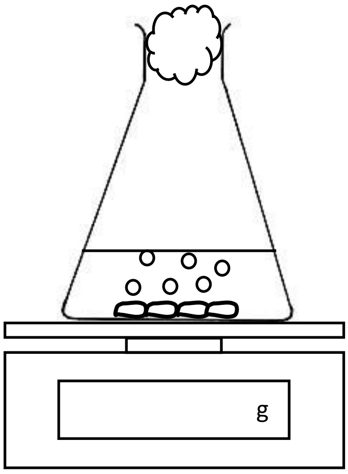
Unit 1—Chemical Changes and Structure Revision Notes

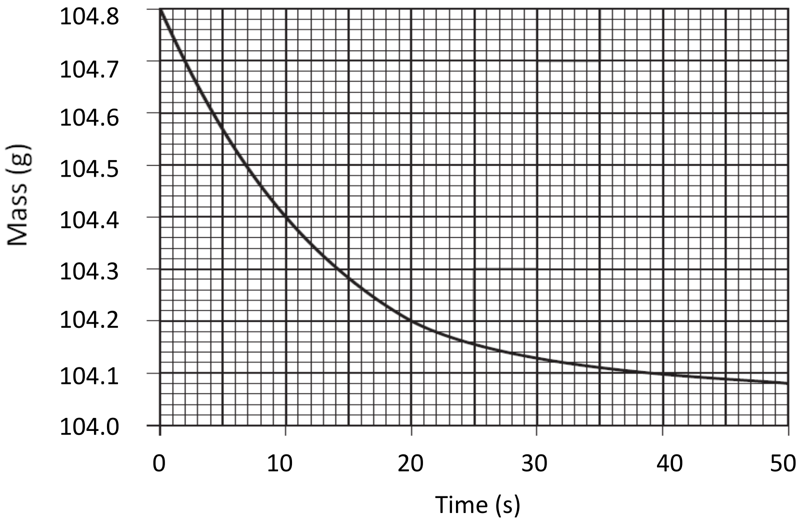
Rates of reaction

<u>The rate of reaction</u> can be increased by:
- increasing the **concentration** of a solution
- decreasing the **particle size** of a solid
- increasing the **temperature**
- adding a **catalyst**.

<u>The average rate of reaction</u> can be calculated from a graph of the change in mass or volume against time.

<u>Measuring a change in mass</u>





Average rate of reaction $= \frac{\textbf{change in mass}}{\textbf{change in time}}$

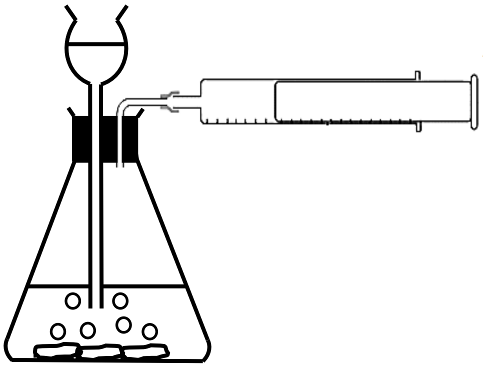
Average rate over first 10 s $= \frac{104.80 - 104.40}{10 - 0} = \frac{0.40}{10} = 0.04\ gs^{-1}$

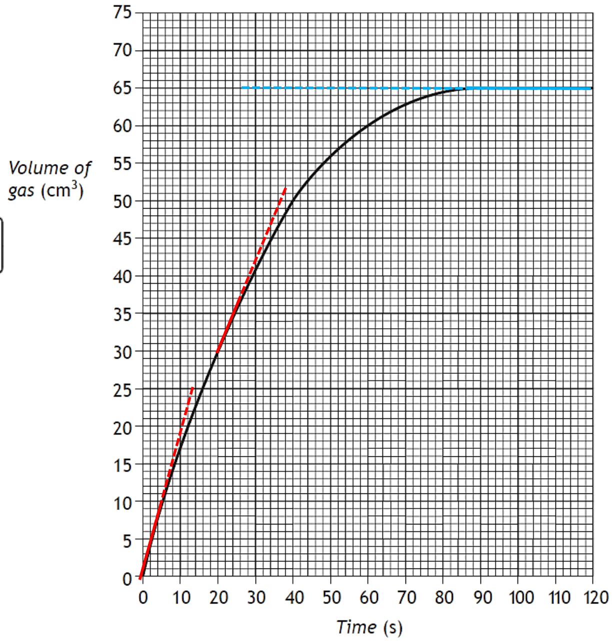
Average rate between 10 s and 20 s $= \frac{104.40 - 104.20}{20 - 10} = \frac{0.20}{10} = 0.02\ gs^{-1}$

Average rate over first 20 s $= \frac{104.80 - 104.20}{20 - 0} = \frac{0.60}{20} = 0.03\ gs^{-1}$

Average rate between 10 s and 50 s $= \frac{104.40 - 104.08}{50 - 10} = \frac{0.32}{40} = 0.008\ gs^{-1}$

Measuring a change in volume





Average rate of rection $= \frac{\text{change in volume}}{\text{change in time}}$

Average rate of reaction $= \frac{65 - 0}{86 - 0}$

$= \frac{65}{86}$

$= 0.76\ cm^3s^{-1}$

Interpreting a graph that follows the course of a reaction.

Gradient (or steepness) of line indicates rate (the steeper the line the faster the rate).

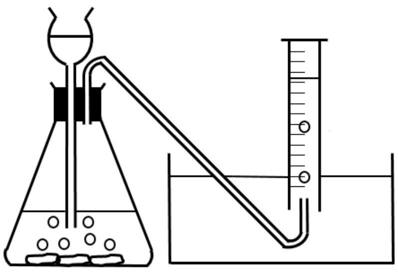
The end of the reaction is marked by the line levelling out, quantity of product (or reactant) no longer changing.

Total volume of gas produced in example above = 65 cm^3

Note: Always give a positive value for rate.
Units for rate (from a graph) = unit for *y*-axis followed by unit for *x*-axis^{-1}
or (from a table) = unit for recorded variable (dependent variable) followed by unit for time^{-1}

In the examples shown above the rate of reaction decreases as the reaction progresses, this is due to a reduction in the concentration of the reactants as the reaction proceeds.

Note: if the gas being collected is insoluble in water then the apparatus in the diagram shown below can be used to show the change in volume with time.

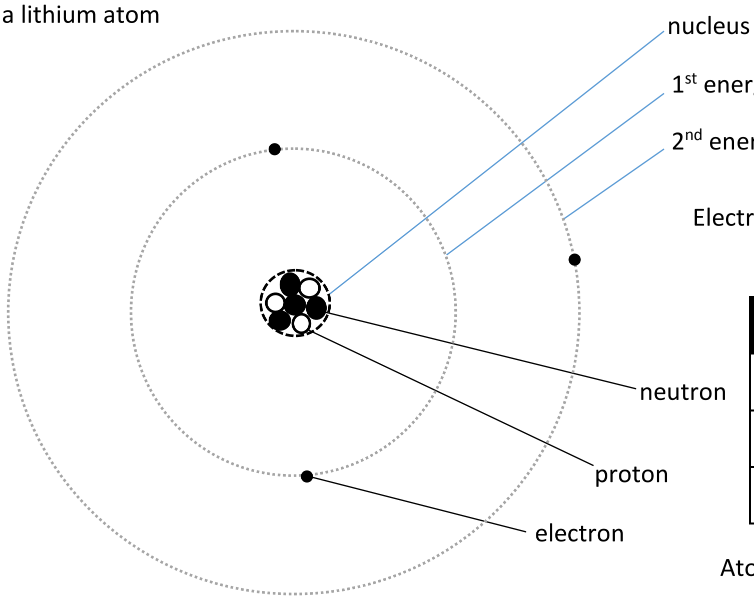


Atomic structure and bonding related to properties of materials

Atomic structure

Atoms contain three types of subatomic particles.

e.g. a lithium atom



Electron arrangement = 2,1

Particle	*Mass*	*Charge*
neutron	*1 amu*	*neutral*
proton	*1 amu*	*positive*
electron	*almost zero*	*negative*

Atoms are neutral

number of protons = number of electrons

Nuclide notation

mass number — $^{7}_{3}\text{Li}$ — atomic number

mass number = number of protons + number of neutrons

atomic number = number of protons

Isotopes - atoms with the **same** number of **protons** but a **different** number of **neutrons**
- atoms with the **same atomic number** but a **different mass number**

e.g. isotopes of chlorine

$$^{35}_{17}\text{Cl} \quad 75\% \qquad\qquad ^{37}_{17}\text{Cl} \quad 25\%$$

Relative atomic mass – the average mass of the isotopes present taking into account their relative proportions.

e.g. relative atomic mass of chlorine $= \dfrac{(35 \times 75) + (37 \times 25)}{100}$

$= \dfrac{2625 + 925}{100}$

$= \dfrac{3550}{100}$

$= \underline{\underline{35.5 \text{ amu}}}$

> **Note:** the relative atomic mass (RAM) of an element is closer to the mass of the most abundant isotope.
>
> However, RAM for Br = 80 amu
> ^{79}Br 50% and ^{81}Br 50%

Electronic structure of the first twenty elements in the Periodic Table

Group 1	Group 2		Group 3	Group 4	Group 5	Group 6	Group 7	Group 0
H 1 **1**	← Atomic number ← Symbol ← Electronic structure ← Electron arrangement		**Group 1 – Alkali metals** **Group 2 – Alkali earth metals** **Group 7 – Halogens** **Group 0 – Noble gases**			A **column** is known as a **GROUP**		He 2 **2**
Li 3 **2,1**	Be 4 **2,2**		B 5 **2,3**	C 6 **2,4**	N 7 **2,5**	O 8 **2,6**	F 9 **2,7**	Ne 10 **2,8**
Na 11 **2,8,1**	Mg 12 **2,8,2**		Al 13 **2,8,3**	Si 14 **2,8,4**	P 15 **2,8,5**	S 16 **2,8,6**	Cl 17 **2,8,7**	Ar 18 **2,8,8**
K 19 **2,8,8,1**	Ca 20 **2,8,8,2**	TRANSITION METALS	A **row** is known as a **PERIOD**					

Notes on Elements and the Periodic Table

Elements are arranged in order of increasing atomic number.
It is the electron arrangement of an atom that determines its chemical properties.
Isotopes have **identical chemical properties** because they have the **same electron arrangement**.
Atoms of elements in the **same group** have the **same number of electrons in their outer energy levels** and as a result have **similar chemical properties**.
The elements in Group 0 (the Noble gases) are the most **stable** elements in the Periodic Table.
The Noble gases have **full outer energy levels**.

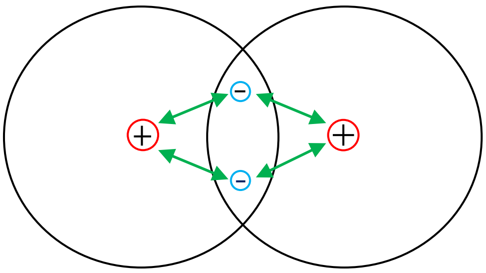
The **diatomic elements** are Hydrogen (H_2), Nitrogen (N_2), Oxygen (O_2), Fluorine (F_2), Chlorine (Cl_2), Bromine (Br_2) and Iodine (I_2) – **HNOF and down**.

An atom (or ion) with a full outer energy level is more stable than one which does not have a full outer energy level.

Covalent bonding

Atoms can achieve a stable electron arrangement by sharing outer electrons – forming a covalent bond.
e.g. hydrogen, H_2

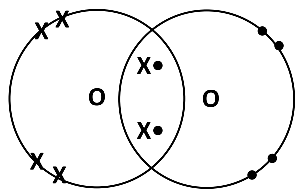
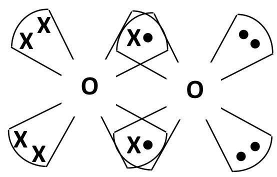
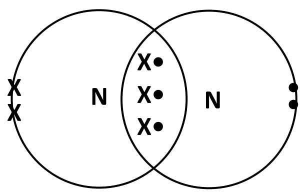
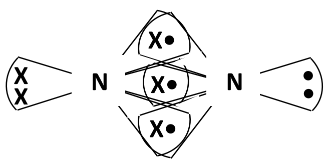
H—H



The shared pair of electrons is attracted to the nuclei of the two bonded atoms.

Both Hydrogen atoms now have an electron arrangement of 2 (a full outer energy level like Helium).

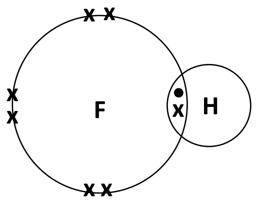
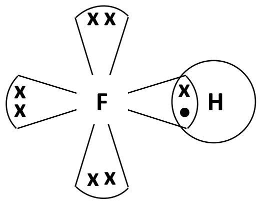
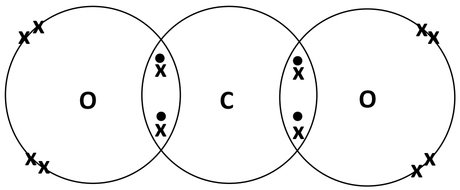
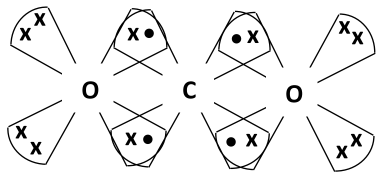
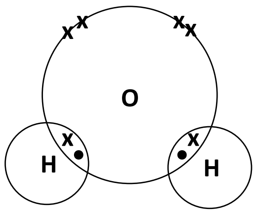
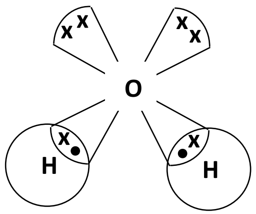
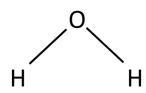
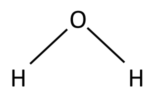
More than one bond can be formed between atoms leading to **double** and **triple** covalent bonds.

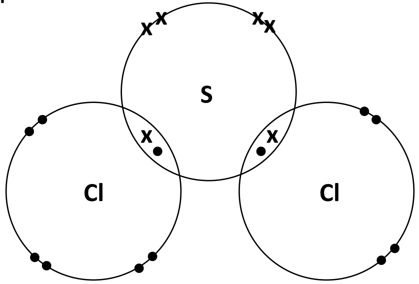
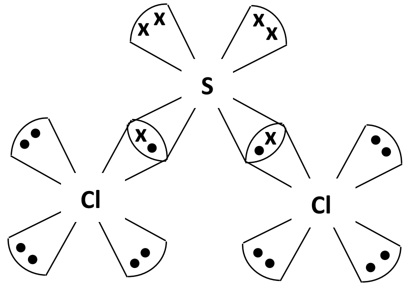
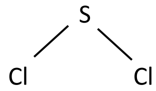
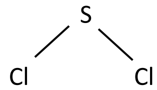
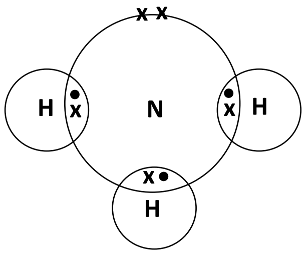
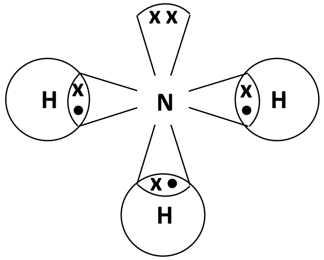
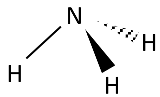
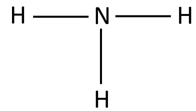
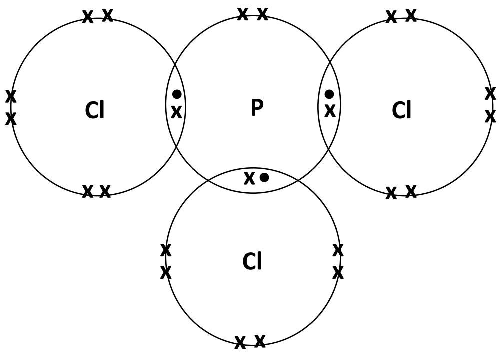
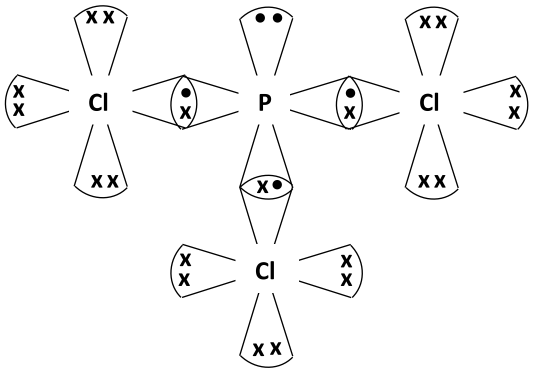
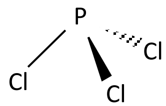
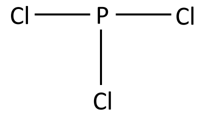
Dot and cross diagram	**Electron cloud diagram**	**Structural formula**
Oxygen, O_2 	Oxygen, O_2 	Oxygen, O_2 O═O
Nitrogen, N_2 	Nitrogen, N_2 	Nitrogen, N_2 N≡N

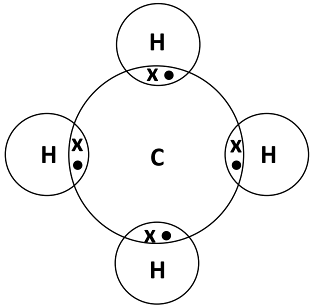
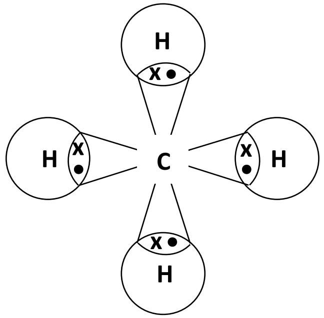
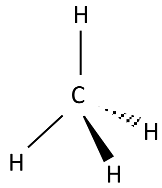
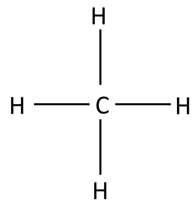
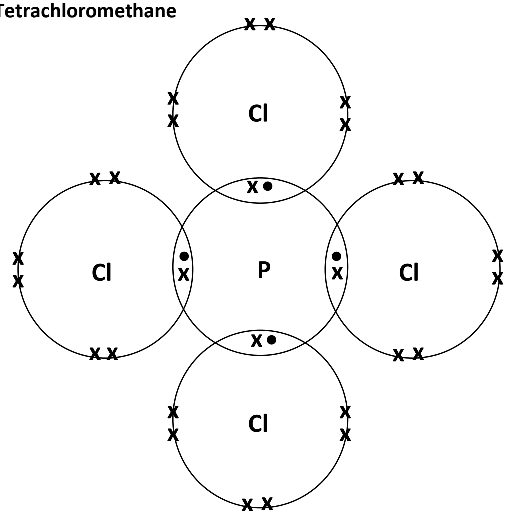
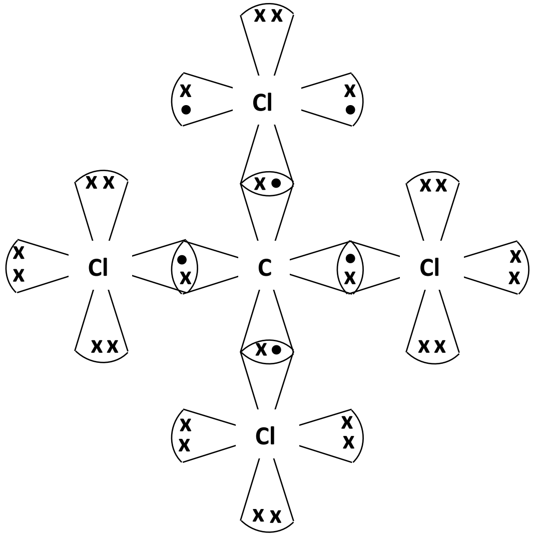
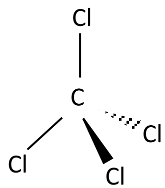
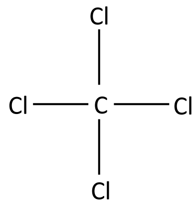
Covalent substances can form either discrete **molecular** or giant **network** structures.

Covalent molecular

Diagrams show how outer electrons are shared to form the covalent bond(s) in a molecule and the shape of simple two-element compounds.

Dot and cross diagram	Electron cloud diagram	Shape	Structural formula
Hydrogen fluoride 		H—F **linear**	H—F **Molecular formula:** HF
Carbon dioxide 		O═C═O **linear**	O═C═O **Molecular formula:** CO_2
Water 		 **bent**	 **Molecular formula:** H_2O

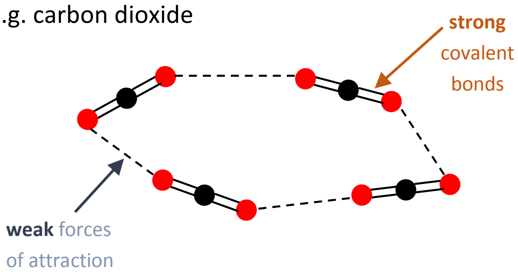
Dot and cross diagram	Electron cloud diagram	Shape	Structural formula
Sulphur dichloride 		 **bent**	 **Molecular formula:** SCl_2
Ammonia 		 **trigonal pyramidal**	 **Molecular formula:** NH_3
Phosphorus trichloride 		 **trigonal pyramidal**	 **Molecular formula:** PCl_3

Dot and cross diagram	Electron cloud diagram	Shape	Structural formula
Methane 		 **tetrahedral**	 **Molecular formula:** CH_4
Tetrachloromethane 		 **tetrahedral**	 **Molecular formula:** CCl_4

Bonding in covalent substances and the related trend in melting points

Covalent molecular

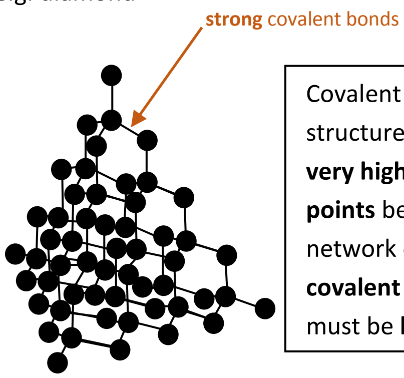
e.g. carbon dioxide



Covalent molecular substances have **low melting points** due to only **weak forces of attraction** between molecules being **broken**.

Covalent network

e.g. diamond

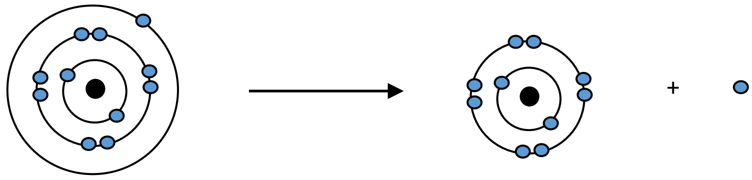


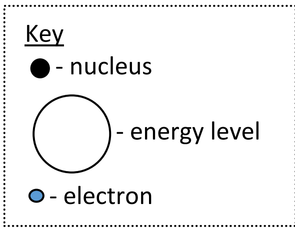
Covalent network structures have **very high melting points** because the network of **strong covalent bonds** must be **broken**.

Ions

Atoms can achieve a stable electron arrangement by losing or gaining electrons and forming **ions**.

e.g. a sodium **atom**, Na, with an electron arrangement of 2,8,1 can lose an electron to become a sodium **ion**, Na^+, with more stable electron arrangement of 2,8.

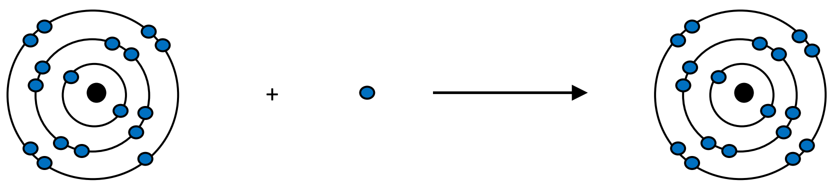




Na 2,8,1 Na^+ 2,8

This reaction can be shown as an ion-electron equation: $Na \rightarrow Na^+ + e^-$

and a chlorine **atom**, Cl, with an electron arrangement of 2,8,7 can gain an electron to become a chloride **ion**, Cl^-, with more stable electron arrangement of 2,8,8.



Cl 2,8,7 Cl^- 2,8,8

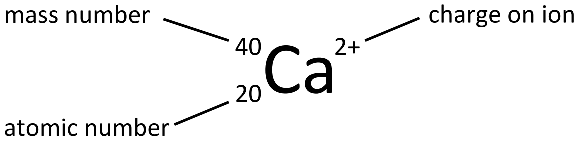
This reaction can be shown as an ion-electron equation: $Cl + e^- \rightarrow Cl^-$

The charge on an ion of an element in group 1 to 0 can be determined using the pattern in the table below.

Group	1	2	3	4	5	6	7	0
Charge on ion	+	2+	3+	not applicable	3-	2-	-	not applicable

Note: The charge on transition metal ions can vary and is given as roman numerals in the name, e.g. in copper(II) chloride the copper ion has a 2+ charge, Cu^{2+}.

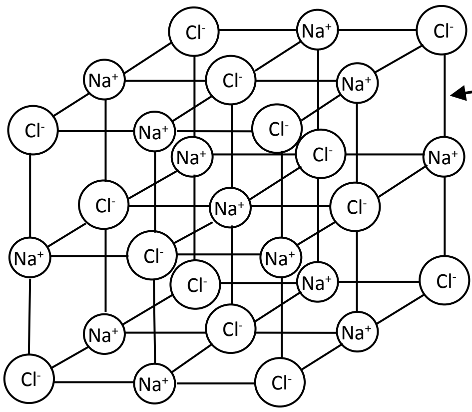
Nuclide notation for ions



There is an imbalance in the number of positive protons and negative electrons within an ion, hence the charge.

Ionic compounds

Ionic compounds form a **lattice** structure of oppositely charged ions in the solid state
e.g. sodium chloride



Ionic bonds are the electrostatic attraction between positive and negative ions.

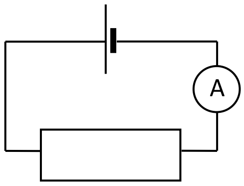
Ionic compounds have **high melting points** because **strong ionic bonds** must be **broken** in order to break down the lattice. The lattice can also be broken down by being dissolved.

Conduction of electricity

For a substance to conduct electricity it must contain charged particles that are free to move.
Covalent substances do not contain charged particles therefore **do not conduct**.
Ionic compounds conduct electricity, only when **molten** or **in solution** due to the breakdown of the lattice resulting in **the ions** being **free to move**. Ionic compounds do not conduct electricity when solid because the ions are not free to move. They are held in a lattice.

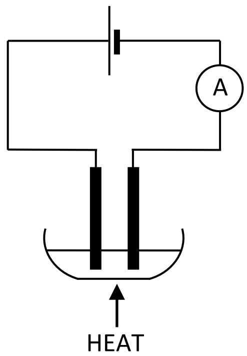
Simple experiments to measure electrical conductivity

of solids

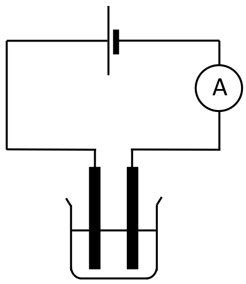


An ammeter (A) or a bulb (⊗) can be used in these experiments.

of melts



of liquids including solutions



Formulae and reaction quantities

The formulae of most elements are given by their symbol (e.g. silicon, Si).
The formulae of the diatomic elements (HNOF and down) are given by their symbol followed by a subscript two (e.g. bromine, Br_2).

Diatomic molecules are molecules which contain **two atoms** (e.g. hydrogen fluoride, HF).

The formula of a covalent molecular substance gives the number of atoms present in the molecule.

The formula of a covalent network or ionic compound gives the simplest ratio of atoms or ions in the substance.

Cross-valency method

The formulae for substances containing two elements can be worked out using the cross-valency method.

The valencies for elements in group 1-0 are given in the table below.

Group	1	2	3	4	5	6	7	0
Valency	1	2	3	4	3	2	1	not applicable

Formula for silicon hydride;

Symbols	Si	H
Valencies	4	1
Formula ratio	1	4
Formula	SiH_4	

Formula for silicon sulfide;

Symbols	Si	S
Valencies	4	2
Formula ratio	2	4
Simplify ratio	1	2
Formula	SiO_2	

When possible, cancel down to the simplest ratio e.g. the formula for silicon sulphide is SiO_2 not Si_2O_4.

Formula for calcium sulfide;

Symbols	Ca	S
Valencies	2	2
Formula ratio	2	2
Simplify ratio	1	1
Formula	CaS	

Where the compound is ionic the charges on the ions can be added e.g. $Ca^{2+}S^{2-}$

Formula for aluminium oxide;

Symbols	Al	O
Valencies	3	2
Formula ratio	2	3
Formula	Al_2O_3	

When showing the charges a bracket is used where there is more than one of a particular ion e.g. $(Al^{3+})_2(O^{2-})_3$

Formulae of compounds which have prefixes in their name

If the name of the compound contains a prefix we do not use the cross-valency method. We use the prefix to write the formula.

Prefix	mono	di	tri	tetra	penta	hexa
Number of atoms or ions	1	2	3	4	5	6

e.g. silicon dioxide, SiO_2 or dinitrogen tetroxide, N_2O_4.

Note: if part of the name has no prefix it is assumed that only 1 atom or ion of this type is present.

Formulae of compounds containing transition metal ions

The charge on transition metal ions can vary and is given as roman numerals within the name of the compound.

Roman numeral	I	II	III	IV	V	VI
Number	1	2	3	4	5	6

e.g. iron(III) oxide, $(Fe^{3+})_2(O^{2-})_3$

Formulae of compounds with ions which contain more than one kind of atom

The formulae for these ions can be found in a table on page 8 of the National 5 Chemistry Data Booklet © Scottish Qualifications Authority 2013, which has been reproduced below.

Formulae of Selected Ions containing more than one kind of Atom

one positive		one negative		two negative		three negative	
Ion	**Formula**	**Ion**	**Formula**	**Ion**	**Formula**	**Ion**	**Formula**
ammonium	NH_4^+	ethanoate	CH_3COO^-	carbonate	CO_3^{2-}	phosphate	PO_4^{3-}
		hydrogencarbonate	HCO_3^-	chromate	CrO_4^{2-}		
		hydrogensulfate	HSO_4^-	dichromate	$Cr_2O_7^{2-}$		
		hydrogensulfite	HSO_3^-	sulfate	SO_4^{2-}		
		hydroxide	OH^-	sulfite	SO_3^{2-}		
		nitrate	NO_3^-	thiosulfate	$S_2O_3^{2-}$		
		permanganate	MnO_4^-				

As we can see from all the examples of ionic formulae given above, when writing these formulae we must ensure that the negative and positive **charges balance** and the compound is electrically neutral.

e.g. sodium carbonate, $(Na^+)_2CO_3^{2-}$ - the sodium ion has **1** positive charge,
the carbonate ion has **2** negative charges,
therefore **two** sodium ions are needed to balance the charge on **one** carbonate ion.

or calcium nitrate, $Ca^{2+}(NO_3^-)_2$ where **two** nitrate ions are needed to balance the charge on **one** calcium ion.

Chemical equations

A chemical equation can be used to describe a reaction, showing the chemicals which react (**reactants**) and the chemicals which are produced (**products**).

reactants ⟶ **products**

e.g.

word equation	sodium	+	water	⟶	sodium hydroxide		+	hydrogen
formula equation	Na	+	H_2O	⟶	Na^+ + OH^-		+	H_2
with state symbols	Na(s)	+	$H_2O(l)$	⟶	$Na^+(aq)$ + $OH^-(aq)$		+	$H_2(g)$

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

Balancing equations

During a chemical reaction no atoms are lost or gained. A balanced equation shows the same number and type of atoms on each side of the equation.

e.g.	methane	+	oxygen	⟶	carbon dioxide	+	water
	CH_4	+	$2O_2$	⟶	CO_2	+	$2H_2O$

Number of atoms of each element

C	1	C	1
H	4	H	~~2~~ 4
O	~~2~~ 4	O	~~3~~ 4

The number of atoms of each type is not balanced.

By placing a 2 in front of the water the total number of Hs and Os on the right hand side is altered and the hydrogen atoms are now balanced.

By placing a 2 in front of the oxygen the total number of Os on the left hand side is altered and the equation is now balanced.

Gram formula mass

The gram formula mass (GFM) of any substance can be calculated using the chemical formula and relative atomic masses of its constituent elements.

Relative atomic masses of elements can be found on page 7 of the National 5 Chemistry Data Booklet.

e.g. GFM of methane, CH_4

GFM = (1 x C) + (4 x H)
= (1 x 12) + (4 x 1)
= 12 + 4
= 16g

GFM of water, H_2O

GFM = (2 x H) + (1 x O)
= (2 x 1) + (1 x 16)
= 2 + 16
= 18g

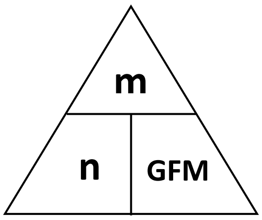
Moles

The gram formula mass is defined as the mass of one **mole** of a substance.

A balanced equation gives the molar ratio of the reactants and products.

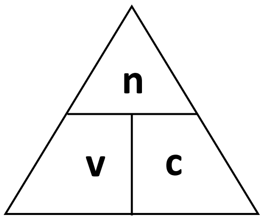
e.g.	CH_4	+	$2O_2$	⟶	CO_2	+	$2H_2O$
Molar ratio:	1 mole		2 moles		1 mole		2 moles

Relationship between number of moles and mass



n = number of moles
m = mass, in grams, **g**
GFM = gram formula mass, **g**

Relationship between number of moles, volume and concentration



n = number of moles
v = volume, in litres, **l**
c = concentration, in moles per litre, **moll^{-1}**

Note: volumes given in cm^3 must be converted to litres (1 cm^3 = 0.001 l, $\frac{cm^3}{1000}$ = litres)

Calculate the **mass** of 2.5 moles of magnesium chloride.

m = n x GFM
= 2.5 x 95.5
= 238.75g

GFM of $MgCl_2$ = (1 x Mg) + (2 x Cl)
= (1 x 24.5) + (2 x 35.5)
= 24.5 + 71
= 95.5g

Calculate the **number of moles** present in 69 g of potassium carbonate.

n = $\frac{m}{GFM}$
= $\frac{69}{138}$
= 0.5g

GFM of $(K^+)_2CO_3^{2-}$
= (2 x K) + (1 x C) + (3 x O)
= (2 x 39) + (1 x 12) + (3 x 16)
= 78 + 12 + 48
= 138g

Calculate the **number of moles** present in 200 cm^3 of a 1.5 moll^{-1} solution of glucose.

n = v x c
= 0.2 x 1.5
= 0.3 moles

v = 200cm^3 = $\frac{200}{1000}$ = 0.2 l

Calculate the **concentration** of a 500 cm^3 solution of 5.85 g of NaCl.

c = $\frac{n}{v}$
= $\frac{0.1}{0.5}$
= 0.2moll^{-1}

n = $\frac{m}{GFM}$ = $\frac{5.85}{58.5}$ = 0.1 moles

GFM of NaCl = (1 x Na) + (1 x Cl)
= (1 x 23) + (1 x 35.5)
= 23 + 35.5
= 58.5g

v = $\frac{500}{1000}$ = 0.5l

Calculate the **volume** of 1.5 moll^{-1} glucose solution which would contain 0.3 moles.

v = $\frac{n}{c}$
= $\frac{0.3}{1.5}$
= 0.2l
= 200cm^3

What **mass** of calcium hydroxide is required to produce 500 cm^3 of 0.1 $moll^{-1}$ calcium hydroxide solution?

m = n x GFM
= 0.05 x 74
= 3.7 g

n = v x c
= 0.5 x 0.1
= 0.05 moles

v = $\frac{500}{1000}$ = 0.5 l

GFM of $Ca^{2+}(OH^-)_2$ = (1 x Ca) + (2 x O) + (2 x H)
= (1 x 40) + (2 x 16) + (2 x 1)
= 40 + 32 + 2
= 74 g

Calculations based on balanced equations

Calculate the mass of hydrogen produced when 4·9 g of magnesium reacts with an excess of dilute sulphuric acid.

$$Mg(s) + H_2SO_4(aq) \longrightarrow MgSO_4(aq) + H_2(g)$$

1 mole ⟷ 1 mole

24.5 g ⟷ 2 g

4.9 g ⟷ $\frac{4.9 \times 2}{24.5}$

= 0.4 g

Rust, iron(III) oxide, that forms on cars can be treated using rust remover which contains phosphoric acid. When painted on, rust remover changes iron(III) oxide into iron(III) phosphate. Calculate the mass of iron(III) oxide that will be removed by 250 cm^3 of 2 $moll^{-1}$ phosphoric acid.

$$Fe_2O_3(s) + 2H_3PO_4(aq) \longrightarrow 2FePO_4(s) + 3H_2O$$

1 mole ⟷ 2 moles

v = 250 cm^3
= 0.25 l

c = 2 $moll^{-1}$

n = v x c
= 0.25 x 2
= 0.5 moles

$\frac{0.5 \times 1}{2}$ ⟷ 0.5 moles

= 0.25 moles

m = n x gfm
= 0.25 x 160
= 40 g

GFM of Fe_2O_3 = (2 x Fe) + (3 x O)
= (2 x 56) + (3 x 16)
= 112 + 48
= 160 g

Acids and bases

The pH scale

pH is related to the concentration of hydrogen and hydroxide ions in pure water, acids and alkalis.

The relationship between pH and concentration of $H^+(aq)$ ions can be explored by carrying out a dilution experiment. The table below summaries what can be observed and calculated from one such experiment in which repeated ten-fold dilution of a solution of 1 moll^{-1} hydrochloric acid was carried out.

DILUTION TOWARDS pH 7 →

Colour of Universal indicator								
[HCl(aq)] in moll^{-1}	1	0.1	0.01	0.001	0.0001	0.00001	0.000001	0.0000001
$[H^+(aq)]$ in moll^{-1}	1×10^{0}	1×10^{-1}	1×10^{-2}	1×10^{-3}	1×10^{-4}	1×10^{-5}	1×10^{-6}	1×10^{-7}
pH	0	1	2	3	4	5	6	7

From the table above, we can see that there is a relationship between pH and the concentration of $H^+(aq)$ ions.

$$[H^+(aq)] = 1 \times 10^{-pH}$$

The pH is a measure of the hydrogen ion concentration.

Water is neutral and has a pH of 7.

A very small proportion of water molecules will dissociate into an equal number of hydrogen and hydroxide ions.

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

In water,

$$[H^+(aq)] = [OH^-(aq)] = 1 \times 10^{-7}$$

The results of a repeated ten-fold dilution of a solution of 1 moll^{-1} sodium hydroxide solution are shown in the table below.

← **DILUTION TOWARDS pH 7**

Colour of Universal indicator								
[NaOH(aq)] in moll^{-1}	0.0000001	0.000001	0.00001	0.0001	0.001	0.01	0.1	1
$[OH^-(aq)]$ in moll^{-1}	1×10^{-7}	1×10^{-6}	1×10^{-5}	1×10^{-4}	1×10^{-3}	1×10^{-2}	1×10^{-1}	1×10^{0}
pH	7	8	9	10	11	12	13	14
$[H^+(aq)]$ in moll^{-1}	1×10^{-7}	1×10^{-8}	1×10^{-9}	1×10^{-10}	1×10^{-11}	1×10^{-12}	1×10^{-13}	1×10^{-14}

A neutral solution has an equal concentration of hydrogen and hydroxide ions.

A solution with a **greater concentration of hydrogen ions** than hydroxide ions is an **acid**.

A solution with a **greater concentration of hydroxide ions** than hydrogen ions is an **alkali**.

The effect of dilution of an acid or alkali with water is related to the concentrations of hydrogen and hydroxide ions.

Formation of acids

Acids are formed when soluble **non-metal oxides** dissolve in water and increase the **hydrogen** ion concentration.

e.g.

sulfur dioxide + water → sulfurous acid

$SO_2(g) + H_2O(l) \rightarrow 2\mathbf{H^+}(aq) + SO_3(aq)$

carbon dioxide + water → carbonic acid

$CO_2(g) + H_2O(l) \rightarrow 2\mathbf{H^+}(aq) + CO_3(aq)$

Formation of alkalis

Alkalis are formed when soluble **metal-oxides** dissolve in water and increase **hydroxide** ion concentration.

e.g.

sodium oxide + water → sodium hydroxide

$(Na^+)_2O^{2-}(s) + H_2O(l) \rightarrow 2Na^+(aq) + 2\mathbf{OH^-}(aq)$

calcium oxide + water → calcium hydroxide

$Ca^{2+}O^{2-}(s) + H_2O(l) \rightarrow Ca^{2+}(aq) + 2\mathbf{OH^-}(aq)$

Formulae of common acids and alkalis

Acid	Formula without charge	Formula showing ions
hydrochloric acid	$HCl(aq)$	$H^+(aq) + Cl^-(aq)$
nitric acid	$HNO_3(aq)$	$H^+(aq) + NO_3^-(aq)$
sulphuric acid	$H_2SO_4(aq)$	$2H^+(aq) + SO_4^{2-}(aq)$

Alkalis	Formula without charge	Formula showing ions
lithium hydroxide	$LiOH(aq)$	$Li^+(aq) + OH^-(aq)$
potassium hydroxide	$KOH(aq)$	$K^+(aq) + OH^-(aq)$
ammonium hydroxide	$NH_4OH(aq)$	$NH_4^+(aq) + OH^-(aq)$

Neutralisation reactions

A **base** is a substance that neutralises an acid.

acid	+	metal oxide	→	salt	+	water
e.g.						
Word equation:						
hydrochloric acid	+	sodium oxide	→	sodium chloride	+	water
Formula equation:						
$HCl(aq)$	+	$NaO(s)$	→	$NaCl(aq)$	+	$H_2O(l)$
Ionic formula equation:						
$H^+(aq) + Cl^-(aq)$	+	$(Na^+)_2O^{2-}(s)$	→	$Na^+(aq) + Cl^-(aq)$	+	$H_2O(l)$
Balanced ionic equation:						
$2H^+(aq) + 2Cl^-(aq)$	+	$(Na^+)_2O^{2-}(s)$	→	$2Na^+(aq) + 2Cl^-(aq)$	+	$H_2O(l)$
The reacting species are determined by omission of spectator ions.						
$2H^+(aq) + \cancel{2Cl^-}(aq)$	+	$(\cancel{Na^+})_2O^{2-}(s)$	→	$\cancel{2Na^+}(aq) + \cancel{2Cl^-}(aq)$	+	$H_2O(l)$
$2H^+$	+	O^{2-}	→	H_2O		

acid	+	alkali	→	salt	+	water
e.g.						
Word equation:						
nitric acid	+	potassium hydroxide	→	potassium nitrate	+	water
Formula equation:						
$HNO_3(aq)$	+	$KOH(aq)$	→	$KNO_3(aq)$	+	$H_2O(l)$
Ionic formula equation:						
$H^+(aq) + NO_3^-(aq)$	+	$K^+(aq) + OH^-(aq)$	→	$K^+(aq) + NO_3^-(aq)$	+	$H_2O(l)$
Balanced ionic equation:						
$H^+(aq) + NO_3^-(aq)$	+	$K^+(aq) + OH^-(aq)$	→	$K^+(aq) + NO_3^-(aq)$	+	$H_2O(l)$
The reacting species are determined by omission of spectator ions.						
$H^+(aq) + \cancel{NO_3^-}(aq)$	+	$\cancel{K^+}(aq) + OH^-(aq)$	→	$\cancel{K^+}(aq) + \cancel{NO_3^-}(aq)$	+	$H_2O(l)$
H^+	+	OH^-	→	H_2O		

acid	+	metal carbonate	→	salt	+	water	+	carbon doxide
e.g.								
Word equation:								
sulfuric acid	+	calcium carbonate	→	calcium sulfate	+	water	+	carbon dioxide
Formula equation:								
$H_2SO_4(aq)$	+	$CaCO_3(s)$	→	$CaSO_4(aq)$	+	$H_2O(l)$	+	$CO_2(g)$
Ionic formula equation:								
$2H^+(aq) + SO_4^{2-}(aq)$	+	$Ca^{2+}(aq) + CO_3^{2-}(aq)$	→	$Ca^{2+}(aq) + SO_4^{2-}(aq)$	+	$H_2O(l)$	+	$CO_2(g)$
Balanced ionic equation:								
$2H^+(aq) + SO_4^{2-}(aq)$	+	$Ca^{2+}(aq) + CO_3^{2-}(aq)$	→	$Ca^{2+}(aq) + SO_4^{2-}(aq)$	+	$H_2O(l)$	+	$CO_2(g)$
The reacting species are determined by omission of spectator ions.								
$2H^+(aq) + \cancel{SO_4^{2-}}(aq)$	+	$\cancel{Ca^{2+}}(aq) + CO_3^{2-}(aq)$	→	$\cancel{Ca^{2+}}(aq) + \cancel{SO_4^{2-}}(aq)$	+	$H_2O(l)$	+	$CO_2(g)$
$2H^+$	+	CO_3^{2-}	→	H_2O	+	CO_2		

Remember: "*Spectator ions are present but they don't take part in the action.*"
These ions appear unchanged on both sides of the equation.

Naming the salt produced during neutralisation

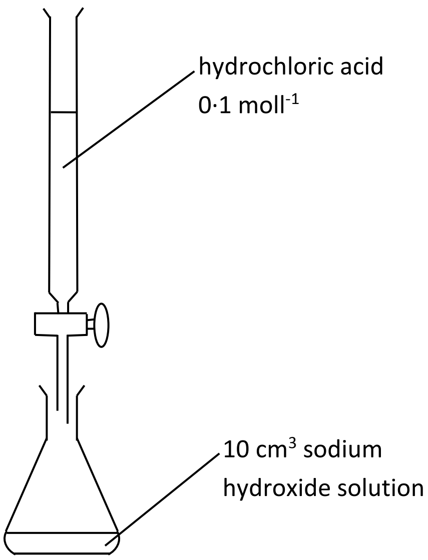
As we can see from the examples above, the first part of the name of the salt comes from the positive ion within the base.

The second part of the name of the salt is derived from the acid.

Name of acid	Name of salt
hydrochloric acid	.... chloride
nitric acid	.... nitrate
sulfuric acid	.... sulfate

Titration

Titration is an analytical technique used to determine the accurate volumes involved in chemical reactions such as neutralisation. An indicator is used to show the end-point of the reaction.
e.g.



	Rough titre	1st titre	2nd titre
Initial burette reading/cm^3	0·3	0·2	0·5
Final burette reading/cm^3	26·6	25·3	25·4
Volume used/cm^3	26·3	25·1	24·9

Using the results in the table, calculate the concentration of the sodium hydroxide solution.

$HCl(aq) + NaOH(aq) \longrightarrow H_2O(l) + NaCl(aq)$

1 mole ⟷ 1mole

Average titre = $\frac{25.1 + 24.9}{2}$ = 25.0 cm^3

v = 25.0 cm^3 = 0.025 l   v = 10 cm^3 = 0.010 l

c = 0.1 moll^{-1}

n = v x c
= 0.025 x 0.1
= 0.0025 moles

0.0025 moles ⟷ 0.0025 moles

c = $\frac{n}{v}$ = $\frac{0.0025}{0.010}$
= 0.25 moll^{-1}