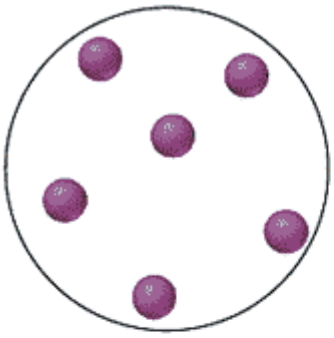
1.0 Basic Chemistry

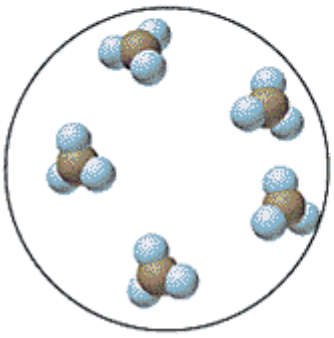
This is the chemistry you should already know from GCSE:

Elements, mixtures and compounds:

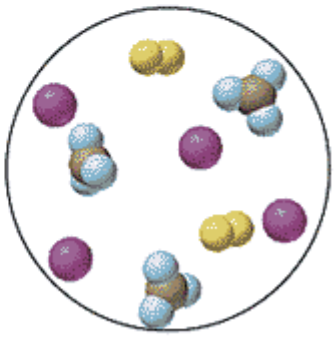


A Atoms of an element

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_2O	Hydrochloric	HCl
Nitrogen	N_2	Carbon dioxide	CO_2	Nitric	HNO_3
Oxygen	O_2	Carbon monoxide	CO	Sulphuric	H_2SO_4
Halogens	X_2 Cl_2	Ammonia	NH_3	Phosphoric	H_3PO_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

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. $Ca(OH)_2$
- In **f**ormula – 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 –

Na^+	:	Cl^-	Write the ions with charges
			Scale up if necessary to =0
NaCl			Bring together omitting the charges

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 note scale up compound ions, **you must NOT use brackets**

Copper (II) Chloride

Cu^{2+}	:	Cl^-	Write the ions with charges
Cu^{2+}	:	Cl^- **x 2**	Scale up if necessary to =0
$CuCl_2$			Bring together omitting the charges

Calcium Hydroxide

Ca^{2+}	:	OH^-	Write the ions with charges
Ca^{2+}	:	(OH^-) **x 2**	Scale up if necessary to =0
$Ca(OH)_2$			Bring together omitting the charges

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

Types of reactions

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

   $CH_{4(g)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O(l)$

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

   $CH_{4(g)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O(l)$

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

   $6CO_{2(g)} + 6H_2O(l) \rightarrow C_6H_{12}O_{6(aq)}$

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

   $2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$

5. **Displacement –** Where a more reactive element 'displaces' a less reactive element

   $Cl_{2(aq)} + 2KI_{(aq)} \rightarrow I_{2(aq)} + 2KCl_{(aq)}$

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

   $CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$

7. **Reversible –** A reaction where reactants → products or products → reactants

   $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$

8. **<u>Acid reactions</u> –** A reaction where an acid forms a salt

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

Base – Is a substance that accepts protons, H^+ ions: NH_3

Alkali – Is a substance that releases hydroxide ions, OH^- in aqueous solution: NaOH

Salt – Is formed when the hydrogen ions in an acid is replaced by a positive metal or ammonium ion

a)	**Metal**	**+**	**Acid**	**→**	**Salt**	**+**	**Hydrogen**		
	Na	**+**	**HCl**	**→**	**NaCl**	**+**	**H_2**		
b)	**Metal Oxide**	**+**	**Acid**	**→**	**Salt**	**+**	**Water**		
	Na_2O	**+**	**2HCl**	**→**	**2NaCl**	**+**	**H_2O**		
c)	**Metal Hydroxide**	**+**	**Acid**	**→**	**Salt**	**+**	**Water**		
	NaOH	**+**	**HCl**	**→**	**NaCl**	**+**	**H_2O**		
d)	**Metal Carbonate**	**+**	**Acid**	**→**	**Salt**	**+**	**Water**	**+**	**Carbon dioxide**
	Na_2CO_3	**+**	**2HCl**	**→**	**2NaCl**	**+**	**H_2O**	**+**	**CO_2**
e)	**Ammonia**	**+**	**Acid**	**→**	**Ammonium salt**				
	NH_3	**+**	**HCl**	**→**	**NH_4Cl**				

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) $Na + HCl \rightarrow NaCl + H_2$

b) $Na_2O + 2HCl \rightarrow 2NaCl + H_2O$

c) $NaOH + HCl \rightarrow NaCl + H_2O$

d) $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

e) $NH_3 + HCl \rightarrow NH_4Cl$

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, H_2O **cannot be formed, therefore** H_2 **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, H_2O **can be formed, therefore** H_2O **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, H_2O **can be formed, therefore** H_2O **is the product**
- What is left is **1 carbon and 2 oxygen's, so** CO_2 **is also formed**

All salts contain the following

- A positive cation - usually a metal or ammonium (NH_4^+)
- 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_2SO_4	HNO_3	HCl	H_3PO_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:

- **B**alance 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

$Fe + 2HCl \rightarrow FeCl_2 + H_2$

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)**

$Fe_{(s)} + 2HCl_{(aq)} \rightarrow FeCl_{2(aq)} + H_{2(g)}$

- 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

Examples – have a go at the following:

1) $Mg(OH)_2$ **+** HCl → $MgCl_2$ **+** H_2O

2) MgO **+** HNO_3 → $Mg(NO_3)_2$ **+** H_2O

3) $CaCO_3$ **+** HNO_3 →

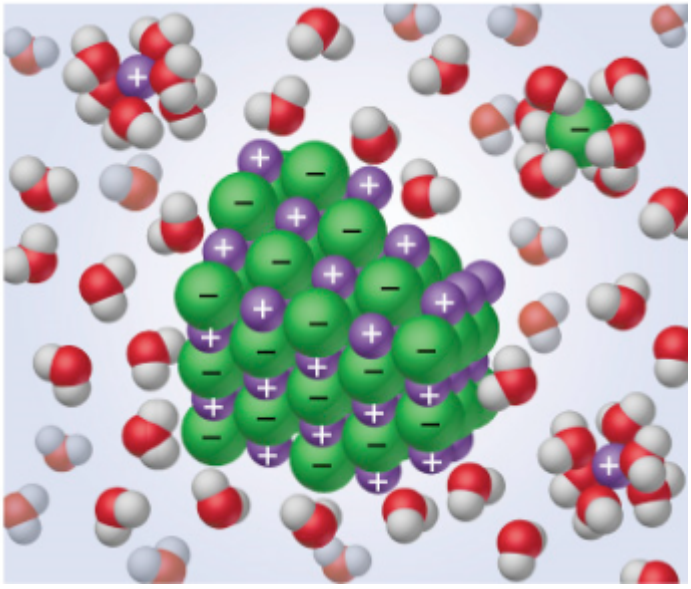
4) Al_2O_3 **+** H_2SO_4 →

5) **Sodium carbonate + Hydrochloric acid →**

6) **Gallium carbonate + Nitric acid →**

9. **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: Click image for animation

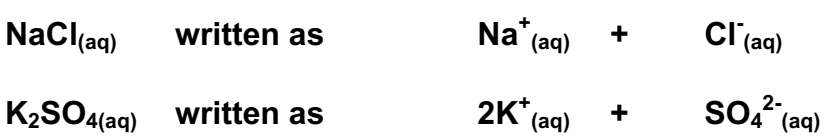


- This allows us to look at the actual aqueous ions involved in the reaction.
- Ions that are not involved in reactions are called **spectator ions** as they do little more than 'watch' the reaction.

Rules:

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

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

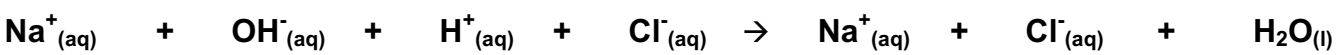


3. **All insoluble ionic compounds, (s) ions will NOT dissociated:**

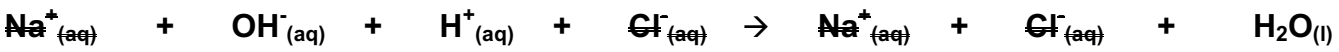
Example 1:

1) Write the full balanced chemical equation

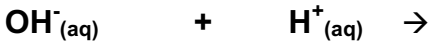
2) Separate any ionic or acids species found with an aqueous state symbols



3) Identify and cross out the spectator ions



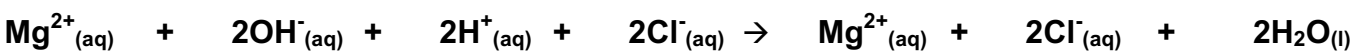
1) Rewrite the **balanced ionic equation** without the spectator ions



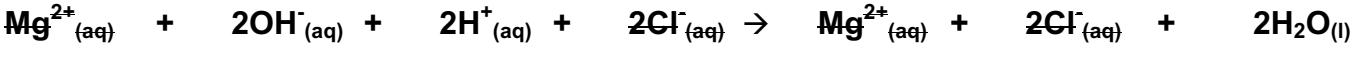
Example 2:

1) Write the full balanced chemical equation

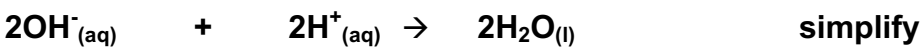
2) Separate any ionic or acids species found with an aqueous state symbols



3) Identify and cross out the spectator ions



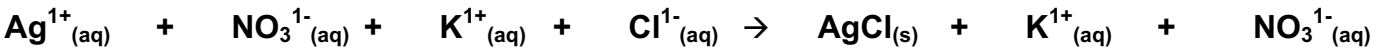
2) Rewrite the **balanced ionic equation** without the spectator ions



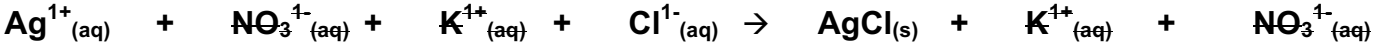
Example 3: A precipitation reaction

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.
- **$Ag^{1+}_{(aq)}$ and $NO_3^{1-}{}_{(aq)}$** 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