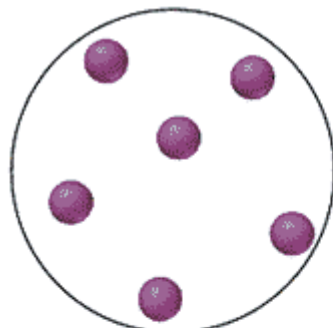
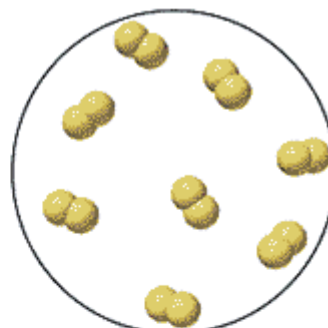

1.0 Basic Chemistry

This is the chemistry you should already know from GCSE:

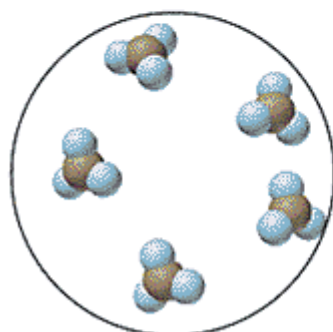
Elements, mixtures and compounds:



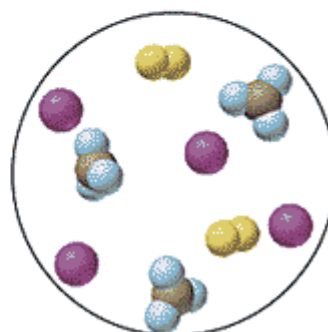
A Atoms of an element



B Molecules of an element



C Molecules of a compound



D Mixture of two elements and a compound

Atom	Simplest building block of matter.
Element	Made up of 1 type of atom.
Mixture	2 or more elements / compounds that are not chemically bonded together. They can be easily separated.
Compound	2 or more elements chemically bonded together.
Molecule	2 or more atoms chemically bonded together

Chemical formulae

1) Common molecules

Name of element	Formula of element	Name compound	Formula of compound	Name of acid	Formula of acid
Hydrogen	H ₂	Water	H ₂ O	Hydrochloric	HCl
Nitrogen	N ₂	Carbon dioxide	CO ₂	Nitric	HNO ₃
Oxygen	O ₂	Carbon monoxide	CO	Sulphuric	H ₂ SO ₄
Halogens	X ₂ Cl ₂	Ammonia	NH ₃	Phosphoric	H ₃ PO ₄

- All gases except Group 0, Noble gases go round in pairs as diatomic molecules.
- All Group VII elements, the Halogens, also go round in pairs as diatomic molecules.

2) Simple ions

Group	1	2	3	4	5	6	7	0
e's in outer shell	1	2	3	4	5	6	7	Full
Gains / loses when reacts to leave a full shell	Loses 1e	Loses 2e	Loses 3e	Loses / gains 4e	Gains 3e	Gains 2e	Gains 1e	
Charge on ion	+1	+2	+3	+/-4	-3	-2	-1	
Example	Li ⁺	Be ²⁺	B ³⁺		N ³⁻	O ²⁻	F ⁻	

3) Compound ions

Charge on ion	Name	Formula
1-	Hydroxide	OH ¹⁻
	Nitrate	NO ₃ ¹⁻
	Hydrogen carbonate	HCO ₃ ¹⁻
2-	Sulphate	SO ₄ ²⁻
	Carbonate	CO ₃ ²⁻
3-	Phosphate	PO ₄ ³⁻
1+	Ammonium	NH ₄ ¹⁺

4) Transition metal ions

- These do not belong to a group so you are told the charge on the ion with a roman numeral

Roman numerals

Charge	1+	2+	3+	4+	5+	6+	7+
Roman numeral	I	II	III	IV	V	VI	VII

5) Acids & Salts

Acid	Sulphuric	Nitric	Hydrochloric	Phosphoric
Formula of acid	H ₂ SO ₄	HNO ₃	HCl	H ₃ PO ₄
Salt	...sulphate	...nitrate	...chloride	...phosphate
Formula ...salt	...SO ₄ ²⁻	...NO ₃ ¹⁻	...Cl ¹⁻	...PO ₄ ³⁻

Question:

Complete the table below:

Name	Formula
Nitrogen	
Bromine	
Hydrogen	
Oxygen	
Chlorine	
Hydrochloric acid	
Carbon monoxide	
Sulphur trioxide	
Water	

Name	Formula
	NH ₃
	CO ₂
	SO ₂
	CH ₄
	I ₂
	NO
	NO ₂
	NH ₃
	H ₂ SO ₄

Writing formula

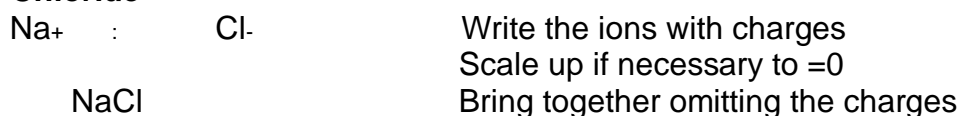
- The ions in a chemical formula must **add up to zero**.
- Use subscripts after an ion in a formula to double/triple that ion so the sum = 0. eg. CuCl_2
- If you are double/tripling ions that consist of more than one element brackets must be used. eg. $\text{Ca}(\text{OH})_2$
- In **f** formula – these are the numbers ‘on the **f**loor’

Examples:

a) Simple formula:

- Use the Periodic table to look up the chemical symbols and the charges on the ions
- Scale up so the charges cancel out
- Non metal endings change to ‘**ide**’

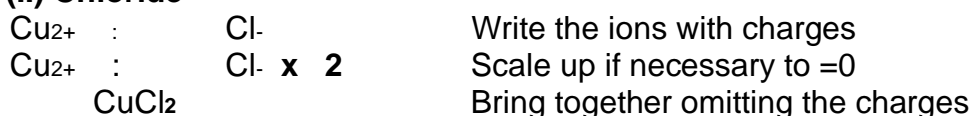
Sodium Chloride –



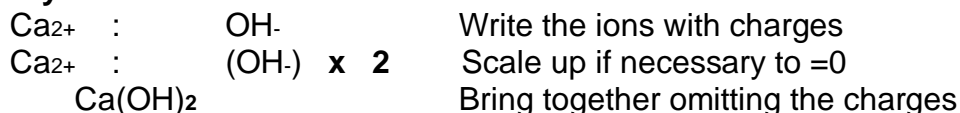
b) Complex formula:

- One of the ions will **not** be on the Periodic table, it will be a **compound ion**.
- The formula is worked out the same as before.
- If you scale up compound ions, **you must use brackets**
- If you do not scale up compound ions, **you must NOT use brackets**

Copper (II) Chloride



Calcium Hydroxide



TIP: Once the formulae is written – NEVER CHANGE THE NUMBERS

Examples – have a go at the following:

- | | |
|-----------------------|---------------------|
| 1 Calcium fluoride | 2 Sodium oxide |
| 3 Aluminium chloride | 4 Gallium nitride |
| 5 Magnesium hydroxide | 6 Sodium nitrate |
| 7 Sodium sulphate | 8 Gallium carbonate |

Question:

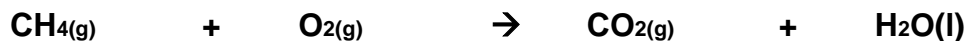
Complete the table below:

Name	Formula
Calcium fluoride	
Sodium oxide	
Aluminium chloride	
Gallium nitride	
Copper (II) hydroxide	
Sodium nitrate	
Sodium sulphate	
Iron (III) carbonate	
Calcium hydrogencarbonate	

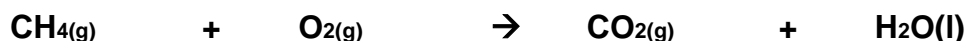
Name	Formula
	NH ₄ NO ₃
	Mg(OH) ₂
	SrSO ₄
	Fe(NO ₃) ₂
	Fe(NO ₃) ₃
	Mn(SO ₄) ₂
	Ga ₂ (CO ₃) ₃
	(NH ₄) ₂ SO ₄
	H ₂ SO ₄

Types of reactions

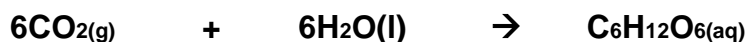
1. **Combustion** – A reaction with oxygen



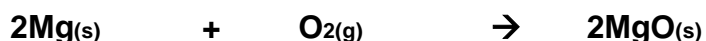
2. **Exothermic** – A reaction that releases heat energy to the surroundings



3. **Endothermic** – A reaction that gains energy from the surroundings



4. **REDOX** – A reaction where REDuction (is gain of electrons) and OXidation (is loss of electrons) takes place



5. **Decomposition** – Where a reactant breaks down into 2 or more products



6. **Reversible** – A reaction where reactants \rightarrow products or products \rightarrow reactants



7. Neutralisation – (Acid reactions) – A reaction where an acid forms a salt



Acids, Bases and salts:

Acid – Is a substance that donates protons, H⁺ ions: HCl

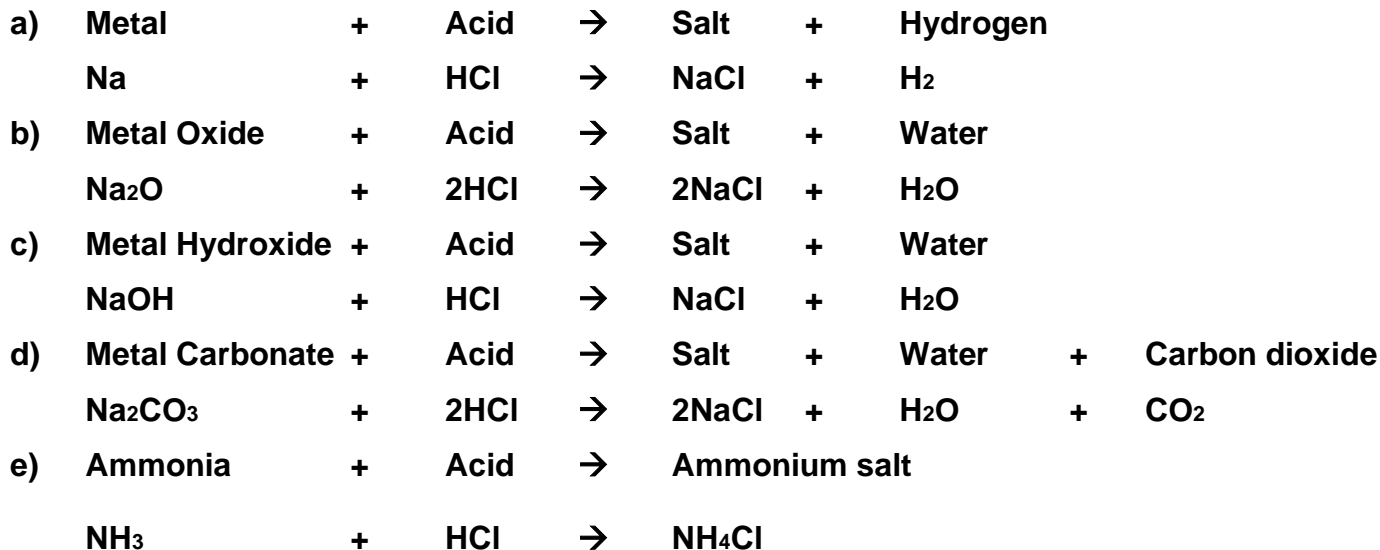
Base – Is a substance that accepts protons, H⁺ ions: NH₃

Alkali – Is a base that releases hydroxide ions, OH⁻ in aqueous solution: NaOH

Salt – When the hydrogen ions in an acid is replaced by a metal or ammonium ion

Acid	Sulphuric	Nitric	Hydrochloric	Phosphoric
Formula of acid	H ₂ SO ₄	HNO ₃	HCl	H ₃ PO ₄
Salt	...sulphate	...nitrate	...chloride	...phosphate
Formula ...salt	...SO ₄ ²⁻	...NO ₃ ¹⁻	...Cl ¹⁻	...PO ₄ ³⁻

Reactions of Acids:



Balancing chemical equations

- The acid reactions will be used as examples, a few connections first.

Acid reactions – A reaction where an acid forms a salt

- a) **Metal + Acid → Salt + Hydrogen**
b) **Metal Oxide + Acid → Salt + Water**
c) **Metal Hydroxide + Acid → Salt + Water**
d) **Metal Carbonate + Acid → Salt + Water + Carbon dioxide**
e) **Ammonia + Acid → Ammonium salt**

- a) **Na + HCl → NaCl + H₂**
b) **Na₂O + 2HCl → 2NaCl + H₂O**
c) **NaOH + HCl → NaCl + H₂O**
d) **Na₂CO₃ + 2HCl → 2NaCl + H₂O + CO₂**
e) **NH₃ + HCl → NH₄Cl**

Chemical connections:

Water or Hydrogen

- If you look at the reactants in **(a)**, you'll notice that the metal has **no oxygen present**.
- This means that water, H₂O **cannot be formed, therefore H₂ is the product**
- If you look at the reactants in **(a) – (d)**, you'll notice that the metal **has oxygen present**.
- This means that water, H₂O **can be formed, therefore H₂O is the product**

Carbon dioxide or not

- If you look at the reactants in **(d)**, you'll notice that the metal has **3 oxygen's and 1 carbon present**.
- This means that water, H₂O **can be formed, therefore H₂O is the product**
- What is left is **1 carbon and 2 oxygen's, so CO₂ is also formed**

All salts contain the following

- A positive cation - usually a metal or ammonium (NH₄⁺)
- A negative anion derived from an acid

Salt – where the hydrogen ion in an acid is replaced with a metal or ammonium ion

Acid	Sulphuric	Nitric	Hydrochloric	Phosphoric
Formula of acid	H ₂ SO ₄	HNO ₃	HCl	H ₃ PO ₄
Salt	...sulphate	...nitrate	...chloride	...phosphate
Formula ...salt	...SO ₄ ²⁻	...NO ₃ ¹⁻	...Cl ¹⁻	...PO ₄ ³⁻

Note – The number of acidic hydrogen's in the acid = the size of the negative charge on the anion formed:

Balancing chemical reactions:

- Balance using **B**ig numbers **B**efore the species with that elements in to scale up the number of moles of reactants → products.
- A rule of thumb to help you balance is to balance the elements in this order - **MACHO**:
Metal
Any other element
Carbon
Hydrogen
Oxygen

A table helps.

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



Fe	1		1	
Cl		1 x 2 = 2	2	
H		2		2

- Put the **2** that you have multiplied up by before the molecule with the element you are scaling up.
- You now have the same number of atoms on each side.

State symbols

- All that remains is to add state symbols to the balanced chemical reaction

Solid	(s)
Liquid	(l)
Gas	(g)
Aqueous (dissolved in water)	(aq)



- All metal elements are solids, (s).
- All acids are dissolved in water, (aq)
- All ionic compounds are either solids or dissolved in water, (s) or (aq)

A rule of thumb:

- Ionic compounds dissolve in water.
- If there is water as a product or water as (aq) in the reactants then the ionic compound's state symbol will be (aq)

- Water is the solvent that (aq) chemistry takes place in. You cannot dissolve water in water so water is a liquid, (l)

Summary:

- | | |
|---------------|------------------------------------|
| Step 1 | Write out the word equation |
| Step 2 | Write the correct chemical formula |
| Step 3 | Balance using MACHO |
| Step 4 | Add the state symbols |

Questions:

Complete the following reactions by writing formula / balancing with state symbols



6) Gallium carbonate + Nitric acid →

7) Copper (II) oxide + Hydrochloric acid →

8) Iron (III) oxide + Nitric acid →

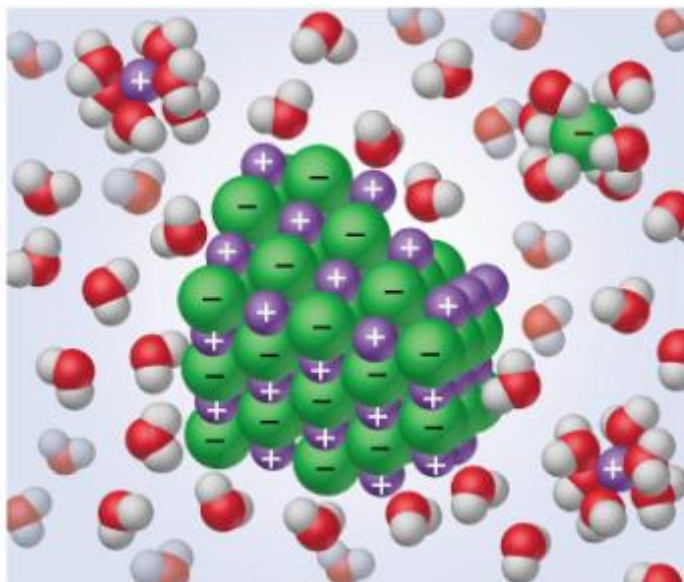
9) Copper (I) Oxide + Sulphuric acid →

10) Iron (II) hydroxide + Phosphoric acid →

8. **Ionic equations** – Where the spectator ions are removed revealing the species involved in the reaction



- Ionic compounds when dissolved in water separate out into their constituent ions
- For example – aqueous NaCl is actually a solution of Na⁺ ions and Cl⁻ ions as shown below:



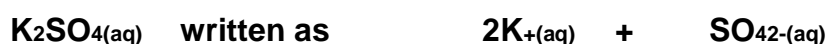
- This allows us to look at the actual aqueous ions involved in the reaction.
- Ions that are not involved in reactions are called **spectator ions** as they do little more than 'watch' the reaction.

Rules:

1. All acids are (aq) therefore can be written with their acidic hydrogens dissociated:



2. All soluble ionic compounds, (aq) ions dissociated:



3. All insoluble ionic compounds, (s) ions will NOT dissociated:



Questions:

Complete the table below, if the ions do not dissociate, leave it blank:

Formula	In water
$\text{CaF}_{2(\text{aq})}$	
$\text{Na}_2\text{O}_{(\text{aq})}$	
$\text{AlCl}_{3(\text{aq})}$	
$\text{Ga}(\text{NO}_3)_{3(\text{aq})}$	
$\text{CuO}_{(\text{s})}$	
$\text{NaNO}_{3(\text{aq})}$	
$\text{HCl}_{(\text{aq})}$	
$\text{FeO}_{(\text{s})}$	
$\text{Ca}(\text{HCO}_3)_{2(\text{aq})}$	

Name	In water
$\text{NH}_4\text{NO}_{3(\text{aq})}$	
$\text{Mg}(\text{OH})_{2(\text{s})}$	
$\text{HNO}_{3(\text{aq})}$	
$\text{Fe}(\text{NO}_3)_{2(\text{aq})}$	
$\text{Fe}(\text{NO}_3)_{3(\text{aq})}$	
$\text{Mn}(\text{SO}_4)_{2(\text{s})}$	
$\text{Ga}_2(\text{CO}_3)_{3(\text{s})}$	
$(\text{NH}_4)_2\text{SO}_{4(\text{aq})}$	
$\text{H}_2\text{SO}_{4(\text{aq})}$	

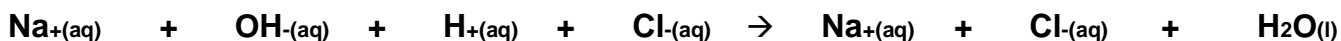
Writing Ionic equations:

Example 1:

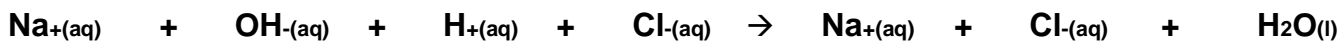
1) Write the full balanced chemical equation



2) Dissociate any ionic or acids species found with an aqueous state symbols



3) Identify and cross out the spectator ions



1) Rewrite the **balanced ionic equation** without the spectator ions

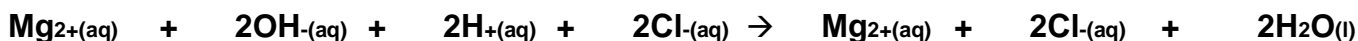


Example 2:

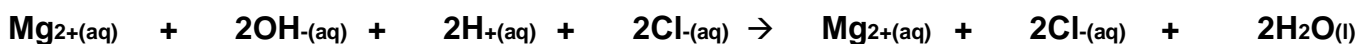
1) Write the full balanced chemical equation



2) Separate any ionic or acids species found with an aqueous state symbols



3) Identify and cross out the spectator ions



2) Rewrite the **balanced ionic equation** without the spectator ions

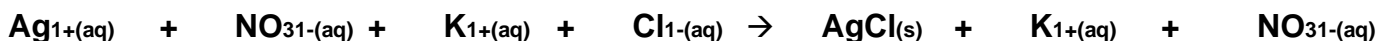


Example 3: A precipitation reaction

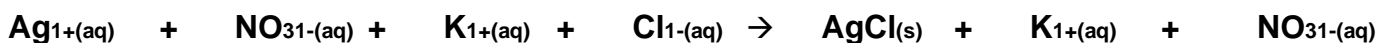
3) Write the full balanced chemical equation



4) Separate any ionic or acids species found with an aqueous state symbols

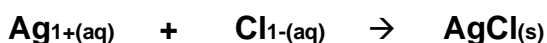


5) Identify and cross out the spectator ions

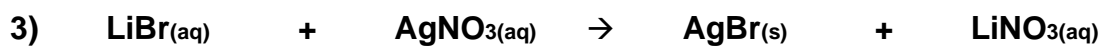


- **AgCl(s)** is in an ionic lattice structure.
- **Ag¹⁺(aq)** and **NO₃⁻(aq)** are dissociated ions
- As they are different, they are **not spectator ions and cannot be cancelled out**

6) Rewrite the **balanced ionic equation** without the spectator ions



Questions:



4) Aqueous aluminium chloride reacts with aqueous sodium hydroxide giving a white precipitate of aluminium hydroxide and aqueous sodium chloride

5) Aqueous barium chloride reacts with sulphuric acid giving a white precipitate of barium sulphate and one other aqueous product