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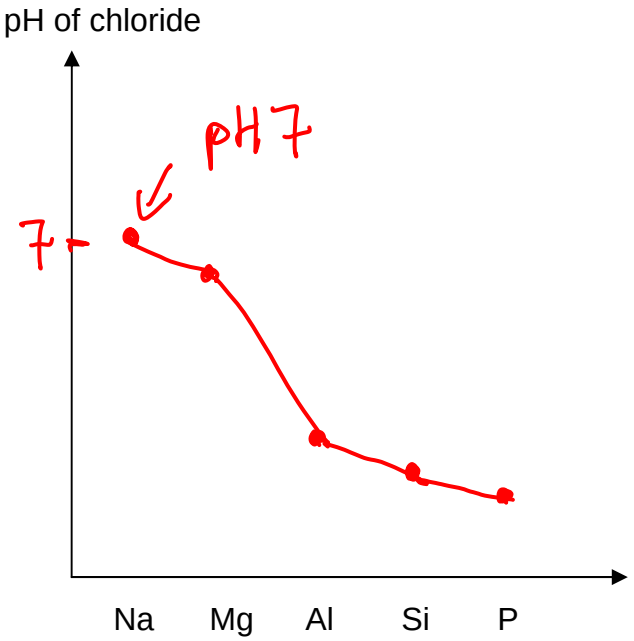
1(a) The chlorides of sodium to phosphorus (NaC*l*, MgCl_2, A*l*Cl_3, SiCl_4 and PCl_5) are separately added to water.

(i) Sketch a graph to show the pH of the resulting mixture, indicating the pH of sodium chloride.



[2]

(ii) Account for the pH value of aluminium chloride.

The pH is **3**. Aluminium chloride undergoes **hydrolysis** to give an acidic solution due to the **high polarising power of Al^{3+}**.

[1]

(iii) Write equations for the reactions of silicon chloride and phosphorus pentachloride with water.

Silicon chloride:

$SiCl_4$ (l) + $2H_2O$ (l) → SiO_2 (s) + 4HCl (aq)

Phosphorus pentachloride:

PCl_5 (l) + $4H_2O$ (l) → H_3PO_4 (aq) + 5HCl (aq)

[2]

(b) Under suitable conditions iodine and chlorine react to give interhalogen compound, ICl_x. When a pure sample of ICl_x was dissolved in an excess of aqueous potassium iodide, the iodine liberated requires 17.1 cm^3 of 0.1 mol dm^{-3} of $Na_2S_2O_3$ for the titration. On the other hand, the chloride ion liberated requires 12.8 cm^3 of 0.1 mol dm^{-3} silver nitrate for complete precipitation.

(i) Determine the value of x. Hence, write a balanced equation for the reaction between ICl_x and I^-.

$ICl_x + I^- \rightarrow I_2 + xCl^-$

$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$

No. of mol of iodine = $0.0171 \times 0.1 \times ½ = 8.55 \times 10^{-4}$

No. of mol of Cl^- = $0.0128 \times 0.1 = 1.28 \times 10^{-3}$

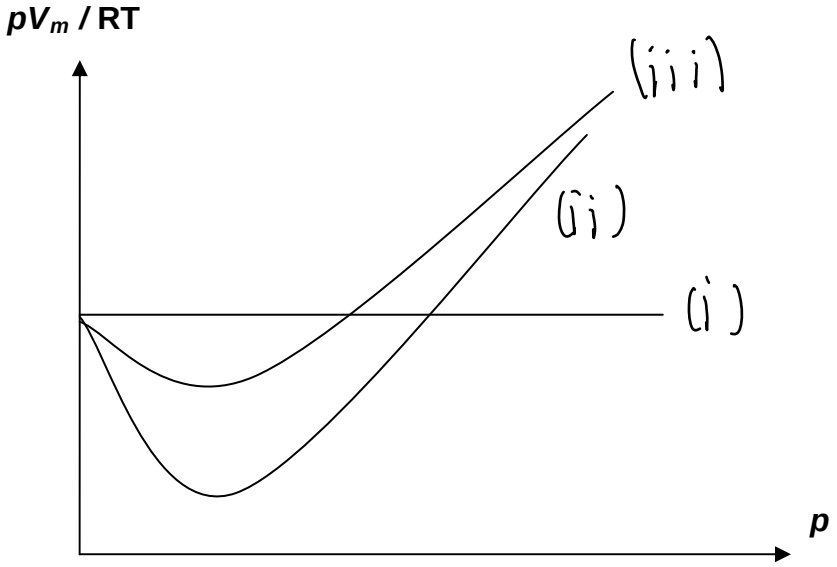
$I_2 : Cl^-$

2:3 x = 3

$ICl_3 + 3I^- \rightarrow 2I_2 + 3Cl^-$

[4]

(ii) Sketch on the same axes, the variation of pV_m / **RT** against p at 300K, for 1 mol of **(i)** an ideal gas and **(ii)** ICl_x gas. Label your graphs clearly where V_m is the gas molar volume.



[2]

(iii) Using the same axes as in **(b)(ii)**, show the change at 700K for one mol of ICl_x. Explain your sketch.

At a higher temperature, the **average K.E of ICl_x increases** and the **intermolecular forces of attractions** between the molecules become **less significant**.

[2]

[Total: 13]

2 This question is about a Group II element, barium and the reactions of its compounds.

(a) Write a balanced chemical equation, with state symbols, for the decomposition of barium nitrate.

$Ba(NO_3)_2 \rightarrow BaO(s) + 2NO_2(g) + ½\ O_2(g)$

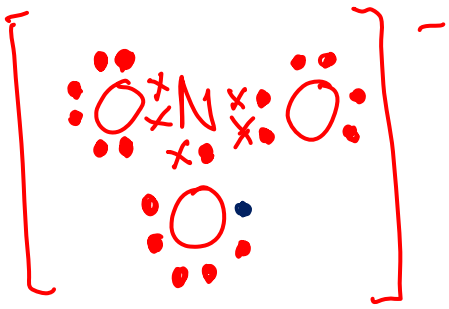
[1]

(b) How would you expect the decomposition temperature of barium nitrate to differ from that of calcium nitrate? Explain your answer.

Decomposition temperature of **barium nitrate will be higher** than **calcium nitrate.** Ba^{2+} has **lower polarizing power**, the nitrate electron cloud **polarized to a lower extent**, therefore easier to decompose, hence lower decomposition temp. Ca^{2+} **higher polarizing power due to smaller size** and hence nitrate anion is polarized to a larger extent.

[3]

(c) Draw the dot-and-cross diagram of the NO_3^- anion.



[2]

(d) The solid product formed in **(a)** reacts with dilute hydrochloric acid to give $BaCl_2$ and H_2O. Write a balanced chemical equation, with state symbols, for the reaction of $BaCl_2$ with concentrated sulfuric acid.

$BaCi_2(s) + \text{conc } H_2SO_4(l) \rightarrow 2HCl(g) + BaSO_4(s)$

[1]

(e) Predict the products formed from the reaction of barium bromide, $BaBr_2$ with concentrated sulfuric acid.

HBr, SO_2 or Br_2

[2]

(f) Suggest an explanation for the difference in products formed in **(d)** and **(e)**. Support your explanation with relevant data from the *Data Booklet*.

$Cl_2 + 2e \rightleftharpoons 2Cl^-$ $E^o = +1.36V$

$Br_2 + 2e \rightleftharpoons 2Br^-$ $E^o = +1.07V$

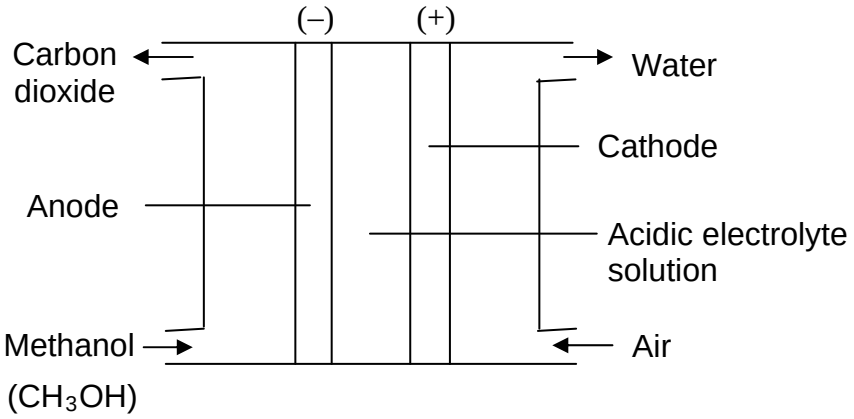
Br^- is a better reducing agents than Cl^-. Br^- can reduce conc. H_2SO_4 to SO_2 but not Cl^-.

$\Rightarrow$ Ease of oxidation from $X^- \rightarrow X_2$ increases from Cl^- to Br^- due to the less positive E^o value.

[3]

[Total: 12]

3 The technology behind Direct Methanol Fuel Cells (DMFC) is still in the early stages of development, but it has successfully powered mobile phones and laptop computers, the target end uses in future years. The fuel and oxygen are pumped continuously to the two electrodes which are made of platinum.



(a) Write equations for the reactions which take place for the fuel cell.

Anode: $CH_3OH\ (l) + H_2O\ (l) \rightarrow CO_2\ (g) + 6\ H^+\ (aq) + 6e^-$

Cathode: $O_2\ (g) + 4H^+\ (aq) + 4e \rightarrow 2H_2O\ (l)$

Overall: $2\ CH_3OH\ (l) + 3O_2\ (g) \rightarrow 2\ CO_2\ (g) + 4H_2O\ (l)$

[3]

(b) Write the cell diagram.

$Pt(s)\ I\ CH_3OH(l)\ I\ CO_2(g)\ I\ H^+\ (aq)\ I\ O_2(g)\ I\ H_2O(l)\ I\ Pt(s)$

[1]

(c) Give an advantage of the fuel cell with methanol as a fuel.

There is no carbon or CO formed in the fuel cell. Or No poisonous gases evolved.

[1]

[Total: 5]

4 Magnesium hydroxide, $Mg(OH)_2$, is sparingly soluble in water. The solubility product of magnesium hydroxide in water is 5.61×10^{-12} mol^3 dm^{-9}.

(a) Write an expression for the solubility product, K_{sp} of magnesium hydroxide.

$[Mg^{2+}][OH^-]^2$

[1]

(b) Calculate the solubility of magnesium hydroxide in g dm^{-3} for a saturated solution of magnesium hydroxide at 25°C.

Let the solubility be x.

$[Mg^{2+}][OH^-]^2 = 5.61 \times 10^{-12}$

$x(2x)^2 = 5.61 \times 10^{-12}$

$x = 1.119 \times 10^{-4}$ mol dm^{-3}

Solubility = 6.53×10^{-3} g

[2]

(c) Calculate the solubility of $Mg(OH)_2$ in 5.00×10^{-2} mol dm^{-3} aqueous sodium hydroxide.

Let the solubility of $Mg(OH)_2$ be x mol dm^{-3}.

$[Mg^{2+}][OH^-]^2 = 5.61 \times 10^{-12}$

$x(2x + 0.05)^2 = 5.61 \times 10^{-12}$

Assuming that x is so small such that $2x + 0.05 \sim 0.05$,

$x(0.05)^2 = 5.61 \times 10^{-12}$

$x = 2.24 \times 10^{-9}$ mol dm^{-3}

[2]

(d) Equal volumes of solutions containing 5.0×10^{-3} mol dm^{-3} magnesium nitrate and 6.0×10^{-3} mol dm^{-3} of sodium hydroxide are mixed. Predict if a precipitate will be formed. Explain your answer with the aid of relevant calculations.

$K_{sp} = [Mg^{2+}][OH^-]^2 = 5.61 \times 10^{-12}$ mol^2 dm^{-6}

On mixing aq $Mg(NO_3)_2$ and NaOH:

New $[Mg^{2+}]$ = V x 5.0 x 10^{-3} / 2V = 2.5 x 10^{-3} mol dm^{-3}
New $[OH^-]$ = V x 6.0 x 10^{-3} / 2V = 3 x 10^{-3} mol dm^{-3}

At saturation point, K_{sp} = Ionic product

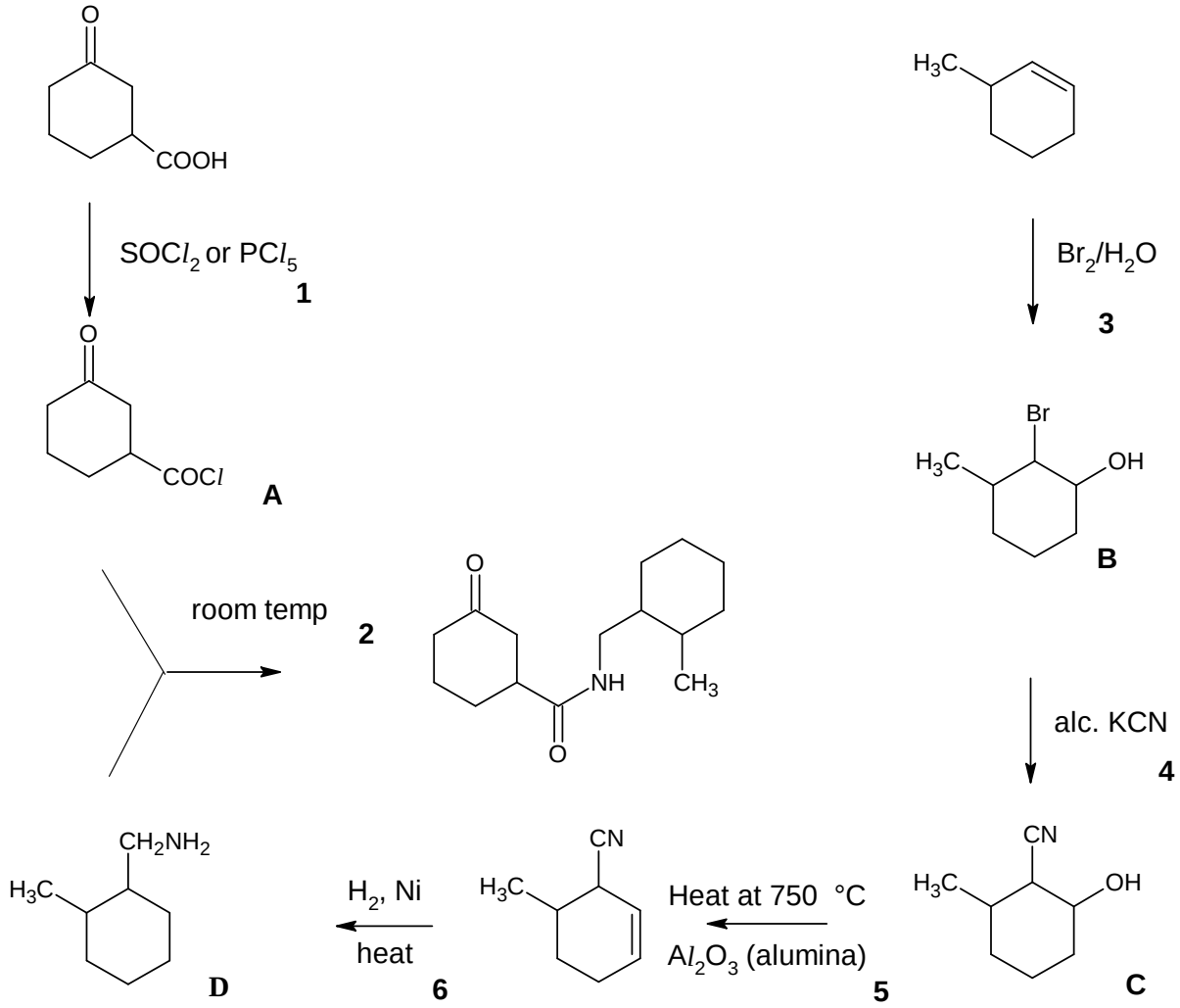
Ionic product = $[Mg^{2+}][OH^-]^2$
= 9 x 10^{-8}[1] >5.61 x 10^{-12} [1]

Yes there will be a ppt.

[3]

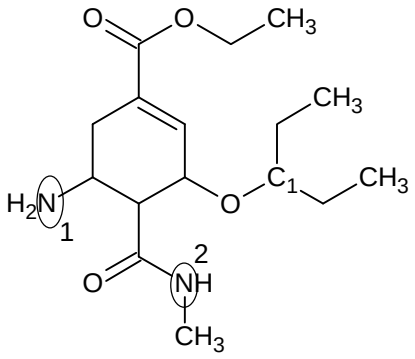
[Total: 8]

5 Complete the reaction scheme below by writing the structural formula of the organic products (**A-D**) and the reagents and conditions (**1-6**) in the spaces below.



Total: [10 marks]

6 **Oseltamivir** (Tamiflu) is an antiviral drug that slows the spread of non-resistant strains of the influenza virus between cells in the body. It blocks the action of a viral enzyme called neuraminidase and has since been indicated for the treatment of H5N1 and H1N1 infection. The standard adult dosage is 75mg twice daily.



Oseltamivir

M_r : 312.4

(a) (i) A male adult patient has been put on a 5-day tamiflu treatment. Calculate the total number of moles of tamiflu taken by this patient over this period of treatment.

No of moles = $(75 \times 10^{-3})/312.4 \times 2 \times 5$
= 0.00240 (3sf)

[1]

(ii) Name all the functional groups in oseltamivir.

Ester, alkene, ether, amine, amide

[4]

(iii) Neuraminidase is described as a tertiary protein. What is a tertiary protein?

Tertiary structure refers to the overall 3-dimensional shape of the protein molecule as a result of folding and coiling of the chains.

[1]

(iv) Describe the hybridisation, geometry and bond angle about C_1 atom.

sp^3

tetrahedral

109.5°

[3]

(v) Compare the basicity of N_1 and N_2 atom of oseltamivir. Explain which is more basic.

N_1 is more basic than N_2. The lone pair on N_1 is more readily available for donation than N_2 due to the presence of 2 alkyl (electron donating groups) on N_1. The availability of the lone pair on N_2 atom Is reduced by the presence of the carbonyl group.

[3]

Total: [10 marks]