

(iii) No. of moles of Co coated = $(8.90 \times 0.2 \times 10^{-1} \times 10) / 58.9 = \underline{0.0302}$

No. of moles of $O_2 = (0.0302) / 2 = 0.0151$

Volume of gas = $0.0151 \times 24 = \underline{0.363\ dm^3\ (or\ 363\ cm^3)}$

[2]

(iv) No of moles of Co to be coated on the leaf = 0.0302 mol
No of moles of electrons to be transferred = $0.0302 \times 2 = 0.0604$ mol

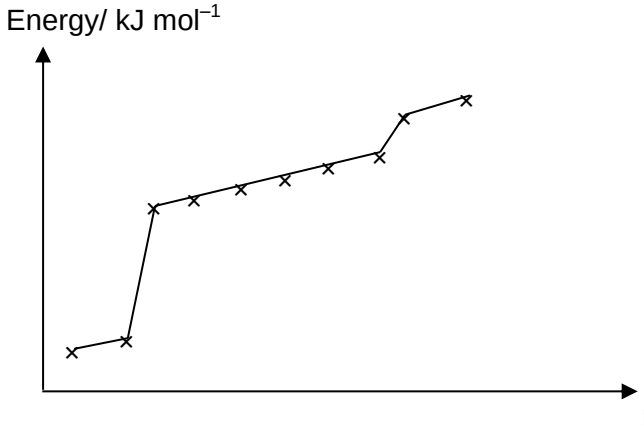
$Q = It = nF$
$0.5 \times t = 0.0604 \times 96500$
$t = 11657.2s = 3.24\ hr$ **[1]**

3 (a) (i) Sodium. At 600°C, sodium is <u>still a liquid</u>. **[1]**

(ii)
- Charge density of Mg^{2+} is greater than Na^+
- <u>Number of delocalized electrons in magnesium is greater than sodium</u>
- <u>More energy is required to overcome the stronger metallic bonding</u> (attraction between Mg^{2+} cations with its sea of delocalized electrons), hence melting point of magnesium is higher than sodium.

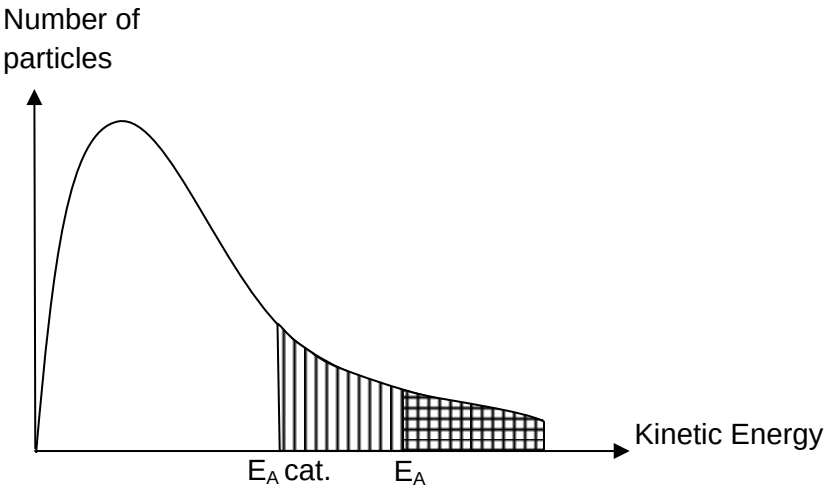
[2]

(ii)



[1] – correct shape of curve (first gap is larger than the second gap)

(b) **(i)**



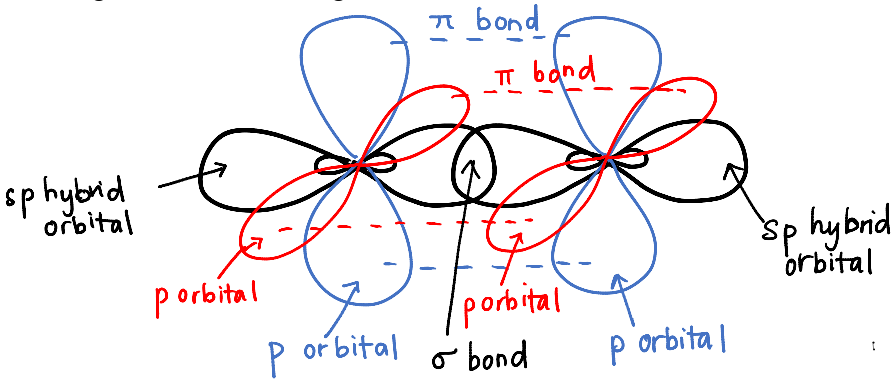
- The activation energy of a catalysed (Ea_{cat}) reaction is lower than that of an uncatalysed (Ea_{uncat}) reaction.
- The catalyst <u>provides an alternate pathway with lower activation energy</u>.
- This <u>increases the proportion of molecules with KE greater than or equal to Ea</u> and <u>increases frequency of effective collision</u> and hence increases rate of reaction.

[3]

(ii)

- C%C consists of 1 σ bond and 2 π bonds
- The σ bond is formed from a head on overlap of the sp hybridised orbitals
- The π bonds are formed from a side on overlap of the p orbitals.

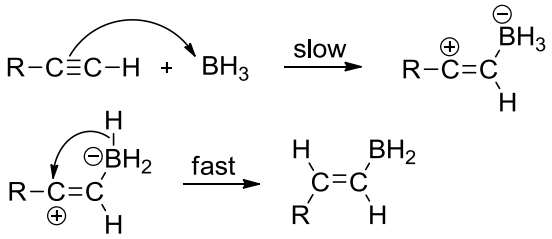
If a diagram is drawn, diagram must be labeled to show the orbitals involved in each overlap.



[2]

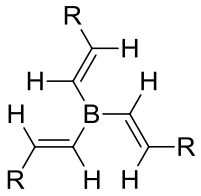
(c) **(i)** The boron atom is <u>electron deficient</u> and is able to accept an electron pair from the C%C bond. **[1]**

(ii)



[2]

(iii)

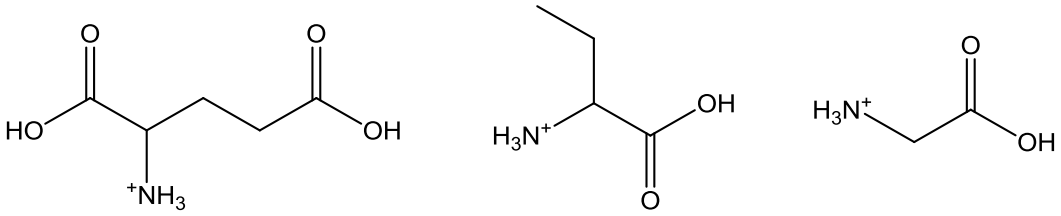


[1]

4 (a) (i) The peptide bond is not formed using the $-CO_2H$ on the α-carbon. **OR**

The peptide bond is formed using the side chain acid group of the N–terminal amino acid. **[1]**

(ii)



[1] for each correct structure

(b) Ile-His-Cys-Pro-Gly-Val-Leu-Pro-Val-Lys-Val **[1]**

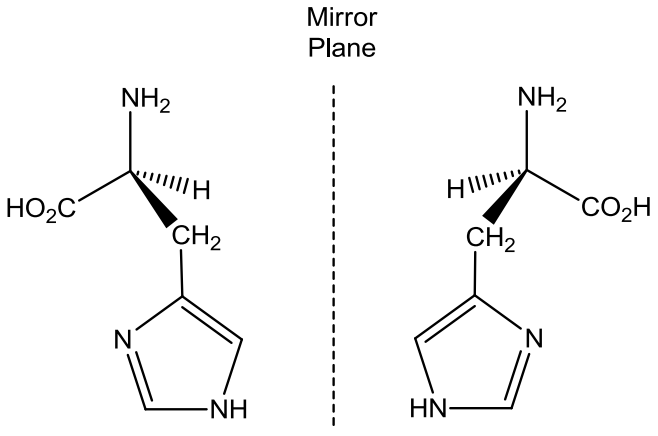
(c) (i) At low pH, –N / –NH becomes $-NH^+$ / $-NH_2^+$. This disrupts the hydrogen bonds in the tertiary structure, and hence leads to denaturation. **[2]**

(ii) In aqueous media, histidine exists as a zwitterion**.** Thus it is able to form ion-dipole interactions with the water molecules, hence allowing it to dissolve well in water. **[2]**

(iii) The sample of histidine extracted from cartilage protein contains only one enantiomer.

The sample obtained from laboratory synthesis is a racemic mixture **OR** contains both enantiomers in equal amounts. **[2]**

(iv)



[1]

5 (a) (i) Bond angle strain as the P-P-P bond angle (60^o) is more acute that the ideal 107^o. **[1]**

(ii) $P_4\ (s) + 5O_2\ (g) \rightarrow P_4O_{10}\ (s)$ **[1]**

(b) (i) $P_4\ (l) + 6H_2O\ (g) + 5O_2\ (g) \rightarrow 4H_3PO_4\ (l) / (g)$ **[1]**

(ii) Mass of H_3PO_4 in 500 cm^3 of Coke = $\frac{0.05}{100} \times 500 \times 1 = 0.25$ g

$\eta_{H_3PO_4} = \frac{0.25}{98.0} = 2.55 \times 10^{-3}$ mol

$[H_3PO_4] = \frac{2.55 \times 10^{-3}}{500/1000} = 5.10 \times 10^{-3}$ mol dm^{-3}

$K_{a_1} = \frac{\left[H_2PO_4^{2-}\right]\left[H^+\right]}{\left[H_3PO_4\right]}$

$7.50 \times 10^{-3} = \frac{\left[H^+\right]^2}{5.10 \times 10^{-3} - \left[H^+\right]}$

$[H^+] = 3.48 \times 10^{-3}$ mol dm^{-3}

pH = 2.46 **[3]**

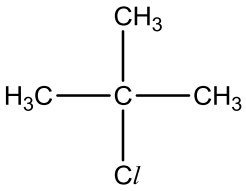
(c) PCl_5 has a large electron cloud/ has a large number of electrons and hence dispersion forces exist between molecules.

PCl_5 is large molecule and hence its volume is not negligible compared to the volume of the container.

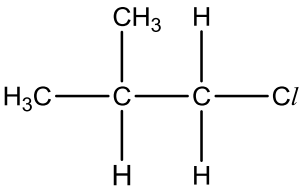
Collisions between PCl_5 molecules are inelastic as energy is expended to overcome the dispersion forces of attraction.

[3]

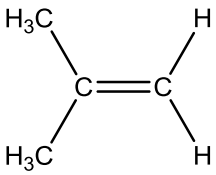
(d) **(i)**



C



D



E

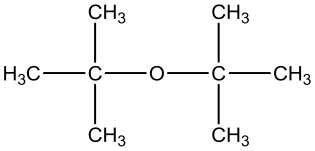
[3]

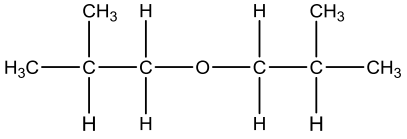
(ii) Either **C** or **D** may undergo nucleophilic substitution with potassium hydroxide to give an alcohol.

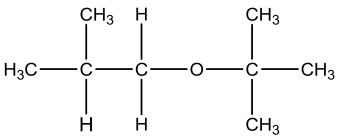
This alcohol acts as a nucleophile and substitutes the Cl atom on **C** or **D** to give **F**.

[2]

(iii) Accept any one of these structures. **[1]**







[Total = 15]