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Oxidation **I**s **L**oss (of electrons) **R**eduction **I**s **G**ain (of electrons)

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.

AQA Chemical Changes 1

Ionic half equations (HT only)

		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

Acids react with some metals to produce salts and hydrogen.

		magnesium + hydrochloric acid → magnesium chloride + hydrogen **zinc + sulfuric acid → zinc sulfate + hydrogen**

Neutralisation of acids and salt production

Acid name	Salt name

sodium hydroxide + hydrochloric acid → sodium chloride + water

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

		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

		magnesium + oxygen → magnesium oxide *2Mg + O_2 → 2MgO*
		e.g. metal oxides reacting with hydrogen, extracting low reactivity metals
		e.g. metals reacting with oxygen, rusting of iron

Extraction of metals and reduction

	For example: **zinc oxide + carbon → zinc + carbon dioxide**

Unreactive metals

The reactivity series

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

	The reactivity of a metal is related to its tendency to form positive ions	
	Carbon and hydrogen are non-metals but are included in the reactivity series	
	A more reactive metal can displace a less reactive metal from a compound.	

	most reactive ↑↓ least reactive	
potassium		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		Pt

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

	Show the overall energy change of a reaction

	Endothermic process
	Exothermic process

	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.

	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.

Types of reaction

The energy change of reactions (HT only)

AQA GCSE Energy changes

Cells and batteries (Chemistry only)

	Make a simple cell by connecting two different metals in contact with an electrolyte	Increase the voltage by increasing the reactivity difference between the two metals.
	Consist of two or more cells connected together in series to provide a greater voltage.	

	Stop when one of the reactants has been used up	Alkaline batteries
	Can be recharged because the chemical reactions are reversed when an external current is supplied	Rechargeable batteries

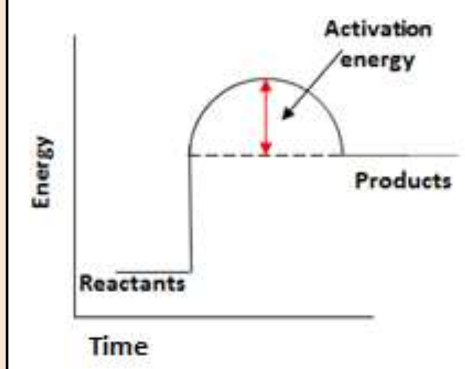
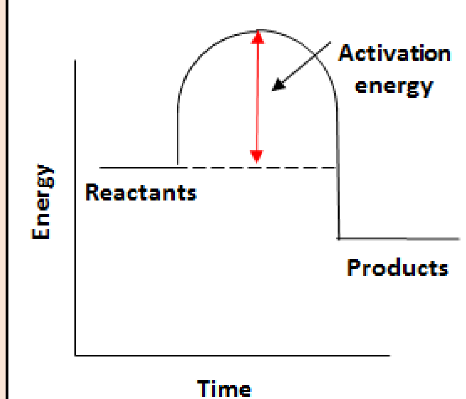
Fuel cells (Chemistry only)

	Negative electrode: $2H_2\ (g) + 4OH^-\ (aq) \rightarrow 4H_2O\ (l) + 4e^-$	Positive electrode: $O_2\ (g) + 2H_2O\ (l) + 4e^- \rightarrow 4OH^-\ (aq)$

	Word equation: *hydrogen + oxygen → water*	Symbol equation: $2H_2 + O_2 \rightarrow 2H_2O$
	Advantages: • No pollutants produced • Can be a range of sizes	Disadvantages: • Hydrogen is highly flammable • Hydrogen is difficult to store

Reaction profiles

	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.

		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.
		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.

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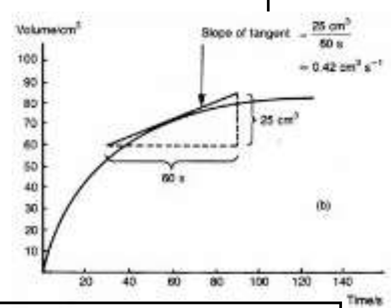
AQA GCSE The rate and extent of chemical change

Rate of reaction

Calculating rates of reactions

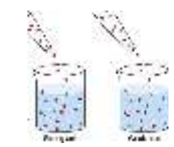
	This can be calculated by measuring the quantity of reactant used or product formed in a given time.	Rate = $\frac{\text{quantity of reactant used}}{\text{time taken}}$ Rate = $\frac{\text{quantity of product formed}}{\text{time taken}}$

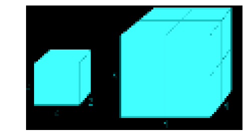
Quantity	Unit
Mass	
Volume	
Rate of reaction	



Factors affecting rates

Factors affecting the rate of reaction	
	The higher the temperature, the quicker the rate of reaction.
	The higher the concentration, the quicker the rate of reaction.
	The larger the surface area of a reactant solid, the quicker the rate of reaction.
	When gases react, the higher the pressure upon them, the quicker the rate of reaction.

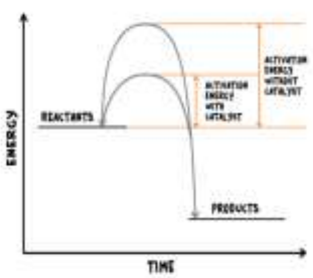




Collision theory and activation energy

	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.
	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.

	A catalyst changes the rate of a chemical reaction but is not used in the reaction.
	These are biological catalysts.
	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

	In some chemical reactions, the products can react again to re-form the reactants.
	A + B $\rightleftharpoons$ C + D
	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

	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.

	States that when a system experiences a disturbance (change in condition), it will respond to restore a new equilibrium state.
	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.
	If the temperature of a system at equilibrium is increased: - Exothermic reaction = products decrease - Endothermic reaction = products increase
	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.