Course Start

Course Start is independent learning you need to complete as a fundamental part of your introduction to the course. It should take you approximately 5 hours to complete.

Course Name	**A Level Chemistry**
How this **Course Start** fits into the first term of the course	This links directly into the skills needed to work through Module 1 (Practical Skills & Mole Theory) and Module 2 (Atomic Structure) that we start in September.
How will my **Course Start** learning be used in lessons?	The skills are ones you have used in Level 2/GCSE and will need to build upon in A-level Chemistry in both theory and practical sessions. The practical planning task is directly used as preparation for the first A-level practical you complete in September.
Course Start learning objectives	• *To start building on Common Practical Assessment Criteria (CPAC) from GCSE/Level 2. In OCR these skills are referred to in Practical Activity Groups or PAG for short.* • *To reinforce learning and skills from GCSE/Level 2 that Module 1 and 2 are heavily built upon.*
Study Skills	• **Research skills** - using directed sources and identifying key information • **Communication skills** - putting your ideas and findings into effective writing and note taking. • **Organisation** - planning time effectively to review skill sets before starting lessons.

Expectations for:

Our specification is: OCR A-level Chemistry A

What this course involves:
Completing Planned Study independent learning of 5 hours per week.
Writing tasks involving a range of practice exam questions including both multiple choice and long answer questions.
Application of numerical skills including analysing graphs and data, plus rearranging equations and following units.
Completing minimum of 12 PAG's (CPAC skills 1-5) which comprises around 18% of the questions asked in the final papers of the A Level.
Studying a diverse range of topics from atomic structure, bonding types, periodicity, energetics, equilibria, kinetics and organic chemistry.
Developing independent learning skills (e.g. time management, preparing for each week's lessons, completing learning tasks outside lessons)

Overview of required tasks:

1) **Complete Risk Assessment from New Student Day**

   (Note: You don't have to have been to New Student Day to complete this task)

   a) *Information sheets are included to help you complete this. "Station 3" on the New Student Day worksheet below contains more detailed information to guide you. Station 1 and 2 are not needed for course start work if you did not attend the day.*

2) **Work through skill activities in Head Start Guide**

   a) *Please mark your own work using the guide mark schemes*

3) **Complete Revision Task on Atomic Structure**

   a) *You may use your GCSE revision guide/textbook to help you.*

New Student Day - Welcome to A-level Chemistry!

Station 1 - How can we tell if our equipment is accurate?

At this station there is a variety of glassware. All this glassware is capable of measuring a volume of liquid. But can we trust the measurements written on them?
We can test this by using water. Water has a well known density of around 1 g cm^{-3} which means that 1cm^3 (or 1ml) should weigh 1g. It does vary a little due to temperature but we're going to account for that in our calculations.

Method:

1) Weigh your empty beaker on the scale - note down its mass in the table.

2) Measure out 25cm^3 in/using the equipment you have chosen.

3) Pour the water into the beaker from step 1 and reweigh the beaker with the water included - note down the new total mass of the beaker + water in the table. This is called weighing by difference and is more accurate than zero-ing the balance.

4) Measure the temperature of the water in the beaker and note this down in the table too. This will allow us to use an accurate value of density for our calculations.

5) Repeat for other pieces of equipment on the table.

6) Calculate the True Mass of Water for each piece of equipment using the density table to the right →

7) Calculate percentage difference between the measured mass of water (C) in the table and the true mass (E).

Temperature (°C)	**Density of water (g cm^{-3})**
16	0.998970
17	0.998802
18	0.998623
19	0.998433
20	0.998232

Temperature (°C)	**Density of water /(g cm^{-3})**
21	0.998021
22	0.997799
23	0.997567
24	0.997326
25	0.997074

Station 1 Results Table	***A***	***B***	***C*** *B - A = C*	***D***	***E*** *Look up D in table above, then use that Density value in the equation below*	***F*** $\text{Percentage difference \%} = \frac{\text{Measured value} - \text{True value}}{\text{True value}} \times 100$
Equipment	**Mass of beaker empty (g)**	**Mass of beaker + water (g)**	**Mass of water (g)**	**Temperature of the water**	**True Mass of Water** Density x Volume ($25cm^3$) = Mass	**Percentage Difference Between Measured Value and the True Value:**
$50cm^3$ Conical Flask						
$50cm^3$ Burette						
$25cm^3$ Volumetric Pipette						
$25cm^3$ Measuring Cylinder						

Station 1 Questions:

Which of these was closest to the expected 25g mass of water? What does that tell you about that equipment accuracy?

Station 2 - Can we tell what kind of accuracy equipment has?

Instead of doing this calculation everytime, we have additional information at our disposal. At the next station is more glassware. Look carefully at the equipment. Each piece will have some information on or next to it that shows you just how accurate those values are. Look for this symbol: **±,** known as the uncertainty value. This represents the range of values a measurement taken with that particular piece of equipment could have,

For example, if a measuring cylinder is labelled as ± 1cm^3 this means that the measurement could be 1cm^3 higher or lower than the value you have measured.See the table below for this example.

Task: Fill in the table below with the uncertainty values for the equipment given. You will then need to calculate the % error in the values you measured earlier!

Station 2 Results Table	**Uncertainty (cm^3)**	**Highest Value (cm^3)** *Measurement + Uncertainty*	**Lowest Value (cm^3)** *Measurement - Uncertainty*	**% error** *% error = (uncertainty / measurement) x 100*
EXAMPLE *25cm^3 measuring cylinder*	*± 1cm^3*	*26*	*24*	*(1 / 25) x 100 = 4%*
250cm^3 Conical Flask	±			
50cm^3 Burette	±			
25cm^3 Volumetric Pipette	±			
25cm^3 Measuring Cylinder	±			

Which piece of equipment has the largest % error? Does this match with the biggest percentage difference between measured value and true value?

Station 3 - How do we use a lab safely?

The other part of chemistry is understanding what practical work we are about to do. This involves being knowledgeable about the equipment and chemicals that you're using. To do this we create a risk assessment. A risk assessment lists all the chemicals and potential hazards you could come across while completing the practical work. It suggests the level of danger for the hazard and then what things you can do to keep yourself as safe as possible.

You will be undertaking an experiment called "Which is Which?" where you need to experiment with 5 unknown chemical compounds to identify them! The practical will be as follows:

You are provided with the following substances, A, B, C, D and E. The five unknown substances listed in random order are:

- *iron (II) sulphate solution*
- *copper (II) sulphate solid*
- *water*
- *copper (II) carbonate solid*
- *sodium chloride.*

You will then be given a series of instructions of tests to complete using further materials:

Chemicals	Equipment
• sulfuric acid • silver nitrate • barium chloride • sodium hydroxide • calcium solid	• Bunsen burner • Distilled water • Universal indicator paper • Glass test tubes • Lab coat & goggles

Use the safety data information at this station to start creating a risk assessment for doing this practical on the next page. You do not need to figure out which letter belongs to which compound yet - only identify what hazards you might encounter when you do this practical. **You will need to finish this risk assessment as part of your course start work over the summer.**

Station 3 - Risk Assessment

Chemical or Equipment	Hazard	How to make it safer / reduce the hazard or risk
0.1M iron (II) sulphate solution		
copper (II) sulphate solid		
copper (II) carbonate solid		
0.1M sodium chloride solution		
1M sulfuric acid solution		
0.05M silver nitrate solution		

0.1M barium chloride solution		
2M sodium hydroxide solution		
Calcium solid		
Bunsen burner		
Glassware		

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Sulfuric (VI) acid

Substance	Hazard	Comment
Concentrated sulfuric(VI) acid	CORROSIVE	DANGER. It causes severe skin burns and eye damage. It reacts violently, becoming very hot, when mixed with water. For a 15-minute exposure, the vapour concentration in the atmosphere should not exceed 0.15 mg m^{-3}.
Moderately concentrated sulfuric(VI) acid *(if 1.5 M or more)* Includes acid used in car batteries.	CORROSIVE	DANGER. It causes severe skin burns and eye damage.
Moderately dilute sulfuric(VI) acid *(if less than 1.5 M but 0.5 M or more)*	IRRITANT	WARNING. It may irritate the eye and skin.
Dilute sulfuric(VI) acid *(if less than 0.5 M)*	**Currently not classified as hazardous**	Dilute acid may still cause harm to the eyes or the skin. Treat as for more concentrated samples. For many activities in school science, 0.4 M is adequate.

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Sodium hydroxide

also applies to **soda lime** *and* **potassium hydroxide**

Substance	Hazard	Comment
Sodium or potassium hydroxide *Solid* *Also known as* **caustic soda** *and* **caustic potash**. **Soda lime** contains about 5% sodium hydroxide, 1% potassium hydroxide, 0.2% silicon dioxide, 14 – 19% water and the remainder calcium hydroxide (it is used to absorb carbon dioxide). **Carbosorb** in addition contains an indicator.	CORROSIVE HARMFUL	DANGER: causes severe skin burns and eye damage. Potassium hydroxide is also harmful if swallowed. It gives out heat when added to water which can cause boiling or create a choking mist. It is used in the home for clearing drains.
Sodium or **potassium hydroxide solution** *(if 0.5 M or more sodium hydroxide; 0.4 M or more potassium hydroxide)*	CORROSIVE HARMFUL	DANGER: causes severe skin burns and eye damage. Potassium hydroxide is also harmful if swallowed if 3 M or more. Fehling's solution contains sodium hydroxide of this concentration. It is used in the home as an oven cleaner.
Dilute sodium or **potassium hydroxide solution** *(if less than 0.5 M but 0.125 M or more sodium hydroxide; if less than 0.4 M but 0.1 M or more potassium hydroxide)*	IRRITANT	WARNING: irritating to the eyes and skin.
Very dilute sodium or **potassium hydroxide solution** *(if less then 0.125 M sodium hydroxide; if less than 0.1 M potassium hydroxide)*	**Currently not classified as hazardous**	It may still cause harm in the eyes or in a cut.

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Silver *and its* compounds

including **silver bromide, chloride, iodide, nitrate(V)** *and* **oxide**

Substance	Hazard	Comment
Silver (metal) *Solid*	**Currently not classified as hazardous**	It is used in jewellery. It is an approved food additive, E174.
Silver bromide, **chloride** and **iodide** *Solids*		Widely used in photographic emulsions. They are decomposed by light to give silver metal and the halogen (which then reacts with other substances in the emulsion).
Silver nitrate(V) *Solid and fairly concentrated solutions (if 0.3 M or more)*	**OXIDISING** **CORROSIVE** **ENVIRONMENTAL HAZARD**	DANGER: oxidiser; causes severe skin burns and eye damage; very toxic to aquatic life. If swallowed, it may cause internal damage due to absorption into the blood, followed by deposition of silver in various tissues. The solid explodes dangerously with magnesium powder and a drop of water. Accidents have caused many injuries and a very careful risk assessment is required before attempting this.
Silver nitrate(V) *Dilute solutions (if less than 0.3 M but 0.18 M or more)*	**CORROSIVE**	DANGER: causes severe eye damage; irritating to skin. It may produce black stains on the skin, which wear off in a few days.
Silver nitrate(V) *Very dilute solutions (if less than 0.18 M but 0.06 M or more)*	**IRRITANT**	WARNING: irritating to eyes and skin. Very dilute solutions are adequate for most school work when testing for halides in solution.
Silver nitrate(V) *Extremely dilute solutions (if less than 0.06 M)*	**Currently not classified as hazardous**	–
Silver nitrate(V) (ammoniacal) (Dissolved in ammonia solution) (Tollen's Reagent)	**EXPLOSIVE** **IRRITANT**	It is used for aldehyde tests and should be prepared only on a test-tube scale, when needed. Dispose of into plenty of water within 30 minutes, otherwise explosives may form. Failure to do this has caused accidents.
Silver oxide *Solid*	**Currently not classified as hazardous**	It is used in some batteries, eg button cells for watches and calculators.

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Barium compounds

Substance	Hazard	Comment
Barium chloride *Solid*	**TOXIC**	DANGER: toxic if swallowed, harmful if inhaled. For a 15-minute exposure, the concentration of barium should not exceed 1.5 mg m^{-3}.
Barium chloride *Solution* *(if 0.4 M or more)*	**HARMFUL**	WARNING: harmful if swallowed.
Barium chloride *Solution* *(if less than 0.4 M)*	**Currently not classified as hazardous**	–
Barium nitrate(V) *Solid* **Barium peroxide** *Solid*	**OXIDISING** **HARMFUL**	DANGER: oxidiser; harmful if swallowed or inhaled. For a 15-minute exposure, the concentration of barium should not exceed 1.5 mg m^{-3}.
Barium nitrate(V) *Solution*	**Currently not classified as hazardous**	–
Barium sulfate(VI) *Solid*	**Currently not classified as hazardous**	Unlike most barium compounds, barium sulfate(VI) is currently not classified as hazardous because it does not dissolve in water or acids. Hence it is safe to eat a 'barium (sulfate) meal', before being X-rayed.

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Copper *and its* compounds

including **copper oxides, carbonate, sulfate, chloride** *and* **nitrate**

Substance	Hazard	Comment
Copper (metal)	**Currently not classified as hazardous**	Sharp edges can present a risk of cuts. *Granulated* copper may be classified by some suppliers as toxic to aquatic life with long lasting effects.
Copper(I) oxides (Cuprous oxides) **Copper(II) oxides** (Cupric oxides)	CORROSIVE IRRITANT ENVIRON. HAZARD	DANGER – copper(I) oxide – *causes serious eye damage; skin irritant; harmful if swallowed/inhaled; toxic to aquatic life. WARNING – copper(II) oxide – causes serious eye irritation; skin irritant; harmful if swallowed/ inhaled; toxic to aquatic life.
Copper(II) carbonate hydroxide (Basic copper carbonate, malachite)	IRRITANT ENVIRON. HAZARD	WARNING – copper(II) carbonate hydroxide – causes serious eye irritation; skin irritant; harmful if swallowed/inhaled; toxic to aquatic life.
Copper(II) sulfate **Copper(II) nitrate** *Solids and concentrated solutions*	CORROSIVE IRRITANT ENVIRON. HAZARD	DANGER – solids and solutions (≥ 1.0M **sulfate**, ≥ 1.3 M **nitrate**) – cause serious eye damage; skin irritant; harmful if swallowed (especially saturated solutions for crystal-growing). *Solid only – very toxic to aquatic life. Water added to anhydrous solid copper(II) sulfate(VI) produces heat.
Copper(II) sulfate **Copper(II) nitrate** *Dilute solutions*	CORROSIVE IRRITANT	DANGER – **sulfate** (< 1.0 M and ≥ 0.2 M) and **nitrate** (< 1.3 M and ≥ 0.2 M) – skin irritant; cause serious eye damage. WARNING – **sulfate** (< 0.2 M and ≥ 0.02 M) and **nitrate** (< 0.15 M and ≥ 0.05 M) – skin and eye irritant. Currently not classified as hazardous – **sulfate** (< 0.02 M) and **nitrate** (< 0.05 M). Benedict's solution and Fehling's solution both contain dilute copper(II) sulfate(VI) but Fehling's solution has other hazards.
Copper(II) chloride *Solid*	IRRITANT ENVIRON. HAZARD	WARNING – eye and skin irritant; harmful if swallowed; toxic to aquatic life.
Copper(II) chloride Solutions *(if 0.8M or more)*	IRRITANT	WARNING – eye and skin; harmful if swallowed (≥ 1.8M).
Copper(II) chloride *Solution (if less than 0.8M)*	**Currently not classified as hazardous**	–

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Iron *and its* compounds

including **iron(II)** and **iron(III) oxides, carbonate, sulfate(VI), chlorides, bromide**

note: **iron(II)** compounds are often called **ferrous**, and **iron(III)** compounds **ferric**

Substance	Hazard	Comment
Iron (metal) *powder*	FLAMMABLE	WARNING: the powder is a flammable solid. Iron filings/powder in the eye are very painful because the iron oxidises rapidly in the saline environment. Samples of iron are often not very pure and on reacting with dilute acids may produce the TOXIC gas hydrogen sulfide (smelling of bad eggs) (see *Sheet 59*). For reaction with sulfur, see *Sheet 82*. Iron often coated with zinc (galvanised) to protect it from corrosion.
Iron (metal) *filings, sheets or bars of metal*	**Currently not classified as hazardous**	
Iron oxides and **iron(II) carbonate**	**Currently not classified as hazardous**	Applies to all iron oxides: iron(III) oxide (haematite), iron(II) iron(III) oxide (magnetite or ferrosoferric oxide). Iron(II) carbonate is usually sold mixed with a sugar (saccharated), to slow down oxidation.
Iron(II) and **iron(III) sulfate(VI)** **ammonium iron(II) sulfate** (Mohr's salt) **ammonium iron(III) sulfate** (ferric alum) *Solid or concentrated solutions (iron(II): if 0.5 M or more; iron(III): if 0.3 M or more)*	IRRITANT	WARNING: Causes skin and serious eye irritation. Iron(III) also harmful by ingestion if 0.6 M or more. Usually solutions are made up in dilute sulfuric acid, which may itself be hazardous (see *Sheet 22*), to slow down oxidation. Ammonium iron(II) and ammonium iron(III) solutions are more stable but are still made up in acid to limit oxidation.
Iron(II) and **iron(III) sulfate(VI)** **ammonium iron(II)** or **iron(III) sulfate** *Dilute solutions (iron(II): if less than 0.5 M; iron(III): if less than 0.3 M)*	**Currently not classified as hazardous**	Solutions which have been made up in sulfuric acid, which may itself be hazardous (see *Sheet 22*).
Iron(II) and **iron(III) chloride** *Hydrated or anhydrous solid, or concentrated solutions (if 0.1 M or more).*	HARMFUL CORROSIVE	DANGER: harmful if swallowed; causes skin irritation and serious eye damage. Some suppliers classify anhydrous solids and solutions more concentrated than 0.2 M as corrosive. Usually solutions are made up in hydrochloric acid (see *Sheet 20*) to slow down oxidation. Solution (about 2 M) used for etching printed circuit boards.
Iron(II) and **iron(III) chloride** *Dilute solutions (if less than 0.1 M)*	**Currently not classified as hazardous**	Usually solutions are made up in hydrochloric acid (see *Sheet 20*) to slow down oxidation.

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Group 2 metals

magnesium and **calcium**

Substance	Hazard	Comment
Magnesium (metal) *Solid (powder, turnings, ribbon)*	FLAMMABLE	DANGER: (*powder, turnings*) flammable solid, self-heating in large (kilogram) quantities; may catch fire; contact with water releases flammable gases. *Ribbon* – classification varies – may be as *powder/turnings* or may be *Currently not classified as hazardous.* It is moderately difficult to ignite but, once burning, it does so very vigorously and is difficult to extinguish. Ordinary fire-fighting methods are not suitable, but dry sand may be used. The flame is very bright and may damage eyesight. View through shade 9 welding filter **only**. It reacts readily with acids to produce hydrogen, an extremely flammable gas (see CLEAPSS *Student Safety Sheet 50*).
Calcium (metal) *solid*	HIGHLY FLAMMABLE	DANGER: In contact with water releases flammable gases. It reacts readily with water (or acids) to produce hydrogen, an extremely flammable gas (see CLEAPSS *Student Safety Sheet 50*). Contact with moisture forms calcium oxide or hydroxide which are CORROSIVE to eyes IRRITANT to skin (see CLEAPSS *Student Safety Sheet 32*). It is difficult to ignite but, once burning, does so vigorously.

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Sodium *and* potassium salts

Substance	Hazard	Comment
Sodium and **potassium chloride, bromide** and **iodide** *Solid & solution*	**Currently not classified as hazardous**	People have been killed through consuming very large amounts of salt. At 'normal' levels, can cause high blood pressure, hence heart disease. Adults should not eat more than 6 g/day, children less. Potassium chloride is approved food additive, E508, used as a 'low-salt' substitute.
Sodium sulfate(VI) *Also* **potassium sulfate(VI)** *Solid & solution*		Hydrated sodium sulfate(VI), $Na_2SO_4.10H_2O$ is known as Glauber's salt. Sodium sulfate(VI) is an approved food additive, E514, as is the potassium salt, E515.
Sodium hydrogensulfate(VI) (bisulfate) *Solid and concentrated solution (if 0.25 M or more)*	CORROSIVE	DANGER: Causes serious eye damage. It is strongly acidic because of acidic hydrogen in $NaHSO_4$. It is used in some toilet cleaners.
Sodium hydrogensulfate(VI) (bisulfate) *Dilute solutions (if less than 0.25 M but 0.1 M or more)*	IRRITANT	WARNING: Causes serious eye irritation. It is strongly acidic because of acidic hydrogen in $NaHSO_4$.
Sodium hydrogensulfate(VI) (bisulfate) *Very dilute solutions (if less than 0.1 M)*	**Currently not classified as hazardous**	It is strongly acidic because of acidic hydrogen in $NaHSO_4$.

Head Start to A Level Chemistry

A quick guide to surviving the first half term of A Level:

- Some things you should know from GCSE (plus a few things that might have passed you by)
- Quick check questions to assess your understanding

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: $Fe_2(SO_4)_2$

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)

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.

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:

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

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 x12) + (6 x 1)	= 30
Na_2SO_4	M_r = (2 x 23) + 32.1 + (4 x 16)	= 142.1
$Ca(NO_3)_2$	M_r = 40.1 + (2 x 14) + (6 x 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!*

Examples:

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

The structure of the atom

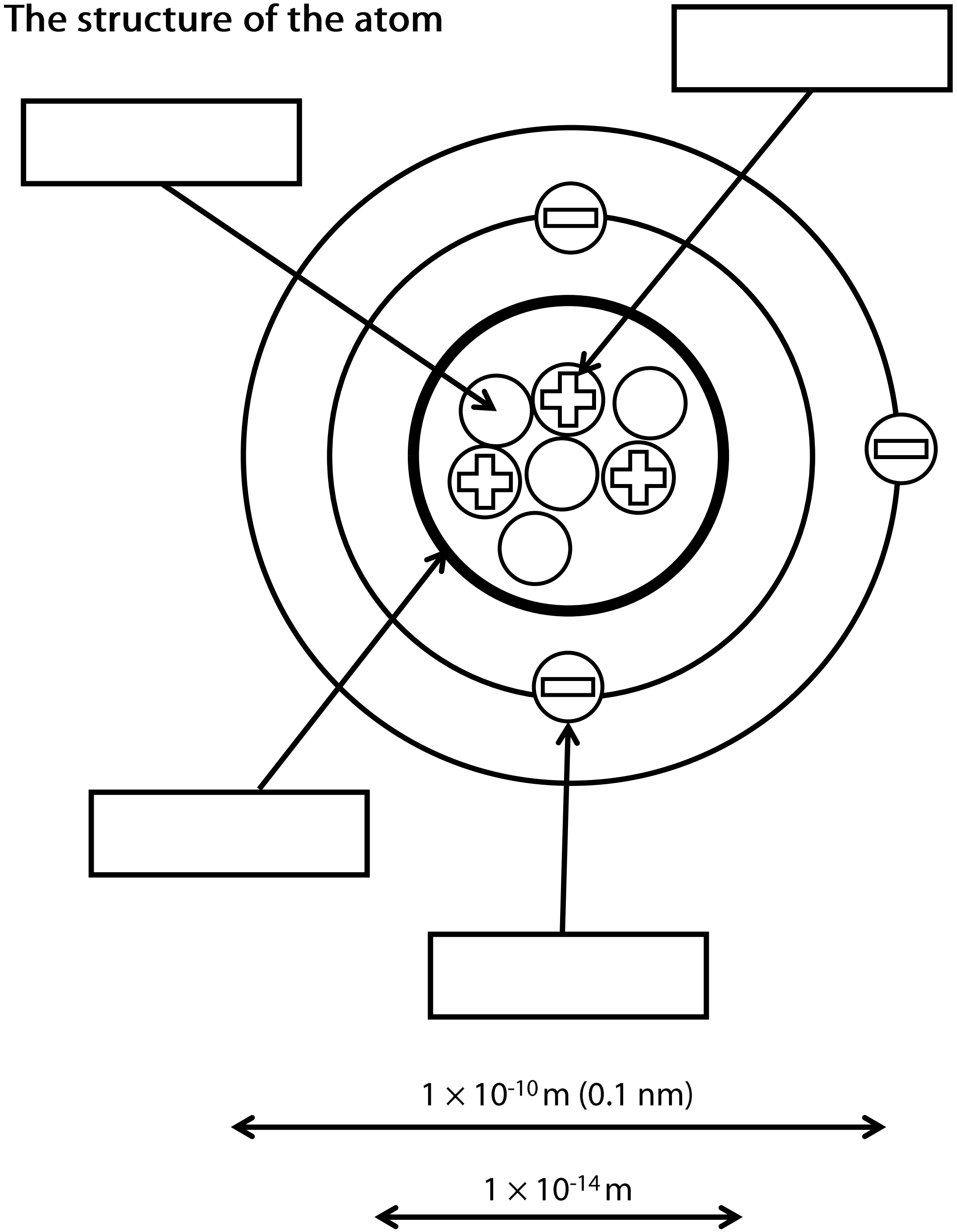

	Diagram	Charge	Mass
Proton	⊕		
Neutron	○		
Electron	⊖		

In this atom there are

	Number
Protons	
Neutrons	
Electrons	

________ number → 7

________ number → 3

$^{7}_{3}\mathrm{Li}$

The atomic number is the number of ________________ in the nucleus.

The mass number is the number of _____________ and _____________ in the nucleus.

In an atom the number of electrons is _____________ as the number of protons.

In an ion the number of electrons is _____________ to the number of protons.

The diameter of the atom is __________.

The diameter of the nucleus is __________.

The nucleus is __________ times smaller than the atom.

Name:____________
Block:____________

Atomic Structure Worksheet

1. **The 3 particles of the atom are:**

   a. ________________________
   b. ________________________
   c. ________________________

   Their respective charges are:

   a. ________________________
   b. ________________________
   c. ________________________

2. The number of protons in one atom of an element determines the atom's ________________________ , and the number of electrons determines ________________________ of and element.

3. The atomic number tells you the number of ________________________ in one atom of an element. It also tells you the number of ________________________ in a neutral atom of that element. The atomic number gives the "identity " of an element as well as its location on the Periodic Table. No two different elements will have the ________________________ atomic number.

4. The ________________________ of an element is the average mass of an element's naturally occurring atom, or isotopes, taking into account the ________________________ of each isotope.

5. The ________________________ of an element is the total number of protons and neutrons in the________________________ of the atom.

6. The mass number is used to calculate the number of ________________________ in one atom of an element. In order to calculate the number of neutrons you must subtract the ________________________ from the ________________________ .

7. **Give the symbol and number of protons in one atom of:**

Lithium	___________________	Bromine	___________________
Iron	___________________	Copper	___________________
Oxygen	___________________	Mercury	___________________
Krypton	___________________	Helium	___________________

8. **Give the symbol and number of electrons in a neutral atom of:**

Uranium	___________________	Chlorine	___________________
Boron	___________________	Iodine	___________________
Antimony	___________________	Xenin	___________________

9. **Give the symbol and number of neutrons in one atom of:**

(To get "mass number", you must round the "atomic mass" to the nearest whole number)

Show your calculations.

Barium	___________________	Bismuth	___________________
Carbon	___________________	Hydrogen	___________________
Fluorine	___________________	Magnesium	___________________
Europium	___________________	Mercury	___________________

10. **Name the element which has the following numbers of particles:**

a. 26 electrons, 29 neutrons, 26 protons ______________________

b. 53 protons, 74 neutrons ______________________

c. 2 electrons (neutral atoms) ______________________

d. 20 protons ______________________

e. 86 electrons, 125 neutrons, 82 protons (charged atom) ______________________

f. 0 neutrons ______________________

11. **If you know only the following information can you always determine what the element is? (Yes/No).**

a. number of protons ___________

b. number of neutrons___________

c. number of electrons in a neutral atom___________

d. number of electrons___________