3 A student makes crystals of the salt sodium sulfate, Na_2SO_4. The student reacts 0.200 mol / dm^3 dilute sulfuric acid, $H_2SO_4(aq)$, with aqueous sodium hydroxide, NaOH(aq).

The student uses the following steps.

step 1 The student places 40.0 cm^3 of NaOH(aq) into a conical flask. This volume contains 0.0100 moles of NaOH.

step 2 The student adds a few drops of methyl orange indicator to the NaOH(aq) in the conical flask.

step 3 The student adds 0.200 mol / dm^3 $H_2SO_4(aq)$ to the flask until the end-point is reached.

step 4 The student transfers the mixture from the conical flask to an evaporating basin and obtains dry crystals.

(a) Complete the symbol equation for the reaction. Include state symbols.

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(.....) + ...(.....)$$

[2]

(b) State the type of exothermic reaction taking place.

..... [1]

(c) Calculate the concentration of NaOH(aq) used in **step 1**.

concentration of NaOH(aq) = ... mol / dm^3 [1]

(d) Name the item of apparatus the student uses to add $H_2SO_4(aq)$ in **step 3**.

..... [1]

(e) Calculate the volume of $H_2SO_4(aq)$, in cm^3, added in **step 3**.

volume of $H_2SO_4(aq)$ = ... cm^3 [2]

(f) State the colour change observed in **step 3**.

from ..... to ..... [2]

(g) The dry crystals formed in **step 4** are coloured and **not** white. This is because the student should do an additional step between **step 3** and **step 4**.

Suggest what the student should do in this additional step to produce white crystals.

.....

..... [1]

(h) In **step 4**, the student gently heats the solution in the evaporating basin until the solution is saturated. The student then stops heating and leaves the hot solution to cool. Crystals start to appear.

(i) Explain the term saturated solution.

.....

.....

..... [2]

(ii) Explain why crystals start to appear as the hot solution cools.

.....

..... [1]

(iii) Suggest the effect, if any, on the mass of crystals collected in **step 4** if the solution in the evaporating basin is allowed to dry without gentle heating.

..... [1]

[Total: 14]