(c) Epsom salts can be used as bath salts to help relieve aches and pains.

Epsom salts are crystals of hydrated magnesium sulfate, $MgSO_4 \cdot xH_2O$.

A sample of Epsom salts was heated to remove the water. 1.57 g of water was removed leaving behind 1.51 g of anhydrous $MgSO_4$.

(i) Calculate the amount, in mol, of anhydrous $MgSO_4$ formed.

amount = ... mol **[2]**

(ii) Calculate the amount, in mol, of H_2O removed.

amount = ... mol **[1]**

(iii) Calculate the value of *x* in $MgSO_4 \cdot xH_2O$.

x = ... **[1]**

2 Sodium tartrate and copper(II) nitrate are both salts.

(a) Sodium tartrate is a salt of tartaric acid. The formula of tartaric acid can be represented as H_xA. In this formula, x is the number of H^+ ions that can be replaced by metal ions to form salts.

A student carries out a titration to find the value of x in the formula of tartaric acid, H_xA.
In the titration, $25.00\,cm^3$ of $0.0500\,mol\,dm^{-3}$ tartaric acid, H_xA, exactly reacts with $12.50\,cm^3$ of $0.200\,mol\,dm^{-3}$ sodium hydroxide, NaOH. A solution of sodium tartrate is produced.

(i) Calculate the amount, in mol, of H_xA used.

amount = ... mol **[1]**

(ii) Calculate the amount, in mol, of NaOH used.

amount = ... mol **[1]**

(iii) Deduce the value for x in the formula of tartaric acid, H_xA.

$x =$ .... **[1]**

(b) A student carries out a titration to find the concentration of some sulfuric acid.

The student finds that 25.00 cm³ of 0.0880 mol dm⁻³ aqueous sodium hydroxide, NaOH, is neutralised by 17.60 cm³ of dilute sulfuric acid, H_2SO_4.

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$
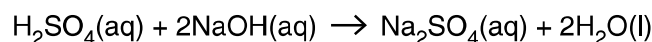
(i) Calculate the amount, in moles, of NaOH used.

answer = ... mol **[1]**

(ii) Determine the amount, in moles, of H_2SO_4 used.

answer = ... mol **[1]**

(iii) Calculate the concentration, in mol dm⁻³, of the sulfuric acid.

answer = ... mol dm⁻³ **[1]**

(c) After carrying out the titration in **(b)**, the student left the resulting solution to crystallise. White crystals were formed, with a formula of $Na_2SO_4 \cdot xH_2O$ and a molar mass of 322.1 g mol⁻¹.

(i) What term is given to the '•xH$_2$O' part of the formula?

.... **[1]**

(ii) Using the molar mass of the crystals, calculate the value of x.

answer = ... **[2]**

[Total: 10]

2 Hydrated aluminium sulfate, $Al_2(SO_4)_3{\cdot}xH_2O$, and chlorine, Cl_2, are used in water treatment.

(a) A student attempts to prepare hydrated aluminium sulfate by the following method.

- The student heats dilute sulfuric acid with an excess of solid aluminium oxide.

- The student filters off the excess aluminium oxide to obtain a colourless solution of $Al_2(SO_4)_3$.

(i) State the formulae of the two **main** ions present in the solution of $Al_2(SO_4)_3$.

.... and .... [2]

(ii) Write an equation for the reaction of aluminium oxide, Al_2O_3, with sulfuric acid.

Include state symbols.

.... [2]

(iii) What does '$\cdot xH_2O$' represent in the formula $Al_2(SO_4)_3{\cdot}xH_2O$?

....

.... [1]

(iv) The student heats 12.606 g of $Al_2(SO_4)_3{\cdot}xH_2O$ crystals to constant mass.

The anhydrous aluminium sulfate formed has a mass of 6.846 g.

Use the student's results to calculate the value of x.

The molar mass of $Al_2(SO_4)_3 = 342.3\,g\,mol^{-1}$.

x = ... [3]