



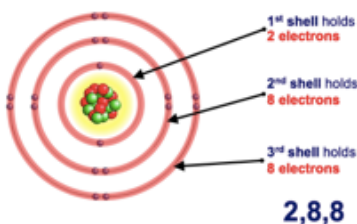
## Elements, compounds and mixtures

- Element – are shown in the periodic table
- Compound – two or more elements chemically bonded
- Mixture – two or more elements or compounds not chemically bonded
- Mixtures can be separated by physical processes – filtration, crystallization, distillation, chromatography

## Atomic models

- Plum pudding model – negative electrons embedded throughout the atom, rest of atom is positive
- Nuclear model – most of the mass of an atom in the nucleus, most of the atom is empty space

## Structure of the atom



Subatomic particle	Mass	Charge	Position in the atom
Proton	1	+1	Nucleus
Neutron	1	0	Nucleus
Electron	Very small	-1	Electron shells

- Atomic number – number of protons in an atom
- Atomic mass – number of protons + neutrons added together
- Electrons fill the shells 2,8,8
- Isotopes are atoms of the same element with a different number of neutrons

## Periodic table

- Mendeleev left gaps and predicted existence of new elements

## Group 1 – Alkali metals

- More reactive going down the group
- Single outer electron feels less electrostatic attraction from the nucleus as we go down the group
- Alkali metal + water  $\rightarrow$  metal hydroxide + hydrogen
- All have 1 electron in the outer shell

## Group 7 – The halogens

- More reactive at the top of the group
- Further down the group the outer electron shell feels less attractive force from the nucleus due to electron shielding
- All have 7 electrons in the outer shell

## Group 0 – Noble gases

- Full outer shell
- Don't react with anything

## Topic 1

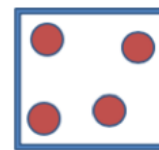
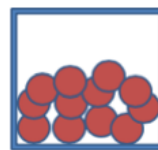
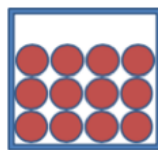
## Atomic structure and the periodic table



# Chemistry Key Knowledge Paper 1

## States of matter and state symbols

- Solid (s)
- Liquid (l)
- Gas (g)
- Aqueous (aq)

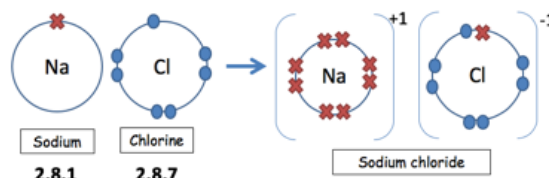


## Ions

- Atoms or groups of atoms that have lost or gained one or more electrons
- Metal atoms form positive ions
- Non-metal atoms form negative ions

## Ionic bonding

- Between metal and non-metal
- The metal atom transfers electrons to the non-metal atom
- Positive and negative ions attract
- Strong electrostatic force holds the ions together



## Ionic compounds

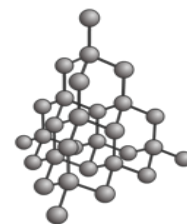
- Ions arranged in layers in a giant lattice structure
- Requires a lot of energy to break the bond so ionic compounds have a high melting and boiling point
- Cannot conduct electricity when solid as the ions cannot move
- Can conduct electricity when molten or dissolved as the ions can move

## Covalent bonding

- Between non-metals
- The atoms share a pair of electrons to get a full outer shell

## Simple covalent molecules

- Made of only a few atoms
- Weak forces between molecules means low boiling and melting points
- Examples –  $\text{H}_2\text{O}$ ,  $\text{CO}_2$ ,  $\text{O}_2$ ,  $\text{CH}_4$



## Giant covalent structures

- Made of billions of atoms
- Diamond, graphite, silica
- Strong covalent bonds between atoms means they have a high melting and boiling point
- Graphite has free electrons that can move so can conduct electricity

## Metallic bonding

- Metals
- Atoms arranged in layers
- Delocalised electrons can move so metals can conduct electricity and heat
- Atoms in a pure metal arranged in layers so the metal can be bent and shaped
- Alloys are stronger – atoms not in layers

## Topic 2 Bonding



## Law of conservation of mass

- Mass of products = mass of reactants

## Relative formula mass

- The sum of the relative atomic masses of the atoms shown in the formula
- Example –  $\text{H}_2\text{O}$      $\text{H} = 1$     $\text{H} = 1$     $\text{O} = 16$     Add them up = 18

## Moles (Higher only)

- Mass of one mole of a substance in grams is equal to its relative formula mass

$$\text{number of moles of substance} = \frac{\text{mass of substance (g)}}{A_r \text{ or } M_r}$$

## Concentration

$$\text{Concentration of solution} = \frac{\text{mass of solute (g)}}{\text{volume of solution (dm}^3\text{)}}$$

- To convert  $\text{cm}^3$  into  $\text{dm}^3$  you divide by 1000



## Extraction of metals

- Unreactive metals like gold are found unreacted in the ground
- Metals less reactive than carbon can be extracted from their oxides by reduction with carbon
- Metals more reactive than carbon can be extracted by electrolysis
- OILRIG – oxidation is the loss of electrons, reduction is the gain of electrons

## Neutralisation

- Acid + alkali  $\rightarrow$  salt + water
- Bases are insoluble metal hydroxides and metal oxides
- Alkalis are soluble metal hydroxides
- All acids contain  $\text{H}^+$  ions
- All alkalis contain hydroxide ions  $\text{OH}^-$
- $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$

## Strong and weak acids (Higher only)

- A strong acid is completely ionized in aqueous solution
- A weak acid is only partially ionized in aqueous solution
- As pH decreases by one, the  $\text{H}^+$  concentration in solution increases by a factor of 10

## Acid + metal

- Acid + metal  $\rightarrow$  salt + hydrogen
- Hydrogen gas test – lit splint makes a squeaky pop

## Acid + carbonates

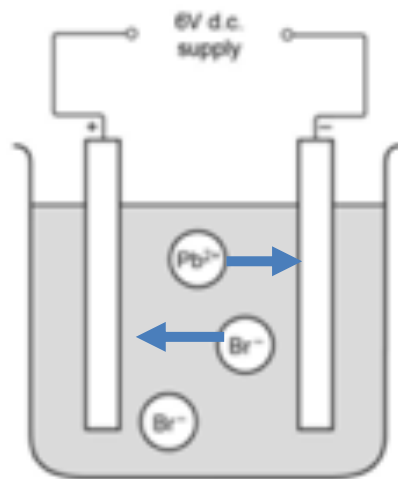
- Acid + metal carbonate  $\rightarrow$  salt + carbon dioxide + water
- Carbon dioxide test – limewater turns cloudy

## Making soluble salts

- Mix excess base with acid
- Add excess base to neutralize all of the acid
- Heat the solution to speed up the reaction
- Filter off the excess oxide
- Evaporate the water to leave crystals of salt

## Electrolysis

- Splitting a compound using electricity
- Solid ionic compounds cannot conduct electricity as there are no free ions
- Ionic compounds can conduct electricity when molten or dissolved as the ions can move
- Positive ions move to negative electrode (cathode)
- Negative ions move to positive electrode (anode)
- $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$
- $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$





## Activation energy

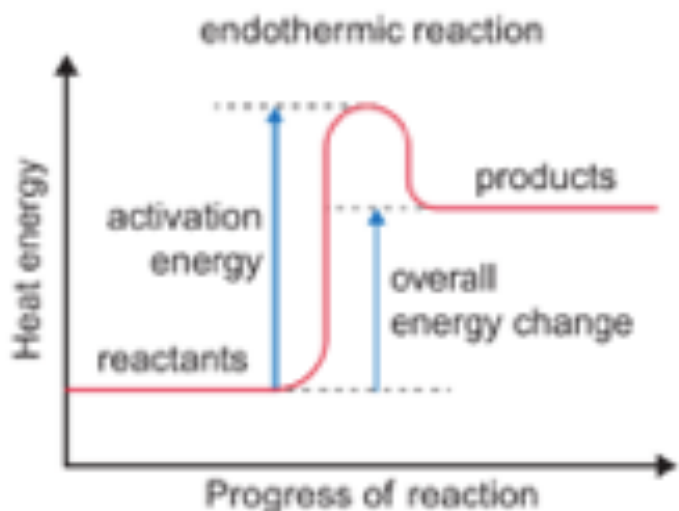
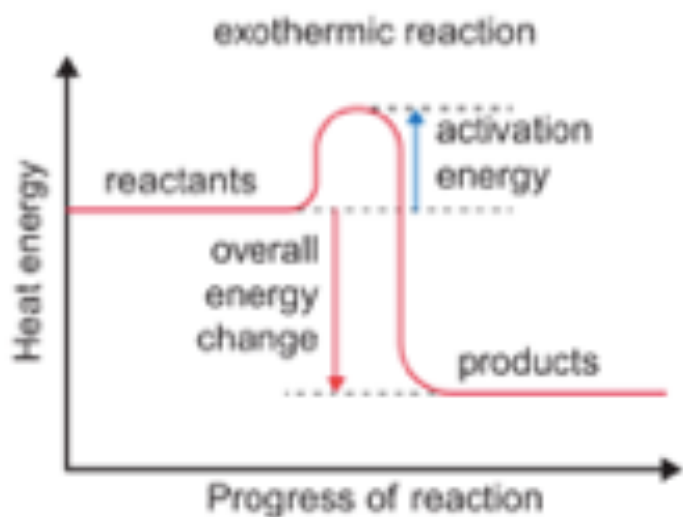
- The energy needed for a reaction to occur

## Exothermic reactions

- Transfers energy to the surroundings
- Temperature of the surroundings goes up
- Combustion and neutralization reactions are exothermic

## Endothermic reactions

- Takes in energy from the surroundings
- Temperature of the surroundings decreases
- Thermal decompositions and photosynthesis are endothermic





## Collision theory

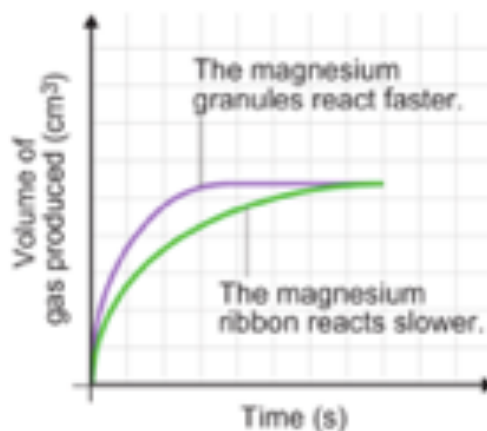
- Chemical reactions only occur when particles collide
- Particles have to collide with enough energy
- Minimum amount of energy needed for particles to react is the activation energy

## Factors affecting rate of reaction

- Increasing surface area increases rate of reaction – more collisions between particles
- Increasing temperature increases rate of reaction – particles move faster and collide more often
- Increasing concentration increases rate of reaction – there are more particles so more collisions

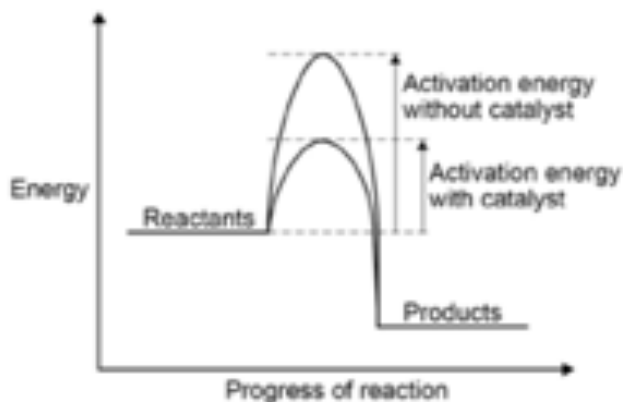
## Rate of reaction

- A steeper line shows a faster rate of reaction
- On this graph the blue line shows a faster rate



## Catalysts

- Catalysts speed up the rate of reaction but are not used up
- Catalysts increase the rate of reaction by lowering the activation energy
- A reaction profile for a catalyst is:



## Reversible reactions

- In some reactions, the products of the reaction can react to produce the original reactants
- Symbol for a reversible reaction:



## Equilibrium

- Equilibrium is reached when the forward and reverse reactions occur at exactly the same rate



## Crude oil

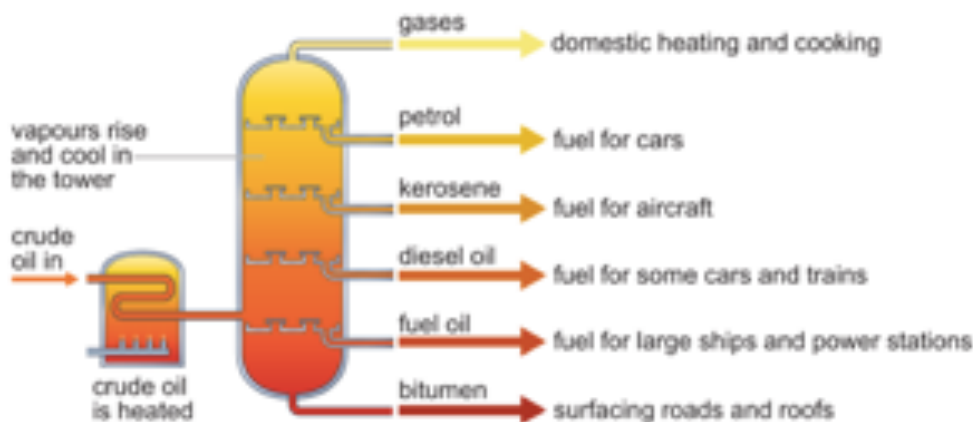
- Remains of plankton buried in mud under the sea
- A mixture of hydrocarbons

## Hydrocarbons

- Molecules made of hydrogen and carbon only

## Fractional distillation

- Crude oil is heated and evaporates
- Gases rise up a fractionating column and cool down and condense
- They condense at different points depending on the boiling point
- Most viscous at the bottom of the column
- Highest boiling point at the bottom of the column



## Alkanes

- Methane, ethane, propane, butane
- General formula  $C_nH_{2n+2}$
- React with oxygen to produce carbon dioxide and water

Name	Structural formula	Chemical formula
Methane		$CH_4$
Ethane		$C_2H_6$
Propane		$C_3H_8$
Butane		$C_4H_{10}$

## Cracking

- Cracking is breaking down longer hydrocarbons into smaller, more useful molecules
- A product of cracking is an alkene
- Test for alkenes: bromine water turns from orange to colourless



## Pure substances

- A single element or compound not mixed with any other substance
- Will melt at specific temperatures

## Formulations

- A mixture that has been designed as a useful product
- Formulations include fuels, cleaning agents, paints, medicines, alloys, fertilisers and foods

## Chromatography

- Used to separate mixtures
- Stationary phase – the chromatography paper
- Mobile phase – the solvent moving
- More soluble dyes move further up
- A pure compound will produce a single spot in all solvents

$$R_f = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}$$

## Test for hydrogen

- Lit splint
- Squeaky pop

## Test for oxygen

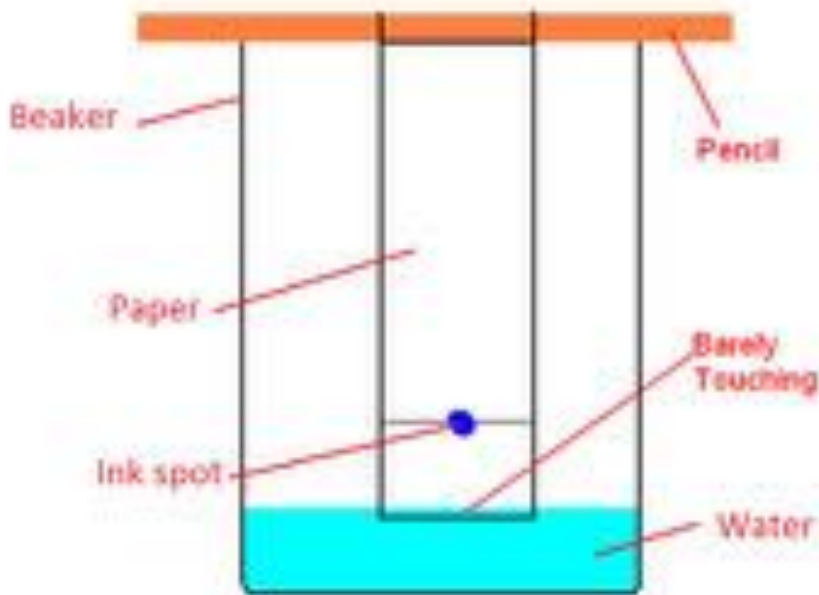
- Re-lights a glowing splint

## Test for carbon dioxide

- Bubble the gas through limewater
- Limewater turns cloudy

## Test for chlorine

- Damp litmus paper turns white







## The atmosphere today

- About 80% nitrogen
- About 20% oxygen
- Small proportions of carbon dioxide, water vapour and noble gases

## The early atmosphere

- Volcanoes released gases – water vapour, nitrogen, methane, ammonia, carbon dioxide
- No oxygen
- Water vapour condensed to form the oceans
- Carbon dioxide dissolved in the oceans

## How carbon dioxide decreased

- Dissolved in the oceans
- Formation of sedimentary rocks and fossil fuels
- Algae and plants used  $\text{CO}_2$  for photosynthesis

## How oxygen increased

- Algae and plants produced  $\text{O}_2$  by photosynthesis



## Greenhouse gases

- Maintain temperature on Earth to support life
- Water vapour, carbon dioxide and methane

## How human activities increase greenhouse gases

- Carbon dioxide – deforestation, burning fossil fuels
- Methane – farming

## Effects of climate change

- Sea levels rise
- More extreme weather
- Extinction of wildlife

## Carbon footprint

- The total amount of carbon dioxide and other greenhouse gases over the full life cycle of a product
- Can be reduced by reducing emissions of carbon dioxide and methane

## Atmospheric pollutants

- Combustion of fuels produces pollutants
- Carbon monoxide is a toxic gas
- Sulfur dioxide and oxides of nitrogen cause respiratory problems in humans and acid rain
- Soot particles cause health problems and global dimming



## Potable water

- Water that is safe to drink

## Desalination

- Making sea water or salty water safe to drink
- Can be done by distillation
- Requires large amounts of energy

## Waste water treatment

- Screening and grit removal
- Sedimentation
- Anaerobic digestion of sewage sludge
- Aerobic biological treatment of effluent

## Methods of extracting metals (Higher only)

- Phytomining – uses plants to absorb metal compounds from the ground. Plants then burnt to produce ash that contains metal compounds
- Bioleaching – uses bacteria to produce solutions with metal compounds

## Life cycle assessment stages

- Extracting and processing raw materials
- Manufacturing and packaging
- Use and operation
- Disposal

## Reusing and recycling

- Obtaining raw materials from the Earth by quarrying and mining causes environmental impacts
- Glass bottles can be crushed and melted to make different glass products
- Metals can be recycled by melting

Advantages of recycling	Disadvantages of recycling
<ul style="list-style-type: none"><li>• Conserves finite oil resources</li><li>• Saves energy</li><li>• Reduces need for mining</li><li>• Reduces waste disposed of in landfill</li><li>• Less pollution</li><li>• Cheaper to recycle than mine new ores</li></ul>	<ul style="list-style-type: none"><li>• Costs of collecting, sorting and melting metals</li><li>• Some metals more expensive to recycle</li></ul>



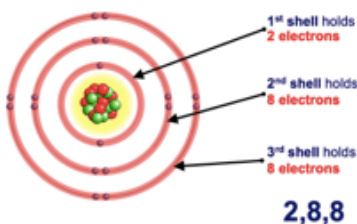
## Elements, compounds and mixtures

- Element – \_\_\_\_\_
- Compound – \_\_\_\_\_
- Mixture – \_\_\_\_\_
- Mixtures can be separated by \_\_\_\_\_

## Atomic models

- Plum pudding model – \_\_\_\_\_
- Nuclear model – \_\_\_\_\_

## Structure of the atom



Subatomic particle	Mass	Charge	Position in the atom
Proton			
Neutron			
Electron			

- Atomic number – \_\_\_\_\_
- Atomic mass – \_\_\_\_\_
- Electrons fill the shells \_\_\_\_\_
- Isotopes are \_\_\_\_\_

## Periodic table

- Mendeleev left \_\_\_\_\_ and predicted \_\_\_\_\_

## Group 1 – Alkali metals

- More reactive going \_\_\_\_\_
- Single outer electron feels less \_\_\_\_\_
- Alkali metal + water  $\rightarrow$  \_\_\_\_\_ + \_\_\_\_\_
- All have 1 \_\_\_\_\_

## Group 7 – The halogens

- More reactive \_\_\_\_\_
- Further down the group the outer electron shell feels less \_\_\_\_\_
- All have 7 \_\_\_\_\_

## Group 0 – Noble gases

- Full \_\_\_\_\_
- Don't \_\_\_\_\_

## Topic 1

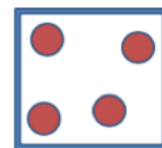
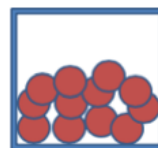
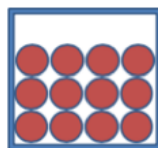
## Atomic structure and the periodic table



# Chemistry Key Knowledge Paper 1

## States of matter and state symbols

- \_\_\_\_\_ ( )
- \_\_\_\_\_ ( )
- \_\_\_\_\_ ( )
- \_\_\_\_\_ ( )

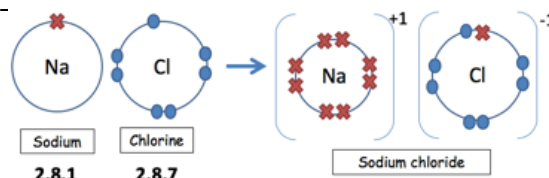


## Ions

- Atoms or groups of atoms that have \_\_\_\_\_
- Metal atoms form \_\_\_\_\_
- Non-metal atoms form \_\_\_\_\_

## Ionic bonding

- Between \_\_\_\_\_ and \_\_\_\_\_
- The metal atom transfers \_\_\_\_\_
- Positive and negative ions \_\_\_\_\_
- Strong \_\_\_\_\_



## Ionic compounds

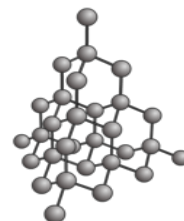
- Ions arranged in \_\_\_\_\_
- Requires a lot of \_\_\_\_\_ so ionic compounds have a high \_\_\_\_\_
- Cannot conduct \_\_\_\_\_ when solid as the ions \_\_\_\_\_
- Can conduct electricity when \_\_\_\_\_ as the ions can move

## Covalent bonding

- Between \_\_\_\_\_
- The atoms share a \_\_\_\_\_

## Simple covalent molecules

- Made of \_\_\_\_\_
- Weak \_\_\_\_\_ between molecules means \_\_\_\_\_
- Examples – \_\_\_\_\_



## Giant covalent structures

- Made of \_\_\_\_\_
- Examples - \_\_\_\_\_
- Strong covalent \_\_\_\_\_ between atoms means they have a \_\_\_\_\_
- Graphite has \_\_\_\_\_ that can \_\_\_\_\_ so can \_\_\_\_\_

## Metallic bonding

- Metals
- Atoms arranged in \_\_\_\_\_
- \_\_\_\_\_ can move so metals can \_\_\_\_\_
- Atoms in a pure metal arranged in \_\_\_\_\_ so the metal can be \_\_\_\_\_
- Alloys are \_\_\_\_\_

**Topic 2**  
**Bonding**



## Law of conservation of mass

- Mass of products = mass of reactants

## Relative formula mass

- The sum of the relative atomic masses of the atoms shown in the formula
- Example –  $\text{H}_2\text{O}$      $\text{H} = 1$     $\text{H} = 1$     $\text{O} = 16$     Add them up = 18

## Moles (Higher only)

- Mass of one mole of a substance in grams is equal to its relative formula mass

$$\text{number of moles of substance} = \frac{\text{mass of substance (g)}}{A_r \text{ or } M_r}$$

## Concentration

$$\text{Concentration of solution} = \frac{\text{mass of solute (g)}}{\text{volume of solution (dm}^3\text{)}}$$

- To convert  $\text{cm}^3$  into  $\text{dm}^3$  you divide by 1000



## Extraction of metals

- Unreactive metals like \_\_\_\_\_ are found \_\_\_\_\_
- Metals less reactive than \_\_\_\_\_ can be extracted from their oxides by \_\_\_\_\_
- Metals more reactive than \_\_\_\_\_ can be extracted by \_\_\_\_\_
- OILRIG – \_\_\_\_\_

## Neutralisation

- Acid + alkali  $\rightarrow$  \_\_\_\_\_ + \_\_\_\_\_
- Bases are \_\_\_\_\_
- Alkalis are \_\_\_\_\_
- All acids contain \_\_\_\_\_
- All alkalis contain \_\_\_\_\_
- $H^+ + OH^- \rightarrow$  \_\_\_\_\_

## Strong and weak acids (Higher only)

- A strong acid is completely \_\_\_\_\_
- A weak acid is only partially \_\_\_\_\_
- As pH decreases by one, the  $H^+$  concentration in solution increases by \_\_\_\_\_

## Acid + metal

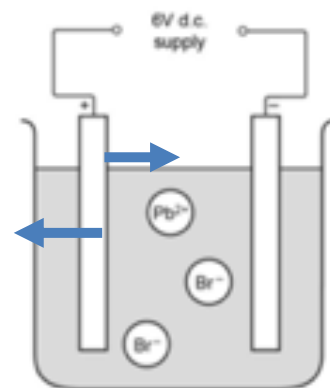
- Acid + metal  $\rightarrow$  \_\_\_\_\_ + \_\_\_\_\_
- Hydrogen gas test – \_\_\_\_\_

## Acid + carbonates

- Acid + metal carbonate  $\rightarrow$  \_\_\_\_\_ + \_\_\_\_\_ + \_\_\_\_\_
- Carbon dioxide test – \_\_\_\_\_

## Making soluble salts

- Mix excess base with \_\_\_\_\_
- Add excess base to \_\_\_\_\_
- Heat the solution to \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_



## Electrolysis

- Splitting \_\_\_\_\_
- Solid ionic compounds cannot conduct \_\_\_\_\_ as there are no \_\_\_\_\_
- Ionic compounds can conduct \_\_\_\_\_ when \_\_\_\_\_ or \_\_\_\_\_ as the ions can \_\_\_\_\_
- Positive ions move to \_\_\_\_\_ (cathode)
- Negative ions move to \_\_\_\_\_ (anode)
- $Cu^{2+} +$  \_\_\_\_\_  $\rightarrow$  \_\_\_\_\_
- $2Cl^- \rightarrow$  \_\_\_\_\_ + \_\_\_\_\_



## Activation energy

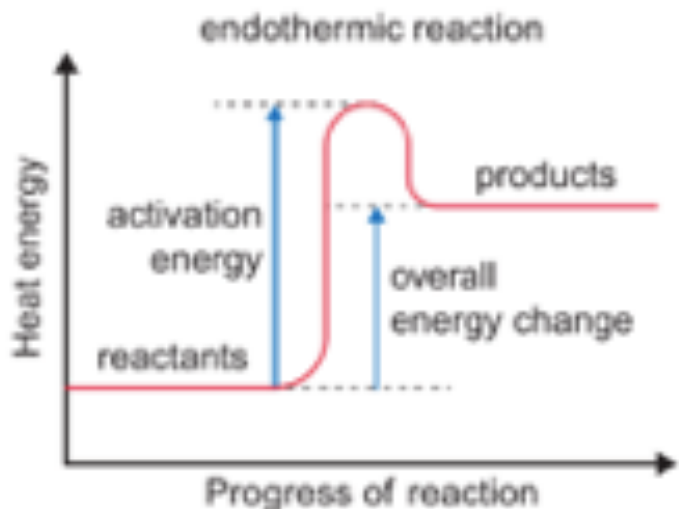
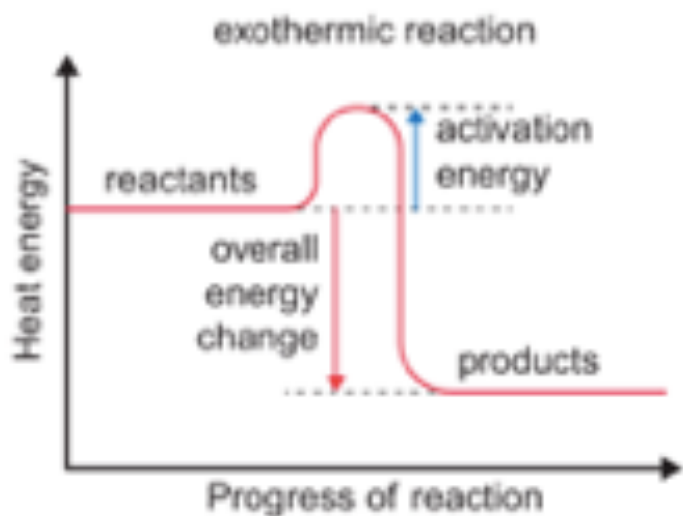
- The energy needed for \_\_\_\_\_

## Exothermic reactions

- Transfers \_\_\_\_\_
- Temperature of the surroundings \_\_\_\_\_
- \_\_\_\_\_ and \_\_\_\_\_ reactions are exothermic

## Endothermic reactions

- Takes in energy from \_\_\_\_\_
- Temperature of the surroundings \_\_\_\_\_
- Thermal decompositions and \_\_\_\_\_ are endothermic





## Collision theory

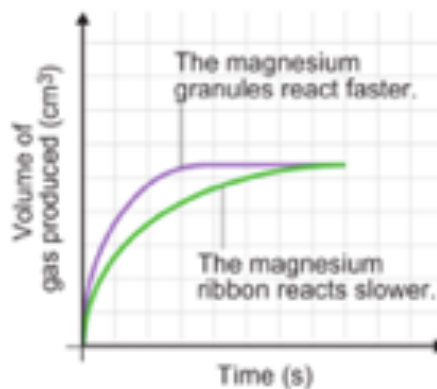
- Chemical reactions only occur when \_\_\_\_\_
- Particles have to \_\_\_\_\_
- Minimum amount of energy needed for particles to react is the \_\_\_\_\_

## Factors affecting rate of reaction

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

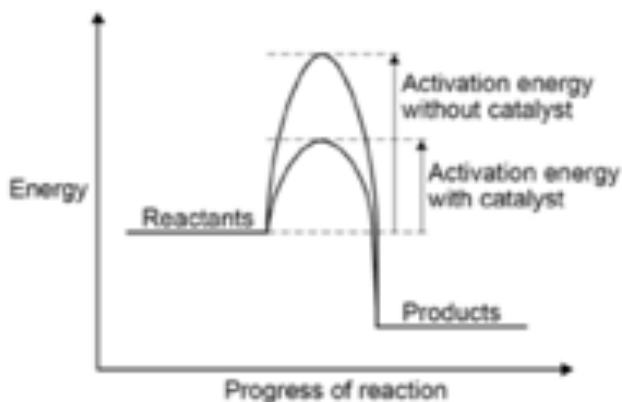
## Rate of reaction

- A steeper line shows \_\_\_\_\_
- On this graph the \_\_\_\_\_ line shows a faster rate



## Catalysts

- Catalysts \_\_\_\_\_
- Catalysts increase the rate of reaction by \_\_\_\_\_
- A reaction profile for a catalyst is:



## Reversible reactions

- In some reactions, the \_\_\_\_\_ of the reaction can react to produce the original \_\_\_\_\_
- Symbol for a reversible reaction:

## Equilibrium

- Equilibrium is reached when the \_\_\_\_\_ -  
\_\_\_\_\_





## Crude oil

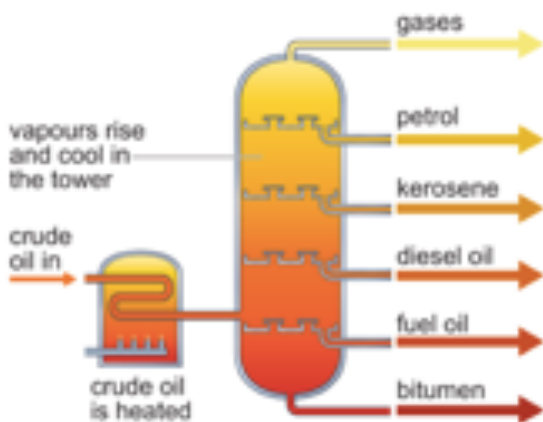
- Remains of \_\_\_\_\_
- A mixture of \_\_\_\_\_

## Hydrocarbons

- Molecules made of \_\_\_\_\_

## Fractional distillation

- Crude oil is \_\_\_\_\_
- Gases \_\_\_\_\_
- They condense at \_\_\_\_\_
- Most viscous at \_\_\_\_\_
- Highest boiling point at \_\_\_\_\_



## Alkanes

- \_\_\_\_\_
- General formula \_\_\_\_\_
- React with oxygen to produce \_\_\_\_\_ and \_\_\_\_\_

Name	Structural formula	Chemical formula
Methane	<pre>  H     H - C - H       H</pre>	
Ethane		
	<pre>  H   H   H   H                 H - C - C - C - C - H                   H   H   H   H</pre>	

## Cracking

- Cracking is \_\_\_\_\_
- A product of cracking is an \_\_\_\_\_
- Test for alkenes: \_\_\_\_\_



## Pure substances

- A single \_\_\_\_\_
- Will melt at \_\_\_\_\_

## Formulations

- \_\_\_\_\_  
Formulations include \_\_\_\_\_

## Chromatography

- Used to \_\_\_\_\_
- Stationary phase – \_\_\_\_\_
- Mobile phase – \_\_\_\_\_
- More soluble dyes move \_\_\_\_\_
- A pure compound will produce a \_\_\_\_\_

$$R_f = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}$$

## Test for hydrogen

- \_\_\_\_\_
- \_\_\_\_\_

## Test for oxygen

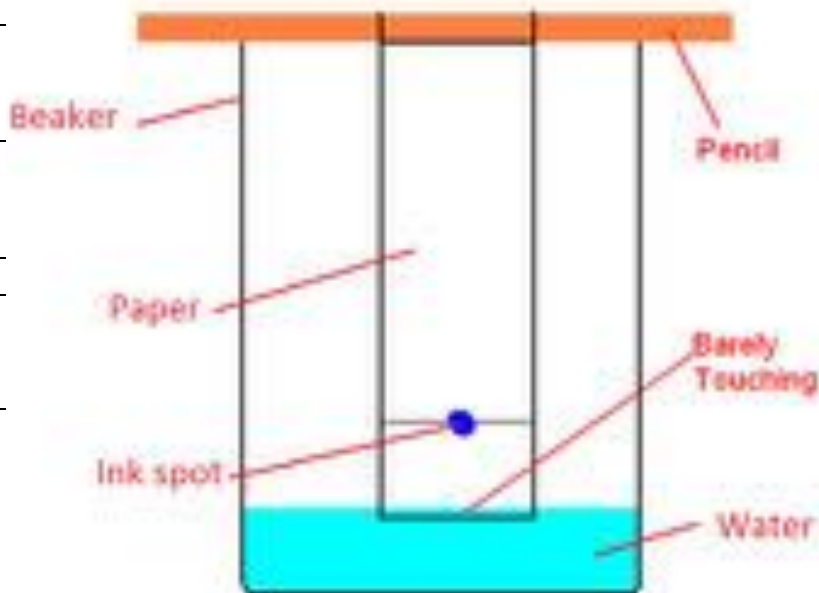
- \_\_\_\_\_

## Test for carbon dioxide

- \_\_\_\_\_
- \_\_\_\_\_

## Test for chlorine

- \_\_\_\_\_





## The atmosphere today

- About 80% \_\_\_\_\_
- About 20% \_\_\_\_\_
- Small proportions of \_\_\_\_\_

## The early atmosphere

- \_\_\_\_\_ released gases – \_\_\_\_\_
- No \_\_\_\_\_
- Water vapour \_\_\_\_\_
- Carbon dioxide \_\_\_\_\_

## How carbon dioxide decreased

- Dissolved \_\_\_\_\_
- Formation of \_\_\_\_\_
- Algae and plants used  $\text{CO}_2$  \_\_\_\_\_

## How oxygen increased

- Algae and plants produced  $\text{O}_2$  by \_\_\_\_\_



## Greenhouse gases

- Maintain \_\_\_\_\_
- Examples - \_\_\_\_\_

## How human activities increase greenhouse gases

- Carbon dioxide – \_\_\_\_\_
- Methane – \_\_\_\_\_

## Effects of climate change

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

## Carbon footprint

- \_\_\_\_\_
- Can be reduced by \_\_\_\_\_

## Atmospheric pollutants

- Combustion of \_\_\_\_\_
- Carbon monoxide is a \_\_\_\_\_ gas
- Sulfur dioxide and oxides of nitrogen cause \_\_\_\_\_
- Soot particles cause \_\_\_\_\_



## Potable water

- Water that is \_\_\_\_\_

## Desalination

- \_\_\_\_\_
- Can be done by \_\_\_\_\_
- Requires \_\_\_\_\_

## Waste water treatment

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

## Methods of extracting metals (Higher only)

- Phytomining – \_\_\_\_\_
- Bioleaching – \_\_\_\_\_

## Life cycle assessment stages

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

## Reusing and recycling

- Obtaining raw materials from the Earth by \_\_\_\_\_ and \_\_\_\_\_ causes environmental impacts
- Glass bottles can be \_\_\_\_\_
- Metals can be recycled by \_\_\_\_\_

Advantages of recycling	Disadvantages of recycling