



HOMWORK BOOKLET

C3&C5 Higher



Balancing Equations

Chemical equations are a simple way to describe how different substances are made in a reaction.

The equation tells us which substances have **reacted** in the reaction. These are called the **reactants** and are found on the **left-hand** side of the equation.

The equation tells us which substances are **produced** in the reaction. These are called the **products** and are found on the **right-hand** side of the equation.

Word equations use words to describe the reaction.

1. Write word equations for the reactions below.

a. Lithium and fluorine react together to produce lithium fluoride.

_____ → _____

b. Magnesium and oxygen react together to produce magnesium oxide.

_____ → _____

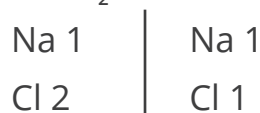
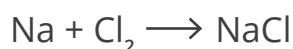
c. Sodium and chlorine react together to produce sodium chloride.

_____ → _____

Symbol equations give us more detail as they show the elements present in the reaction and also the number of each element.

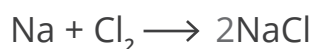
To balance a symbol equation:

Step 1 - Write the symbol equation.



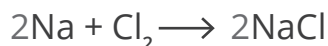
Step 2 - List the elements that are present on each side of the arrow.

Step 3 - Write down the number of each element present on each side.

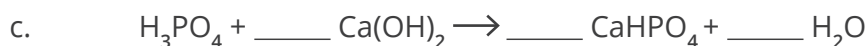
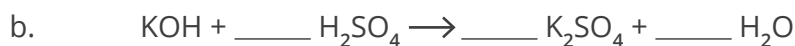
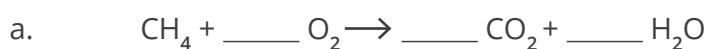


Step 4 - Identify which elements have different amounts on each side.

Step 5 - Through trial and error, place numbers in front of the chemical formulae to balance the equation.



2. Balance the symbol equations below.





Relative Formula Mass

The relative formula mass (M_r) is the sum of the relative atomic masses (A_r) of all the atoms present in a compound.

To calculate relative formula mass:

Step 1 – Work out how many atoms of each element are in the chemical formula.

Step 2 – Find the relative atomic mass of each element on the periodic table.

Step 3 – Add together the relative atomic masses for all the atoms of each element in the formula.

e.g. The chemical formula for water is H_2O .

There are two atoms of hydrogen and one atom of oxygen.

Relative atomic masses (A_r): H = 1, O = 16

Relative formula mass (M_r) = $(1 \times 2) + 16 = 18$

1. How many atoms of each element are present in the compounds below?

a. CO_2

b. H_2SO_4

c. $Mg(NO_3)_2$

2. Calculate the relative formula mass of the compounds below.

a. NH_3

$M_r =$ _____

b. HNO_3

$M_r =$ _____

c. C_2H_5OH

$M_r =$ _____



Calculating Percentage by Mass

Percentage by mass of an element tells us the percentage of a chemical compound made up of that element.

$$\text{percentage mass of Y} = \frac{A_r \text{ of element Y} \times \text{number of atoms of Y}}{M_r \text{ of compound}} \times 100$$

To calculate percentage by mass of an element:

Step 1 - Calculate the relative formula mass (M_r) of the compound.

Step 2 - Find the relative atomic mass (A_r) of the element.

Step 3 - Multiply the A_r of the element by the number of atoms of that element present in the compound.

Step 4 - Divide the mass of the element by the M_r of the compound and multiply by 100.

Worked example:

Calculate the percentage by mass of oxygen in copper sulfate (CuSO_4).

Relative atomic masses (A_r): Cu = 63.5, S = 32, O = 16

M_r of $\text{CuSO}_4 = 63.5 + 32 + (16 \times 4) = 159.5$

$$\text{percentage by mass of oxygen} = \frac{(16 \times 4)}{159.5} \times 100 = 40\%$$

1. Calculate the percentage by mass of carbon in carbon dioxide (CO_2).

Give your answer to 2 significant figures.

Relative atomic masses (A_r): C = 12, O = 16

percentage by mass = _____ %

2. Calculate the percentage by mass of sodium in sodium hydroxide (NaOH).

Give your answer to 2 significant figures.

Relative atomic masses (A_r): Na = 23, O = 16, H = 1

percentage by mass = _____ %



3. Calculate the percentage by mass of aluminium in aluminium sulfate ($\text{Al}_2(\text{SO}_4)_3$).
Give your answer to 2 significant figures.

Relative atomic masses (A_r): Al = 27, S = 32, O = 16

percentage by mass = _____ %





Concentrations of Solutions in g/dm³

Concentration is a measure of the amount of a substance in a volume of liquid. The more particles of a substance present in a solution, the higher the concentration.

In chemistry, there are two ways to measure the concentration of a solution. This can be done by calculating the mass of the substance in grams or by calculating the number of moles.

To calculate concentration, you must be working in dm³.

$$\text{concentration (g/dm}^3\text{)} = \frac{\text{mass (g)}}{\text{volume (dm}^3\text{)}}$$

The equation can be rearranged to calculate mass and volume.

1. Calculate the **concentration** of the solution produced when a 3.2g of sodium chloride is dissolved in 8dm³ of water.

$$\text{concentration} = \underline{\hspace{2cm}} \text{ g/dm}^3$$

2. Calculate the **mass** of magnesium chloride you would need to dissolve in 4dm³ of water to make a 0.9g/dm³ solution.

$$\text{mass} = \underline{\hspace{2cm}} \text{ g}$$

3. Calculate the **concentration** of the solution produced when 5.2g of potassium chloride is dissolved in 200cm³ of water.

Give your answer in g/dm³.

$$\text{concentration} = \underline{\hspace{2cm}} \text{ g/dm}^3$$

4. Calculate the **volume** of water required to add to 4.5g of sodium carbonate to make a 15g/dm³ solution.

Give your answer in cm³.

$$\text{volume} = \underline{\hspace{2cm}} \text{ cm}^3$$



Concentrations of Solutions in mol/dm³

(HT only)

Concentrations of solutions can be calculated in mol/dm³ if you know the number of moles and volume of a solution.

$$\text{number of moles} = \frac{\text{mass (g)}}{\text{relative formula mass}}$$

1. Calculate the **concentration** of the solution produced when 0.4 moles of sodium chloride are dissolved in 8dm³ of water.

$$\text{concentration} = \text{_____ mol/dm}^3$$

2. Calculate the **number of moles** of sodium chloride in 4dm³ of a 2.5mol/dm³ solution.

$$\text{number of moles} = \text{_____ mol}$$

3. Calculate the **volume** of water required to add to 2.25 moles of hydrochloric acid to make a 1.5mol/dm³ solution.

$$\text{volume} = \text{_____ dm}^3$$

A titration is a technique that is used to determine the concentration of an unknown acid or alkali. A known volume of a solution of unknown concentration, such as an acid, is placed in a conical flask and an alkali of known concentration is added gradually from a burette until the acid is been neutralised. The end-point of the titration can be determined using an indicator.

The concentration of the acid used can be calculated from the volume of the known concentration of alkali used to neutralise the acid.

To calculate the concentration of a solution of unknown concentration:

Step 1 - Write the balanced symbol equation for the reaction.

Step 2 - Calculate the number of moles of the solution of known concentration by multiplying concentration by volume (make sure the volume is in dm³).

Step 3 - Use the ratio from the symbol equation to calculate the number of moles of the solution of unknown concentration.

Step 4 - Calculate the concentration of the solution of unknown concentration by dividing the number of moles of the solution of unknown concentration by the volume of the solution used in the reaction.

**Worked example:**

In a titration, 22cm³ of a 1.25mol/dm³ solution of sodium hydroxide was required to neutralise the 25cm³ of hydrochloric acid.

Calculate the concentration of the hydrochloric acid.

Balanced symbol equation: $\text{HCl} + \text{NaOH} \longrightarrow \text{NaCl} + \text{H}_2\text{O}$

$$22 \div 1000 = 0.022\text{dm}^3$$

$$\text{number of moles of NaOH} = 1.25 \times 0.022 = 0.0275 \text{ mol}$$

The ratio of HCl to NaOH in the symbol equation is 1:1 so 0.0275 moles of HCl have reacted.

$$25 \div 1000 = 0.025\text{dm}^3$$

$$\text{concentration of HCl} = \frac{0.0275}{0.025} = 1.1\text{mol/dm}^3$$

4. In a titration, 20cm³ of a 2.0mol/dm³ solution of hydrochloric acid (HCl) was needed to neutralise 25cm³ of sodium hydroxide (NaOH).

Calculate the concentration of the sodium hydroxide.

concentration = _____ mol/dm³

5. In a titration, 10cm³ of 1.2mol/dm³ solution of sulfuric acid (H₂SO₄) was needed to neutralise 25cm³ of potassium hydroxide (KOH).

Calculate the concentration of the potassium hydroxide.

concentration = _____ mol/dm³



Mole Calculations (HT only)

A mole is the amount of any species that has the same number of atoms as 12 grams of the isotope carbon-12. The word 'species' can refer to atoms, molecules, ions or electrons.

For example, one mole of calcium carbonate contains 6.02×10^{23} molecules of calcium carbonate and one mole of sodium contains 6.02×10^{23} atoms of sodium. The mass of one mole of any substance is equal to its relative formula mass in grams.

$$\text{number of moles} = \frac{\text{mass (g)}}{\text{relative formula mass}}$$

The equation can be rearranged to find the mass of a substance using the number of moles and the M_r of the substance.

1. a. Calculate the number of moles in 360g of water (H_2O).

number of moles = _____ mol

- b. Calculate the number of moles in 24.4g of $\text{Sr}(\text{OH})_2$.

number of moles = _____ mol

- c. Calculate the number of moles in 4.44g of SrCO_3 .

number of moles _____ mol

2. a. Calculate the mass of 0.9 moles of Fe_2O_3 .

mass = _____ g

- b. Calculate the mass of 11 moles of H_2SO_4 .

mass = _____ g

- c. Calculate the mass of 0.2 moles of $\text{Pb}_3(\text{PO}_4)_2$.

mass = _____ g



Limiting Reactants (HT only)

Homework 3

The reactant that is completely used up in a chemical reaction is called the **limiting reactant**. The mass of product made in the reaction depends on the mass of the limiting reactant. The reactants that are left over when the limiting reactant is used up is said to be in **excess**.

To identify the limiting reactant:

Step 1 - Write the balanced symbol equation for the reaction.

Step 2 - Calculate the M_r of each reactants.

Step 3 - Calculate the number of moles of each reactant using the mass and M_r .

Step 4 - Work out how many moles of each reactant would be needed to completely react with the other reactant.

Worked example:

10g of calcium carbonate is added to 10g of hydrochloric acid.

Which reactant is the limiting reactant?

Balanced symbol equation: $\text{CaCO}_3 + 2\text{HCl} \longrightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$

M_r of $\text{CaCO}_3 = 40 + 12 + (16 \times 3) = 100$

M_r of $\text{HCl} = 1 + 35.5 = 36.5$

number of moles of $\text{CaCO}_3 = \frac{10}{100} = 0.1 \text{ mol}$

number of moles of $\text{HCl} = \frac{10}{36.5} = 0.27 \text{ mol}$

From the symbol equation, we can see that 2 moles of hydrochloric acid are needed to react with 1 mole of calcium carbonate, so 0.2 moles of hydrochloric acid would be needed to react with 0.1 moles of calcium carbonate. However, we have 0.27 moles of hydrochloric acid, so the hydrochloric acid is in excess. Therefore, calcium carbonate is the limiting reactant.

1. 7.2g of magnesium is added to 49g of sulfuric acid (H_2SO_4) to produce magnesium sulfate (MgSO_4) and hydrogen.

Show that magnesium is the limiting reactant.

2. 14g of lithium is added to 14.2g of chlorine to produce lithium chloride (LiCl).

Show that chlorine is the limiting reactant.



Calculating Gas Volume (HT only)

Homework 3

The volume of one mole of any gas at room temperature and pressure is 24dm^3 .

$$\text{volume of gas (dm}^3\text{)} = \text{number of moles} \times 24$$

1. a. Calculate the volume of 10 moles of oxygen at room temperature and pressure.

$$\text{volume} = \underline{\hspace{2cm}} \text{ dm}^3$$

- b. Calculate the number of moles of carbon dioxide in 4.8dm^3 of gas at room temperature and pressure.

$$\text{number of moles} = \underline{\hspace{2cm}} \text{ mol}$$

- c. Calculate the number of moles of fluorine in 150cm^3 of gas at room temperature and pressure.

Give your answer in standard form.

$$\text{number of moles} = \underline{\hspace{2cm}} \text{ mol}$$

The equation for calculating gas volume can be used with the equation below to calculate the mass of gas in a particular volume.

$$\text{mass} = \text{number of moles} \times \text{relative formula mass}$$

2. a. Calculate the mass of carbon dioxide in a balloon containing 36dm^3 of carbon dioxide at room temperature and pressure.

$$\text{mass} = \underline{\hspace{2cm}} \text{ g}$$

- b. Calculate the mass of chlorine in a container that can hold 600cm^3 of chlorine at room temperature and pressure.

$$\text{mass} = \underline{\hspace{2cm}} \text{ g}$$



Reaction Profiles

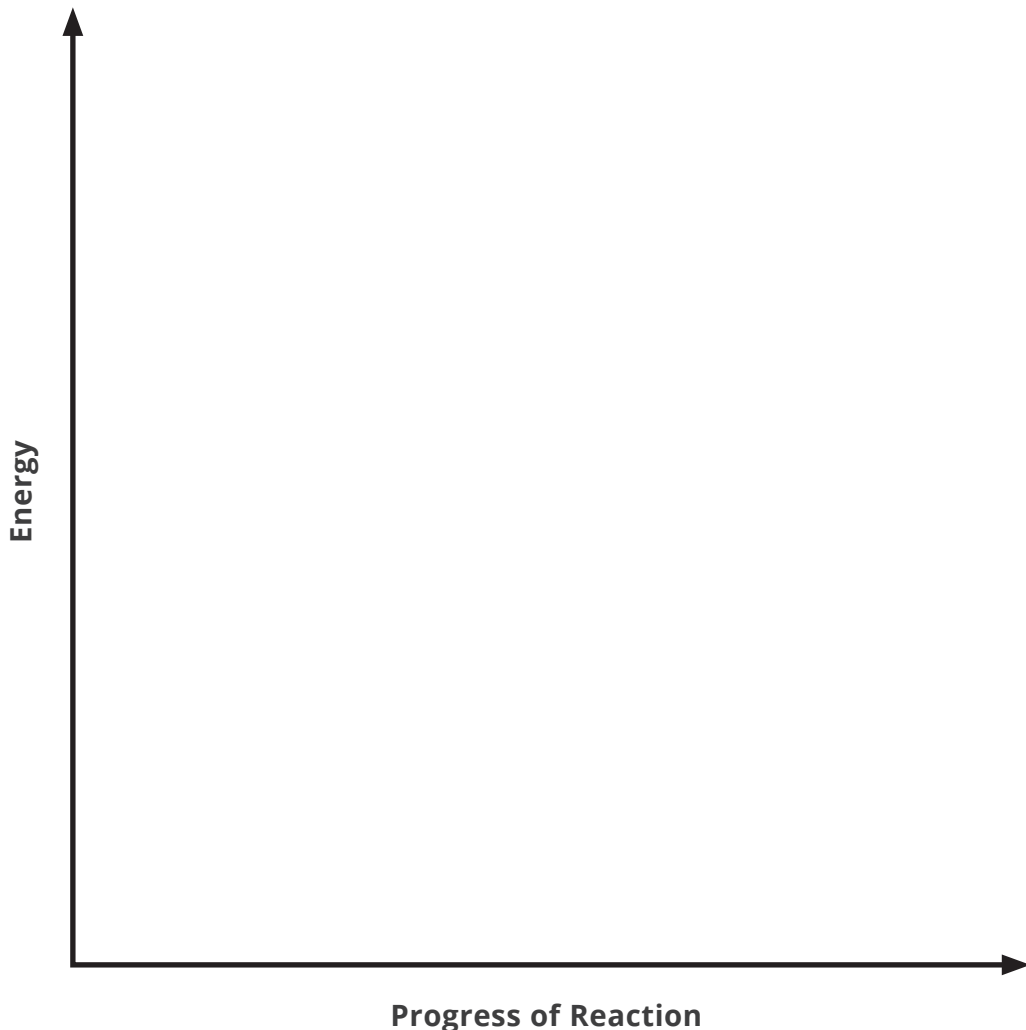
1. Define the term 'activation energy'.

2. Explain the effect that an endothermic reaction has on the surroundings.

3. Draw the reaction profile for an endothermic reaction.

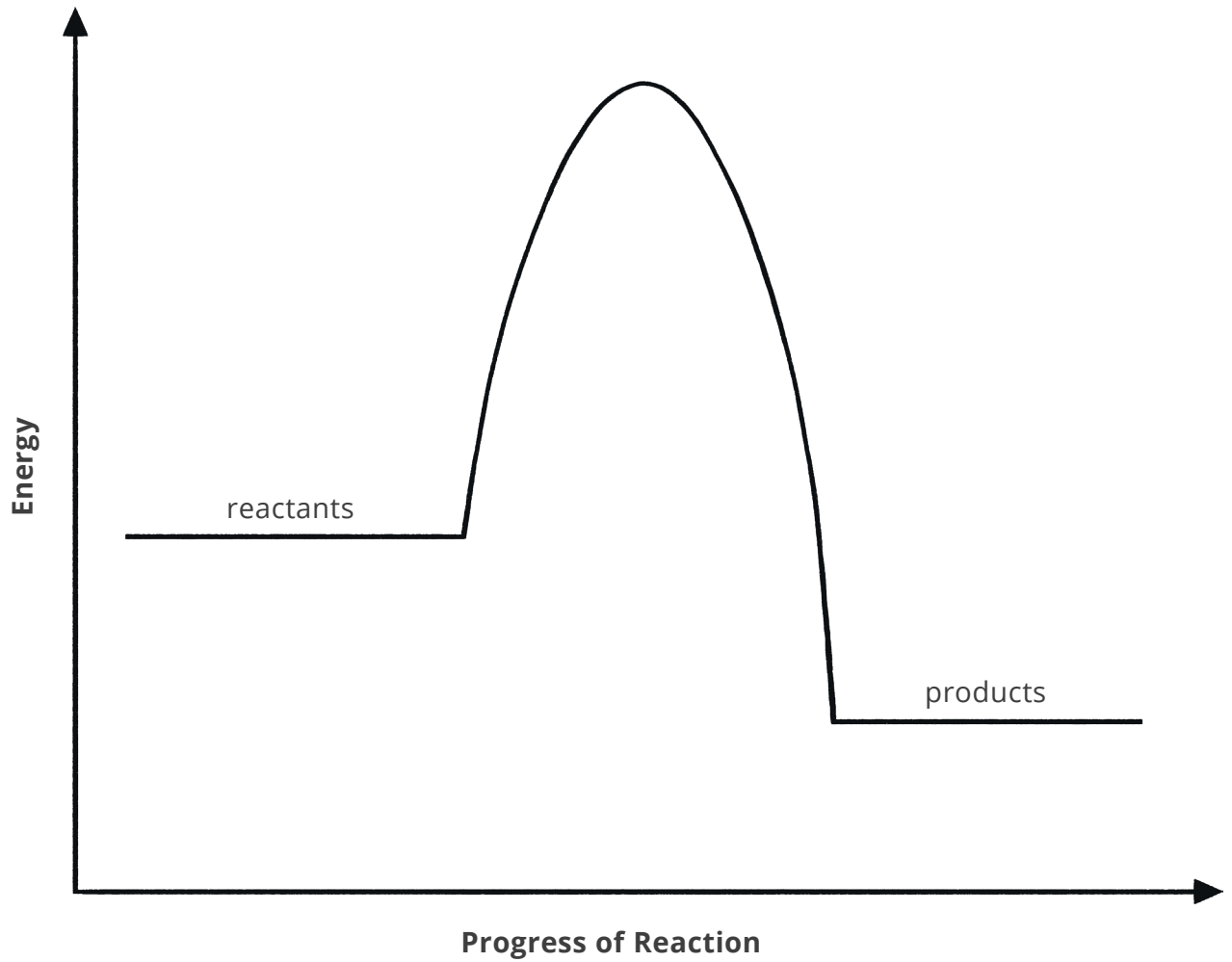
You should include labels showing the position of:

- the reactants;
- the products;
- the activation energy;
- the overall energy change of the reaction.



4. **Figure 1** shows a reaction profile.

Figure 1



a. Name the type of reaction shown in **Figure 1**.

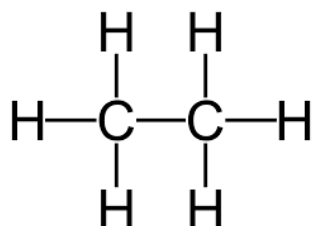
b. Sketch a line on **Figure 1** to show how using a catalyst would affect this reaction profile.

c. Explain your answer to part (b).

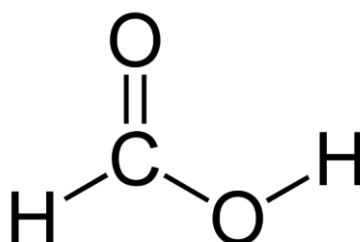
Breaking Bonds

Using the table below fill in and calculate the total amount of energy required to break the bonds in each of the following compounds.

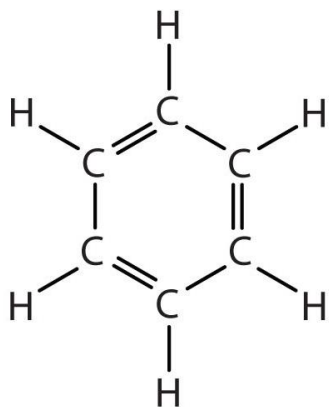
Bond	Energy Required (kJ/mol)	Bond	Energy Required (kJ/mol)
C – C	347	C = C	614
C – H	413	C = O	745
C – O	358	O – H	467



Bond	Frequency	Energy Required	Total
C – H			
C – C			
Total (kJ/mol)			



Bond	Frequency	Energy Required	Total
C – H			
C = O			
C – O			
O – H			
Total (kJ/mol)			



Bond	Frequency	Energy Required	Total
Total (kJ/mol)			

Challenge

Looking at the diagram below work out the total amount of energy required to break all the bonds.

