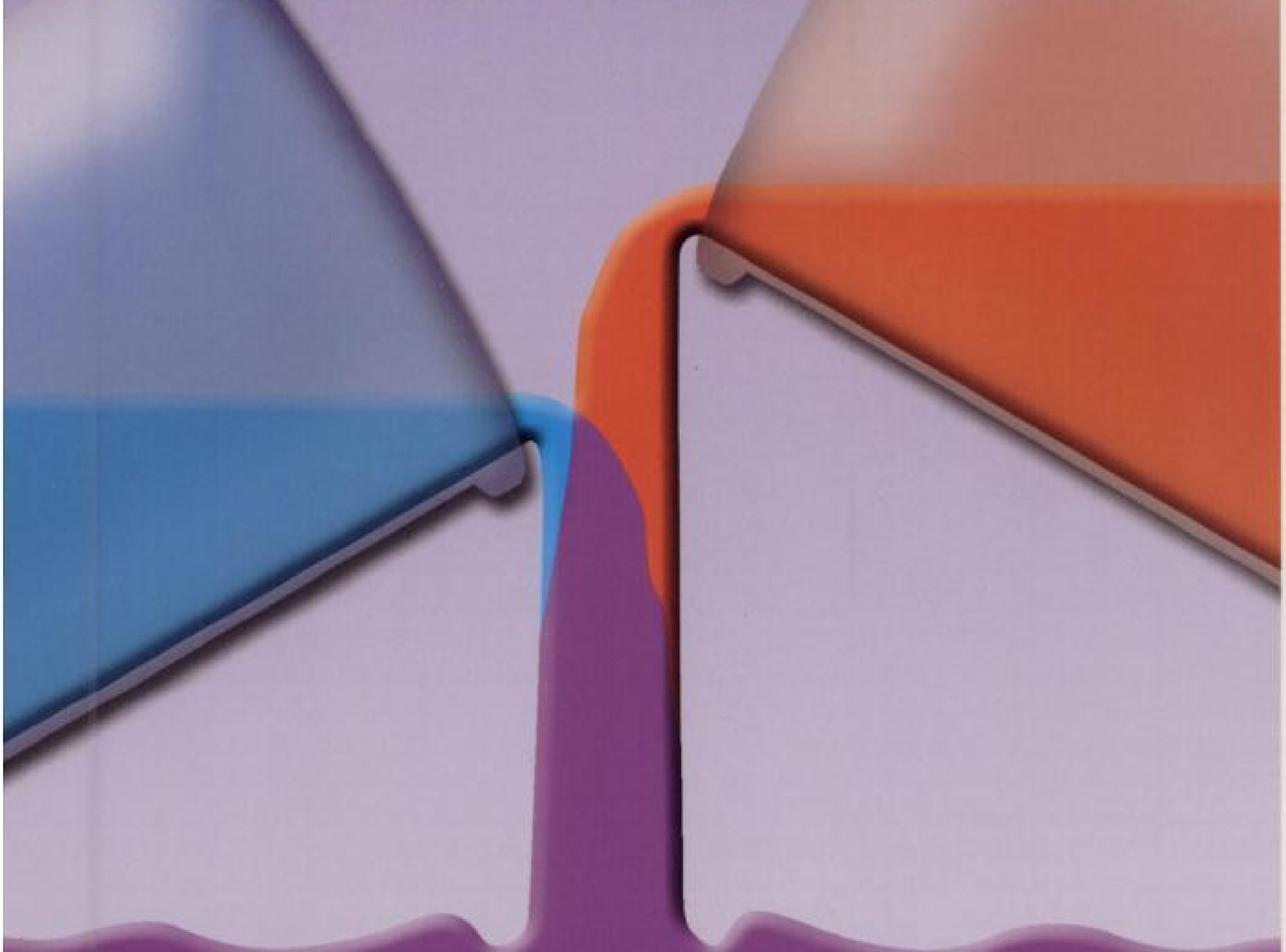
Revised for the New National Curriculum



Calculations for GCSE Chemistry

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Contents

There is one carbon atom on the left-hand side and one carbon atom on the right-hand side. There are four hydrogen atoms on the left-hand side, and therefore we need to put four hydrogen atoms on the right-hand side. Putting $2H_2O$ on the right-hand side will accomplish this:

$$CH_4(g) + O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

There is one molecule of O_2 on the left-hand side and four O atoms on the right-hand side. We can make the two sides equal by putting $2O_2$ on the left-hand side:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

This is a balanced equation. The numbers of atoms of carbon, hydrogen and oxygen on the left-hand side are equal to the numbers of atoms of carbon, hydrogen and oxygen on the right-hand side.

Practice with equations

1. For practice, try writing the equations for the reactions:

(a) Hydrogen + Copper(II) oxide(CuO) → Copper + Water

(b) Carbon + Carbon dioxide → Carbon monoxide

(c) Carbon + Oxygen → Carbon dioxide

(d) Magnesium + Sulphuric acid → Hydrogen + Magnesium sulphate ($MgSO_4$)

(e) Copper + Chlorine → Copper(II) chloride ($CuCl_2$)

2. Now try balancing the equations for the reactions:

(a) Calcium + Water → Hydrogen + Calcium hydroxide solution

$$Ca(s) + H_2O(l) \rightarrow H_2(g) + Ca(OH)_2(aq)$$

(b) Copper + Oxygen → Copper(II) oxide

$$Cu(s) + O_2(g) \rightarrow CuO(s)$$

(c) Sodium + Oxygen → Sodium oxide

$$Na(s) + O_2(g) \rightarrow Na_2O(s)$$

(d) Iron + Hydrochloric acid → Hydrogen + Iron(II) chloride solution

$$Fe(s) + HCl(aq) \rightarrow H_2(g) + FeCl_2(aq)$$

(e) Iron + Chlorine → Iron(III) chloride

$$Fe(s) + Cl_2(g) \rightarrow FeCl_3(s)$$

(f) Sodium oxide + Water → Sodium hydroxide

$$Na_2O(s) + H_2O(l) \rightarrow NaOH(aq)$$

(g) Hydrogen peroxide → Oxygen + Water

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

$$\text{Percentage of women} = \frac{\text{Number of women}}{\text{Total number of passengers}} \times 100\%$$

$$\text{Percentage of women} = \frac{60}{75} \times 100\% = 80\%.$$

(b) Number of men = 15

$$\text{Percentage of men} = \frac{\text{Number of men}}{\text{Total number of passengers}} \times 100\%$$

$$\text{Percentage of men} = \frac{15}{75} \times 100\% = 20\%.$$

If we've got the right answers they should add up to 100%. Good!

Example 2 Analysis shows that 40 g of sodium hydroxide contains 23 g of sodium, 16 g of oxygen and 1 g of hydrogen. Calculate the percentages of sodium, oxygen and hydrogen.

Method:

Mass of sodium hydroxide = 40 g
Mass of sodium = 23 g

$$\text{Percentage of sodium} = \frac{\text{Mass of sodium}}{\text{Total mass of compound}} \times 100\%$$

$$\text{Percentage of sodium} = \frac{23}{40} \times 100\% = 57.5\%.$$

Mass of oxygen = 16 g

$$\text{Percentage of oxygen} = \frac{\text{Mass of oxygen}}{\text{Total mass of compound}} \times 100\%$$

$$\text{Percentage of oxygen} = \frac{16}{40} \times 100\% = 40\%.$$

Mass of hydrogen = 1 g

$$\text{Percentage of hydrogen} = \frac{\text{Mass of hydrogen}}{\text{Total mass of compound}} \times 100\%$$

$$\text{Percentage of hydrogen} = \frac{1}{40} \times 100\% = 2.5\%.$$

Check. Do the percentages add up to 100%? 57.5% sodium + 40% oxygen + 2.5% hydrogen = 100%. That's satisfying!

Percentage Composition

From the formula of a compound, we can work out the percentage by mass of each element present in the compound.

3. The Masses of Solids which React Together

The Mole

Looking at equations tells us a great deal about chemical reactions. For example,

$$Fe(s) + S(s) \rightarrow FeS(s)$$

tells us that iron and sulphur combine to form iron(II) sulphide, and that one atom of iron combines with one atom of sulphur. Chemists are interested in the exact quantities of substances which react together in chemical reactions. For example, in the reaction between iron and sulphur, if you want to measure out just enough iron to combine with, say, 10 g of sulphur, how do you go about it? What you need to do is to count out equal numbers of atoms of iron and sulphur.

Is this possible? A chemist called Avogadro, working in Italy two hundred years ago, thought his way through the problem. It looks very simple once you have followed his argument.

Avogadro reasoned in this way:

We know from their relative atomic masses that an atom of carbon is 12 times as heavy as an atom of hydrogen. Therefore, we can say:

If	1 atom of carbon is	12 times as heavy as 1 atom of hydrogen,
then	1 dozen C atoms are	12 times as heavy as 1 dozen H atoms,
and	1 hundred C atoms are	12 times as heavy as 1 hundred H atoms,
and	1 million C atoms are	12 times as heavy as 1 million H atoms,

and it follows that when we see a mass of carbon which is 12 times as heavy as a mass of hydrogen, the two masses must contain equal numbers of atoms. If we have 12 g of carbon and 1 g of hydrogen, we know that we have the same number of atoms of carbon and hydrogen. The same argument applies to any element. When we take the relative atomic mass of an element in grams:

40 g Calcium	24 g Magnesium	32 g Sulphur	12 g Carbon	1 g Hydrogen

all these masses contain the same number of atoms. This number is 6.022×10^{23}. The amount of an element which contains this number of atoms is called one **mole** of the element. (The symbol for *mole* is **mol**.) The ratio 6.022×10^{23}/mol is called the **Avogadro constant**.

(f) 303 g potassium nitrate, KNO_3

(g) 9.8 g sulphuric acid, H_2SO_4

(h) 499 g copper(II) sulphate-5-water, $CuSO_4.5H_2O$.

7. Given Avogadro's constant is 6.0×10^{23}/mol, calculate the number of atoms in:

(a) 35.5 g of chlorine
(b) 27 g of aluminium
(c) 3.1 g of phosphorus
(d) 336 g of iron
(e) 48 g of magnesium
(f) 1.6 g of oxygen
(g) 0.40 g of oxygen
(h) 216 g of silver.

Reminder: Ratio calculations

The problems that follow involve ratio-type calculations. A sure and certain method of solving them is the **unitary method**. The first step is to use the information you are given to work out what **one unit** costs or produces, etc.

Example 1 A cook uses 9 kg of onions to make soup for 60 people. What mass of onions must she use to make soup for 180 people?

Method: We use the data to find out what mass of onions is needed for **one** person and then multiply by the final number of people, 180.

Soup for 60 people needs 9 kg of onions.

Soup for 1 person needs $\frac{9}{60}$ kg onions.

Soup for 180 people needs $180 \times \frac{9}{60}$ kg onions = 27 kg onions

Answer: The cook needs to use 27 kg of onions.

Example 2 When heated in a lime kiln, 100 tonnes of limestone give 56 tonnes of quicklime. What mass of quicklime can be obtained from 75 tonnes of limestone?

Method: We use the data to find out what **one** tonne of limestone will yield and then multiply by the actual mass of limestone.

100 tonnes of limestone give 56 tonnes of quicklime.

1 tonne of limestone gives $\frac{56}{100}$ tonnes of quicklime.

75 tonnes of limestone give $75 \times \frac{56}{100} = 42$ tonnes of quicklime.

Answer: The mass of quicklime is 42 tonnes.

7. Calculate the mass of sulphur that must be burned to give 100 g of sulphur dioxide.

8. In the reduction of copper(II) oxide by hydrogen, according to the equation

$$CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O(g)$$

what mass of copper can be obtained from:

(a) 79.5 g of copper(II) oxide (b) 15.9 g of copper(II) oxide?

Look up the relative atomic masses, and use them in the equation.

9. What mass of carbon dioxide can be produced by heating 10 g of calcium carbonate?
Write the equation. Put in the relative atomic masses, and do a ratio type of calculation.

10. What mass of hydrogen can be made by reacting 12 g of magnesium with an excess of dilute sulphuric acid?
First, the equation; second, the relative atomic masses; third, a ratio type of calculation.

11. What mass of carbon can be completely burned in 32 g of oxygen?
There are three steps to remember.

12. What mass of iron must be heated with excess sulphur to produce 4.4 g of iron(II) sulphide?
You should remember the three steps by now.

Section 2

These problems can be solved without calculators.

1. Calculate what mass of carbon you would need to reduce 15.9 g copper(II) oxide to copper by the reaction

$$CuO(s) + C(s) \rightarrow Cu(s) + CO(g)$$

2. Iron will react with chlorine to form iron(III) chloride:

$$2Fe(s) + 3Cl_2(g) \rightarrow 2FeCl_3(s)$$

Find the mass of iron(III) chloride that can be obtained from 8.00 g iron.

3. A mixture of 8 g iron and 4 g sulphur is heated, and the elements react to form iron(II) sulphide, FeS. How much iron will be left over at the end of the reaction?

4. Calculate the mass of carbon dioxide you can obtain by the action of acid on 15 g calcium carbonate, in the reaction

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

5. Calculate what mass of sodium hydroxide you would need to neutralise a solution containing 7.3 g hydrogen chloride by the reaction

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

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Example 2 Given that 0.96 g of magnesium combines with 2.84 g of chlorine, what is the empirical formula for magnesium chloride?

Elements	*Magnesium*		*Chlorine*
Symbols	Mg		Cl
Masses	0.96 g		2.84 g
Relative atomic masses	24		35.5
Number of moles	$\frac{0.96}{24}$		$\frac{2.84}{35.5}$
	= 0.04		= 0.08
Divide through by the smaller number	= 1 mole	to	2 moles
Number of atoms	= 1 atom	to	2 atoms
Empirical formula		$MgCl_2$	

Example 3 If the percentage of water in magnesium sulphate crystals is 51.2%, what is n in the formula $MgSO_4 \cdot nH_2O$?

Note that, when we say that the percentage of water in the crystals is 51.2%, we mean that 100 g of crystals contain 51.2 g of water. The difference, 48.8 g is the mass of magnesium sulphate.

Compounds	*Magnesium sulphate*		*Water*
Formulas	$MgSO_4$		H_2O
Masses	48.8 g		51.2 g
Relative molecular masses	120		18
Number of moles	$\frac{48.8}{120}$		$\frac{51.2}{18}$
	= 0.406		= 2.85
Divide through by the smaller number	= 1 mole	to	7 moles
Empirical formula		$MgSO_4 \cdot 7H_2O$	

Example 4 When 127 g of copper combine with oxygen, 143 g of an oxide are formed. What is the empirical formula of the oxide?

Method: You will notice here that the mass of oxygen is not given to you. You obtain it by subtraction.

Mass of copper = 127 g

Mass of oxide = 143 g

Mass of oxygen = 143 g − 127 g = 16 g.

Now you can carry on as before:

Elements	*Copper*	*Oxygen*
Symbols	Cu	O
Masses	127 g	16 g

(d) 6 g of magnesium combine with 4 g of oxygen

(e) 1.8 g of magnesium form 2.5 g of magnesium nitride

(f) 9 g of aluminium form 89 g of aluminium bromide.

6. Barium chloride forms a hydrate which contains 85.25% barium chloride and 14.75% water of crystallisation. What is the formula of this hydrate?
What is the mass of barium chloride in 100 g of the hydrate?
What is the mass of water in 100 g of the hydrate?
What is the relative formula mass of barium chloride?
What is the relative formula mass of water?
How many moles of barium chloride are present in 100 g of the hydrate?
How many moles of water are present in 100 g of the hydrate?
What is the ratio of moles of barium chloride to moles of water?
What is the formula of barium chloride hydrate?

7. Calculate the empirical formulas of these hydrates:

(a) magnesium sulphate crystals, which contain 48.8% of magnesium sulphate and 51.2% of water

(b) copper sulphate crystals, which contain 63.9% of copper sulphate and 36.1% of water

(c) crystals of chromium(III) nitrate, which contain 59.5% of chromium(III) nitrate and 40.5% of water.

8. Calculate the empirical formulas of the compounds with the following compositions:

(a) 20.0% magnesium, 26.6% sulphur, 53.3% oxygen

(b) 35.0% nitrogen, 5.0% hydrogen, 60.0% oxygen

(c) 60.0% carbon, 13.3% hydrogen, 26.7% oxygen

(d) 40.0% carbon, 6.7% hydrogen, 53.3% oxygen

9. A metal M forms a chloride of formula MCl_2 and relative formula mass 127. The chloride reacts with sodium hydroxide solution to form a precipitate of the metal hydroxide. What is the relative formula mass of the hydroxide?

A 56

B 71

C 73

D 90

E 146

10. A porcelain boat was weighed. After a sample of the oxide of a metal M, of $A_r = 119$, was placed in the boat, the boat was reweighed. Then the boat was placed in a reduction tube and heated while a stream of hydrogen was passed over it. The oxide was reduced to the metal M. The boat was allowed to cool with hydrogen still passing over it, and

2. What volume of hydrogen (at r.t.p.) is formed when 12 g of magnesium react with an excess of acid?

$$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$$

How many moles of hydrogen are produced from 1 mole of magnesium?
What is the volume of this number of moles of hydrogen?
How many moles of magnesium are there in 12 g of the metal?
What is the volume of hydrogen produced from this number of moles of magnesium?

3. What volume of hydrogen (at r.t.p.) is produced when 6.5 g of zinc react with an excess of acid?

$$Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$$

How many moles of hydrogen are formed from 1 mole of zinc?
What is the volume of this number of moles of hydrogen?
How many moles of zinc are present in 6.5 g of zinc?
What volume of hydrogen is formed from this number of moles?

4. What is the volume of carbon dioxide (at r.t.p.) obtained by heating 10.0 g of calcium carbonate?

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

How many moles of carbon dioxide are formed from 1 mole of calcium carbonate?
What is the volume of this number of moles of carbon dioxide?
How many moles of calcium carbonate are there in 10 g of this solid?
What volume of carbon dioxide is formed from this number of moles?

5. Calculate the volume of oxygen (at r.t.p.) needed for the complete combustion of 125 cm^3 of methane. What volume of carbon dioxide is formed?

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

How many moles of oxygen react with 1 mole of methane?
How many volumes of oxygen react with 1 volume of methane?
What volume of oxygen reacts with 125 cm^3 of methane?
How many moles of carbon dioxide are formed by combustion of 1 mole of methane?
How many volumes of carbon dioxide are formed from 1 volume of methane?
What volume of carbon dioxide is formed from 125 cm^3 of methane?

Section 2

1. The complete combustion of carbon in oxygen yields carbon dioxide. Calculate the volume of oxygen at r.t.p. that would react with 10.0 g of carbon and the volume of carbon dioxide formed.

   Hint: Mass of C ... moles of C ... moles of O_2 .. volume of O_2 ... volume of CO_2.

The symbol M is often used for mol/dm^3. This solution can be described as a 6 M sodium hydroxide solution.

Figure 6.1 gives more examples.

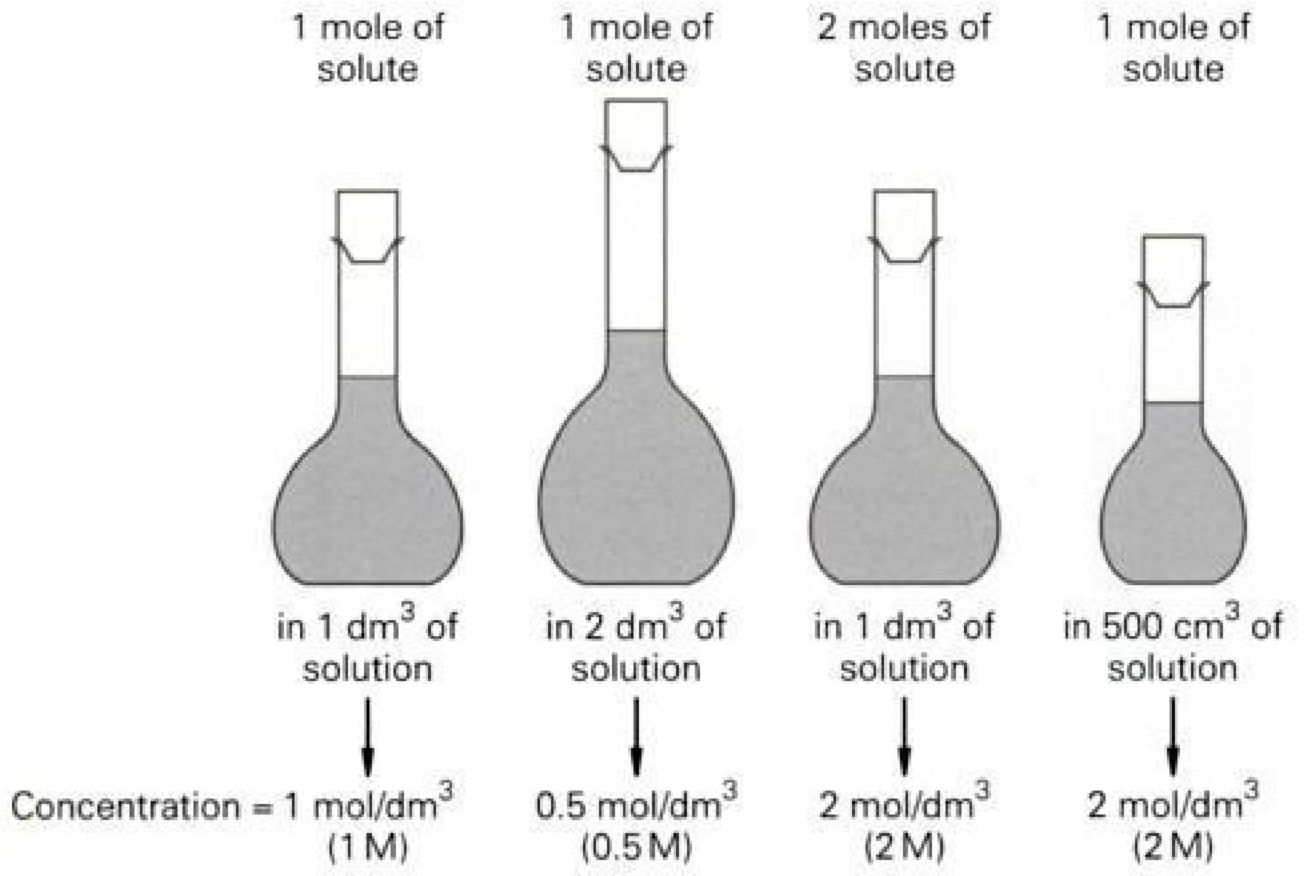
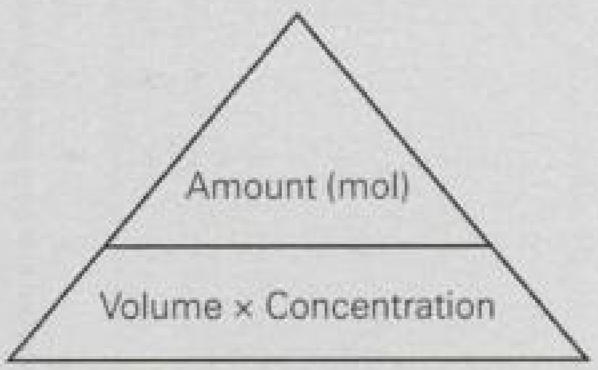


Figure 6.1 How to calculate concentration

A triangle for rearranging the equation

You may find it helpful to use this triangle to rearrange the equation.



Cover up the quantity you want. Then what you see is the equation you need to use.

Cover up concentration. You see: $\frac{\text{Amount (mol)}}{\text{Volume}}$, then

$$\text{Concentration} = \frac{\text{Amount (mol)}}{\text{Volume}}$$

Cover up Volume. You see: $\frac{\text{Amount (mol)}}{\text{Concentration}}$, then

$$\text{Volume} = \frac{\text{Amount (mol)}}{\text{Concentration}}$$

Cover up Amount (mol) . You see: Volume × Concentration, then

Amount (mol) = Volume × Concentration

(b) Amount of solute (mol) = Volume (dm^3) × Concentration (mol/dm^3)

Amount of sulphuric acid (mol) = Volume (dm^3) × Concentration (mol/dm^3)

$= 22.5 \times 10^{-3}\ dm^3 \times 0.80\ mol/dm^3$

$= 18.0 \times 10^{-3}\ mol$

Since $2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

Number of moles of sodium hydroxide = 2 × Number of moles of sulphuric acid

$= 36.0 \times 10^{-3}\ mol$

But, amount of sodium hydroxide (mol) = Volume × Concentration

$= 25.0 \times 10^{-3}\ dm^3 \times c$

where c = concentration

Therefore, $25.0 \times 10^{-3}\ dm^3 \times c = 36.0 \times 10^{-3}\ mol$

$$c = \frac{36.0 \times 10^{-3}\ mol}{25.0 \times 10^{-3}\ dm^3}$$

$= 1.44\ mol/dm^3$

Answer: The concentration of the sodium hydroxide solution is $1.44\ mol/dm^3$.

Note that, although the titration figures in this example are the same as those in Example 1, the concentration of sodium hydroxide is twice what it was calculated to be in Example 1 because, in Example 2, 1 mole of acid neutralises 2 moles of alkali.

Example 3 What volume of hydrochloric acid of concentration $0.25\ mol/dm^3$ (0.25 M) is needed to neutralise 5.3 g of anhydrous sodium carbonate?

Method: You tackle this example, as before, by finding the number of moles of each substance. For the solid, use the expression:

$$\text{Number of moles of solid} = \frac{\text{Mass of solid}}{\text{Mass of 1 mole of solid}}$$

For the solution, use the expression:

Amount of solute (mol) = Volume (dm^3) × Concentration (mol/dm^3)

Relative formula mass of Na_2CO_3 $= (2 \times 23) + 12 + (3 \times 16) = 106$

Number of moles of Na_2CO_3 $= \text{Mass}/M_r = \frac{5.3}{106}$

$= 0.05$

Since

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$

(a) What volume of ammonia (at r.t.p.) could be removed by 50 dm^3 of 1.50 mol/dm^3 sulphuric acid?

(b) What use could be made of the product?

8. An experiment was done to find the percentage composition of an alloy of sodium and lead. The alloy reacts with water:

$$\text{Alloy} + \text{Water} \rightarrow \text{Sodium hydroxide} + \text{Hydrogen} + \text{Lead}$$

$$2Na.Pb(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g) + 2Pb(s)$$

3.00 g of the alloy were added to about 100 cm^3 of water. When the reaction was complete, the sodium hydroxide formed was titrated against 1.00 mol/dm^3 hydrochloric acid. The volume of acid required to neutralise the sodium hydroxide was 12.0 cm^3. Calculate

(a) the amount in moles of HCl used

(b) the amount in moles of NaOH neutralised

(c) the amount in moles of Na in 3.00 g of the alloy

(d) the mass in grams of Na in 3.00 g of alloy

(e) the percentage composition by mass.

9. 100 cm^3 of 1.0 mol/dm^3 ammonia solution was neutralised by a certain volume of 1.0 mol/dm^3 sulphuric acid. The resulting solution was evaporated and allowed to crystallise. Crystals of ammonium sulphate formed.

$$2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

(a) What volume of 1.0 mol/dm^3 sulphuric acid was required to neutralise 100 cm^3 of 1.0 mol/dm^3 ammonia?

(b) What mass of ammonium sulphate was formed in (a)?

(c) Explain why the mass of crystals obtained from the solution is less than the calculated quantity.

10. Ammonia is manufactured by the Haber process. A 500 cm^3 sample of the gases leaving the catalyst chamber was bubbled into 0.100 mol/dm^3 sulphuric acid. 20.0 cm^3 of the acid were neutralised. What was the percentage by volume of ammonia in the sample? Name two other gases which were present.

$$2NH_3(g) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

11. Solid calcium hydroxide is shaken with water at room temperature until a saturated solution has been formed. A titration is carried out to find the concentration of the solution. 25.0 cm^3 of the saturated solution are neutralised by 10.5 cm^3 of 0.100 mol/dm^3 hydrochloric acid.

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

Calculate the solubility of calcium hydroxide in

(a) mol/dm^3 (b) g/dm^3.

(b) Which new bonds are made in the product? How much energy is given out when these new bonds are made?

(c) Calculate the energy change of reaction.

(d) Is the reaction exothermic or endothermic?

5. The equation for the combustion of ethene is

$$CH_2{=}CH_2(g) + 3O{=}O(g) \rightarrow 2O{=}C{=}O(g) + 2H{-}O{-}H(g)$$

(a) Calculate the sum of all the bond energies in the reactants.

(b) Calculate the sum of all the bond energies in the products.

(c) Find the energy change of reaction.

(d) State whether the reaction is exothermic or endothermic.

6. Ethene adds hydrogen to form ethane:

$$CH_2{=}CH_2 + H_2 \rightarrow CH_3{-}CH_3$$

(a) Draw the structural formulas of the substances.

(b) Which bonds are (i) broken in the reactants (ii) formed in the product?

(c) Calculate how much energy is required or liberated in the reaction.

(d) Explain why the reaction is exothermic.

7. In the synthesis of ammonia,

$$N_2 + 3H_2 \rightarrow 2NH_3$$

(a) Calculate (i) the energy needed per mole to break all the bonds in the reactants (ii) the energy given out per mole when the bonds in the product are formed.

(b) Explain why the reaction is exothermic.

9. Solubility

Solubility

Solubility is defined as the mass in grams of solute required to saturate 100 g of solvent at a stated temperature. A **saturated solution** is one that contains the maximum amount of solute that can be dissolved at that temperature. When values of solubility are plotted against temperature, the graph obtained is called a **solubility curve**. Figure 9.1 shows solubility curves for a number of substances over temperatures of 0 °C to 100 °C.

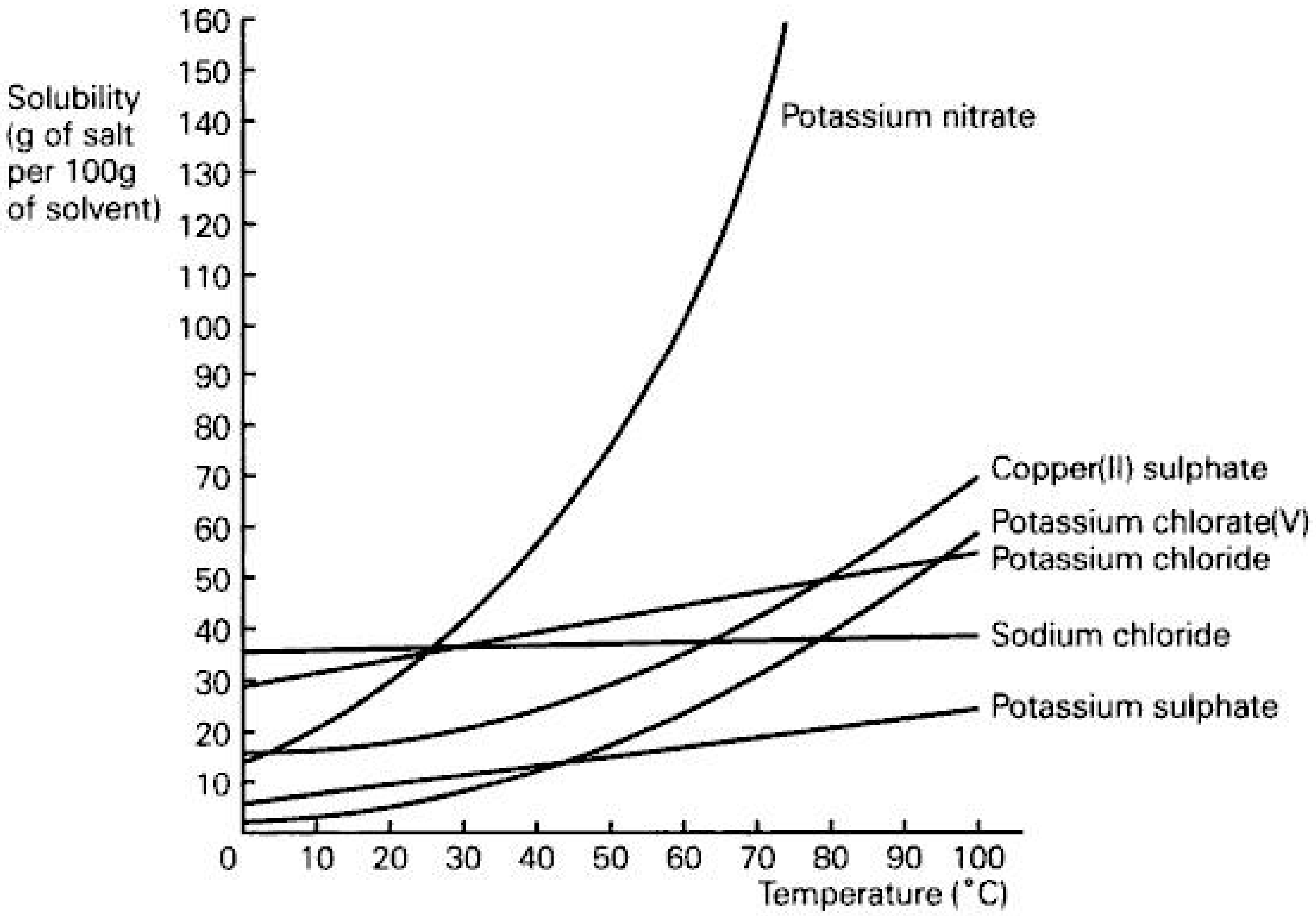


Figure 9.1 Solubilities of some salts in water

Example 1 If 8 g of potassium chloride saturate 20 g of water at 40 °C, what is the solubility of potassium chloride?

Method: Problems of this kind are a simple ratio type of calculation. (See Reminder, p. 16.)

If 20 g water are saturated by 8 g potassium chloride,

100 g water are saturated by $\frac{100 \times 8}{20} = 40$ g potassium chloride.

10. Electrolysis

When a current passes through a solution of a salt of a metal which is low in the electrochemical series, metal ions are discharged and metal atoms are deposited on the cathode (see Figure 10.1).

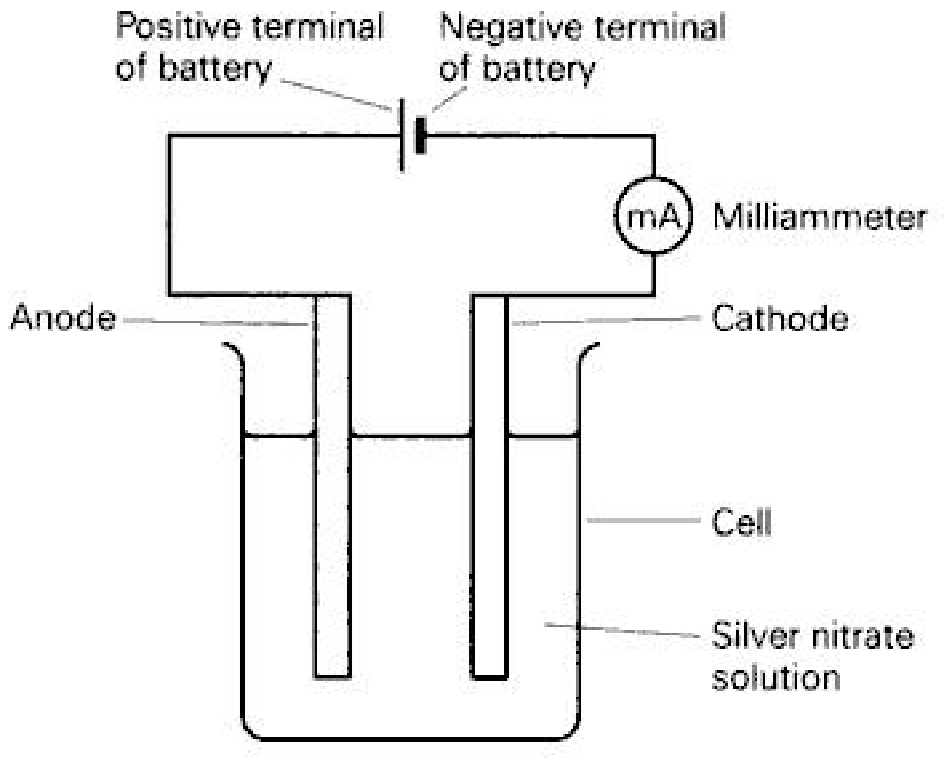


Figure 10.1 The electrolysis of silver nitrate solution

Calculating the Mass of Solid Deposited during Electrolysis

The cathode process is

$$Ag^+(aq) + e^- \rightarrow Ag(s)$$

This equation tells us that 1 silver ion accepts 1 electron to form 1 atom of silver. Therefore 1 mole of silver ions need 1 mole of electrons to form 1 mole of silver atoms.

When 1 mole of silver is deposited, the cathode increases in mass by 108 g (the mass of 1 mole of silver), and 1 mole of electrons pass through the cell. We can find the quantity of electric charge that is needed to deposit 108 g of silver. Electric charge is measured in coulombs (C). One coulomb is the electric charge that passes when 1 ampere flows for 1 second.

Charge in coulombs = Current in amperes × Time in seconds

Using a cell such as that in Figure 10.1, we can pass a current through a milliammeter in the circuit for a known time. From the current and the time, we know the electric charge that has passed. By weighing the cathode before and after the passage of the current, we

8. (a) 111 g; 123.5 g; 171 g; 85 g
   (b) 27.8 g; 30.9 g; 42.8 g; 21.3 g

Section 2

1. (a) 26 g (b) 14 g (c) 4 g (d) 6 g (e) 7 g (f) 8 g
2. (a) 2.0 (b) 2.0 (c) 0.25 (d) 0.10 (e) 0.25 mol
3. (a) 23 g (b) 7 g (c) 14 g (d) 8 g (e) 16 g (f) 32 g
4. (a) 1.0 (b) 2.0 (c) 0.33 (d) 3.0 (e) 0.5 (f) 0.125 mol
5. (a) 2070 g (b) 10.6 g (c) 25.4 g (d) 20.0 g (e) 10.0 g (f) 40.0 g (g) 42.0 g (h) 13.0 g (i) 35.5 g (j) 2.00 g
6. (a) 1.00 (b) 0.25 (c) 0.50 (d) 0.20 (e) 0.20 (f) 3.0 (g) 0.10 (h) 2.0
7. (a) 6.0×10^{23} (b) 6.0×10^{23} (c) 6.0×10^{22} (d) 3.6×10^{24} (e) 1.2×10^{24} (f) 6.0×10^{22} (g) 1.5×10^{22} (h) 1.2×10^{24}

Problems on Reacting Masses of Solids (p. 19)

Section 1

1. 40 g
2. 10 g
3. 44 g
4. 14.7 g
5. 32 g
6. 4 g
7. 50 g
8. (a) 63.5 g (b) 12.7 g
9. 4.4 g
10. 1 g
11. 12 g
12. 2.8 g

Section 2

1. 2.40 g
2. 23.2 g
3. 1 g
4. 6.6 g
5. 8.0 g
6. 71 g
7. 27 g
8. 10.6 g

Section 3

1. 1250 tonne
2. 0.05 g
3. 3.06 kg
4. (a) $2O_2$, $2H_2O$ (b) 2.25 kg
5. (a) $3O_2 \rightarrow 2O_3$ (b) 64 g
6. 19 kg/year
7. Yes, 1 mol C (12 g) combines with 4 mol F^- (4 × 19 g)
8. (a) 0.01 mol (b) 0.02 mol
   (c) 2 mol
   (d) $Zn(s) + 2Ag^+(aq) \rightarrow Zn^{2+}(aq) + 2Ag(s)$
9. 127
10. (a) 0.56 g (b) 8.0×10^{-2} mol

Chapter 4

Problems on Formulas (p. 25)

Section 1

1. Na_2O
2. Mg_3N_2
3. Fe_3O_4
4. $HgBr_2$
5. Al_2O_3
6. PbO_2
7. (a) C_7H_{16} (b) Mg_3N_2
   (c) Al_2S_3 (d) $CaBr_2$
   (e) Cr_2S_3

Section 2

1. (a) SO_2 (b) SO_3 (c) NO (d) NO_2 (e) CH_4 (f) CH_2
2. (a) P_2O_3 (b) NH_3 (c) Pb_3O_4 (d) SiO_2 (e) MnO_2 (f) N_2O_5 (g) $CrCl_3$
3. $A = C_2F_4$ $B = C_4H_8O_2$
   $C = C_2H_6$ $D = C_6H_6$
   $E = C_3H_6$ $F = C_2H_6O_2$
   $G = C_2H_4Cl_2$ $H = C_6H_3N_3O_6$

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