CALCULATE VOLUME

4.3.1

Each tablet contains the same number of moles of $CaCO_3$ and $MgCO_3$. One tablet reacted with excess hydrochloric acid to produce 0.24 dm^3 of carbon dioxide at r.t.p.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$
$$MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$$

(i) Calculate how many moles of $CaCO_3$ there are in one tablet.

number of moles CO_2 = ...

number of moles of $CaCO_3$ and $MgCO_3$ = ...

number of moles of $CaCO_3$ = ...

[3]

(ii) Calculate the volume of hydrochloric acid, 1.0 mol / dm^3, needed to react with one tablet.

number of moles of $CaCO_3$ and $MgCO_3$ in one tablet = ...
Use your answer to **(c)(i)**.

number of moles of HCl needed to react with one tablet = ...

volume of hydrochloric acid, 1.0 mol / dm^3, needed to react with one tablet = ...

[2]

(i) number of moles CO_2 = 0.24/24 = 0.01
conseq number of moles of $CaCO_3$ and $MgCO_3$ = 0.01
conseq number of moles of $CaCO_3$ = 0.005 [3]

(ii) Calculate the volume of hydrochloric acid, 1.0 mole/dm^3, needed to react with one tablet.
number of moles of $CaCO_3$ and $MgCO_3$ in one tablet = 0.01
Expect same as answer to (c)(i). NO marks to be awarded. Just mark consequentially to this response
conseq number of moles of HC*l* needed
to react with one tablet = 0.02 [1]

conseq volume of hydrochloric acid, 1.0 mole/dm^3, needed to react with one tablet = 0.02 dm^3 or 20 cm^3 [1]

4.3.2

Chemists use the concept of the mole to calculate the amounts of chemicals involved in a reaction.

(a) Define *mole*.

.....

[1]

(b) 3.0 g of magnesium was added to 12.0 g of ethanoic acid.

$Mg + 2CH_3COOH \rightarrow (CH_3COO)_2Mg + H_2$

The mass of one mole of Mg is 24 g.

The mass of one mole of CH_3COOH is 60 g.

(i) Which one, magnesium or ethanoic acid, is in excess? You must show your reasoning.

.....

[3]

(ii) How many moles of hydrogen were formed?

.....

[1]

(iii) Calculate the volume of hydrogen formed, measured at r.t.p.

.....

[2]

(c) In an experiment, 25.0 cm^3 of aqueous sodium hydroxide, 0.4 mol/dm^3, was neutralised by 20.0 cm^3 of aqueous oxalic acid, $H_2C_2O_4$.

$$2NaOH + H_2C_2O_4 \rightarrow Na_2C_2O_4 + 2H_2O$$

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

(i) Calculate the number of moles of NaOH in 25.0 cm^3 of 0.4 mol/dm^3 solution.

.....

[1]

(ii) Use your answer to **(i)** and the mole ratio in the equation to find out the number of moles of $H_2C_2O_4$ in 20 cm^3 of solution.

.....

[1]

(iii) Calculate the concentration, mol/dm^3, of the aqueous oxalic acid.

.....

[2]

(a) Avogadro's Number of particles
or formula mass in grams
or 6×10^{23} particles accept atoms, ions and molecules
or as many particles as there are carbon atoms in 12.00g of ^{12}Ca
ANY one **[1]**

(b) **(i)** moles of Mg = 3/24 = 0.125
moles of CH_3COOH = 12/60 = 0.200
magnesium is in excess

OR 3.0g of magnesium react with 15g of acid
only 12.0 g of acid present
magnesium is in excess **[3]**

(ii) **Mark conseq to (i) but NOT to any simple integer**
moles of H_2 = 0.1 **[1]**

(iii) **Mark conseq to (ii) but NOT to any simple integer**
Volume of hydrogen = 0.1 x 24
= 2.4 dm^3 **[2]**

(c) **(i)** moles of NaOH = 25/1000 x 0.4 = 0.01 **[1]**

(ii) **Mark conseq to (i) but NOT to any simple integer**
moles of acid = 0.01/2 = 0.005 **[1]**

(iii) **Mark conseq to (ii) max 10M**
concentration of acid = 0.005 x 1000/20 **[1]**
= 0.25 mol/dm^3 **[1]**

TOTAL = [10]

4.3.3

(a) A small piece of marble, calcium carbonate, was added to 5 cm^3 of hydrochloric acid a 25 °C. The time taken for the reaction to stop was measured.

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

(i) One piece of marble, 0.3 g, was added to 5 cm^3 of hydrochloric acid, concentration 1.00 mol / dm^3. Which reagent is in excess? Give a reason for your choice.

mass of one mole of $CaCO_3$ = 100 g

number of moles of $CaCO_3$ = ...

number of moles of HCl = ...

reagent in excess is .....

reason ..... [4]

(ii) Use your answer to **(ii)** to calculate the maximum volume of carbon dioxide produced measured at r.t.p.

..... [1]

(i) mass of one mole of $CaCO_3$ = 100
number of moles of $CaCO_3$ = 0.3/100 = 0.003 [1]
moles of HCl = 5/1000 x 1 = 0.005 [1]
reagent in excess is $CaCO_3$ [1]
ecf from above
would need 0.006 moles of HCl
or hydrochloric acid only reacts with 0.0025 moles of $CaCO_3$ [1]
NOTE this mark needs to show recognition of the 1:2 ratio

(ii) mark **ecf** to **(ii)**, that is from moles of limiting reagent in **(ii)**
moles of CO_2 = 0.005 x 0.5 x 24 = 0.06 dm^3 [1]
NOT cm^3 unless numerically correct. 60 cm^3
Ignore other units
NOTE If both number of moles integers then no ecf for **(ii)** and **(iii)**

4.3.4

Sulfuric acid was first made in the Middle East by heating the mineral, green vitriol, $FeSO_4.7H_2O$. The gases formed were cooled.

$FeSO_4.7H_2O(s) \rightarrow FeSO_4(s) + 7H_2O(g)$
green crystals yellow powder

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

On cooling

$SO_3 + H_2O \rightarrow H_2SO_4$ sulfuric acid
$SO_2 + H_2O \rightarrow H_2SO_3$ sulfurous acid

9.12 g of anhydrous iron(II) sulfate was heated. Calculate the mass of iron(III) oxide formed and the volume of sulfur trioxide, at r.t.p., formed.

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

mass of one mole of $FeSO_4$ = 152 g

number of moles of $FeSO_4$ used = ...

number of moles of Fe_2O_3 formed = ...

mass of one mole of Fe_2O_3 = ... g

mass of iron(III) oxide formed = ... g

number of moles of SO_3 formed = ...

volume of sulfur trioxide formed = ... dm^3

[6]

number of moles of $FeSO_4$ used = 9.12/152 = 0.06	[1]
number of moles of Fe_2O_3 formed = 0.03*	[1]
mass of one mole of Fe_2O_3 = 160 g	[1]
mass of iron(III) oxide formed = 0.03 × 160 = 4.8 g	[1]
number of moles of SO_3 formed = 0.03	[1]
volume of sulfur trioxide formed = 0.03 × 24 = 0.72 dm^3	[1]

If mass of iron(III) oxide greater than 9.12 g, then only marks 1 and 2 available

Apply **ecf** to number of moles of Fe_2O_3* when calculating volume of sulfur trioxide.
Do not apply **ecf** to integers

4.3.5

Ethanol is manufactured from glucose, $C_6H_{12}O_6$, by fermentation according to the following equation.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

In an experiment, 30.0

(i) Calculate the number of moles of glucose in 30.0 g.

g of glucose was fermented.

..... mol [2]

(ii) Calculate the maximum mass of ethanol that could be obtained from 30.0 g of glucose.

..... g [2]

(iii) Calculate the volume of carbon dioxide at room temperature and pressure that can be obtained from 30.0 g of glucose.

..... dm^3 [1]

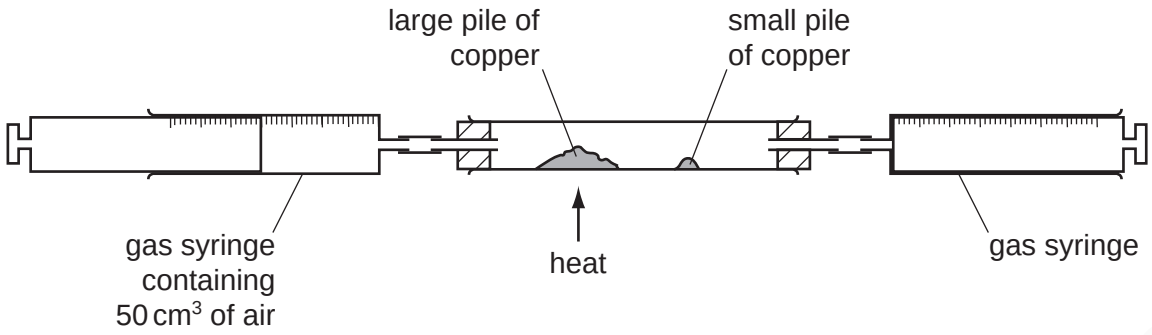
(i) Mr = 180 (1) (30/180) = 0.167 (1) [2]

(ii) 2 × 0.167 or 2 × 46 or 0.333 or 92 [1]

(2 × 0.167 × 46) = 15.3(33) (g) [1]

(iii) (2 × 0.167 × 24) = 8 (dm^3) [1]

4.3.6 The percentage of oxygen in air can be determined by the following experiment.



The gas syringe contains 50 cm^3 of air. The large pile of copper is heated and the air is passed from one gas syringe to the other over the hot copper. The large pile of copper turns black. The gas is allowed to cool and its volume measured.

The small pile of copper is heated and the remaining gas passed over the hot copper. The copper does not turn black. The final volume of gas left in the apparatus is less than 50 cm^3.

What is the approximate volume of the gas left in the apparatus?

..... [1]

39–40 cm^3 **note:** units required [1]

4.3.7

The alkanes are generally unreactive. Their reactions include combustion, substitution and cracking.

(a) The complete combustion of an alkane gives carbon dioxide and water.

(i) 10 cm^3 of butane is mixed with 100 cm^3 of oxygen, which is an excess. The mixture is ignited. What is the volume of unreacted oxygen left and what is the volume of carbon dioxide formed?

$$C_4H_{10}(g) + 6\tfrac{1}{2}O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$$

Volume of oxygen left = ... cm^3

Volume of carbon dioxide formed = ... cm^3 [2]

(ii) Why is the incomplete combustion of any alkane dangerous, particularly in an enclosed space?

.....

[2]

(a) (i) $35\,cm^3$ [1]
$40\,cm^3$ [1]

(ii) forms carbon monoxide [1]

poisonous **or** toxic **or** lethal **or** prevents blood carrying oxygen
or effect on haemoglobin [1]
NOT just harmful