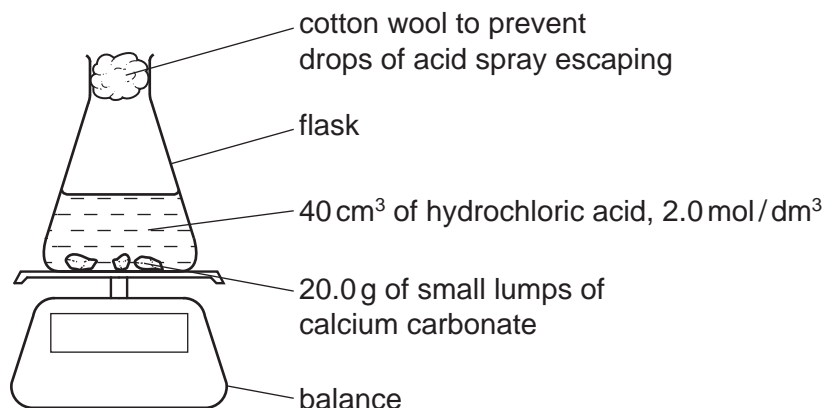**1** 20.0 g of small lumps of calcium carbonate and 40 cm³ of hydrochloric acid, concentration 2.0 mol/dm³, were placed in a flask on a top pan balance. The mass of the flask and contents was recorded every minute.

cotton wool to prevent
drops of acid spray escaping

flask

40 cm³ of hydrochloric acid, 2.0 mol/dm³

20.0 g of small lumps of
calcium carbonate

balance

The mass of carbon dioxide given off was plotted against time.

mass of
carbon dioxide

0

0   time

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$
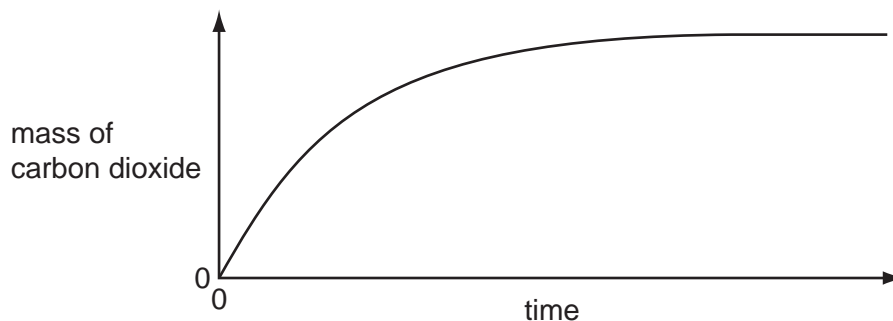
In all the experiments mentioned in this question, the calcium carbonate was in excess.

(a) Explain how you could determine the mass of carbon dioxide given off in the first five minutes.

.... [1]

(ii) Label the graph **F** where the reaction rate is the fastest, **S** where it is slowing down and **0** where the rate is zero. [2]

(iii) Explain how the shape of the graph shows where the rate is fastest, where it is slowing down and where the rate is zero.

....

....

.... [2]

(b) Sketch on the same graph, the line which would have been obtained if 20.0 g of small lumps of calcium carbonate and 80 cm³ of hydrochloric acid, concentration 1.0 mol/dm³, had been used. [2]

(c) Explain in terms of collisions between reacting particles each of the following.

    (i) The reaction rate would be slower if 20.0 g of larger lumps of calcium carbonate and 40 cm³ of hydrochloric acid, concentration 2.0 mol/dm³, were used.

    ....

    ....

    .... [2]

    (ii) The reaction rate would be faster if the experiment was carried out at a higher temperature.

    ....

    ....

    .... [2]

(d) Calculate the maximum mass of carbon dioxide given off when 20.0 g of small lumps of calcium carbonate react with 40 cm³ of hydrochloric acid, concentration 2.0 mol/dm³.

$$CaCO_3(s) \ + \ 2HCl(aq) \ \rightarrow \ CaCl_2(aq) \ + \ H_2O(l) \ + \ CO_2(g)$$

number of moles of HCl used =

mass of carbon dioxide = ... g [4]

[Total: 15]

2 Soluble salts can be made by the neutralisation of an acid by a base. Insoluble salts can be made by precipitation.

(a) The following is a brief description of the preparation of the soluble salt, nickel(II) chloride-6-water, from the insoluble base nickel(II) carbonate.

Nickel(II) carbonate is added in small amounts to hot dilute hydrochloric acid until it is in excess. The mixture is filtered. The filtrate is partially evaporated and then allowed to cool until crystals of nickel(II) chloride-6-water form.

(i) Why is it necessary to use excess carbonate?

....

.... [1]

(ii) Explain why it is necessary to filter.

.... [1]

(iii) Why partially evaporate rather than evaporate to dryness?

....

.... [1]

(iv) What additional steps are needed to obtain dry crystals?

....

.... [2]

(b) Potassium chloride can be made from hydrochloric acid and potassium carbonate.

(i) Why must a different experimental method be used for this preparation?

....

.... [1]

(ii) Give a description of the different method used for this salt preparation.

....

....

....

.... [4]

(c) Insoluble salts are made by precipitation. An equation for the preparation of barium sulfate is given below.

$$BaCl_2(aq) + MgSO_4(aq) \rightarrow BaSO_4(s) + MgCl_2(aq)$$
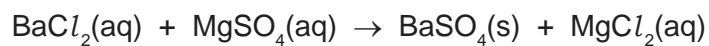
This reaction can be used to find x in the formula for hydrated magnesium sulfate $MgSO_4.xH_2O$.

A known mass of hydrated magnesium sulfate, $MgSO_4.xH_2O$, was dissolved in water. Excess aqueous barium chloride was added. The precipitate of barium sulfate was filtered, washed and dried. Finally it was weighed.

Mass of hydrated magnesium sulfate = 1.476 g

Mass of barium sulfate formed = 1.398 g

The mass of one mole of $BaSO_4$ = 233 g

The number of moles of $BaSO_4$ formed = ...   [1]

The number of moles of $MgSO_4.xH_2O$ = ...   [1]

The mass of one mole of $MgSO_4.xH_2O$ = ... g   [1

The mass of one mole of $MgSO_4$ = 120 g

The mass of xH_2O in one mole of $MgSO_4.xH_2O$ = ...   [1]

x = ...   [1]

[Total: 15]

3 Titanium is a transition element. It is isolated by the following reactions.

titanium ore → titanium(IV) oxide → titanium(IV) chloride → titanium

 TiO_2 $TiCl_4$ Ti
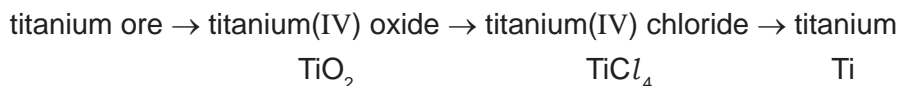
(a) Why is it usually necessary to include a number in the name of the compounds of transition elements?

.... [1]

(b) Titanium(IV) chloride is made by heating the oxide with coke and chlorine.

$$TiO_2 + 2Cl_2 \rightleftharpoons TiCl_4 + O_2$$

$$2C + O_2 \rightleftharpoons 2CO$$
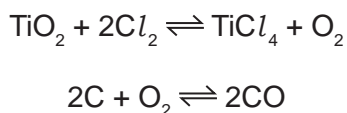
Explain why the presence of coke ensures the maximum yield of the metal chloride.

....

....

.... [2]

(c) Explain why the change, titanium(IV) chloride to titanium, is reduction.

....

.... [1]

(d) Complete the table which shows some of the properties of titanium and its uses.
The first line has been completed as an example.

property	related use
soluble in molten steel	making steel titanium alloys
....	making aircraft and space vehicles
resistant to corrosion, especially in sea water	....

[2]

(e) The titanium ore contains 36.8% iron, 31.6% titanium and the remainder is oxygen.

   (i) Determine the percentage of oxygen in this titanium compound.

   percentage of oxygen = ... %   [1]

   (ii) Calculate the number of moles of atoms for each element.
   The number of moles of Fe is shown as an example.
   number of moles of Fe = 36.8/56 = 0.66

   number of moles of Ti   = ...

   number of moles of O   = ... [1]

   (iii) What is the simplest ratio for the moles of atoms?

   Fe   :   Ti

   ....
                                                                [1]

   (iv) What is the formula of this titanium compound?

   .... [1]

[Total: 10]

4 Soluble salts can be made using a base and an acid.

(a) Complete this method of preparing dry crystals of the soluble salt cobalt(II) chloride-6-water from the insoluble base cobalt(II) carbonate.

Step 1
Add an excess of cobalt(II) carbonate to hot dilute hydrochloric acid.

Step 2

....

....

Step 3

....

....

Step 4

....

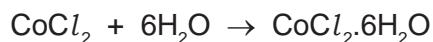.. [4]

(b) 6.0 g of cobalt(II) carbonate was added to 40 cm³ of hydrochloric acid, concentration 2.0 mol / dm³. Calculate the maximum yield of cobalt(II) chloride-6-water and show that the cobalt(II) carbonate was in excess.

$$CoCO_3 + 2HCl \rightarrow CoCl_2 + CO_2 + H_2O$$

$$CoCl_2 + 6H_2O \rightarrow CoCl_2.6H_2O$$

Maximum yield

Number of moles of HCl used = ...

Number of moles of $CoCl_2$ formed = ...

Number of moles of $CoCl_2.6H_2O$ formed = ...

Mass of one mole of $CoCl_2.6H_2O$ = 238 g

Maximum yield of $CoCl_2.6H_2O$ = ... g   [4]

To show that cobalt(II) carbonate is in excess

Number of moles of HCl used = ... (use value from above)

Mass of one mole of $CoCO_3$ = 119 g

Number of moles of $CoCO_3$ in 6.0 g of cobalt(II) carbonate = ...   [1]

Explain why cobalt(II) carbonate is in excess ....

.... [1]

[Total: 10]