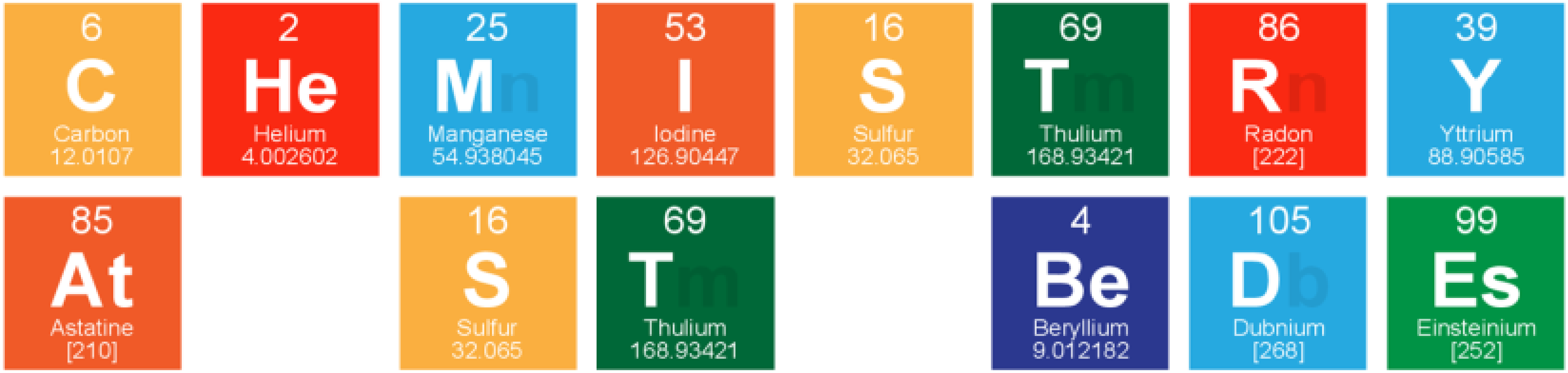
St Bede’s Catholic College

Year 11 into Year 12

Chemistry Transition Work



You will study OCR A Chemistry

Year 1:

Module 2: Foundations in Chemistry – atoms, moles, formula, redox, bonding

Module 3: Periodic table and energy – trends, energy changes, equilibria, rates of reaction

Module 4: Core organic chemistry – alkanes, alkenes, polymers, alcohols

Year 2:

Module 5: Physical chemistry and transition elements

Module 6: Organic chemistry and analysis

The **full specification** can be found on the OCR A website: https://www.ocr.org.uk/qualifications/as-and-a-level/chemistry-a-h032-h432-from-2015/specification-at-a-glance/

You will sit **three exams** at the end of Year 13. These are:

- Paper 1- Periodic table, elements and physical chemistry (37%) - modules 1, 2, 3 and 5 only
- Paper 2- Synthesis and analytical techniques (37%) - modules 1, 2, 4 and 6 only
- Paper 3 - Unified chemistry (26%) – all modules

You will also have a **practical endorsement**.

How can I prepare myself before starting in September?

CGP have two revision guides, you are advised to work through these books and study them so you can hit the ground running! The second book is particularly important if you are not a strong mathematician as 20% of all exam questions in A-level Chemistry are mathematical calculations.

1. Head Start to A-Level Chemistry https://www.cgpbooks.co.uk/secondary-books/as-and-a-level/science/chemistry/cbr72-head-start-to-a-level-chemistry-with
2. A-Level Chemistry: Essential Maths Skills https://www.cgpbooks.co.uk/secondary-books/as-and-a-level/science/chemistry/cmr71-a-level-chemistry-essential-maths

You MUST also **complete the transition tasks** below and bring them (self-assessed in a different coloured pen) to your first Chemistry lesson of Year 12.

Start by watching these four YouTube videos:
https://www.youtube.com/playlist?list=PLq1fr6xeGNhaaj4t8iw81Z9VYcQ5135lE

Then answer the four pages of **‘quick check questions’** using the notes pages above to support you.

Ions and Ionic Compounds

Formation of ions from atoms

Ions form from individual atoms by the loss or gain of electrons. Ions *tend* to have full outer shells containing 8 electrons.

- Elements in **groups 1-3** form ions with a **positive charge**
- Elements in **groups 5-7** form ions with a **negative charge**
- Elements in group 0 and 4 do not tend to form ions.

Compound ions

These ions contain more than one atom. They tend to form when a neutrally charged covalent molecule loses or gains one or more hydrogen ions (H^+).

For example, H_2SO_4 loses two hydrogen ions to form the sulfate ion, SO_4^{2-}. Ammonia, NH_3, gains a hydrogen ion to produce the ammonium ion, NH_4^+.

Naming ions

Positive ions almost all come from metals and have the same name as the element: potassium, calcium, zinc etc. The only exception is ammonium.

Negative ions end in 'ide' (for a single atom that gains electrons) or 'ate' – for an ion containing oxygen and another element.

Transition metal ions

Transition metals can form ions with variable charges; for this reason the charge on the metal ion should be referred to in the name of the compound, e.g. iron (III) oxide.

Constructing ionic formulae

When positive and negative ions combine to form ionic compounds, they add together so that the **overall charge is zero.**

Examples:

Aluminium chloride: Al^{3+} and Cl^-
Need 3 Cl^- (3 x -1) to balance the Al^{3+}
Formula: $AlCl_3$

Ammonium carbonate: NH_4^+ and CO_3^{2-}
Need 2 NH_4^+ (2 x +1) to balance CO_3^{2-}
Formula: $(NH_4)_2CO_3$

Copper (I) sulfide: Cu^+ and S^{2-}
Need 2 Cu^+ (2 x +1) to balance S^{2-}
Formula: Cu_2S

Iron (III) sulfate: Fe^{3+} and SO_4^{2-}
Need 2 Fe^{3+} (2 x +3) and 3 SO_4^{2-} (3 x -2)
Formula: $Fe_2(SO_4)_3$

Charge	Examples	Charge	Examples
+1	Na^+ K^+ NH_4^+	-1	Cl^- Br^- NO_3^-
+2	Mg^{2+} Ca^{2+}	-2	O^{2-} S^{2-} SO_4^{2-}
+3	Al^{3+}	-3	N^{3-} PO_4^{3-}

Ionic Compounds: Quick Check Questions

Formulae of ions

Give the formulae (separately) of the cation and anion present in each of the following compounds:

1. Sodium nitride
2. Magnesium oxide
3. Calcium nitrate
4. Aluminium hydroxide
5. Lithium carbonate
6. Iron (III) chloride
7. Copper (I) nitride

Names from formulae

Give the names of the following compounds from their formulae – make sure to include the charge on transition metal ions.

1. $Fe(OH)_3$
2. Na_2CO_3
3. $LiNO_3$
4. Al_2O_3
5. Fe2O3
6. MnO
7. NiSO4
8. NaH

Formulae from names

Give the formulae of the following compounds:

1. Lithium carbonate
2. Aluminium iodide
3. Ammonium hydroxide
4. Sodium sulfate
5. Iron (II) nitrate
6. Magnesium fluoride
7. Calcium nitride
8. Strontium hydroxide
9. Copper (I) carbonate
10. Calcium sulfide
11. Aluminium nitrate
12. Vanadium (V) oxide
13. Titanium (IV) chloride

Check your answers

Common Reaction Types

Neutralisation

Acids are substances that produce hydrogen ions (H^+) in solution
In **neutralisation**, hydrogen ions combine with the negative ion from a base to form water.
Bases can contain:

- Hydroxide ions (OH^-)
- Oxide ions (O^{2-})
- Carbonate ions (CO_3^{2-})

(Ammonia (NH_3) is also a base, but it does not produce water when it reacts with acids).
Salts are ionic compounds formed whenever acids react with bases (or metals).

Balanced equations for neutralisation reactions:

The first thing to do is work out the products from the general equation:
Acid + metal hydroxide/oxide → metal salt + water
Acid + metal carbonate → metal salt + water + carbon dioxide

- ✓ Make sure the formulae of all reactants and products are correct – in particular check the formulae of bases and salts according to charges on ions
- ✓ Balance the hydrogen atoms – often this is all you need to do!
- ✓ If it's too hard to balance, you probably have a formula wrong!

Redox and displacement

Redox stands for reduction and oxidation. The most common definitions for these are:

Oxidation	Reduction
Gain of oxygen	Loss of oxygen
Loss of electrons	Gain of electrons

Simple redox reactions often include an **element** in either the reactants, products or both. This is because when substances are converted from elements to compounds (or vice versa) they tend to lose or gain electrons.

Displacement reactions occur when a **more reactive element displaces a less reactive element from a compound**. All displacement reactions are redox reactions.

Precipitation

Precipitation occurs when two solutions are mixed to form an insoluble solid. They are frequently used in tests for ions and are represented by ionic equations.

Combustion

This is a rapid reaction where a substance, typically an organic compound such as a hydrocarbon, reacts with oxygen to give out heat and light. Hydrocarbons produce carbon dioxide and water when completely combusted.

Common Reaction Types: Quick Check Questions

Identifying reaction types

For each of the following balanced equations, decide whether the reaction is best described as: neutralisation, precipitation, redox, displacement or combustion. Some reactions may have more than one correct label!

1. $MgCO_3$ (s) + 2HCl (aq) $\rightarrow$ $MgCl_2$ (aq) + H_2O (l) + CO_2 (g)
2. 2Mg (s) + O_2 (g) $\rightarrow$ 2MgO (s)
3. CH_4 (g) + 2O_2 (g) $\rightarrow$ CO_2 (g) + 2H_2O (l)
4. Cl_2 (aq) + 2KBr (aq) $\rightarrow$ 2KCl (aq) + Br_2 (aq)
5. 2Na (s) + Cl_2 (g) $\rightarrow$ 2NaCl (s)
6. NaCl (aq) + $AgNO_3$ (aq) $\rightarrow$ AgCl (s) + $NaNO_3$ (aq)
7. $FeSO_4$ (aq) + 2LiOH (aq) $\rightarrow$ $Fe(OH)_2$ (s) + Li_2SO_4 (aq)
8. $FeSO_4$ (aq) + Zn (s) $\rightarrow$ $ZnSO_4$ (aq) + Fe (s)
9. H_2SO_4 (aq) + 2NaOH (aq) $\rightarrow$ Na_2SO_4 (aq) + 2H_2O (l)

Naming products

Name the products when the following substances react together:

1. Hydrochloric acid and sodium carbonate
2. Lithium hydroxide and copper (II) sulfate
3. Sulfuric acid and magnesium oxide
4. Fluorine and sodium iodide
5. Magnesium and copper (II) sulfate
6. Propane and oxygen
7. Magnesium and nitric acid

Balancing equations

Balance the following equations:

1. CuO + HCl $\rightarrow$ $CuCl_2$ + H_2O
2. SO_2 + O_2 $\rightarrow$ SO_3
3. $Ca(OH)_2$ + HCl $\rightarrow$ $CaCl_2$ + H_2O
4. $KClO_3$ $\rightarrow$ KCl + O_2
5. I_2 + $Na_2S_2O_3$ $\rightarrow$ NaI + $Na_2S_4O_6$
6. C + SO_2 $\rightarrow$ CS_2 + CO
7. Al + HNO_3 $\rightarrow$ $Al(NO_3)_3$ + H_2
8. NH_3 + O_2 $\rightarrow$ NO + H_2O

Redox and displacement

The following redox reactions all take place readily at room temperature:

Mg + $ZnSO_4$ $\rightarrow$ Zn + $MgSO_4$
Fe + $CuCl_2$ $\rightarrow$ $FeCl_2$ + Cu
Zn + $Fe(NO_3)_2$ $\rightarrow$ $Zn(NO_3)_2$ + Fe

1. What is the name give to all three reactions?
2. Put the metals Mg, Zn, Cu and Fe in order of decreasing reactivity.
3. Which metal is the strongest reducing agent?

Check your answers

Types of Equation

Word equations

Word equations are not used very much at A Level!

If you are asked to write a word equation, remember:

- Don't mix words and formulae (most commonly happens with water and carbon dioxide)
- Do include full names of compounds, such as iron (II) hydroxide

Symbol equations

If you are asked to write an equation for a reaction, you can assume that it will be a symbol equation, and that it should be balanced.

Half equations

Half equations only apply to redox reactions. Because oxidation is the loss of electrons and reduction is the gain of electrons, each half of a redox reaction can be represented by a separate equation, with electrons used to balance the change in charge.

For example, this is the ionic equation for the displacement of bromine by chlorine:

$$Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$$

The two half equations would be:

$Cl_2 + 2e^- \rightarrow 2Cl^-$	reduction (electrons gained)
$2Br^- \rightarrow Br_2 + 2e^-$	oxidation (electrons lost)

Ionic equations

Ionic equations are equations in which **spectator ions are not included**. Spectator ions are those which do not undergo a chemical change during the reaction.

There are three main examples of where we use ionic equations: precipitation, neutralisation and redox.

Precipitation reactions:

In a precipitation reaction, an aqueous cation and anion come together to produce an insoluble solid called a precipitate. So for the following example:

$Fe(NO_3)_2\,(aq) + 2NaOH\ (aq) \rightarrow Fe(OH)_2\ (s) + NaNO_3\ (aq)$

Iron (II) hydroxide is the precipitate (shown by the state symbol). The sodium and nitrate ions remain in solution, so they are the spectator ions. The ionic equation would therefore be:

$$Fe^{2+}\,(aq) + 2OH^-\ (aq) \rightarrow Fe(OH)_2\ (s)$$

Neutralisation reactions:

In neutralisation reactions, it is the reaction of the H+ ion with the anion from the base that is important. The ions in the salt are the spectator ions. In fact, the main ionic equation for neutralisation is simply this: $H^+ + OH^- \rightarrow H_2O$

Redox reactions:

In a redox reaction, the spectator ions are those that do not change their charge. For example, in the following displacement:

$$Mg + CuSO_4 \rightarrow Cu + MgSO_4$$

The sulfate ions do not change. The chemical change occurring is that magnesium is displacing copper. The ionic equation becomes:

$$Mg + Cu^{2+} \rightarrow Cu + Mg^{2+}$$

State symbols:

State symbols are **(s)** – solid, **(l)** – liquid, **(g)** – gas and **(aq)** – aqueous.

Ionic compounds and metals are solids; many non-metal elements and covalent compounds are gases. Acids are always aqueous and water is liquid. Other aqueous solutions should be indicated in the question.

Equations: Quick Check Questions

Writing symbol equations

Write balanced symbol equations for the reactions that occur between the following:

1. Hydrochloric acid and sodium oxide
2. Nitric acid and calcium carbonate
3. Sulfuric acid and potassium hydroxide
4. Chlorine and sodium iodide
5. Magnesium and hydrochloric acid
6. Propane and oxygen (complete combustion)
7. Sodium and chlorine
8. Magnesium and copper (II) nitrate

State symbols

Write balanced symbol equations, with state symbols, for the following reactions:

1. Marble chips (calcium carbonate) and hydrochloric acid
2. The formation of a precipitate of magnesium hydroxide from mixing solutions of magnesium chloride and sodium hydroxide
3. The complete combustion of butane
4. The thermal decomposition of calcium carbonate to produce calcium oxide and carbon dioxide

Check your answers

Ionic equations

Write ionic equations for the following reactions. (SS) means state symbols are required.

1. The precipitation of nickel (II) hydroxide (SS)
2. The precipitation of iron (III) carbonate (SS)
3. The reaction between hydrochloric acid and calcium carbonate
4. The reaction between sodium hydroxide and sulfuric acid
5. The reaction between nitric acid and sodium oxide
6. The reaction between magnesium and hydrochloric acid
7. The reaction between sodium bromide and fluorine

Half equations

Write half equations (ion-electron equations) for the following redox processes:

1. The formation of magnesium from magnesium ions
2. The formation of chlorine from chloride ions
3. The oxidation of iron (II) to iron (III)
4. The oxidation of oxide ions to oxygen
5. The reduction of chromium (III) ions to chromium

Chemical Calculations

Relative Formula Mass (M_r)

The relative formula mass (RFM, or Mr) is simply the **sum of the relative atomic masses** of all the atoms or ions present in the formula:

C_2H_6:	$M_r = (2 \times 12) + (6 \times 1)$	= 30
Na_2SO_4	$M_r = (2 \times 23) + 32.1 + (4 \times 16)$	= 142.1
$Ca(NO_3)_2$	$M_r = 40.1 + (2 \times 14) + (6 \times 16)$	= 164.2

It can be considered as having no units (it is relative to the masses of other particles) or can be measured in g mol^{-1}, since it is the mass of one mole of a substance.

Moles

The official definition of a mole is "the amount of substance that contains $6.02214076 \times 10^{23}$ elementary particles".

- By elementary particles, we could mean atoms, ions, or molecules – it depends on what type of particle makes up that substance.

For example:

- One mole of neon contains $6.02214076 \times 10^{23}$ neon atoms
- One mole of oxygen contains $6.02214076 \times 10^{23}$ oxygen molecules (O_2)
- One mole of water contains $6.02214076 \times 10^{23}$ water molecules (H_2O)

Solutions and concentration

Solutions contain a solute dissolved in a solvent (usually water). The concentration of solute is measured in terms of the number of moles dissolved in 1 dm^3, so is expressed as mol dm-3. If you remember that concentration is expressed in moles per dm^3, this gives us the equation:

Concentration = mol / dm^3

Moles and mass

The easiest way to remember the formula is to think about how you would work out mass from molar mass.

- If the molar mass of carbon dioxide is 44, it's easy to see that the mass of 2 moles is 88. Therefore the formula is:

Mass = moles x molar mass

You can then rearrange to find any of the three quantities.

- *Avoid using a formula triangle to do this – it won't help you in the long run!*

<u>Examples:</u>

Calculate the mass of 3.2 moles of Na_2CO_3 (Mr = 106)

mass = moles x M_r = 3.2 x 106 = 339.2 g

Calculate the number of moles in 1.335 g of $Fe(OH)_3$ (Mr = 106.8)

moles = mass / M_r = 1.335 / 106.8 = 0.0125 moles

Molar gas volume

At any given temperature and pressure, the volume of a gas depends on the number of particles. At room temperature and pressure, the volume of one mole of **any gas** is 24 dm^3. This leads to the relationship:

Volume = moles x molar volume (24 dm^3)

You can then rearrange to find any of the three quantities. This is actually easier than the mass relationship, because the volume of one mole does not depend on the gas.

Calculations: Quick Check Questions

Calculating RFM / M_r

Calculate the RFM of the following:

1. $FeCl_2$
2. Li_2CO_3
3. $(NH_4)_2SO_4$
4. $K_3Fe(CN)_6$

Mass and moles

Calculate the number of moles present in:

1. 11.7 g NaCl
2. 24.2 g CO_2
3. 236.16 g Li_2CO_3
4. 0.06605 g $(NH_4)_2SO_4$
5. Calculate the mass in grams of:
6. 0.5 moles of $CaSO_4$
7. 110 moles of $MgBr_2$
8. 2 x 10-3 moles of C_4H_{10}
9. 0.35 moles of KNO_3

Solutions and concentration

Calculate the following:

1. The number of moles of HCl in 2 dm^3 of a 0.1 mol dm^{-3} solution
2. The number of moles of NaOH in 25 cm^3 of a 2 mol dm^{-3} solution
3. The concentration of a solution, in mol dm^{-3}, containing 0.5 g NaOH dissolved in 250 cm^3 water
4. The volume of a 0.15 mol dm^{-3} solution of nitric acid that contains 3 moles of acid.

Molar gas volume

Calculate the number of moles present in the following (at room temperature and pressure):

1. 0.24 dm^3 of ammonia
2. 3.2 dm^3 of hydrogen
3. 240 cm^3 of methane
4. 72 cm^3 of oxygen

Calculate the volume (in dm^3) of the following:

5. 2.5 moles of nitrogen
6. 0.030 moles of sulfur dioxide
7. 44 moles of propane
8. 0.12 moles of carbon dioxide

Mixed calculations

Calculate the following (a little harder!)

1. The mass of 60 cm^3 of methane gas (CH_4) at room temperature and pressure
2. The volume occupied by 13.2 g CO_2 at room temperature and pressure
3. The formula of a group 2 metal carbonate, given that 0.080 moles has a mass of 6.744 g
4. The volume of ammonia (NH_3) gas that would dissolve in 300 cm^3 to produce a solution with concentration 0.5 mol dm^{-3}

Check your answers