✓ I am confident that I understand this and I can apply this to problems

? I have some understanding but I need to revise this some more

✗ I don't know this or I need help because I don't understand it

National 5 outcomes are in bold Underlying knowledge in non-bold

Rates of Reaction	Covered (✓)	How well can you do this?
		✗ ? ✓
1. The collision theory can be used to explain the effects of particle size and surface area on reaction rates		✗ ? ✓
2. The collision theory can be used to explain the effects of concentration on reaction rates		✗ ? ✓
3. The collision theory can be used to explain the effects of temperature on reaction rates		✗ ? ✓
4. Average rate of reaction, or stage in a reaction, can be calculated from initial and final quantities and the time interval		✗ ? ✓
5. Catalysts can be classified as either heterogeneous or homogeneous		✗ ? ✓

Atomic structure: **Nuclide Notation, Ions and Isotopes**		
	Covered (✓)	How well can you do this?
6. Calculate the number of n, p and e from the mass number and atomic number, and vice versa		× ? ✓
7.State that an atom which has lost or gained electrons is known as an ion.		× ? ✓
8. Calculate the number of n, p and e from nuclide notation, including ions, eg $^{37}_{17}Cl^{-}$		× ? ✓
9. State what is meant by isotopes		× ? ✓
10. State that most elements exist as a mixture of isotopes		× ? ✓
11.State that the relative atomic mass of an element is the average mass taking into account all the isotopes present.		× ? ✓

Chemical Formula and Equations		
	Covered (✓)	How well can you do this?
12.State that the chemical formula of a compound tells us what elements are present and how many atoms of each.		✗ ? ✓
13. Formulae can be written for 2 element compounds		✗ ? ✓
14. Formulae can be written for names using prefixes, including mono-, di-, tri-, tetra-.		✗ ? ✓
15. Formulae can be written for compounds which include Roman numerals in their names, eg iron (III) chloride.		✗ ? ✓
16. Formulae can be written for compounds involving group ions but not requiring brackets, eg Na_2SO_4.		✗ ? ✓
17.Formulae requiring brackets can be written for compounds, eg $Mg(OH)_2$.		✗ ? ✓
18.Chemical reactions can be described using word equations		✗ ? ✓
19. Chemical reactions can be described using chemical symbol equations.		✗ ? ✓

Covalent Molecular,Covalent network and Ionic Lattices		
	Covered (✓)	How well can you do this?
20. State that atoms can be held together by bonds		× ? ✓
21. State that atoms can achieve a stable electron arrangement		× ? ✓
23. Describe the covalent bond in terms of atoms sharing pairs of electrons		× ? ✓
24. State that a molecule is a group of atoms held together by covalent bonds		× ? ✓
25. State that (usually) only atoms of non-metal elements bond to form molecules		× ? ✓
26.A diatomic molecule is made up of two atoms There are 7 diatomic elements in the periodic table.		× ? ✓
27.Explain the covalent bond as a situation in which two positive nuclei are held together by their common attraction for the shared pair of electrons		× ? ✓
28.Atoms can share more than one pair of electrons		× ? ✓

leading to the presence of double and triple bonds.		
29 Draw a diagram to show how the outer electrons form a covalent bond		× ? ✓
	Covered (✓)	How well can you do this?
30.Draw diagrams to show the shape of simple two element molecules		× ? ✓
31.Covalent substances can exist as small molecules known as covalent discrete molecules		× ? ✓
32.Certain covalent substances can exist as a giant network structure		× ? ✓
33. A covalent network structure consists of a giant lattice of covalently bonded atoms		× ? ✓
34.Discrete covalent substances have low melting and boiling points due to the weak forces of attraction that need to be overcome		× ? ✓
35. Covalent network substances have high melting and boiling points due to the strong covalent bonds which need to be broken.		× ? ✓
36. Ionic bonding is the electrostatic force of		× ? ✓

attraction between oppositely charged ions		
37. Ionic compounds are usually formed when metals combine with non-metals		× ? ✓
38. An ionic structure consists of a giant lattice of oppositely charged ions		× ? ✓
39.Ionic compounds have high melting and boiling points as strong ionic bonds need to be broken to break down the lattice		× ? ✓
	Covered (✓)	How well can you do this?
40. Ionic compounds do not conduct electricity in the solid state since the ions are not free to move, but these compounds do conduct electricity when dissolved in water or when molten as the ions are now free to move		× ? ✓
41. Different ionic compounds form different shaped lattice structures.		× ? ✓
Calculations involving Gram Formula mass, balanced equations and concentration: **<u>Balanced equations</u>**		
	Covered (✓)	How well can you do this?
42. Formulae equations can be balanced to show the		× ? ✓

relative number of moles of reactant(s) and product(s)		
43. The gram formula mass of any substance is known as the Mole		× ? ✓
44. The number of moles can be calculated from the mass of a substance and vice versa		× ? ✓
45. The mass of a reactant or product can be calculated using a balanced equation		× ? ✓

<u>Acids and Bases</u>

	Covered (✓)	How well can you do this?
46. In water and neutral solutions, the concentration of hydrogen ions (H^+) is equal to the concentration of hydroxide (OH^-) ions		× ? ✓
47. A very small proportion of water molecules will dissociate into an equal number of hydrogen ions (H^+) and hydroxide ions (OH^-)		× ? ✓
48. An acidic solution contains more hydrogen ions (H^+) than hydroxide ions (OH^-)		× ? ✓
49. An alkaline solution contains more hydroxide ions (OH^-) than hydrogen ions (H^+)		× ? ✓

50. The effect of dilution on the pH of an acid or alkali is explained in terms of the decreasing concentration of hydrogen and hydroxide ions.		× ? ✓
51. A 10x dilution changes the pH number by 1		× ? ✓
52. pH is a measure of hydrogen ion (H^+) concentration		× ? ✓
53. Neutral solutions have an equal concentration of H^+ and OH^- ions		
54. Neutralisation of an acid with either a metal hydroxide(alkali) or a metal carbonate involves spectator ions		× ? ✓
	Covered (✓)	How well can you do this?
55. A spectator ion is present during a chemical reaction but does not take part in the reaction		× ? ✓
56. Titration is an analytical technique used to determine volumes involved in chemical reactions such as neutralisation.		× ? ✓
57. Indicators are often used to show the end-point of a titration.		× ? ✓

Rate of Reactions

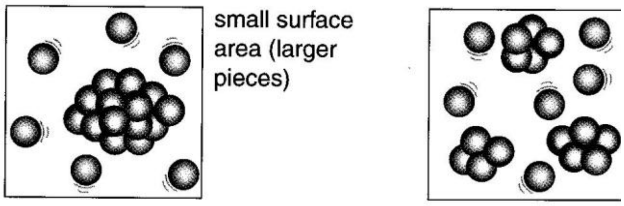
Before a reaction can occur the reactant molecules must collide and the collisions must have sufficient energy to produce a product.

There are four factors that affect the rate of reactions

- Particle size
- Concentration
- Temperature
- Catalyst

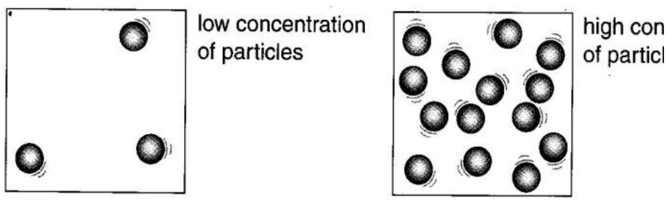
Particle size

The **smaller** the particle size the **faster** the rate of reaction.
This is a result of smaller particles allowing a greater surface area of reacting molecules to be in contact and therefore a greater chance of a successful collision.



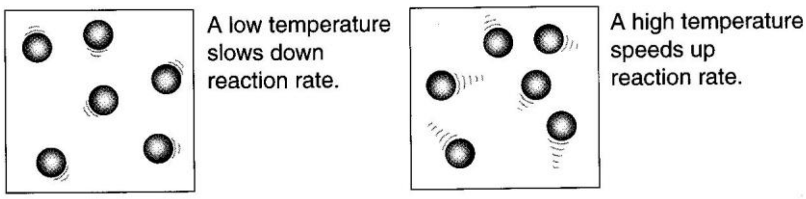
Concentration

The **higher** the concentration, the **faster** the rate of reaction. This is because higher concentrations have greater numbers of reacting molecules and therefore a greater chance of successful collision.



Temperature

The **higher** the temperature, the **faster** the rate of reaction. When a substance is heated the molecules are all given more energy. As a result they move faster; increasing the chance of a successful collision.



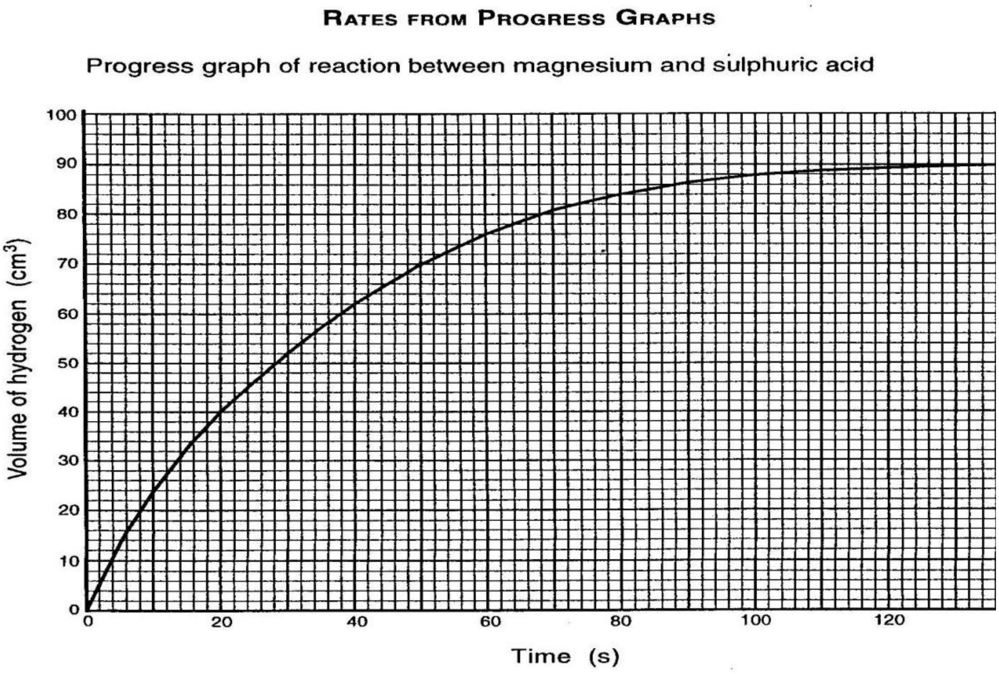
Catalyst

A catalyst **speeds up** the rate of reaction. A catalyst will remain unchanged during the reaction. The mass of catalyst remaining at the end of a reaction is the **SAME** as the mass used at the start.

Catalysts which are in the same physical state as the reactants are known as HOMOGENEOUS catalysts.

Catalysts which are in a different physical state as the reactants are known as HETEROGENEOUS catalysts

Calculating the average rate of reaction



It is difficult to measure the rate at any one time as the rate is constantly changing. However, it is possible to work out the average rate over a period of time.

$$\textbf{average rate} = \frac{\textbf{change in quantity}}{\textbf{change in time}}$$

In the example above the change in quantity is the change in volume of hydrogen. To calculate the average rate for the first 20 seconds:

$$\text{average rate} = \frac{\text{change in volume}}{\text{change in time}}$$

$$= \frac{40\text{cm}^3}{20\text{s}}$$

$$= \mathbf{2cm^3s^{-1}}$$

Atomic and Mass Number

Atoms of different elements are different and have a different number on the Periodic Table called the **atomic number**.

The atomic number is the number of protons in an atom.

The sum of the protons and neutrons in an atom is known as the **mass number.**
Consider the information below about sodium in which the sodium atom is represented in nuclide notation.

$$^{23}_{11}\mathrm{Na}$$

- Sodium has an atomic number of 11, so it has 11 protons (positive charges).
- The sodium atom has no overall charge so it must have 11 electrons (negative charges).
- The number of neutrons is given by the **mass number minus the atomic number** therefore sodium has **23-11=12 neutrons.**

Isotopes and Relative Atomic Mass

Isotopes of an element are atoms with the same number of protons but a different number of neutrons therefore **isotopes have the same atomic number but a different mass number.**

Chlorine has two common isotopes

$^{35}_{17}\mathrm{Cl}$	$^{37}_{17}\mathrm{Cl}$
ATOMIC No = 17 MASS No = 35	ATOMIC No = 17 MASS No = 37
17 protons 17 electrons 18 neutrons (35-17)	17 protons 17 electrons 20 neutrons (37 – 17)

The isotopes will react chemically the same way because they have identical numbers of electrons. Most elements exist as a mixture of different isotopes.

The **relative atomic mass** of an element is the **average atomic mass** taking into account the proportion of each isotope. The relative atomic mass of chlorine is **35.5.**
Chorine has two isotopes ^{35}Cl and ^{37}Cl and the average mass is **35.5 is closer to 35 than 37**. **This tells us that ^{35}Cl is more abundant(large amount of) than ^{37}Cl.**

Ions

Ions are formed when atoms **gain electrons to make negative ions** or when atoms **lose electrons to form positive ions**.

$^{35}_{17}Cl^{-}$ Gained e-

17 protons
18 electrons (17+1)
18 neutrons (35-17)

$^{23}_{11}Na^{+}$ Lost e-

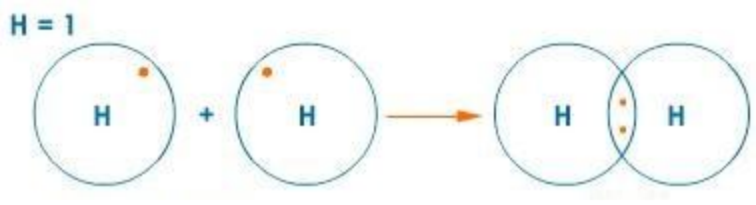
11 protons
10 electrons (11-1)
12 neutrons (23-11)

Bonding

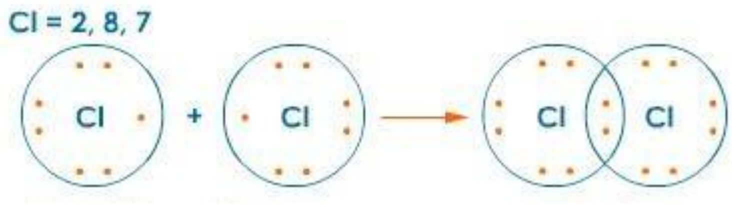
Compounds are formed when atoms of different elements join together. These atoms are held together by bonds. The atoms form bonds to achieve a full outer electron arrangement, this is also known as a stable electron arrangement. This stable arrangement can be achieved by two separate methods giving rise to two types of compounds, COVALENT and IONIC.

Covalent Molecules (Discrete Molecules)

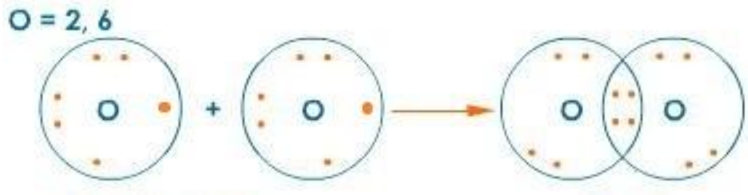
Most covalent compounds exist as molecules, which are a group of usually non metal atoms, held together by a covalent bond.
Covalent bonds are formed when electrons are shared between two positive nuclei. It is the attraction between the negative pair of electrons and the positive nuclei that hold the atoms together.
The seven diatomic elements exist as molecules with pairs of electrons shared between their atoms.



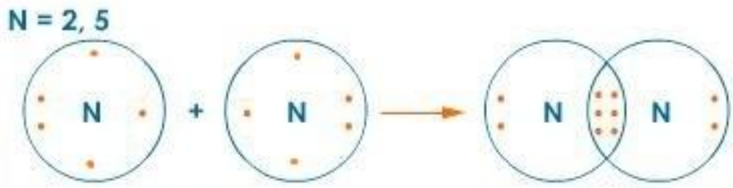
The diagram above shows how the unpaired outer electron in a hydrogen atom links up with another hydrogen atom to form a hydrogen molecule with a shared pair of electrons. Only unpaired electrons can form bonds as shown in the formation of chlorine below.



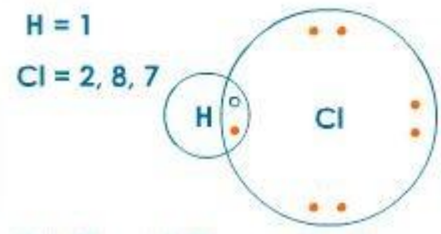
Oxygen has two unpaired electrons in its outer electron arrangement and therefore can form a double bond as shown.



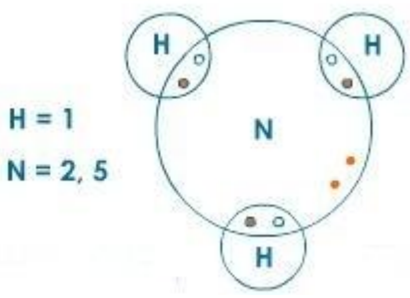
The nitrogen atom has three unpaired electrons and can therefore form a triple bond



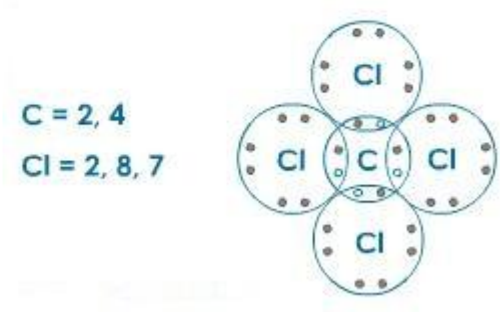
These diagrams can also be used to show how outer electrons form compounds. Again it is only unpaired outer electrons that can form bonds some examples are shown below.



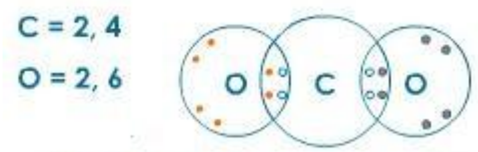
Hydrogen chloride



Nitrogen Hydride (Ammonia)



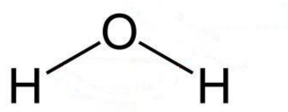
Carbon tetrachloride



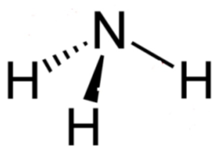
Carbon dioxide shows double bonds being formed in a compound.
Molecules also have distinctive shapes and fall into four main structures as shown below.

Linear structure include hydrogen chloride and carbon dioxide, H-Cl and O=C=O, both of these structures are described as 2 D and flat.

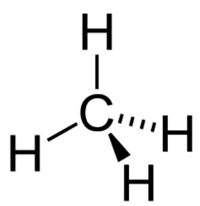
V shaped include water and hydrogen sulphide, this is again a 2 D shape and flat.



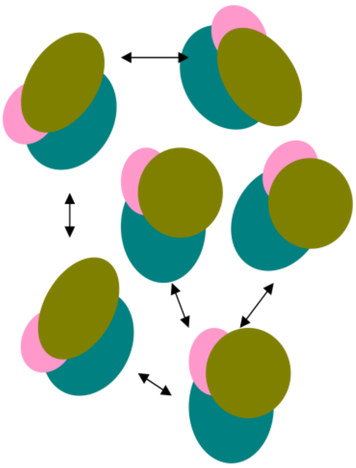
Pyramidal is the shape that nitrogen hydride has and is described as 3 D. The solid wedge bond is coming towards you and the dotted bond is going away from you.



The final shape is tetrahedral and again its described as 3D. Carbon hydride (methane) has this shape.



Most covalent molecular compounds have low melting and boiling points, and are usually liquid or gas at room temperature. When these compounds changes state it is not the strong covalent bonds inside the molecules that are broken but weak forces of attractions between the molecules. This requires a lot less energy and hence the melting and boiling points are low.

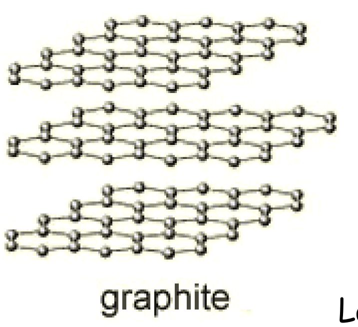


The bonds between these molecules are weak and easily broken.

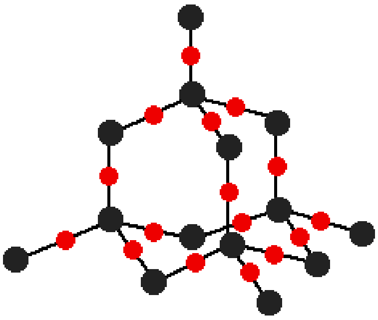
<u>Covalent Network</u>

The second type of structure covalent compounds can have is network. This is a giant lattice of millions of atoms joined together with strong covalent bonds. Unlike molecules these structures have very high melting and boiling points. When these strutures change state a lot of energy is required as its covalent bonds that are being broken and not weak forces of attraction. Substances that have this network structure include diamond, graphit and silicon dioxide. Some of the structures are shown below.

Tetrahedral structure of carbon atoms



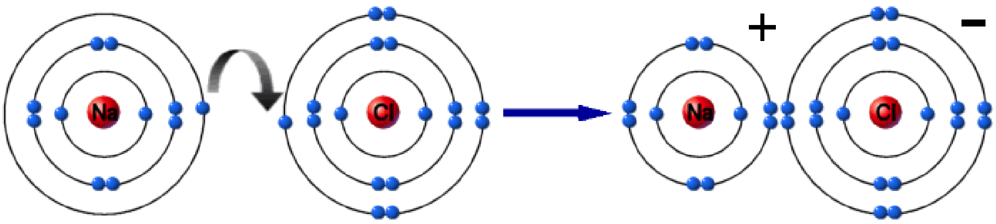
Layers of carbon with delocalised electrons between them.



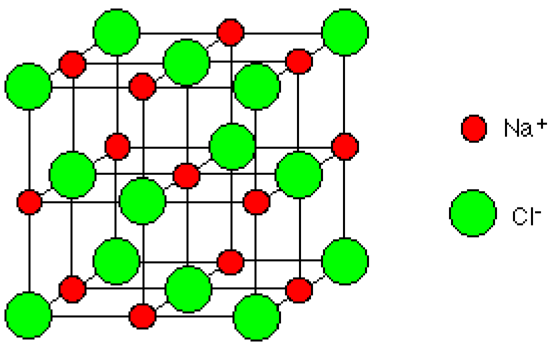
Silicon dioxide, very similar to diamonds structure.

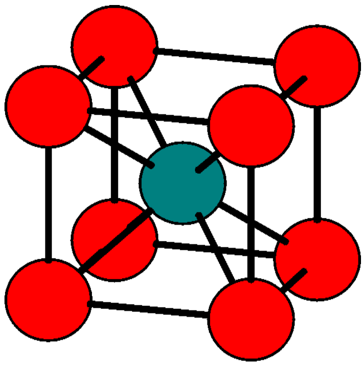
Ionic

Ionic compounds are usually made from a metal and a non metal. The bond is made when electrons are transferred from the metal to the non metal. This allows both to have a stable electron arranmgement. The metal atom becomes positivelky chared and the non metalk becomes negatively charrged. The electrostatic force of attraction betrween the metal ion amnd the non metal ion holds them together. The diagram below shows how sodium chloride is formed.



In the solid state the ions are arranged in a giant lattice of oppositely charged ions. These compounds have very high melting and boiling points as the strong ionic bonds within the lattice must be broken. All ionic compounds are solid at room temperature. There are two main shapes of an ionic(crystal) lattice and these are shown below.





Ionic solids can not conduct electricity as their ions are held in the lattice and are not free to move. If we melt an ionic solid or dissolve it in water the lattice breaks allowing the ions to move and hence conduct electricity.

Compounds and Formula

Compounds are formed when two or more elements are joined together. When naming compound containing two elements, the element furthest to the left comes first in the name. The other element comes second and ends in "ide".

e.g. when copper joins with chlorine the compound formed is called copper chloride.

If compounds have more than two elements and one is oxygen they will usually end in "ate" or "ite".

e.g. Copper Carbonate contains copper, carbon and oxygen and sodium sulphite contains sodium, sulphur and oxygen.

Chemical Formula will allow us to find out the elements it contains, and the number of atoms of each element in a molecule or the ratio of the elements in larger structures such as ionic compounds.

CO_2 is the formula of carbon dioxide and tells us that it contains 1 carbon atom joined to two oxygen atoms. The formula for sodium chloride however is NaCl, this tells us for every one sodium ion there is 1 chloride ion.

Some elements have a chemical formula. There are seven diatomic element, these consist of molecules containing only two atoms. These are Hydrogen, H_2, Nitrogen, N_2, Oxygen O_2 and the halogens excluding astatine, F_2, Cl_2, I_2, and Br_2.

Chemical formulae of Two Element Compounds

Some two element compounds have meaningful names that allow us to simply write down the formula. If a compounds name contains a prefix like mono, di, tri or tetra the name tells us the formula. These prefixes equate to a number as shown in the table.

Prefix	Meaning
Mono	One
Di	Two
Tri	Three
Tetra	Four
Penta	Five
Hexa	Six

When writing the formula for these compounds if there is no prefix before the element it means there is only one of those elements in the formula.

Sulphur trioxides formula would contain 1 sulphur atom and three oxygen atoms, as we don't put the number 1 into formula we have SO_3.

Dinitrogen tetroxide would have 2 nitrogen atoms and 4 oxygen atoms giving a formula of N_2O_4.

Carbon Terachloride would contain I carbon atom and 4 chlorine atoms giving a formula of CCl_4.

Not all two element compounds will contain prefixes. This means we have to use a different method to work out the formulae of these compounds. This method requires the use of valency, this is the number of bonds an atom can make, sometimes called the combining power.

Writing Formulae Using Valency Rules.

The valency of an atom of an element, is equal to the number of bonds it can make with another atom. This can be worked out from its position in the periodic table. All elements in the same group have the same valency, e.g. all elements in group 1 have a valency of 1, and all elements in group 6 have a valency of 2.

The table below shows the valency of each group.

Group	1	2	3	4	5	6	7	8(0)
Valency	1	2	3	4	3	2	1	0

Group 8 elements, the noble gases have a zero valency as they have a full outer electron arrangement and don't form bonds.

Complete the table below writing in the valency of each of the elements.

Element	Valency
Calcium	
Phosphorus	
Caesium	
Gallium	
Arsenic	
Radon	
Iodine	

As transition metals are not in the groups we use a different rule for these elements. All transition metals have a valency of two unless the name contains a roman numeral. This numeral will indicate the valency of the metal e.g. Iron (III) chloride tells us the valency of iron is three whereas if the name was iron chloride the valency of the iron would be 2.

(I = 1, II = 2, III = 3, IV = 4, V = 5 and VI = 6.)

Using Valency Rules

When working out chemical formula we should follow these steps;

1. Write down the symbols for the elements, in the same order that they appear in the name.
2. Underneath each symbol write the element's valency
3. Cancel down (simplify) valencies if possible
4. Swap valencies.

Examples

Work out the formula of sodium oxide

Symbols Na O

Valency 1 2 Swap valencies

Formula Na_2O

Work out the formula of Iron sulphide

Symbols Fe S

Valency ~~2~~ ~~2~~ Cancel down

1 1 Swap Valencies

Formula FeS

Work out the formula for Iron (III) oxide

Symbols Fe O

Valency 3 2 can't cancel down swap valencies

Formula Fe_2O_3.

Work out the formula for Copper (I) Nitride

Work out the formula for Manganese (IV) oxide

Formulae with more than two elements.

Compounds ending in "ate", "ite", containing hydroxide or ammonium have more than two elements. All of these compounds contain group ions which can be found in the data book.

The formula given in the data booklet will have a charge, this charge indicates the valency of the group ion, and not the individual elements present. The table below shows some of the group ions and their valencies

Group ion	Formula	Valency
Hydroxide	OH^-	One
Carbonate	CO_3^{2-}	Two
Nitrate	NO_3^-	One
Sulphate	SO_4^{2-}	Two
Phosphate	PO_4^{3-}	Three
Hydrogensulphite	HSO_3^-	One
Ammonium	NH_4^+	One
Hydrogencarbonate	HCO_3^-	One

To work out the formula of a compound containing a group ion, you deal with the group formula in the same way as you would use the symbol of an element.

The same rules apply as before, swapping valencies. If the valency being swapped to the group ion is greater than one, the formula of the group ion must go inside a bracket. We do not include the charges on the group ion at this stage.

Write the formula for sodium carbonate

Symbols Na CO_3

Valency 1 2 cant cancel swap valencies

Formula Na_2CO_3

Write the formula for Calcium Hydroxide

Symbols Ca (OH)

Valency 2 1 Swap valencies bracket needed

Formula $Ca(OH)_2$ Number being swapped goes outside bracket

Write the formula for Iron (III) sulphate

Symbols Fe (SO$_4$)

Valency 3 2

Formula $Fe_2(SO_4)_3$

Work out the formula for Ammonium Phosphate below

<u>Ionic Formula</u>

Ionic formula shows the charges on the ions contained in an ionic compound. The formula is initially worked out as normal and then the charges added. The value of the charge is equal to the valency with metal ions being positive and non metal ions being negative. The charges on the group ions are shown on page 4 of the data book. Unlike valency we do not cancel charges and they should balance out to give an overall neutral charge. If we have more than one of an individual ion, the ion goes in a bracket with the charge.

Using the examples from the previous page we can write the ionic formulae.

<u>Sodium Carbonate</u>

Normal Formula Na_2CO_3

Ionic Formula $(Na^{+})_2CO_3^{\ 2-}$

The sodium in inside a bracket as there is two of them. You can also see that the overall charge is neutral.

<u>Calcium Hydroxide</u>

Normal Formula $Ca(OH)_2$

Ionic Formula $Ca^{2+}(OH^{-})_2$

Chemical Equations

Chemists have devised a shorthand way of showing what happens in chemical reactions. They use word equations to show what happens and these can then be changed into formula equations.

In any equation there are two sides. On the left hand side of a word equation are the reactants, the substances that we start with. On the right hand side are the products, the substances we have made.

Reactants $\longrightarrow$ Products

When writing a word or formula equation we do not use "and", but use a "+" instead. An arrow is used to separate each side instead of an "=" sign as both sides of the equation are no longer equal.

Read the following worked examples.

In a reaction sodium has reacted with oxygen to form sodium oxide. Write the word and formula equation for this reaction.

Word Equation

Sodium + Chlorine $\longrightarrow$ Sodium Chloride

When writing word equation the second part of the name should go on the line below the first part.

Formula Equation

$Na + Cl_2 \longrightarrow NaCl$

The formula for each reactant and product is worked out using the rules previously discussed.

Copper carbonate will break down into Copper Oxide and Carbon Dioxide when heated. Write a word and formula equation for this reaction.

Word Equation

Copper Carbonate	$\longrightarrow$	Copper oxide	+	Carbon Dioxide

Formula Equation

$$Cu(CO_3) \longrightarrow CuO + CO_2$$

Write word and formula equation for magnesium burning in oxygen to produce magnesium oxide.

Word Equation

Magnesium	+	Oxygen	$\longrightarrow$	Magnesium Oxide

Formula Equation

$$Mg + O_2 \longrightarrow MgO$$

Write the word and formula equations for the following examples.

Potassium chloride is formed when chlorine gas comes into contact with potassium metal.

Word Equation

Formula Equation

Nitrogen and hydrogen react to make nitrogen hydride

Word Equation

Formula Equation

Balancing Equations

Balancing an equation involves changing the quantities of reactants and products to ensure that they are equal on both sides of the equation.

Na	+	O_2	$\longrightarrow$	Na_2O	*Reactants and Products unequal*
4Na	+	O_2	$\longrightarrow$	$2Na_2O$	*Balanced*

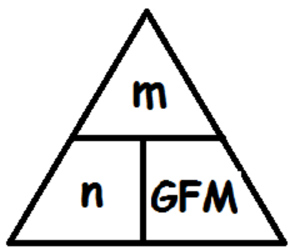
Gram Formula Mass

The gram formula mass of any molecule is calculated by adding together the relative atomic masses of all of the atoms in the molecule, based on the formula. **The gram formula mass is also known as one mole of the substance.**

Carbon Dioxide: CO_2 1 Carbon + 2 Oxygen = (1 x 12) + (2x 16) = 44g

Sodium Chloride NaCl 1 Sodium + 1 Chlorine = (1 x 23) + (1 x 35.5) = 58.5g

Molar Mass Calculations



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

n = m / GFM
m = n x GFM

a) Calculate the number of moles in 10g of sodium hydroxide.

FORMULA NaOH
GFM = 23 + 16 + 1 = 40g
m = 10g

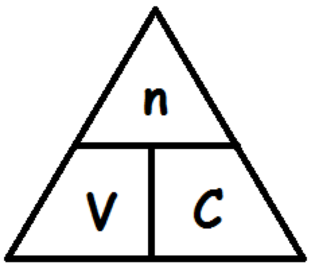
n = m /GFM = 10/40 = 0.25 moles

b) Calculate the mass of 2 moles of Calcium Chloride

FORMULA $CaCl_2$
GFM = 40 + (2 x 35.5) = 111g
n = 2 moles

m = n x GFM = 2 x 111 = 222g

Calculations involving Moles and Concentrations



n = number of moles
V = volume in litres
C = concentration in moles per litre ($molL^{-1}$)

n = V x C
V = n / C
C = n / V

a) Calculate the number of moles in $500cm^3$ of a 0.2 $molL^{-1}$ solution

V = 500 cm^3 = 0.5 litres
C = 0.2 $molL^{-1}$

n = C x V = 0.5 x 0.2 = 0.1 moles

Calculations using both Triangles

a) Calculate the mass of sodium hydroxide required to prepare $250cm^3$ of a solution of 0.1 $molL^{-1}$.

ALWAYS calculate number of moles first.

The question tells us:

$V = 250cm^3 = 0.25\ L$
$C = 0.1\ molL^{-1}$

The substance is sodium hydroxide, formula $NaOH$
GFM = 23 + 16 + 1 = 40g

Step 1 $n = V \times C = 0.25 \times 0.1 = 0.025$ moles

Step 2 $m = n \times GFM = 0.025 \times 40 =$ **1g**

The mass of sodium hydroxide required is 1g.

b) What will the concentration of a solution be if 50g of sodium hydroxide is dissolved in $500cm^3$ of water?

m = 50g
$V = 500cm^3 = 0.5L$
sodium hydroxide, formula $NaOH$
GFM = 23 + 16 + 1 = 40g

Step 1 $n = m / GFM = 50/40 = 1.25$moles

Step 2 $C = n/V = 1.25/0.5 = 2.5\ molL^{-1}$

The concentration of the solution will be $2.5\ molL^{-1}$.

Calculations from Balanced Equations

A balanced equation tells us the number of moles of reactants required to form the products.

$$Ca \quad + \quad 2HCl \longrightarrow CaCl_2 \quad + \quad H_2$$

This equation tells us that 1 mole of Calcium reacts with 2 moles of Hydrochloric acid to form 1 mole of Calcium Chloride and 1 mole of Hydrogen.

What mass of calcium chloride will be produced if 20g of calcium reacts will excess hydrochloric acid?

Ca	+	$2HCl$	$\longrightarrow$	$CaCl_2$	+	H_2
1 mole		~~2 moles~~		1 mole		~~1 mole~~
1 mole			$\longrightarrow$	1mole		
40g			$\longrightarrow$	111g		
1g			$\longrightarrow$	111/40g		
20g			$\longrightarrow$	111/40 x 20		
				= **55.5g**		

Conductivity of Acids and Alkalis

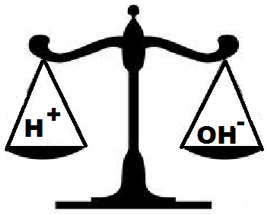
Both acids and alkalis are good conductors of electricity. This means that both acids and alkalis are ionic compounds… they contain free moving ions

The ion common to all acidic solutions is the hydrogen ion, H^+.
The ion common to all alkaline solution is the hydroxide ion, OH^-.

Water has a very low conductivity. This means there are very few ions present. Water is made up of mainly covalently bonded H_2O molecules, a few of which break up or dissociate into H^+ and OH^- ions.

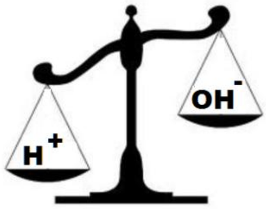
$$H_2O \rightleftharpoons H^+ + OH^-$$

Concentration of Ions



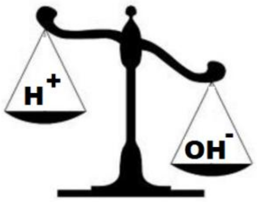
NEUTRAL

Water and neutral solutions contain equal concentrations of H^+ and OH^- ions. This means that the concentration of H^+ and OH^- ions is the same.



ACIDIC

Acidic solutions contain more H^+ ions than OH^- ions.



ALKALINE

Alkaline solutions contain more OH^- ions than H^+ ions.

As you dilute an acid, the pH rises towards neutral, 7, and the acidity decreases/ the concentration of H^+ ions decreases

As you dilute an alkali, the pH falls towards neutral, 7, the alkalinity decreases/ the concentration of hydroxide ions decreases.

Acids have more hydrogen ions than pure water
Alkalis have more hydroxide ions than pure water

Neutralisation

Neutralisation is the cancelling out of an acid by another substance. The other substance is called a base

Neutralisation moves the pH of an acid up towards 7 or alkali down towards 7.

As discussed earlier, a base is a substance that neutralises an acid to form a salt. Metal oxides, metal hydroxides and metal carbonates are all bases.

Acid + Alkali

Soluble metal hydroxides are alkalis. All of the reactions between acids and alkalis follow the general equation:

ACID + ALKALI $\rightarrow$ SALT + WATER

For example:

Hydrochloric acid + sodium hydroxide $\rightarrow$ sodium chloride + water

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

We can write the equation showing the ions involved:

$$H^+ Cl^- + Na^+OH^- \rightarrow Na^+ Cl^- + H_2O$$

Not all of these ions are involved in the reaction. Looking at the above equation, there are 2 ions that do not change during the reaction. These are known as spectator ions because they do not take an active part in the reaction. We can write the equation again with the spectator ions, Na^+ and Cl^- removed.

$$H^+ + OH^- \rightarrow H_2O$$

So in the reaction between an acid and an alkali, the hydrogen and hydroxide ions react to form water

Acid + Metal oxide

Metal oxides which neutralise acids are often referred to as basic oxides. All reactions between acids and metal oxides follow the general equation:

ACID + METAL OXIDE $\rightarrow$ SALT + WATER

For example:

Hydrochloric acid + magnesium Oxide $\rightarrow$ magnesium chloride + Water

$$2HCl + MgO \rightarrow MgCl_2 + H_2O$$

The equation showing the ions involved is:

$$2H^+ Cl^- + Mg^{2+} O^{2-} \longrightarrow Mg^{2+} (Cl^-)_2 + H_2O$$

The equation with spectator ions omitted is:

$$2H^+ + O^{2-} \longrightarrow H_2O$$

So in the reaction between acids and metal oxides, the hydrogen and oxide ions react to form water.

Acid + Metal Carbonates

Many metal carbonates are insoluble and as such are useful neutralisers. This means that when all of the acid has been neutralised, any unreacted metal carbonate settle to the bottom of the test tube or beaker and can be removed by filtration.

All reactions between acids and metal carbonates follow the general equation:

ACID + METAL CARBONATE ➡ SALT + WATER + CARBON DIOXIDE

For example:

Hydrochloric acid + magnesium carbonate ➡ magnesium chloride + water + carbon dioxide

$$2HCl + MgCO_3 \longrightarrow MgCl_2 + H_2O + CO_2$$

The equation showing the ions involved is:

$$2H^+Cl^- + Mg^{2+} CO_3^{2-} \longrightarrow Mg^{2+} (Cl^-)_2 + H_2O + CO_2$$

The equation with spectator ions removed is:

$$2H^+ + CO_3^{2-} \longrightarrow H_2O + CO_2$$

So in the reaction between acids and metal carbonates, the hydrogen and carbonate ions react to from water and carbon dioxide.

Acid + Metal

The reactivity of a metal is important in determining whether a metal will neutralise an acid. **Only metals which are above hydrogen in the electrochemical** series, found in the data book, will react with acids. Metals such as magnesium, aluminium and zinc react with dilute acids.
Metals such as copper, silver and gold do **not** react with dilute acids

All reactions between acids and suitable metals follow the general equation:

ACID + METAL ➡ SALT + HYDROGEN
hydrochloric Acid + magnesium ➡ magnesium chloride + hydrogen

$$2HCl + Mg \rightarrow MgCl_2 + H_2$$

The equation showing the ions involved is:

$$2H^+Cl^- + Mg \rightarrow Mg^{2+}(Cl^-)_2 + H_2$$

The equation with spectator ions removed is:

$$2H^+ + Mg \rightarrow Mg^{2+} + H_2$$

So in the reaction between acids and metals, the hydrogen ions receive electrons from the metal to form hydrogen molecules.

What is a Salt?

Salts are formed during neutralisation reactions. They are formed when the hydrogen ion of the acid is replaced by metal ions from the neutraliser/base

So in the reaction between hydrochloric acid and sodium chloride the H^+ ion of the hydrochloric acid is replaced by the Na^+ ion from the sodium hydroxide. This results in the salt, sodium chloride, NaCl, being formed.

Naming Salts

The name of a salt is derived from the metal ion of the neutraliser and the negative ion of the acid.

Salts from Hydrochloric acid are called chlorides.
Salts from Nitric acid are called nitrates.
Salts from Sulfuric acid are called sulfates.

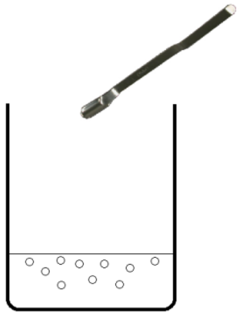
For example:

Name of the Acid	Neutraliser	Name of the Salt
Hydrochloric	Sodium hydroxide	Sodium chloride
Hydrochloric	Copper(II) oxide	Copper(II) chloride
Nitric	Zinc(II) carbonate	Zinc(II) nitrate
Nitric	Potassium hydroxide	Potassium nitrate
Sulfuric	Magnesium carbonate	Magnesium sulfate
Sulfuric	Aluminium	Aluminium sulfate

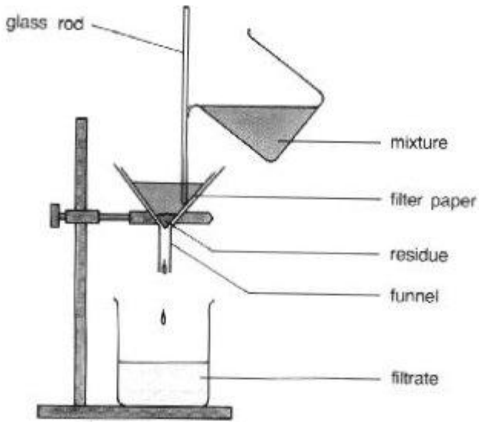
Preparing a Soluble Salt

Soluble salts can be produced by carrying out a neutralisation reaction and then removing any water formed by evaporation.

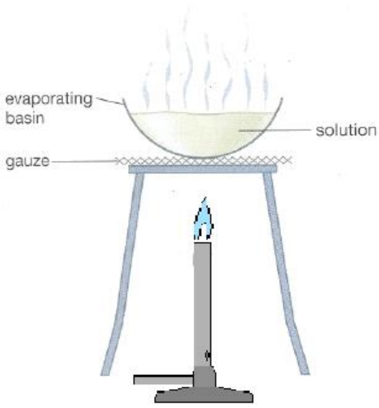
Add a spatula of calcium carbonate to $25cm^3$ of hydrochloric acid and you will see effervescence as carbon dioxide is released. Continue to add small quantities of calcium carbonate until the effervescence stops and no more gas is released.



Any unreacted neutraliser must be removed by filtration.

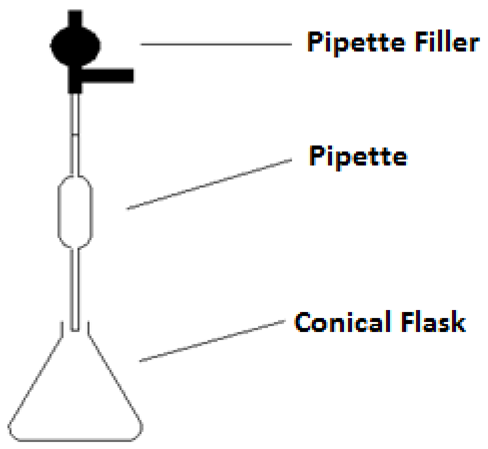


The final stage is to remove the water from the salt solution by evaporation.

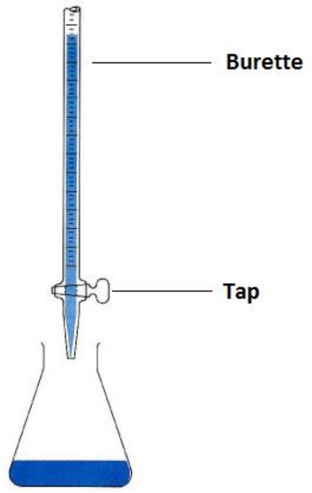


Acid-Base Titrations

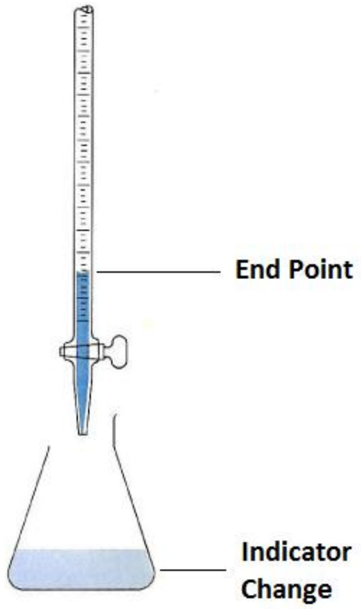
Titration is an analytical technique which allows a solution of an alkali to be neutralised accurately by the addition of an acid using an indicator to determine when the solution becomes neutral. The apparatus used is set up as follows:



A conical flask is filled with a known volume and concentration of alkali by using a pipette.



A burette is filled with a known concentration of acid. The tap is used to control the flow of acid into the conical flask containing the alkali.



When the indicator changes, signifying that the solution is now neutral, this is known as the end point or equivalence point. The volume of acid added is noted from the burette.

Titrations are carried out multiple times to ensure that the results are accurate. The first attempt is known as the Rough titration as this gives a rough estimate of the expected results. The titration is repeated until the results are concordant, meaning that results within 0.2ml of each other are obtained.

Volumetric Titration Calculations

What volume of 0.1 mol l^{-1} hydrochloric acid is required to neutralise $25cm^3$ of 0.2 mol l^{-1} sodium hydroxide?

To do this calculation we can use the formula:

$$P_{acid} \times V_{acid} \times C_{acid} = P_{alkali} \times V_{alkali} \times C_{alkali}$$

Where: P = Power (the number of H+ or OH- ions the acid/alkali has)
V = Volume, in cm^3
C = Concentration, in mol l^{-1}

STEP 1 Write down the formula of acid and the alkali and work out their power

Hydrochloric acid has the formula HCl and so has P = 1
Sodium hydroxide has the formula NaOH and so has P = 1

STEP 2 Write down the volume and concentration information given for both acid and alkali in the question

HCl has a concentration of 0.1 mol l^{-1}
NaOH has a volume of $25cm^3$ and a concentration of 0.2 mol l^{-1}

STEP 3 Put all of the values into the equation

$$P_{acid} \times V_{acid} \times C_{acid} = P_{alkali} \times V_{alkali} \times C_{alkali}$$

$$1 \times V_{acid} \times 0.1 = 1 \times 25 \times 0.2$$

$$0.1\,V_{acid} = 5$$

$$V_{acid} = 5/0.1$$

$$V_{acid} = 50cm^3$$

So, $50cm^3$ of 0.1 mol l^{-1} hydrochloric acid is neutralised by $25cm^3$ of 0.2 mol l^{-1} sodium hydroxide.