Knowledge Organisers and Retrieval Questions

Name: ______________________________

Higher Triple Chemistry

Chapter 1: Atomic structure

Knowledge organiser

Development of the model of the atom

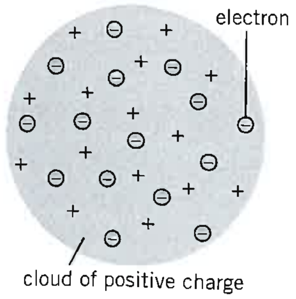
Dalton's model

John Dalton thought of the ________ as a solid sphere that could not be divided into smaller parts. His model did not include ________, ________, or ________.

The plum pudding model

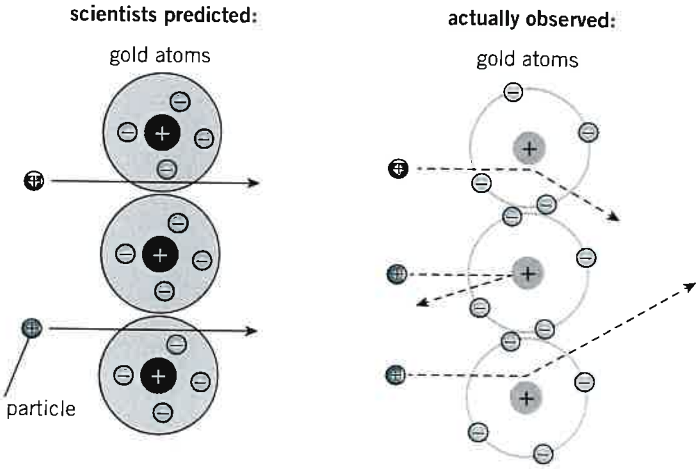
Scientists' experiments resulted in the discovery of sub-atomic ________ particles. The first to be discovered were electrons – tiny, ________ charged particles.

The discovery of electrons led to the ____________ of the atom – a cloud of ________ charge, with negative ________ embedded in it. ________ and ________ had not yet been discovered.



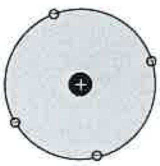
Alpha scattering experiment

1 Scientists fired small, ________ charged particles (called ______ particles) at a piece of ______ foil only a few atoms thick.
2 They expected the alpha particles to travel ______ through the gold.
3 They were surprised that some of the alpha particles ______ back and many were ______ (alpha scattering).
4 To explain why the alpha particles were repelled the scientists suggested that the positive charge and mass of an atom must be concentrated in a small space at its centre. They called this space the ________.



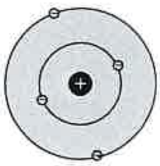
Nuclear model

Scientists replaced the plum pudding model with the nuclear model and suggested that the electrons ______ the nucleus, but not at set ______.



Electron shell (Bohr) model

Niels Bohr calculated that electrons must orbit the nucleus at fixed distances. These orbits are called ______ or ______ ______.



The proton

Further experiments provided evidence that the nucleus contained smaller particles called ______. A proton has an ______ charge to an electron.

The neutron

James Chadwick carried out experiments that gave evidence for a particle with no charge. Scientists called this the ______ and concluded that the ______ and ______ are in the nucleus, and the electrons orbit the nucleus in ______.

Relative mass

One property of protons, neutrons, and electrons is ______ ______ – their masses compared to each other. Protons and neutrons have the same mass, so are given a relative mass of ______. It takes almost ______ electrons to equal the mass of a single proton – their relative mass is so small that we can consider it as ______.

Size

The atom has a radius of ______. ______ (plural of nucleus) are around ______ times smaller than atoms and have a radius of around ______.

Elements and compounds

Elements are substances made of one type of atom. Each atom of an element will have the same number of _______.

__________ are made of different types of atoms chemically _______ together. The atoms in a compound have _________ numbers of protons.

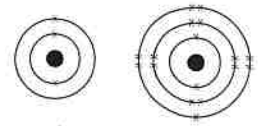
Drawing atoms

Electrons in an atom are placed in fixed shells. You can put

- up to _______ electrons in the first shell
- eight electrons each in the _________ and _________ shells.

You must fill up a shell before moving on to the next one.

Name the elements



__________ __________

Mixtures

- A mixture consists of _________ elements or compounds that are not _________ combined together.
- The substances in a mixture can be _________ using physical processes.
- These processes do not use _________ reactions.

Separating mixtures

- _________ – insoluble solids and a liquid
- _________ – soluble solid from a solution
- _____________ – solvent from a solution
- _____________ – two liquids with similar boiling points
- _____________ – identify substances from a mixture in solution

Atoms and particles

	Relative charge	Relative mass	
Proton			= _______ number
Neutron			= _______ number – _______ number
Electron			= same as the number of _______

All atoms have _______ numbers of protons and electrons, meaning they have _______ overall charge:

total negative charge from electrons = total positive charge from protons

Isotopes

Atoms of the same element can have a different number of _________, giving them a different overall _________.
Atoms of the same element with _________ numbers of neutrons are called **isotopes**.

The **relative atomic mass** is the average _______ of all the atoms of an element:

$$\text{relative atomic mass} = \frac{(\text{abundance of isotope 1} \times \text{mass of isotope 1}) + (\text{abundance of isotope 2} \times \text{mass of isotope 2})\ldots}{100}$$

Key terms

Make sure you can write a definition for these key terms.

abundance atom atomic number aqueous compound electron element energy level isotope neutron nucleus orbit product proton reactant relative atomic mass relative charge relative mass shell

Chapter 2: The Periodic Table

Knowledge organiser

Development of the Periodic Table

The Periodic Table has changed over time as scientists have organised it differently. Mendeleev was able to accurately predict the properties of undiscovered elements based on the gaps in the table.

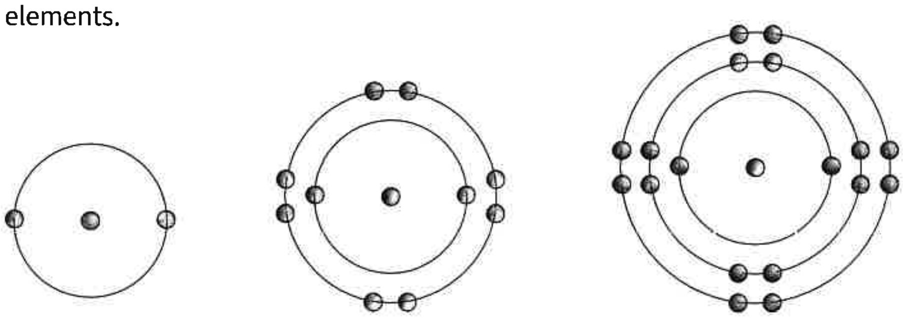
	First lists of elements	Mendeleev's Periodic Table	Modern Periodic Table
How are elements ordered?			
Are there gaps?			
How are elements grouped?			
Metals and non-metals			
Problems			

Group 0

Elements in **Group 0** are called the ________ ________. They have the following properties:

- full outer shells with ________ electrons, so do not need to ________ or ________ electrons
- are very ________________ so exist as single atoms as they do not bond to form molecules
- boiling points that ___________ down the group.

Name the group 0 elements.



___________ ___________ ___________

Key terms

Make sure you can write a definition for these key terms.

alkali metals chemical properties displacement groups halogens inert isotopes noble gas organised Periodic Table reactivity undiscovered unreactive

Group 1 elements

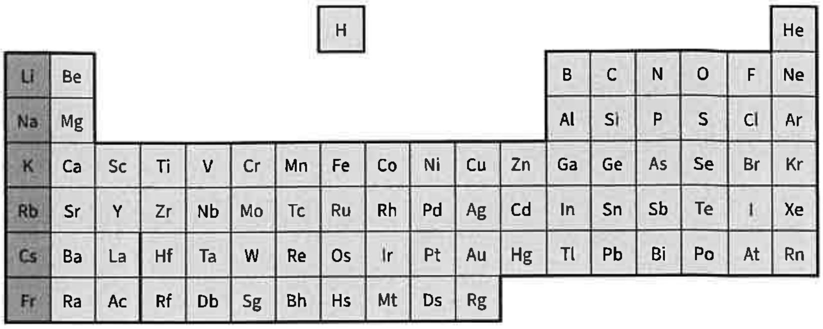
Group 1 elements react with oxygen, chlorine, and water, for example:

lithium + oxygen → ________

lithium + chlorine → ________

lithium + water → ________ + ________

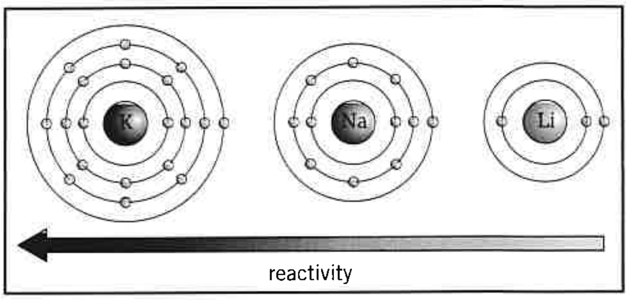
Group 1 elements are called ________ because they react with water to form an alkali (a solution of their metal hydroxide).



Group 1 properties

Group 1 elements all have ________ electron in their outer shell.
Reactivity ________ down Group 1 because as you move down the group:

- the atoms ________ in size
- the outer electron is further away from the nucleus, and there are more shells ________ the outer electron from the nucleus
- the ________ attraction between the nucleus and the outer electron is ________ so it is easier to lose the one ________ electron
- the melting point and boiling point ________ down Group 1.



Group 7 elements

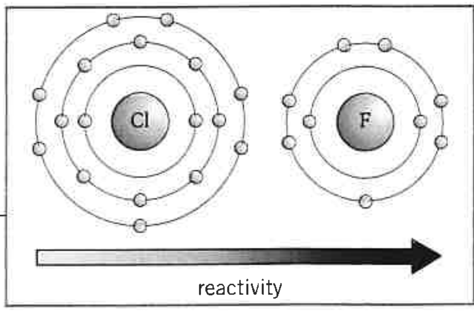
Group 7 elements are called the ________. They are non-metals that exist as molecules made up of ________ of atoms.

Name	Formula	State at room temperature	Melting point and boiling point	Reactivity
fluorine				
chlorine				
bromine				
iodine				

Group 7 reactivity

Reactivity decreases down Group 7 because as you move down the group:

- the atoms ________ in size
- the outer shell is further away from the nucleus, and there are more ________ between the nucleus and the outer shell
- the electrostatic attraction from the nucleus to the outer shell is ________ so it is harder to ________ one electron to fill the outer shell.



Group 7 displacement

More reactive Group 7 elements can take the place of less reactive ones in a compound. This is called ________.
For example, fluorine displaces chlorine as it is more ________:

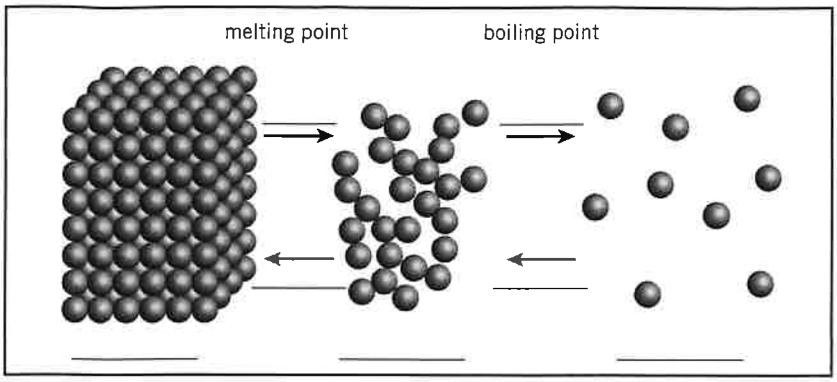
fluorine + potassium chloride → ________ + ________

Chapter 3: Bonding 1

Knowledge organiser

Particle model

The three states of matter can be represented in the particle model.



(HT only) This model assumes that:

-
-
-

The amount of energy needed to change the state of a substance depends on the _______ between the particles. The stronger the _______ between the particles, the _______ the melting or boiling point of the substance.

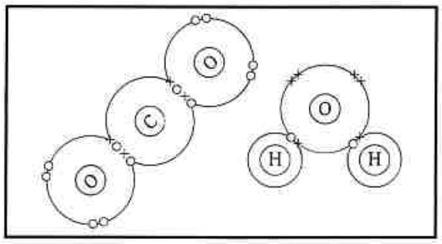
Covalent bonding

Atoms can _______ or _______ electrons to form strong chemical bonds.

A **covalent bond** is when electrons are _______ between _______ atoms.

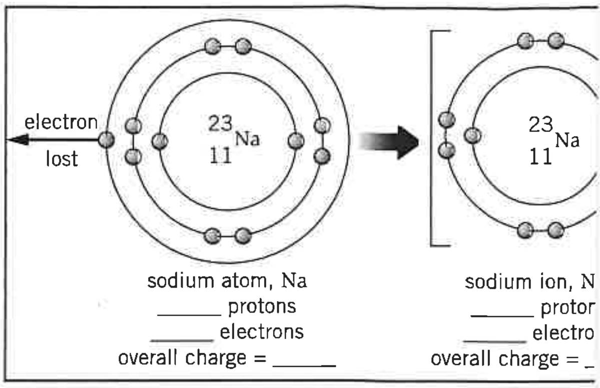
The number of electrons shared depends on how many _______ electrons an atom needs to make a full _______.

If you include electrons that are shared between atoms, each atom has a full outer shell.
Single bond = each atom shares _____ pair of electrons.
Double bond = each atom shares _____ pairs of electrons.



Ions

Atoms can _______ or _______ electrons to give a full outer shell. The number of protons is then diff from the number of electrons. The resulting particle a charge and is called an _______.



Conductivity

Solid ionic substances do not _______ electricity be the ions are fixed in position and not free to carry _

When _______ or _______ in water, ionic substa do _______ electricity because the ions are _____ to move and carry charge.

Melting points

Ionic substances have _______ melting points be the _______ force of attraction between _______ charged ions is strong and so requires lots of _____ to break.

Covalent structures

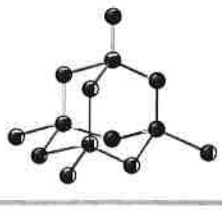
There are three main types of covalent structure:

Structure and bonding

Giant covalent

Many billions of atoms, each one with a _______ covalent bond to a number of others.

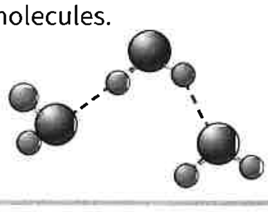
An example of a giant covalent structure is _______.



Small molecules

Each molecule contains only a few atoms with strong covalent bonds between these atoms. Different molecules are held together by weak _______ _______.

For example, _______ is made of small molecules.



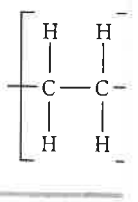
Large molecules

Many repeating units joined by covalent bon to form a _______.

The small section is bonded to many identical sections to the left and right. The 'n' represents _______.

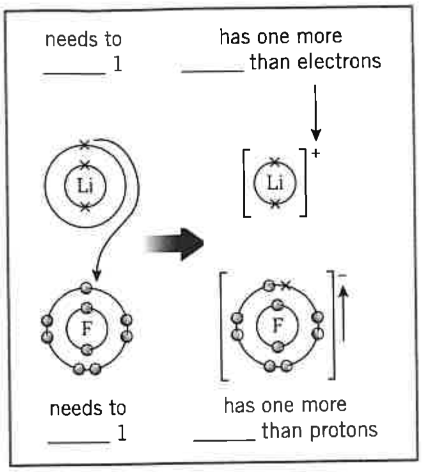
Separate chains are held together by intermolecular forces that are stronger than in _____ molecules.

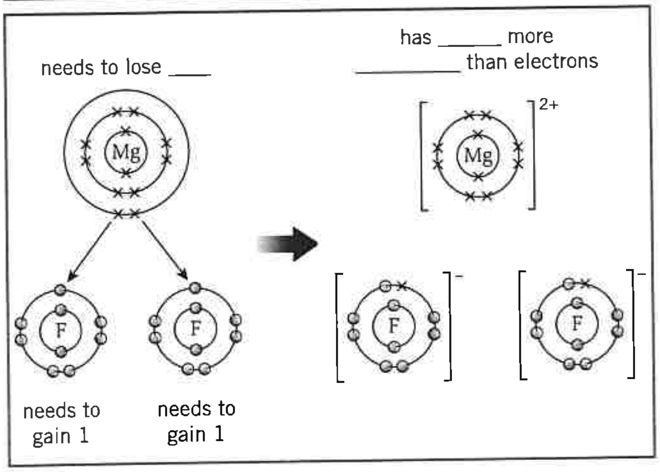
_______ are examples of long molecules.



Ionic bonding

When metal atoms react with non-metal atoms they ________ electrons to the non-metal atom.

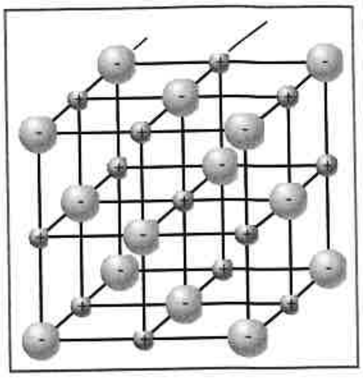




Metal atoms _____ electrons to become ________ ions.
Non-metal atoms _____ electrons to become ________ ions.

Giant ionic lattice

When metal atoms ________ electrons to non-metal atoms you end up with ________ and ________ ions. These are attracted to each other by the strong **electrostatic force of attraction**. This is called _____ ______.



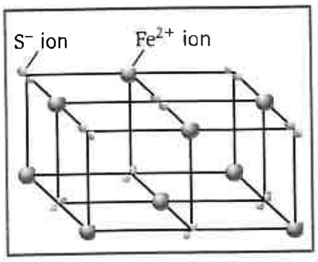
The electrostatic force of attraction works in all ________, so many billions of ions can be bonded together in a ________ structure.

Formulae

The formula of an ionic substance can be worked out

1 from its ________________:
for every ________ magnesium ion there are ________ fluoride ions – so the formula for magnesium fluoride is MgF_2

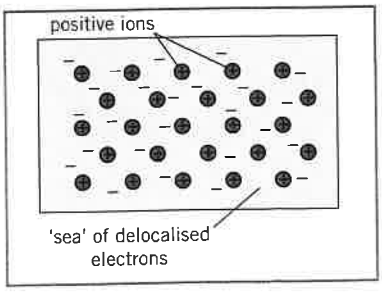
2 from a ____________:
there are nine Fe^{2+} ions and 18 S^{-} ions – simplifying this ratio gives a formula of ________



Metals: Structure and properties

The atoms that make up metals form ________. The electrons in the outer shells of the atoms are ____________ – this means they are free to move through the ________ structure.

The positive metal ions are then attracted to these delocalised electrons by the ________________________.



Some important properties of metals are:

-
-
-

Chapter 3: Bonding 2

Knowledge organiser

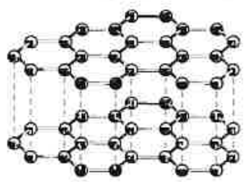
Properties			
	High melting and boiling points because the ________ covalent bonds between the atoms must be ________ to melt or boil the substances. This requires a lot of ______. ________ at room temperature.	________ melting and boiling points because only the ________ forces need to be overcome to melt or boil the substances, not the ________ between the atoms. This does not require a lot of energy as the intermolecular forces are ________. Normally ________ or ________ at room temperature.	Melting and boiling points are ________ compared to giant ____________ substances but higher than for small molecules. Large molecules have ________ intermolecular forces than small molecules, which require more ________ to overcome. Normally ________ at room temperature.

Most covalent structures do not ________ electricity because they do not have ____________ ____________ or ________ that are free to move to carry charge.

Graphite

Graphite is a giant covalent structure, but is different to other giant covalent substances.

Structure



Made only of ________ – each carbon atom bonds to ________ others, and forms hexagonal rings in ________. Each carbon atom has one ________ electron, which is delocalised and therefore ________ to move around the structure.

Hardness

The layers can ________ over each other because they are not ________ bonded. Graphite is therefore softer than ________, even though both are made only of carbon, as each atom in diamond has ________ strong covalent bonds.

Conductivity

The ________ ________ electrons are free to move through graphite, so can carry charges and allow an electrical current to ________. Graphite is therefore a ________ of electricity.

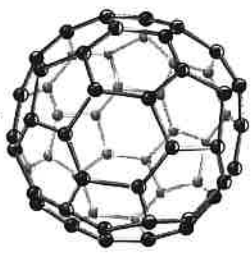
Graphene

Graphene consists of only a single layer of ________. Its strong covalent bonds make it a ________ material that can also conduct electricity. It could be used in composites and high-tech electronics.

Fullerenes

- ________ cages of carbon atoms bonded together in one molecule
- can be arranged as a ________ or a ________ (called a **nanotube**)
- molecules held together by ________ ________ forces, so can slide over each other
- conduct electricity

Spheres

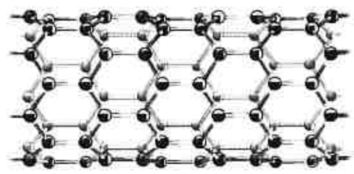


Buckminsterfullerene was the first fullerene to be discovered, and has ________ carbon atoms.

Other fullerenes exist with different numbers of carbon atoms arranged in rings that form hollow shapes.

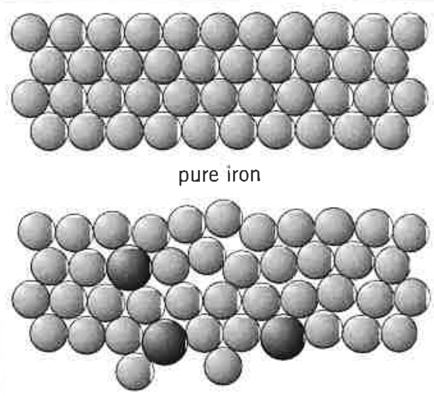
Fullerenes like this can be used as ________ and in ________ ________.

Nanotubes



The carbon atoms in nanotubes are arranged in cylindrical tubes.
Their high __________ strength (they are difficult to break when pulled) makes them useful in electronics.

Alloys



Pure metals are often too ________ to use as they are. Adding atoms of a different element can make the resulting mixture ________ because the new atoms will be a different ________ to the pure metal's atoms. This will disturb the ________ arrangement of the layers, preventing them from ________ over each other.

The harder mixture is called an **alloy**.

Measuring particles

We use different units and scales to measure the size of particles.

Particle	Particulate matter	Size	Standard form	Full form
grain of sand	N/A	0.1 mm	1×10^{-4} m	0.0001 m
coarse particles (e.g., dust)	PM_{10}	10 µm	1×10^{-5} m	0.00001 m
fine particles	$PM_{2.5}$	100 nm	1×10^{-7} m	0.0000001 m
nanoparticles	$< PM_{2.5}$	1 to 100 nm	1×10^{-9} to 1×10^{-7} m	0.000000001 m to 0.0000001 m

PM stands for ________________ and is another way of measuring very small particles.

Uses of nanoparticles

Nanoparticles often have very different ________ to bulk materials of the same substance, caused by their high surface area-to-volume-ratio.

Nanoparticles have many uses and are an important area of research. They are used in ____________, ____________, ____________, and as ____________.

However, nanoparticles have the potential to be hazardous to health and to ____________, so it is important that they are researched further.

Key terms

Make sure you can write a definition for these key terms.

conductivity *conductor* *delocalised electron* *electrostatic force of attraction* *ion* *lattice* *layer* *malleable* *nanoparticle* *particulate matter* *surface area to volume ratio* *transfer*

Chapter 4: Calculations

Knowledge organiser

Formula mass

Every substance has a ______________, M_r.

M_r = ____

Avogadro's constant (HT only)

One mole of a substance contains ________ atoms, ions, or molecules. This is **Avogadro's constant**.

One mole of a substance has the same _______ as the M_r of the substance. For example, the M_r (H_2O) = ____, so ____g of water molecules contains ________ molecules, and is called one ________ of water.

You can write this as: moles = ________

Theoretical yield

The **theoretical yield** of a chemical reaction is the mass of a product that you expect to be ________.

Even though no ______ are gained or lost during a chemical reaction, it is not always possible to obtain the theoretical yield because:

-
-
-

Percentage yield

The **yield** is the amount of ________ that you actually get in a chemical reaction.

Percentage yield is the actual yield as a proportion of the theoretical yield:

percentage yield =

Atom economy

The **atom economy** of a reaction tells you the __________ of atoms that you started with that are part of ________ products.

High atom economies are more sustainable, as they mean ________ atoms are being wasted in products that are not useful.

The percentage atom economy is calculated by:

atom economy =

Key terms

Make sure you can write a definition for these key terms.

atom economy *burette* *concordant* *end point* *excess reactant* *formula mass* *limiting reactant* *percentage yield* *pipette* *room temperature and pressure* *theoretical yield* *titration* *titre* *useful* *yield*

Using balanced equations (HT or

In a balanced symbol equation the sum of the M_r

Write down the steps for how to calculate the mass of a product from a given mass of a specific reactant.

1. ________________________________
2. ________________________________
 ____
3. ________________________________
 ____
4. ________________________________

Concentration

Concentration is the amount of solute in a ________ of solvent.

The unit of concentration is g/dm^3. Concentration can be calculated using:

concentration (g/dm^3) =

Sometimes volume is measured in cm^3:

volume (dm^3) = $\frac{\quad}{\quad}$

- lots of solute in little solution = ________ ________
- little solute in lots of solution = ________ ________

Moles of gases (HT only)

At any given temperature and pressure, the same number of moles of a gas will ________ the same volume.

At room temperature (________) and pressure (________), one mole of *any* gas will occupy ________.

To calculate the number of moles of a gas:

moles of a gas = $\frac{\quad}{24\,dm^3}$

or

moles of a gas = $\frac{\quad}{cm^3}$

...ly)

...of the reactants equals the sum of the M_r of the products.

Write down the steps for how to balance an equation.

1. ______
2. ______
______
3. ______
4. ______

Excess and limiting reactants (HT only)

In a chemical reaction between two or more reactants, often one of the reactants will run out before the others. You then have some of the other reactants left over. The reactant that is left over is in ______. The reactant that runs out is the ______ ______.

Write down the steps for working out which reactants are in excess, and which is the limiting reactant.

1. ______
2. ______
______
3. ______
______
4. ______
5. ______

Concentration in mol/dm³

Concentration can also be measured in mol/dm³.

concentration of solution (mol/dm³) =

You can use this formula and mass = moles × M_r to calculate ______ ______.

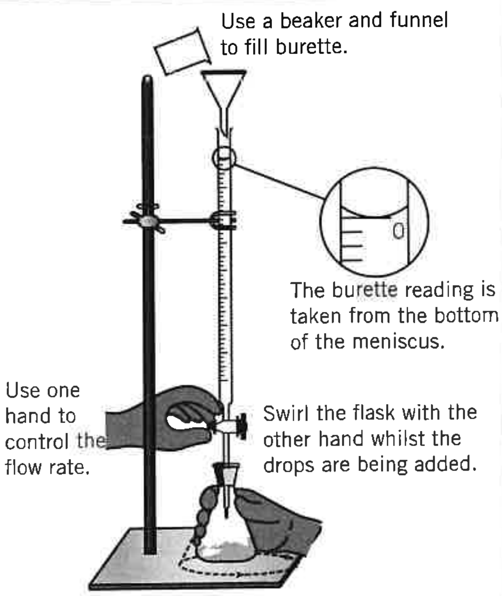
- The greater the mass of solute in solution, the greater the number of ______ of solute, and therefore the greater the ______.
- If the ____ number moles of solute is dissolved in a smaller volume of solution, the concentration will be ____.

mol is a the unit of moles

Titration

Titration is an experimental technique to work out the concentration of an ______ solution in the reaction between an ______ and an ______.

1 Use a ______ to extract a known volume of the solution with an unknown concentration. A pipette measures a ______ volume only.
2 Add the solution of unknown concentration to a ______ flask and put the conical flask on a white tile.
3 Add a few ______ of a suitable indicator to the conical flask.
4 Add the other solution with a known concentration to the ______.
5 Carry out a rough titration to find out approximately what volume of solution in the burette needs to be added to the solution in the conical flask. Add the solution from the burette to the solution in the conical flask 1 cm³ at a time until the ______ is reached.
6 The ______ is when the indicator just changes ______.
7 Record the ______ of the end point as your rough value.
8 Now repeat steps 1–7, but as you approach the end point add the solution from the burette drop-by-drop. ______ the conical flask in between drops.
9 Record the volume of the end point.



Calculating concentration

To calculate the concentration of the unknown solution (the solution in the conical flask):

1 Write a ______ for the reaction.
2 Calculate the moles used from the known solution using:

moles =

3 Use the ______ from the balanced symbol equation to deduce the number of moles present in the unknown solution.
4 Calculate the concentration of the unknown solution using:

concentration (mol/dm³) =

Chapter 5: Chemical changes 1

Knowledge organiser

Reactions of metals

The ______ of a metal is how chemically reactive it is. When added to water, some metals react very vigorously – these metals have ______ reactivity. Other metals will barely react with water or acid, or won't react at all – these metals have ______ reactivity.

Reactivity series

The reactivity series places ______ in order of their reactivity.

Sometimes, for example in the table below, hydrogen and carbon are included in the series, even though they are ______.

Reaction with water	Reaction with acid	Reactivity series: Metal	Reactivity series: Reactivity	Extraction method
		potassium	high reactivity	
		sodium		
		lithium		
		calcium		
		magnesium		
		aluminium		
		~~(carbon)~~	Decreasing reactivity	
		zinc		
		iron		
		tin		
		lead		
		~~(hydrogen)~~		
		copper		
		silver		
		gold	low reactivity	

Metal extraction

Some metals, like gold, are so ______ that they are found as pure metals in the Earth's ______ and can be mined.

Most metals exist as compounds in rock and have to be ______ from the rock. If there is enough metal compound in the rock to be worth extracting it is called an ______.

Metals that are ______ reactive than carbon can be extracted by ______ with carbon. For example:

iron oxide + carbon → ______ + ______

Metals that are more reactive than carbon can be extracted using a process called ______.

Reduction and oxidation

If a substance gains oxygen in a reaction, it has been ______.

If a substance loses oxygen in a reaction, it has been ______.

For example:

iron + oxygen → iron oxide

iron has been ______

______ + carbon → iron + carbon dioxide

______ has been reduced

Salts

When acids react with metals or metal compounds, they form ______. A salt is a compound where the ______ from an acid has been replaced by a metal. For example nitric acid, HNO_3, reacts with sodium to form ______. The H in nitric acid is replaced with Na.

The table shows how to name salts.

Acid	hydrochloric acid	sulfuric acid	nitric acid
Formula			
Ions formed in solution			
Type of salt formed			
Sodium salt example			

Displacement reactions

In a **displacement** reaction a ______ reactive element takes the place of a *less* reactive element in a compound.

For example:

copper sulfate + iron → ______ + ______

____$_4$(aq) + ____(s) → ____(aq) + ____(s)

______ is more reactive than copper, so iron displaces the copper in copper sulfate.

Reactivity and ions

A metal's reactivity depends on how readily it forms an ______ by losing electrons.

In the displacement reaction of copper sulfate and iron, iron forms an ion more easily than copper.

At the end of the reaction you are left with ______ ions, not ______ ions.

Ionic equations (HT only)

When an ionic compound is dissolved in a solution, we can write the compound as its separate ions. For example, $CuSO_4$(aq) can be written as ________ and ________.

The displacement reaction of copper sulfate and iron can be written as:

____

The SO_4^{2-} is unchanged in the reaction – it is a ______________ ______________. Spectator ions are removed from the equation to give an **ionic equation**:

____

Metals, covalent substances, and solid ionic substances do not split into ions in the ionic equation.

Steps for writing an ionic equation (HT only)

1.
2.
3.
4.

Half equations (HT only)

In the displacement reaction, an iron atom loses two electrons to form a iron ion:

Fe(s) → ______ + ______

A copper ion gains two electrons to form a copper atom:

______ + ______ → Cu(s)

These two equations are called ____________ – they each show half of the ionic equation.

Reduction and oxidation: electrons (HT only)

Oxidation and reduction (**redox** reactions) can be defined in terms of oxygen, but can also be defined as the ______ or ______ of electrons.

Oxidation is the ______ of electrons, and reduction is the ______ of electrons.

In the example displacement reaction:

- iron atoms have been ______
- copper ions have been ______.

Acids and alkalis

Acids are compounds that, when dissolved in water, release ____ ions. There are three main acids: ________ ________, ________ ________, and ________ ________.

Alkalis are compounds that, when dissolved in water, release ______ ions.

The **pH** scale is a measure of acidity and alkalinity. It runs from 1 to 14.

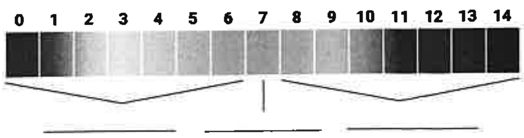
- Aqueous solutions with pH < 7 are ______.
- Aqueous solutions with pH > 7 are ______.
- Aqueous solutions with pH = 7 are ______.

Indicators

Indicators can show if something is an acid or an alkali.

- ________ ________ can also tell us the approximate pH of a solution.
- ________ ________ ________ can give us the exact pH of a solution.

The pH scale



Chapter 5: Chemical changes 2

Knowledge organiser

Reactions of acids

Reactions of acids with metals

Acids react with some metals to form ________ and ________.

magnesium + hydrochloric acid → ____________

Neutralisation reactions

Reactions of acids with metal hydroxides

Acids react with metal hydroxides to form ________ and ________.

hydrochloric acid + sodium hydroxide → ____________

The ionic equation for this reaction is always:

____

Reactions of acids with metal oxides

Acids react with metal oxides to form ________ and ________.

________ + ________ → ________ + ________

Reactions of acids with metal carbonates

Acids react with metal carbonates to form a ________, ________ and ________.

hydrochloric acid + sodium carbonate → ____________________

____

Alkalis and bases

________ neutralise acids to form water in **neutralisation** reactions. Some metal hydroxides dissolve in water to form ________ solutions, called alkalis.

Some metal oxides and metal hydroxide do not dissolve in ________. They are **bases**, but are not alkalis.

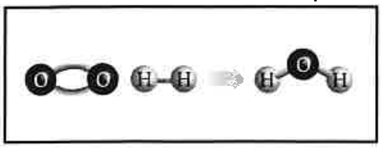
Balancing symbol equations

When writing symbol equations you need to ensure that the number of each ________ on each side is ________.

$H_2 + O_2 \rightarrow H_2O$

unbalanced

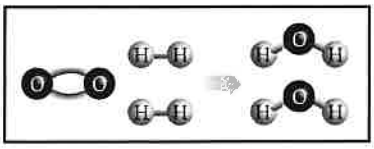
there are ___ hydrogen atoms on each side, but ___ oxygen atoms in the reactants and ___ in the product



$\_\_H_2 + O_2 \rightarrow \_\_H_2O$

balanced

there are ___ hydrogen atoms on each side, and ___ oxygen atoms on each side



State symbols

A balanced symbol equation should also include state symbols. Complete the table.

State	Symbol

Key terms

Make sure you can write a definition for these key terms.

displacement *electrolysis* *extraction* *half equation* *ion* *ionic equation*
metal *ore* *oxidation* *reactivity* *reactivity series* *redox* *reduction*
spectator ion *state symbols*

Strong and weak acids

Sulfuric acid, nitric acid, and hydrochloric acid, are all ________ **acids**. This means that, when dissolved in water, every molecule splits up into ions – they are completely ionised:

- ________ (aq) → $2H^+$(aq) + SO_4^{2-}(aq)
- HNO_3(aq) → ________ + ________
- HCl(aq) → H^+(aq) + ________

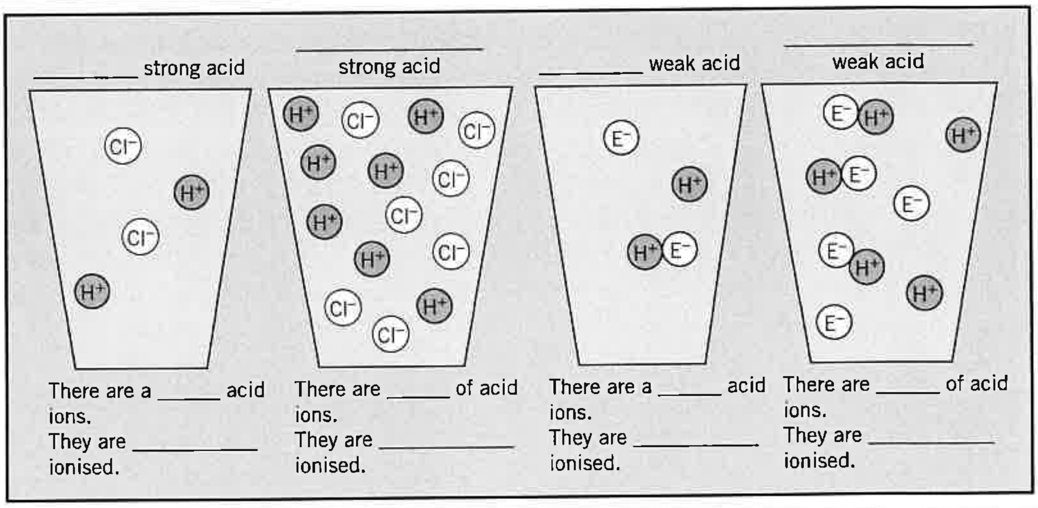
________ acid, ________ acid, and ________ acid are **weak acids**. This means that only a percentage of their molecules split up into ions when dissolved in water – they are ________ ionised.

For a given concentration, the ________ the acid, the ________ the pH.

Concentrated and dilute acids

Concentration tells us how much of a substance there is dissolved in water:

- more concentrated acids have lots of acid in a ________ volume of water
- less concentrated acids (dilute acids) have little acid in a large volume of water.

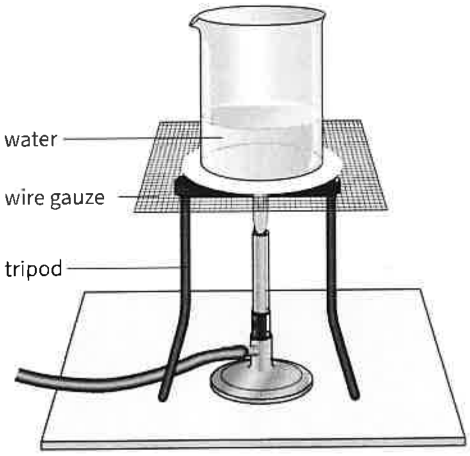


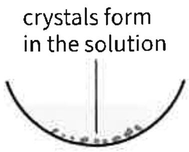
Crystallisation

You can produce a solid salt from an insoluble base by **crystallisation**.

The experimental method is:

1. ________________
2. ________________
   ____
3. ________________
4. ________________
   ____
5. ________________
6. ________________
7. ________________
   ____





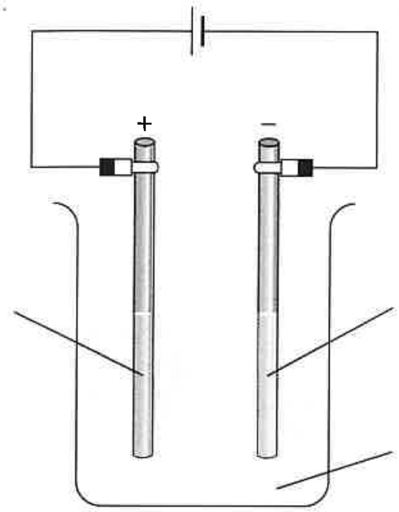
Chapter 6: Electrolysis

Knowledge organiser

Electrolysis

In the process of **electrolysis**, an electric ________ is passed through an **electrolyte**. An electrolyte is a ________________ that contains ________ and so can conduct electricity. This causes the ions to move to the ________, where they form pure elements.

Label the diagram.



Electrolysis of molten compounds

Solid ionic compounds do not conduct electricity as the ions cannot move. To undergo electrolysis they must be ________ or dissolved, so the ions are free to move.

When an ionic compound is molten:

- The positive metal ions are *attracted* to the ________, where they will ________ electrons to form the pure metal
- The negative non-metal ions are *attracted* to the ________, where they will ________ electrons and become the pure non-metal.

For example, molten sodium chloride, NaCl, can undergo electrolysis to form ________ at the cathode and ________ at the anode.

Half equations (HT only)

sodium chloride → sodium + chlorine

________ ________ → ________ + ________

- at the cathode:

________ + ________ → ________

- at the anode:

________ → ________ + ________

Electrolysis of aqueous solutions

Solid ionic compounds can also undergo electrolysis when dissolved in water.

- It requires ________ energy to dissolve ionic compounds in water than it does to melt them.
- However, in the electrolysis of solutions, the pure elements are not always produced. This is because the water can also undergo ________:

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

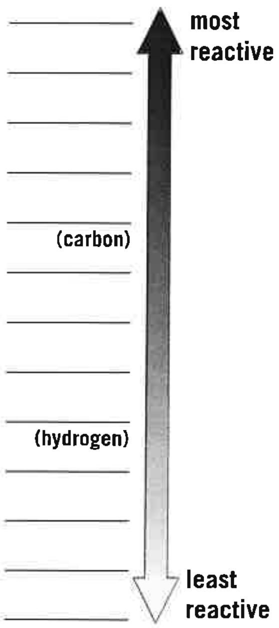
Products at the anode

In In the electrolysis of a solution, if the non-metal contains oxygen then oxygen ________ is formed at the anode:

- The ________ ions formed from the ionisation of water are attracted to the anode.
- The $OH^-(aq)$ ions ________ electrons to the anode and form oxygen gas.
- $4OH^-(aq) \rightarrow$ ________________

If the non-metal ion is a halogen, then the halogen gas is formed at the anode.

- $2Cl^-(aq) \rightarrow$ ____________



Products at the cathode

In the electrolysis of a solution, if the metal is ________ **reactive** than hydrogen then hydrogen gas is formed at the cathode:

- The ________ ions from the ionisation of water are attracted to the cathode and react with it.
- The $H^+(aq)$ ions ________ electrons from the cathode and form hydrogen gas.
- $2H^+(aq) +$ ____________
- The metal ions remain in ________.

Electrolysis of aluminium oxide

Electrolysis can be used to extract metals from their ionic compounds.

Electrolysis is used if the metal is more reactive than ________.

Aluminium is extracted from ______________ ______________ by electrolysis.

1 The aluminium oxide is mixed with a substance called ________, which lowers the melting point.
2 The mixture is then heated until it is ________.
3 The resulting molten mixture undergoes electrolysis.

aluminium oxide → aluminium + oxygen

$2Al_2O_3(l)$ → ________ + ________

cathode: pure aluminium is formed

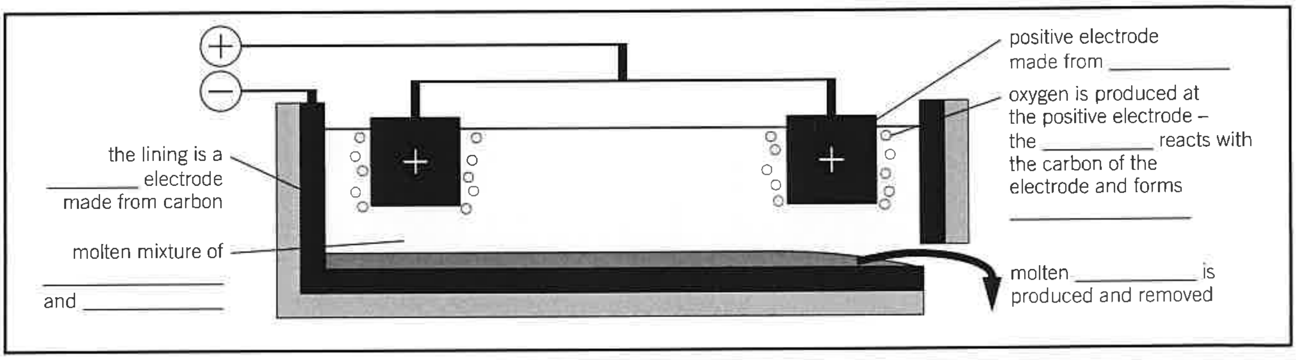
________ + ________ → ________

anode: oxygen is formed

________ → $O_2(g) + 4e^-$

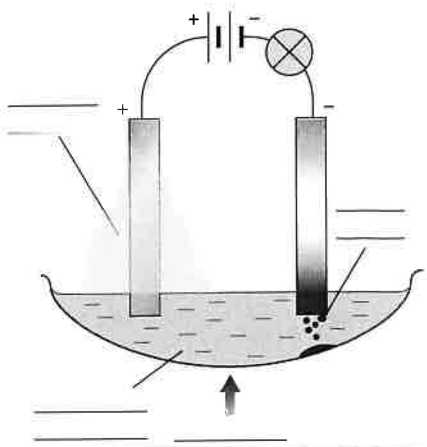
In the electrolysis of aluminium, the anode is made of ____________.

The graphite reacts with the ____________ to form ______________ and so slowly wears away. It therefore needs to be replaced frequently.



Electrolysis of zinc chloride

Molten zinc chloride is broken down by electrolysis. This means ____________ metal is collected at the ____________ and a ______________ is collected at the ____________. Free ____________ from the molten zinc chloride are able to move around and carry ____________, hence why the bulb lights up. Label the diagram.



Key terms

Make sure you can write a definition for these key terms.

anode cathode cryolite electrode electrolysis electrolyte reactivity

Chapter 7: Energy changes

Knowledge organiser

Energy changes

During a chemical reaction, energy transfers occur.

Energy can be transferred:

- to the surroundings – ________
- from the surroundings – ________

This energy transfer can cause a ____________ change.

Energy is always conserved in chemical reactions.

This means that there is the ____________

____

____

The surroundings

When chemists say energy is transferred from or to "the *surroundings*" they mean ____________________.

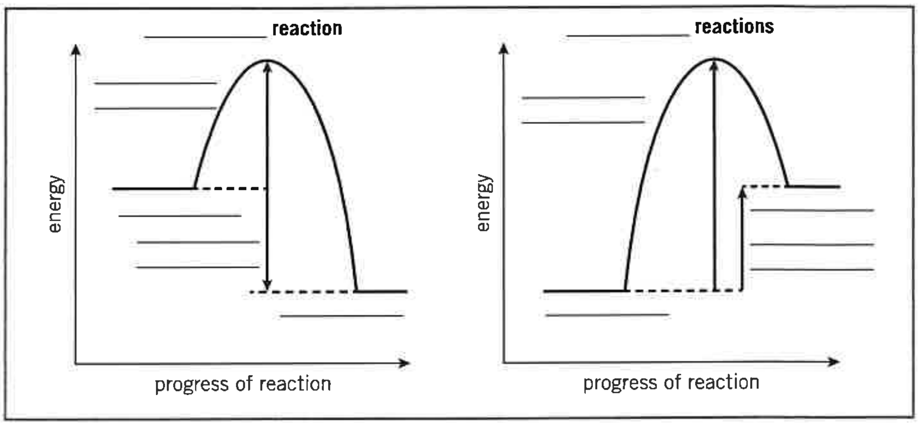
For example, imagine you have a reaction mixture in a test tube. If you measure the temperature in the test tube using a thermometer, the thermometer is then part of the surroundings.

- If the thermometer records an increase in temperature, the reaction in the test tube is ____________.
- If the thermometer records a decrease in temperature, the reaction in the test tube is ____________.

Reaction profiles

A ________ ________ shows whether a reaction is exothermic or endothermic.

The ________ ________ is the minimum amount of energy that particles must have to react when they ________.



Bonds (HT only)

Atoms are held together by strong ________ bonds. In a reaction, those bonds are ________ and new ones are made between ________ atoms.

- Breaking a bond ________ energy so is ________.
- Making a bond ________ energy so is ________.

Breaking bonds

If a lot of energy is released when ________ the bonds and only a ________ energy is required to break them, then overall energy is released and the reaction as a whole is ________.

Making bonds

If a ________ energy is released when making the bonds and a ________ is required to break them, then overall energy is taken in and the reaction as a whole is ________.

Bond calculations

Different bonds require different amounts of energy to be broken (their **bond energies**). To work out the overall energy change of a reaction, you need to:

1 work out how much energy is required to break all the bonds in the ________

2 work out how much energy is ________ when making all the bonds in the products.

overall energy transferred = ____________ – ____________

- A ________ number means an endothermic reaction.
- A ________ number means an exothermic number.

Reaction	Energy transfer	Temperature change	Example	Everyday use	Bonds
exothermic			• • •	• •	
endothermic			• •	•	

Chemical cells

In a metal displacement reaction, one metal is ______________. These electrons are ______________ to another metal, which gains the electrons and so is __________.

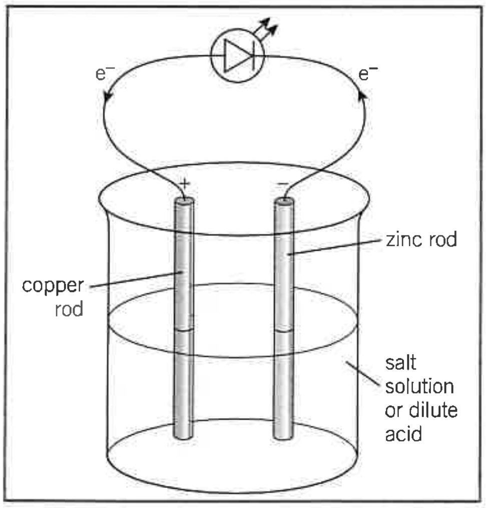
By using a **chemical cell** to conduct this reaction, the electron's movement generates a __________.

In the cell shown, the zinc atoms from the electrode lose electrons, turn into _______, and move into the solution.

The __________ travel through the circuit to the __________ electrode, causing the LED to __________.

Once at the copper electrode, a metal ion *from the solution* will pick the electrons up and become a _______ atom.

The greater the difference in reactivity between the two metals in the cell, the greater the _______ _________ produced.



Batteries

A **battery** is formed of _______________ cells connected in _______.

- Some batteries are ____________. An external electric current is applied, which reverses the reaction.
- Some batteries, like _______ batteries, are not rechargeable because the reaction is not _________. Once the reactants are used up, the chemical reaction _______ and no more potential differences are _______.

Hydrogen fuel cells

Fuel cells use a _________ and _________ from the air to generate a potential difference.

________ fuel cells generate electricity from hydrogen and oxygen. The overall reaction is:

$$2H_2(g) + O_2(g) \rightarrow \_\_\_\_\_\_\_\_$$

The hydrogen is oxidised to produce _________.

There are different types of hydrogen fuel cell. In alkaline fuel cells, the half equations are below:

- $2H_2(g) + 4OH^-(aq) \rightarrow$ _________ + _________
- _________ + _________ + $4e^- \rightarrow 4OH^-(aq)$

Advantages

-
-

Disadvantages

-
-

Key terms

Make sure you can write a definition for these key terms.

activation energy *battery* *bond energy* *chemical cell* *combustion* *endothermic* *exothermic* *fuel cell* *neutralisation* *oxidation* *reaction profile* *rechargeable* *thermal decomposition*

Chapter 8: Rates and equilibrium 1

Knowledge organiser

Rates of reaction

The **rate of a reaction** is how quickly the __________ turn into the __________.

To calculate the rate of a reaction, you can measure:

- how quickly a reactant is used up

  mean rate of reaction = ____________________

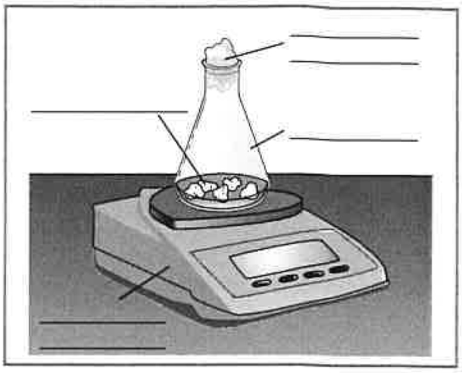
- how quickly a product is produced.

  mean rate of reaction = ____________________

For reactions that involve a gas, this can be done by ______________________________ ______________________________.

Change in mass

The reaction mixture is placed on a mass balance. As the reaction proceeds and the __________ product is given off, the mass of the flask will __________.



The rate for the reaction is then:

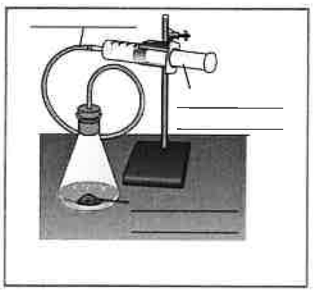
rate = ____________________

The mass is measured in grams and time is measured in seconds. Therefore, the unit of rate is ____.

Volume of gas produced

The reaction mixture is connected to a __________ or an upside down measuring cylinder. As the reaction proceeds the gas is collected.

The rate for the reaction is then:



rate = ____________________

Volume is measured in ____ and time in __________, so the unit for rate is ____.

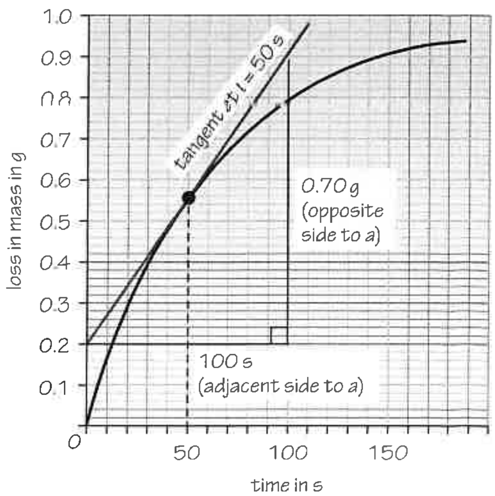
Calculating rate from graphs (HT only)

The results from an experiment can be plotted on a graph.

- A steep gradient means ______________________________.
- A shallow gradient means ______________________________.

Mean rate at specific time

To obtain the rate at a specific time draw a __________ to the graph and calculate its __________.

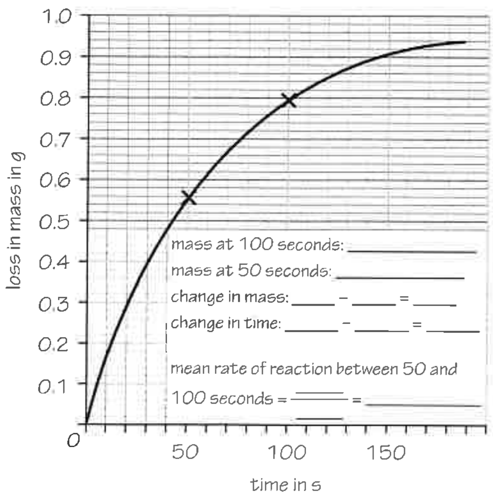


Rate at 50 s = ——— =

The gradient is the change in y divided by the change in x for a right-angled triangle drawn from the tangent.

Mean rate between two points in time

To get the mean rate of reaction between two points in time:



Collision theory

For a reaction to occur, the reactant particles need to ________. When the particles collide, they need to have enough ________ to react or they will just bounce apart. This amount of energy is called the ________ ________.

You can increase the rate of a reaction by:

- ________________________________
- ________________________________
- ________________________________

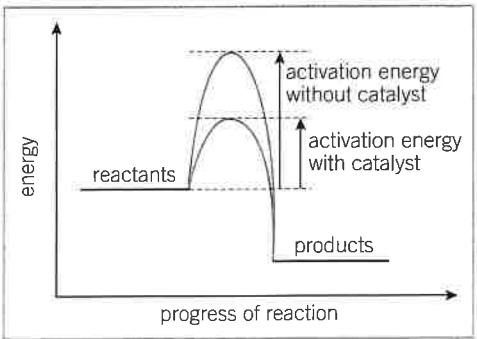
Factors affecting rate of reaction

Condition that increases rate	How is this condition caused?	Why it has that effect
increasing the temperature		1 2
increasing the concentration of solutions		
increasing the pressure of gases		
increasing the surface area of solids		

Catalysts

Some reactions have specific substances called ________ that can be added to increase the rate. These substances are not used up in the reaction.

A catalyst provides a different ________ ________ that has a ________ activation energy. As such, more particles will collide with enough energy to react, so more collisions result in a reaction.



Chapter 8: Rates and equilibrium 2

Knowledge organiser

Reaction conditions

The conditions of a reaction refer to the external environment of the reaction. When the reaction occurs in a closed system, you can change the conditions by:

-
-
-

Le Châtelier's principle (HT only)

At equilibrium, the amount of reactants and products is constant. In order to change the amounts of reactant and product at equilibrium the ______________________ of the reaction must be changed. The closed system will then counteract the change by favouring either the ________________ or the ____________________. This is known as **Le Châtelier's principle**.

Changing concentrations (HT only)

Change	Effect	Explanation
decrease concentration of product		
increase concentration of product		
decrease concentration of reactant		
increase concentration of reactant		

Changing temperature (HT only)

Change	Effect	Explanation
increase temperature of surroundings		
decrease temperature of surroundings		

Changing pressure (HT only)

Change	Effect	Explanation
increase the pressure		
decrease the pressure		

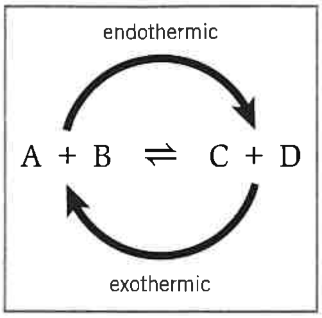
Key terms

Make sure you can write a definition for these key terms.

activation energy *catalyst* *collision* *collision theory* *closed system*
conditions *dynamic equilibrium* *frequency of collision* *gradient*
Le Châtelier's principle *rate of reaction* *reversible reaction* *tangent*

ɿeversible reactions

n some reactions, the ɿroducts can react to produce he original reactants. This is alled a **reversible reaction**. Vhen writing chemical quations for reversible eactions, use the ____ symbol.



n this reaction:

- A and B can react to form C and D – the ____________ reaction.
- C and D can react to form A and B – the ________________ reaction.

he different directions of the reaction have _________ energy hanges.

f the forward reaction is ____________, the reverse reaction vill be *exothermic*.

he same amount of energy is transferred in each _________.

Equilibrium

In a _________ system no reactants or products can escape. If a reversible reaction is carried out in a closed system, it will eventually reach _________ _________ – a point in time when the forward and reverse reactions have the same rate.

At dynamic equilibrium:

-
-
-

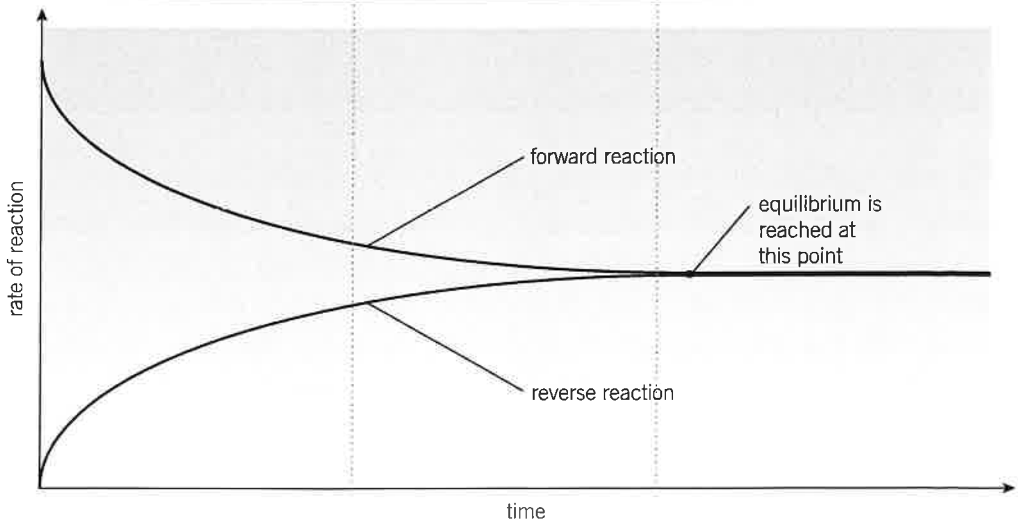
Dynamic equilibrium

At dynamic equilibrium the amount of reactant and product are constant, but not necessarily ________.

You could have a mixture of reactants and products in a 50:50 ratio, in a 75:25 ratio, or in any ratio at all. The _________ of the reaction are what change that ratio.

ɧow dynamic equilibrium is reached

Progress of reaction	start of reaction	middle of reaction	at dynamic equilibrium
Amount of A + B	high	decreasing	________
Frequency of collisions A + B	high	________	________
Rate of forward reaction	________	________	______________________



Amount of C + D	________	________	________
Frequency of collisions C + D	________	________	constant
Rate of reverse reaction	________	________	______________________

Chapter 9: Crude oils and fuels

Knowledge organiser

Crude oil

Crude oil is incredibly important to our society and economy. It is formed from the remains of ancient ________ – living organisms (mostly ________) that died ________ of years ago.

Raw crude oil is a thick black ________ made of a large number of different ________ mixed together. Most of the compounds are ________ of various sizes. Hydrocarbons are ______________________ ______________________ ______________________.

Combustion

Hydrocarbons are used as ________. This is because when they react with ________ they release a lot of ________. This reaction is called ________. Complete combustion is a type of combustion where the only products are ________ and ________.

Properties

Whether or not a particular hydrocarbon is useful as a fuel depends on its properties:

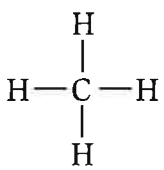
- ________ – how easily it burns
- ________ – the temperature at which it boils
- ________ – how thick it is

Its properties in turn depend on the length of the molecule. Complete the table.

Chain length	Flammability	Boiling point	Viscosity
long chain	low		
short chain			

Alkanes

One ________ of hydrocarbon molecules are called **alkanes**. Alkane molecules only have ________ bonds in them. The first four alkanes are:



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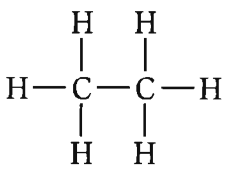

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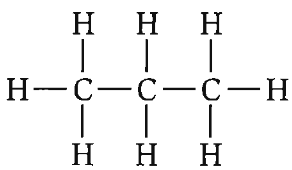

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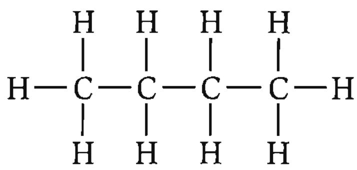


____

The different alkanes have different numbers of carbon atoms and hydrogen atoms. You can always work the molecular formula of an alkane by using ________.

Key terms

Make sure you can write a definition for these key terms.

alkanes alkenes boiling point combustion cracking crude oil feedstock flammability fractional distillation fuel hydrocarbon viscosity

Fractional distillation

The different hydrocarbons in crude oil are separated into ____ based on their ______ points in a process called **fractional distillation**. All the molecules in a fraction have a similar number of __________ atoms, and so a similar boiling point.

The process takes place in a fractionating column, which is hot at the bottom and cooler at the top.

The process works like this:

1 ______________________________
____

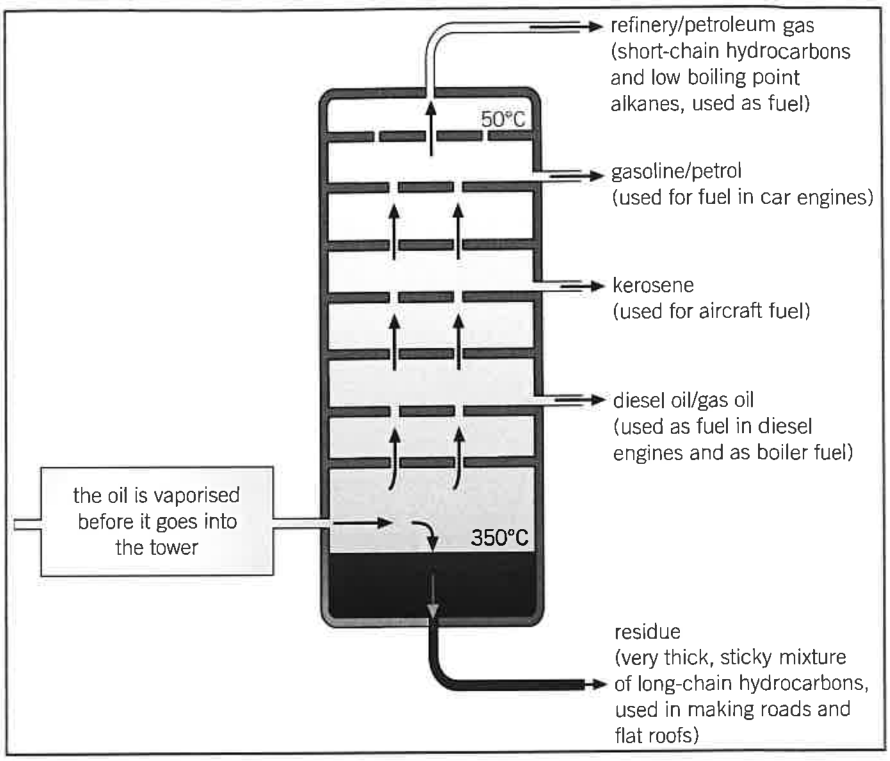
2 ______________________________

3 ______________________________

4 ______________________________
____

5 ______________________________
____

6 ______________________________



Products from fractional distillation

Many useful products come from the separation of crude oil by fractional distillation.

Fuels	Feedstock	Useful materials produced
petrol, diesel oil, kerosene, heavy fuel oil, and liquefied petroleum gases		

Cracking

Not all hydrocarbons are as useful as each other. ______________ ______________ tend to be less useful than shorter ones. As such, there is a higher demand for shorter-chain hydrocarbons than longer-chain hydrocarbons.

A process called **cracking** is used to __________ longer hydrocarbons and turn them into shorter ones.

Cracking produces shorter alkanes and **alkenes**.

Two methods of cracking are:

- ______________________________
____
- ______________________________
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Alkenes

Alkenes are a family of hydrocarbons that contain ______________ ______________ between carbon atoms.

Alkenes are also used as ______, and to produce __________ and many other materials.

They are much more reactive than __________. When mixed with bromine water, the bromine water turns from __________ to __________. This can be used to tell the difference between alkanes and alkenes.

Chapter 10: Organic reactions

Knowledge organiser

Organic chemistry

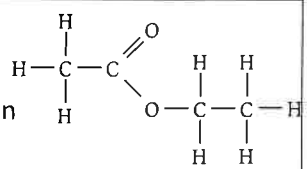
There are lots of different 'families' of carbon-containing compounds, for example, alkanes and **alkenes**. These families are called specific atoms in specific orders, called the ________ group. **Complete the table and draw the structural diagrams in the rele**

Homologous series	Functional group	First four of homologous series	Formation	Uses	C
alkenes				• •	• c p a • ir m _ • b c _ a
alcohols			________ → ________ + ________ ________(aq) → ________(aq) + ________	• • •	• s e c w p a 2_
carboxylic acids				•	• c _ g a

Key terms **Make sure you can write a definition for these key terms.**

addition reaction *alcohols* *alkene* *alkoxide* *carboxylic acid* *ester* *fermentation* *crackin*

a ________ ________. Each compound within a homologous series has similar properties and reactions. They all contain
vant boxes.

ombustion reaction	Other reactions	Other information
omplete combustion roduces ________ nd ________ complete combustion ore likely, resulting in a ________ flame oth types of alkene ombustion release ________ per mole than kanes	**Addition with halogens** $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$ The two atoms from the halogen molecule are ________ across the carbon – carbon double bond. Draw the structural diagram of the reaction. **Addition with hydrogen** $C_2H_4 + H_2 \rightarrow C_2H_6$ The two atoms from the hydrogen molecule are ________ across the carbon – carbon double bond to form an ________. Draw the structural diagram of the reaction. **Addition with steam** $C_2H_4 + H_2O \rightarrow C_2H_5OH$ React with steam at high ________ and ________ in the presence of a ________ to form alcohols. Draw the structural diagram of the reaction.	Alkenes are called ________ because they have double bonds. As such, atoms can be added to the molecule by breaking the double bond. This contrasts with alkanes which are called ________ as there is no space to add more atoms. Alkenes have a general formula ______.
ort alcohols are very fective ________ and mbust easily, burning ith a ________ flame and oducing carbon dioxide nd water ________ + 3________ → 2____ + 4____	**Reaction with sodium** Alcohols react with ________ to release hydrogen. The product from this reaction is called an ________, which if added to water forms a strongly alkaline solution. **Oxidation** Alcohols can react with ________ ________, like potassium dichromate, to form carboxylic acids.	Alcohols are highly flammable and must not be handled near ________ flames.
rboxylic acids can undergo ________, but we do not nerally do this or use them a fuel	Carboxylic acids react in the same way as other acids. **Reaction with sodium carbonate** Carboxylic acids react with bases to form ________. For example, carboxylic acids react with a metal carbonate to produce a salt, carbon dioxide, and water. **Reaction with alcohols** Carboxylic acids react with alcohols to make ________ and ________. The reaction requires ________ ________ as a catalyst.  Esters have distinctive smells and are used in perfumes and flavourings. The product of ethanol and ethanoic acid is ________ ________.	(HT only) When added to water, carboxylic acids are ________ to form weakly acidic solutions. They are weak acids.

functional group *homologous series* *oxidation* *oxidising agent* *saturated* *unsaturated*