1 Calcium carbonate (limestone) decomposes when heated.

$$CaCO_3 \rightarrow CaO + CO_2$$

When 20.0 g of calcium carbonate are decomposed, 11.2 g of calcium oxide (lime), CaO, are formed.

Calculate the mass of calcium oxide formed when 160.0 g of calcium carbonate are decomposed.

..... g [1]

[Total: 1]

2 Some car airbags contain sodium azide.
When a car airbag is used the sodium azide, NaN_3, decomposes.
The products are nitrogen and sodium.

The equation for the decomposition of sodium azide is shown.

$$2NaN_3(s) \rightarrow 2Na(l) + 3N_2(g)$$

Calculate the mass, in g, of sodium azide needed to produce 144 dm^3 of nitrogen using the following steps.

(a) Calculate the number of moles in 144 dm^3 of N_2 measured at room temperature and pressure.

moles of N_2 = ...mol [1]

(b) Determine the number of moles of NaN_3 needed to produce this number of moles of N_2.

moles of NaN_3 = ...mol [1]

(c) Calculate the relative formula mass, M_r, of NaN_3.

M_r = ... [1]

(d) Calculate the mass of NaN_3 needed to produce 144 dm^3 of N_2.

.....g [1]

[Total: 4]

3 Titanium is extracted from an ore called rutile. Rutile is an impure form of titanium(IV) oxide, TiO_2.

Calculate the volume of chlorine gas, $Cl_2(g)$, at room temperature and pressure, that reacts completely with 400 g of $TiO_2(s)$ using the following steps.

$$TiO_2(s) + 2Cl_2(g) + 2C(s) \rightarrow TiCl_4(g) + 2CO(g)$$

(a) Calculate the relative formula mass, *M*r, of TiO_2.

*M*r of TiO_2 = ... [1]

(b) Calculate the number of moles in 400 g of TiO_2.

..... mol [1]

(c) Determine the number of moles of Cl_2 that react with 400 g of TiO_2.

moles of Cl_2 = ... mol [1]

(d) Calculate the volume of Cl_2 that reacts with 400 g of TiO_2.

volume of Cl_2 = ... dm^3 [1]

[Total: 4]

4 Dilute sulfuric acid reacts with aqueous sodium hydrogencarbonate in a neutralisation reaction.

$$H_2SO_4(aq) + 2NaHCO_3(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) + 2CO_2(g)$$

In a titration, 0.200 mol / dm^3 aqueous sodium hydrogencarbonate was used to neutralise 20.0 cm^3 of dilute sulfuric acid of concentration 0.150 mol / dm^3.

(a) Calculate the number of moles of dilute sulfuric acid used in the titration.

.....mol [1]

(b) Calculate the number of moles of sodium hydrogencarbonate needed to neutralise the dilute sulfuric acid.

.....mol [1]

(c) Calculate the volume, in cm^3, of 0.200 mol / dm^3 aqueous sodium hydrogencarbonate needed to neutralise the dilute sulfuric acid.

.....cm^3 [1]

[Total: 3]

5 Iron(II) sulfate decomposes when heated strongly.

$$2FeSO_4(s) \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$$

15.20 g of $FeSO_4(s)$ was heated and formed 4.80 g of $Fe_2O_3(s)$.

[M_r, $FeSO_4$ = 152; M_r, Fe_2O_3 = 160]

Calculate the percentage yield for this reaction.

..... % [3]

[Total: 3]

6 In a titration, a student added 25.0 cm^3 of 0.200 mol / dm^3 aqueous sodium hydroxide to a conical flask. The student then added a few drops of methyl orange to the solution in the conical flask. Dilute sulfuric acid was then added from a burette to the conical flask. The volume of dilute sulfuric acid needed to neutralise the aqueous sodium hydroxide was 20.0 cm^3.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

(a) What was the colour of the methyl orange in the aqueous sodium hydroxide?

..... [1]

(b) Determine the concentration of the dilute sulfuric acid in g/dm^3.

Calculate the number of moles of aqueous sodium hydroxide added to the conical flask.

..... mol

Calculate the number of moles of dilute sulfuric acid added from the burette.

..... mol

Calculate the concentration of the dilute sulfuric acid in mol/dm^3.

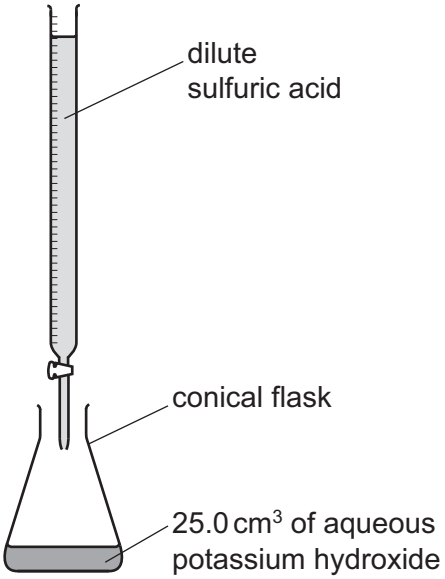
..... mol/dm^3

Calculate the concentration of the dilute sulfuric acid in g/dm^3.

..... g/dm^3 [4]

[Total: 5]

7 Dilute sulfuric acid and aqueous potassium hydroxide can be used to make potassium sulfate crystals using a method that includes titration.



A student titrated 25.0 cm^3 of 0.0500 mol / dm^3 aqueous potassium hydroxide with dilute sulfuric acid in the presence of an indicator. The volume of dilute sulfuric acid needed to neutralise the aqueous potassium hydroxide was 20.0 cm^3.

The equation for the reaction is shown.

$$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$$

Determine the concentration of the dilute sulfuric acid using the following steps.

(a) Calculate the number of moles of aqueous potassium hydroxide used.

..... mol [1]

(b) Calculate the number of moles of dilute sulfuric acid needed to neutralise the aqueous potassium hydroxide.

..... mol [1]

(c) Calculate the concentration of the dilute sulfuric acid.

..... mol/dm^3 [1]

(d) After the titration has been completed, the conical flask contains an aqueous solution of potassium sulfate and some of the dissolved indicator.

Describe how to prepare a pure, dry sample of potassium sulfate crystals from new solutions of dilute sulfuric acid and aqueous potassium hydroxide of the same concentrations as used in the titration. Include a series of key steps in your answer.

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 8]

8 Another oxide of phosphorus has the empirical formula P_2O_3.

One molecule of this oxide of phosphorus contains four atoms of phosphorus.

Calculate the mass of **one** mole of this oxide of phosphorus.

mass = ... g [2]

[Total: 2]

9 A 0.095 g sample of gaseous element **Y** occupies 60.0 cm^3 at room temperature and pressure.

(a) Determine the number of moles of element **Y** in 60.0 cm^3.

moles of element **Y** = ... mol [1]

(b) Calculate the relative molecular mass of element **Y** and hence suggest the identity of element **Y**.

relative molecular mass = ...

identity of element **Y** = ... [2]

[Total: 3]

10 A 1.68 g sample of phosphorus was burned and formed 3.87 g of an oxide of phosphorus.

Calculate the empirical formula of this oxide of phosphorus.

empirical formula = ... [4]

[Total: 4]

11 Many organic compounds, such as alcohols, carboxylic acids and esters, contain the elements carbon, hydrogen and oxygen only.

Compound **R** has the following composition by mass: C, 60.00%; H, 13.33%; O, 26.67%.

Calculate the empirical formula of compound **R**.

empirical formula = ... [2]

[Total: 2]

12 Many organic compounds, such as alcohols, carboxylic acids and esters, contain the elements carbon, hydrogen and oxygen only.

Compound **S** has the empirical formula C_2H_4O and a relative molecular mass of 88.

Calculate the molecular formula of compound **S**.

molecular formula = ... [2]

[Total: 2]

13 The equation for the reaction between calcium carbonate and hydrochloric acid is shown.

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

How many moles of calcium carbonate will give 24 cm^3 of carbon dioxide when reacted with an excess of the acid?

A 1 mol **B** 0.1 mol **C** 0.01 mol **D** 0.001 mol

[1]

[Total: 1]

14 A compound, X, contains 40.0 % carbon, 6.7 % hydrogen and 53.3 % oxygen by mass.

The relative molecular mass, M_r, of X is 60.

What is the molecular formula of X?

A CH_2O **B** CH_4O **C** C_2H_4O **D** $C_2H_4O_2$

[1]

[Total: 1]

15 25 cm^3 of 0.1 mol/dm^3 hydrochloric acid exactly neutralises 20 cm^3 of aqueous sodium hydroxide.

The equation for this reaction is shown.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

What is the concentration of the sodium hydroxide solution?

A 0.080 mol/dm^3

B 0.800 mol/dm^3

C 0.125 mol/dm^3

D 1.25 mol/dm^3

[1]

[Total: 1]

16 Alkenes can be made from alkanes by cracking.

(a) Explain the term *cracking*.

.....

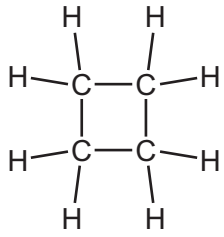
..... [2]

(b) One mole of an alkane, when cracked, produced one mole of hexane, C_6H_{14}, and two moles of ethene.
What is the molecular formula of the original alkane?

..... [1]

[Total: 3]

17 A hydrocarbon has the following structural formula.



(a) State the molecular formula and the empirical formula of this hydrocarbon.

molecular formula.....

empirical formula..... [2]

(b) Draw the structural formula of an isomer of the above hydrocarbon.

[1]

(c) Explain why these two hydrocarbons are isomers.

.....

..... [2]

(d) Are these two hydrocarbons members of the same homologous series?
Give a reason for your choice.

.....

..... [1]

[Total: 6]

18 Esters, polyesters and fats all contain the ester linkage.

Esters can be made from alcohols and carboxylic acids. For example, the ester ethyl ethanoate can be made by the following reaction.

$$CH_3COOH + CH_3CH_2OH \rightarrow CH_3COOCH_2CH_3 + H_2O$$

6.0 g of ethanoic acid, M_r = 60, was reacted with 5.5 g of ethanol, M_r = 46.
Determine which is the limiting reagent and the maximum yield of ethyl ethanoate, M_r = 88.

number of moles of ethanoic acid = ... [1]

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

the limiting reagent

is ..... [1]

number of moles of ethyl ethanoate formed

= ..... [1]

maximum yield of ethyl ethanoate

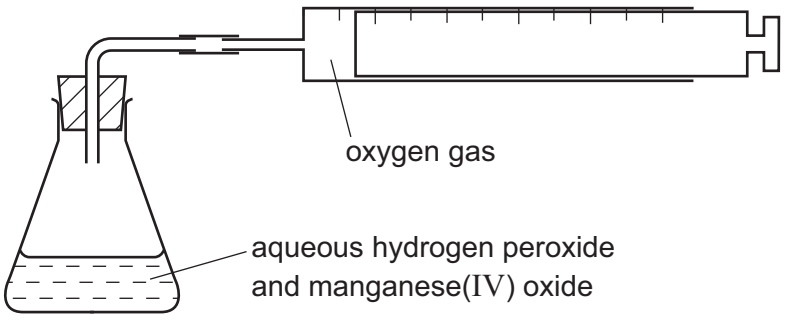
= ..... [1] [5]

[Total: 5]

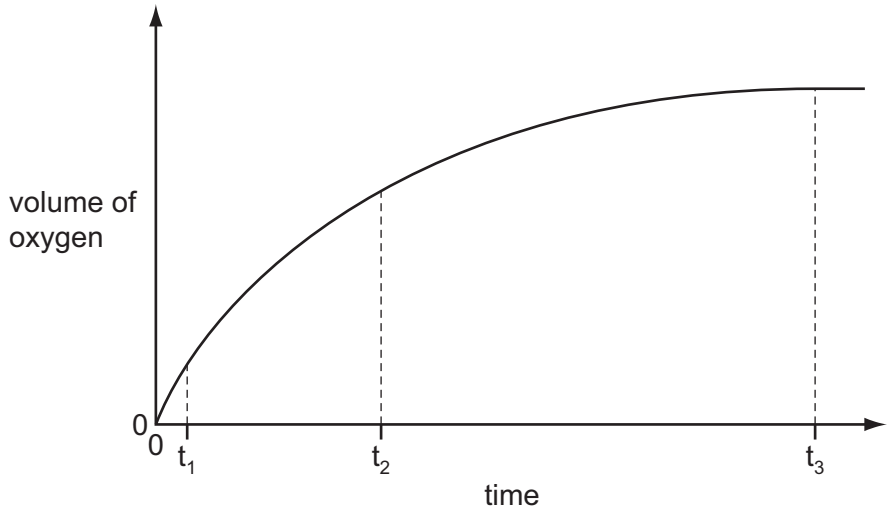
19 Hydrogen peroxide decomposes to form water and oxygen. This reaction is catalysed by manganese(IV) oxide.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The rate of this reaction can be investigated using the following apparatus.



40 cm^3 of aqueous hydrogen peroxide was put in the flask and 0.1 g of small lumps of manganese(IV) oxide was added.
The volume of oxygen collected was measured every 30 seconds. The results were plotted to give the graph shown below.



(a) **(i)** How do the rates at times t_1, t_2 and t_3 differ?

.....

..... [2]

(ii) Explain the trend in reaction rate that you described in **(a)(i)**.

.....

.....

..... [2]

(b) The experiment was repeated using 0.1 g of finely powdered manganese(IV) oxide. All the other variables were kept the same.

(i) On the axes, sketch the graph that would be expected.

[2]

(ii) Explain the shape of this graph.

.....

.....

.....

..... [2]

(c) Describe how you could show that the catalyst, manganese(IV) oxide, was not used up in the reaction. Manganese(IV) oxide is insoluble in water.

.....

.....

.....

.....

..... [4]

(d) In the first experiment, the maximum volume of oxygen produced was 96 cm^3 measured at r.t.p. Calculate the concentration of the aqueous hydrogen peroxide in mol / dm^3.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

(i) number of moles of O_2 formed = ... [1]

(ii) number of moles of H_2O_2 in 40 cm^3 of solution = ... [1]

(iii) concentration of the aqueous hydrogen peroxide in mol / dm^3 = ... [1]

[Total: 15]