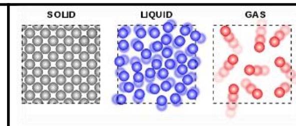
AQA BONDING, STRUCTURE AND THE PROPERTIES OF MATTER 1

Chemical bonds

Ionic	*Particles are oppositely charged ions*	Occurs in compounds formed from metals combined with non metals.
Covalent	*Particles are atoms that share pairs of electrons*	Occurs in most non metallic elements and in compounds of non metals.
Metallic	*Particles are atoms which share delocalised electrons*	Occurs in metallic elements and alloys.

The three states of matter

Solid, liquid, gas	*Melting and freezing happen at melting point, boiling and condensing happen at boiling point.*	 The amount of energy needed for a state change depends on the strength of forces between particles in the substance.	(HT only) Limitations of simple model: • There are no forces in the model • All particles are shown as spheres • Spheres are solid

s	solid
l	liquid
g	gas

Properties of ionic compounds

High melting and boiling points	Large amounts of energy needed to break the bonds.
Do not conduct electricity when solid	Ions are held in a fixed position in the lattice and cannot move.
Do conduct electricity when molten or dissolved	Lattice breaks apart and the ions are free to move.

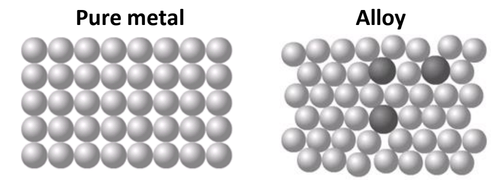
Metals as conductors

Good conductors of electricity	Delocalised electrons carry electrical charge through the metal.
Good conductors of thermal energy	Energy is transferred by the delocalised electrons.

Properties of metals and alloys

High melting and boiling points	This is due to the strong metallic bonds.
Pure metals can be bent and shaped	Atoms are arranged in layers that can slide over each other.

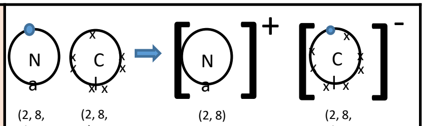
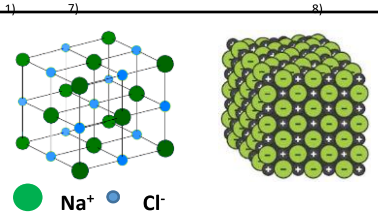
Alloys	*Mixture of two or more elements at least one of which is a metal*	Harder than pure metals because atoms of different sizes disrupt the layers so they cannot slide over each other.



Ionic bonding

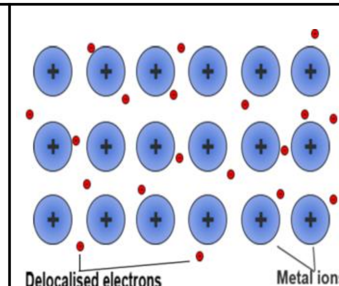
Electrons are transferred so that all atoms have a noble gas configuration (full outer shells).	*Metal atoms lose electrons and become positively charged ions*	Group 1 metals form +1 ions Group 2 metals form +2 ions
	Non metals atoms gain electrons to become negatively charged ions	Group 6 non metals form -2 ions Group 7 non metals form -1 ions

Ionic compounds

Dot and cross diagram	
Giant structure	

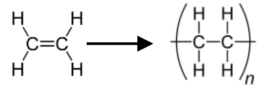
Structure	• *Held together by strong electrostatic forces of attraction between oppositely charged ions* • *Forces act in all directions in the lattice*

Metallic bonding

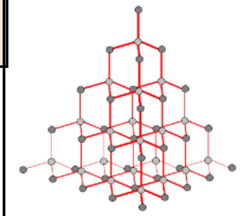
Giant structure of atoms arranged in a regular pattern		Electrons in the outer shell of metal atoms are delocalised and free to move through the whole structure. This sharing of electrons leads to strong metallic bonds.

AQA BONDING, STRUCTURE AND THE PROPERTIES OF MATTER 2

Polymers

Very large molecules	*Solids at room temperature*	Atoms are linked by strong covalent bonds.	

Diamond

Each carbon atom is bonded to four others		Very hard.	Rigid structure.
		Very high melting point.	Strong covalent bonds.
		Does not conduct electricity.	No delocalised electrons.

Properties of small molecules

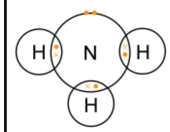
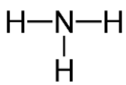
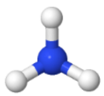
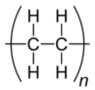
Usually gases or liquids	*Covalent bonds in the molecule are strong but forces between molecules (intermolecular) are weak*	Low melting and boiling points.	Due to having weak intermolecular forces that easily broken.
		Do not conduct electricity.	Due to them molecules not having an overall electrical charge.
		Larger molecules have higher melting and boiling points.	Intermolecular forces increase with the size of the molecules.

Giant covalent structures

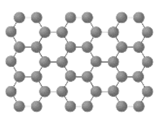
Diamond, graphite, silicon dioxide	*Very high melting points*	Lots of energy needed to break strong, covalent bonds.

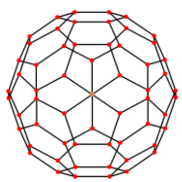
Covalent bonding

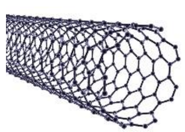
Atoms share pairs of electrons

Can be small molecules e.g. ammonia		Dot and cross : + Show which atom the electrons in the bonds come from - All electrons are identical
		2D with bonds: + Show which atoms are bonded together - It shows the H-C-H bond incorrectly at 90°
		3D ball and stick model: + Attempts to show the H-C-H bond angle is 109.5°
Can be giant covalent structures e.g. polymers		

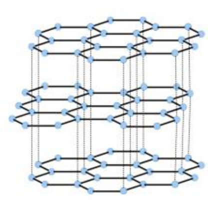
Graphene and fullerenes

Graphene	 *Single layer of graphite one atom thick*	Excellent conductor.	Contains delocalised electrons.
		Very strong.	Contains strong covalent bonds.

Fullerenes		Buckminsterfullerene, C_{60} First fullerene to be discovered.	Hexagonal rings of carbon atoms with hollow shapes. Can also have rings of five (pentagonal) or seven (heptagonal) carbon atoms.

Carbon nanotubes		*Very thin and long cylindrical fullerenes*	Very conductive.	Used in electronics industry.
			High tensile strength.	Reinforcing composite materials.
			Large surface area to volume ratio.	Catalysts and lubricants.

Graphite

Each carbon atom is bonded to three others forming layers of hexagonal rings with no covalent bonds between the layers		Slippery.	Layers can slide over each other.
		Very high melting point.	Strong covalent bonds.
		Does conduct electricity.	Delocalised electrons between layers.

AQA Chemical Changes 1

Oxidation Is Loss (of electrons) Reduction Is Gain (of electrons)

Ionic half equations (HT only)

For displacement reactions	*Ionic half equations show what happens to each of the reactants during reactions*	For example: The ionic equation for the reaction between iron and copper (II) ions is: **$Fe + Cu^{2+} \rightarrow Fe^{2+} + Cu$** The half-equation for iron (II) is: **$Fe \rightarrow Fe^{2+} + 2e^-$** The half-equation for copper (II) ions is: **$Cu^{2+} + 2e^- \rightarrow Cu$**

Oxidation and reduction in terms of electrons (HT ONLY)

Reactions of acids

Reactions of acids and metals

HT ONLY: Reactions between metals and acids are redox reactions as the metal donates electrons to the hydrogen ions. This displaces hydrogen as a gas while the metal ions are left in the solution.

Reactions with acids	*metal + acid → salt + hydrogen*	**magnesium + hydrochloric acid → magnesium chloride + hydrogen** **zinc + sulfuric acid → zinc sulfate + hydrogen**

Acids react with some metals to produce salts and hydrogen.

Neutralisation of acids and salt production

Acid name	Salt name
Hydrochloric acid	Chloride
Sulfuric acid	Sulfate
Nitric acid	Nitrate

sodium hydroxide + hydrochloric acid → sodium chloride + water

calcium carbonate + sulfuric acid → calcium sulfate, + carbon dioxide + water

Neutralisation	*Acids can be neutralised by alkalis and bases*	An **alkali** is a soluble base e.g. metal hydroxide. A **base** is a substance that neutralises an acid e.g. a soluble metal hydroxide or a metal oxide.

Reactivity of metals

Metal oxides

Metals and oxygen	*Metals react with oxygen to form metal oxides*	**magnesium + oxygen → magnesium oxide** *$2Mg + O_2 \rightarrow 2MgO$*
Reduction	*This is when oxygen is removed from a compound during a reaction*	e.g. metal oxides reacting with hydrogen, extracting low reactivity metals
Oxidation	*This is when oxygen is gained by a compound during a reaction*	e.g. metals reacting with oxygen, rusting of iron

Extraction of metals and reduction

Extraction using carbon

Metals less reactive than carbon can be extracted from their oxides by reduction.	For example: **zinc oxide + carbon → zinc + carbon dioxide**

Unreactive metals, such as gold, are found in the Earth as the metal itself. They can be mined from the ground.

The reactivity series

	Reactions with water	Reactions with acid
Group 1 metals	*Reactions get more vigorous as you go down the group*	*Reactions get more vigorous as you go down the group*
Group 2 metals	*Do not react with water*	*Observable reactions include fizzing and temperature increases*
Zinc, iron and copper	*Do not react with water*	*Zinc and iron react slowly with acid. Copper does not react with acid.*

Metals form positive ions when they react	*The reactivity of a metal is related to its tendency to form positive ions*	The reactivity series arranges metals in order of their reactivity (their tendency to form positive ions).
Carbon and hydrogen	*Carbon and hydrogen are non-metals but are included in the reactivity series*	These two non-metals are included in the reactivity series as they can be used to extract some metals from their ores, depending on their reactivity.
Displacement	*A more reactive metal can displace a less reactive metal from a compound.*	Silver nitrate + Sodium chloride → Sodium nitrate + Silver chloride

Metal		Symbol
potassium	most reactive	K
sodium		Na
calcium		Ca
magnesium		Mg
aluminium		Al
carbon		C
zinc		Zn
iron		Fe
tin		Sn
lead		Pb
hydrogen		H
copper		Cu
silver		Ag
gold		Au
platinum	least reactive	Pt

AQA Chemical Changes 2

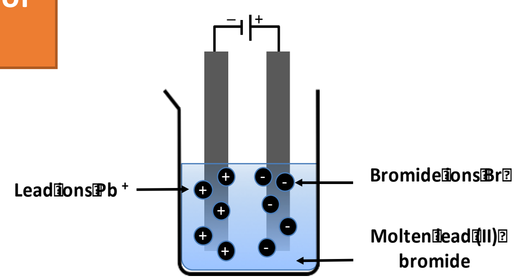
Electrolysis

Process of electrolysis	*Splitting up using electricity*	When an ionic compound is melted or dissolved in water, the ions are free to move. These are then able to conduct electricity and are called electrolytes. Passing an electric current though electrolytes causes the ions to move to the electrodes.
Electrode	*Anode Cathode*	The positive electrode is called the anode. The negative electrode is called the cathode.
Where do the ions go?	*Cations Anions*	Cations are positive ions and they move to the negative cathode. Anions are negative ions and they move to the positive anode.

Electrolysis of aqueous solutions

The ions discharged when an aqueous solution is electrolysed using inert electrodes depend on the relative reactivity of the elements involved.

At the negative electrode	Metal will be produced on the electrode if it is less reactive than hydrogen. Hydrogen will be produced if the metal is more reactive than hydrogen.
At the positive electrode	Oxygen is formed at positive electrode. If you have a halide ion (Cl^-, I^-, Br^-) then you will get chlorine, bromine or iodine formed at that electrode.



Extracting metals using electrolysis

Metals can be extracted from molten compounds using electrolysis.
This process is used when the metal is too reactive to be extracted by reduction with carbon.
The process is expensive due to large amounts of energy needed to produce the electrical current. Example: aluminium is extracted in this way.
Aluminium extraction uses CRYOLITE to lower the melting point of aluminium oxide. Electrodes have to be replaced regularly as they are made of GRAPHITE (CARBON) which react with the oxygen produced.

Higher tier: Half equations, for example:

At the cathode: $Pb^{2+} + 2e^- \rightarrow Pb$

At the anode: $2Br^- \rightarrow Br_2 + 2e^-$

Reactions of acids

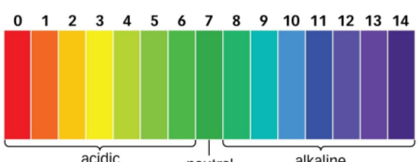
Strong and weak acids (HT ONLY)

Strong acids	*Completely ionised in aqueous solutions e.g. hydrochloric, nitric and sulfuric acids.*
Weak acids	*Only partially ionised in aqueous solutions e.g. ethanoic acid, citric acid.*
Hydrogen ion concentration	*As the pH decreases by one unit (becoming a stronger acid), the hydrogen ion concentration increases by a factor of 10.*

Soluble salts

Soluble salts	*Soluble salts can be made from reacting acids with solid insoluble substances (e.g. metals, metal oxides, hydroxides and carbonates).*
Production of soluble salts	*Add the solid to the acid until no more dissolves. Filter off excess solid and then crystallise to produce solid salts.*

The pH scale and neutralisation



You can use universal indicator or a pH probe to measure the acidity or alkalinity of a solution against the pH scale.

Acids	*Acids contain hydrogen ions (H^+) in aqueous solutions.*
Alkalis	*Aqueous solutions of alkalis contain hydroxide ions (OH^-).*

In neutralisation reactions, hydrogen ions react with hydroxide ions to produce water:

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

AQA GCSE Energy changes

Types of reaction

Endothermic	*Energy is taken in from the surroundings so the temperature of the surroundings decreases*	• Thermal decomposition • Sports injury packs
Exothermic	*Energy is transferred to the surroundings so the temperature of the surroundings increases*	• Combustion • Hand warmers • Neutralisation

The energy change of reactions (HT only)

Breaking bonds in reactants	*Endothermic process*
Making bonds in products	*Exothermic process*

Overall energy change of a reaction

Exothermic	Energy released making new bonds is greater than the energy taken in breaking existing bonds.
Endothermic	Energy needed to break existing bonds is greater than the energy released making new bonds.

Bond energy calculation

Calculate the overall energy change for the forward reaction

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

Bond energies (in kJ/mol): H-H 436, H-N 391, N≡N 945

Bond breaking: 945 + (3 x 436) = 945 + 1308 = 2253 kJ/mol

Bond making: 6 x 391 = 2346 kJ/mol

Overall energy change = 2253 - 2346 = -93kJ/mol

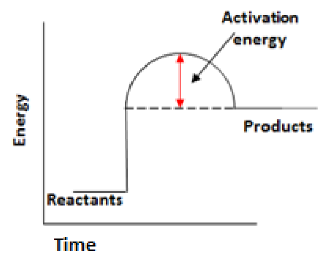
Therefore reaction is exothermic overall.

Reaction profiles	*Show the overall energy change of a reaction*

Reaction profiles

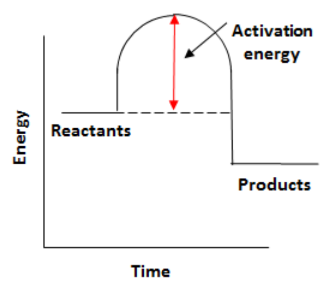
Activation energy	*Chemical reactions only happen when particles collide with sufficient energy*	The minimum amount of energy that colliding particles must have in order to react is called the activation energy.

Endothermic



Products are at a higher energy level than the reactants. As the reactants form products, energy is transferred from the surroundings to the reaction mixture. The temperature of the surroundings decreases because energy is taken in during the reaction.

Exothermic



Products are at a lower energy level than the reactants. When the reactants form products, energy is transferred to the surroundings. The temperature of the surroundings increases because energy is released during the reaction.

AQA GCSE QUANTITATIVE CHEMISTRY

Relative formula mass (M_r)

M_r	*The sum of the relative atomic masses of the atoms in the numbers shown in the formula. The Mr is the mass of 1 mole of the formula in grams.*	The sum of the M_r of the reactants in the quantities shown equals the sum of the M_r of the products in the quantities shown.	$2Mg + O_2 \rightarrow 2MgO$ 48g + 32g = 80g 80g = 80g

Conservation of mass and balanced symbol equations

Balanced symbol equations	*Represent chemical reactions and have the same number of atoms of each element on both sides of the equation*	$H_2 + Cl_2 \rightarrow 2HCl$ Subscript script — Normal Subscript (small number at the bottom, after the element) numbers show the number of atoms of the element to its left. Normal script (in front of the formula) numbers show the number of molecules.
Conservation of mass	*No atoms are lost or made during a chemical reaction*	Mass of the products equals the mass of the reactants.

Limiting reactants (HT only)

The reactant that is completely used up	*Limits the amount of product that is made*	Less moles of product are made.

Chemical measurements

Whenever a measurement is taken, there is always some uncertainty about the result obtained	*Can determine whether the mean value falls within the range of uncertainty of the result*	1. Calculate the mean 2. Calculate the range of the results 3. Estimate of uncertainty in mean would be half the range

Concentration of solutions

Measured in mass per given volume of solution (g/dm^3)	*Conc. = mass (g) / volume (dm^3)*	HT only Greater mass = higher concentration. Greater volume = lower concentration.

Using moles to balance equations (HT only)

The balancing numbers in a symbol equation can be calculated from the masses of reactants and products	*Convert the masses in grams to amounts in moles and convert the number of moles to simple whole number ratios.*

Mass changes when a reactant or product is a gas

Mass appears to increase during a reaction	*One of the reactants is a gas*	Magnesium + oxygen → magnesium oxide
Mass appears to decrease during a reaction	*One of the products is a gas and has escaped*	Calcium carbonate → carbon dioxide + calcium oxide

Moles (HT only)

Chemical amounts are measured in moles (mol)	*Mass of one mole of a substance in grams = relative formula mass*	One mole of H_2O = 18g (1 + 1 + 16) One mole of Mg = 24g
Avogadro constant	*One mole of any substance will contain the same number of particles, atoms, molecules or ions.*	6.02×10^{23} per mole One mole of H_2O will contain 6.02×10^{23} molecules One mole of NaCl will contain 6.02×10^{23} Na^+ ions

Number of moles = $\frac{\text{mass (g)}}{A_r}$ or $\frac{\text{mass (g)}}{M_r}$	How many moles of sulfuric acid molecules are there in 4.7g of sulfuric acid (H_2SO_4)? Give your answer to 1 significant figure. $\frac{4.7}{98}$ = 0.05 mol (M_r of H_2SO_4)

Amounts of substances in equations (HT only)

Chemical equations show the number of moles reacting and the number of moles made	*$Mg + 2HCl \rightarrow MgCl_2 + H_2$* *One mole of magnesium reacts with two moles of hydrochloric acid to make one mole of magnesium chloride and one mole of hydrogen*	If you have a 60g of Mg, what mass of HCl do you need to convert it to $MgCl_2$? A_r : Mg =24 so mass of 1 mole of Mg = 24g M_r : HCl (1 + 35.5) so mass of 1 mole of HCl = 36.5g So 60g of Mg is 60/24 = 2.5 moles Balanced symbol equation tells us that for every one mole of Mg, you need two moles of HCl to react with it. So you need 2.5x2 = 5 moles of HCl You will need 5 x 36.5g of HCl= 182.5g

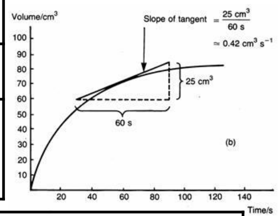
AQA GCSE The rate and extent of chemical change

Rate of reaction

Calculating rates of reactions

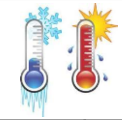
Rate of chemical reaction	*This can be calculated by measuring the quantity of reactant used or product formed in a given time.*	Rate = quantity of reactant used / time taken Rate = quantity of product formed / time taken

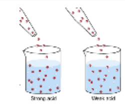
Quantity	Unit
Mass	Grams (g)
Volume	cm^3
Rate of reaction	Grams per cm^3 (g/cm^3) HT: moles per second (mol/s)

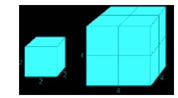


Factors affecting rates

Factors affecting the rate of reaction	
Temperature	*The higher the temperature, the quicker the rate of reaction.*
Concentration	*The higher the concentration, the quicker the rate of reaction.*
Surface area	*The larger the surface area of a reactant solid, the quicker the rate of reaction.*
Pressure (of gases)	*When gases react, the higher the pressure upon them, the quicker the rate of reaction.*



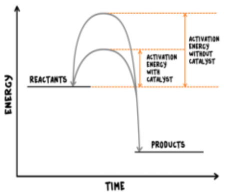




Collision theory and activation energy

Collision theory	*Chemical reactions can only occur when reacting particles collide with each other with sufficient energy.*	Increasing the temperature increases the frequency of collisions and makes the collisions more energetic, therefore increasing the rate of reaction.
Activation energy	*This is the minimum amount of energy colliding particles in a reaction need in order to react.*	Increasing the concentration, pressure (gases) and surface area (solids) of reactions increases the frequency of collisions, therefore increasing the rate of reaction.

Catalysts



If a catalyst is used in a reaction, it is not shown in the word equation.

Catalyst	A catalyst changes the rate of a chemical reaction but is not used in the reaction.
Enzymes	These are biological catalysts.
How do they work?	Catalysts provide a different reaction pathway where reactants do not require as much energy to react when they collide.

Reversible reactions and dynamic equilibrium

Reversible reactions

Reversible reactions	In some chemical reactions, the products can react again to re-form the reactants.
Representing reversible reactions	A + B $\rightleftharpoons$ C + D
The direction	The direction of reversible reactions can be changed by changing conditions: A + B $\underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}}$ C + D

Energy changes and reversible reactions

If one direction of a reversible reaction is exothermic, the opposite direction is endothermic. The same amount of energy is transferred in each case.

For example: Hydrated copper sulfate $\underset{\text{exothermic}}{\overset{\text{endothermic}}{\rightleftharpoons}}$ Anhydrous copper sulfate + Water

Equilibrium

Equilibrium in reversible reactions	When a reversible reaction occurs in apparatus which prevents the escape of reactants and products, equilibrium is reached when the forward and reverse reactions occur exactly at the same rate.

Changing conditions and equilibrium (HT)

The relative amounts of reactants and products at equilibrium depend on the conditions of the reaction.

Le Chatelier's Principles	States that when a system experiences a disturbance (change in condition), it will respond to restore a new equilibrium state.
Changing concentration	If the concentration of a reactant is increased, more products will be formed . If the concentration of a product is decreased, more reactants will react.
Changing temperature	If the temperature of a system at equilibrium is increased: - Exothermic reaction = products decrease - Endothermic reaction = products increase
Changing pressure (gaseous reactions)	For a gaseous system at equilibrium: - Pressure increase = equilibrium position shifts to side of equation with smaller number of molecules. - Pressure decrease = equilibrium position shifts to side of equation with larger number of molecules.